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D. G. Tatkare Mahavidyalay, Mangaon,

District-Raigad, (MS) India, 402 104.

Affiliated to University of Mumbai

Anjuman Islam Janjira Degree College of Science

Murud-Janjira, District-Raigad, (MS) India, 402401.

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INTERNATIONAL CONFERENCE

ON

RECENT TRENDS IN CHEMICAL SCIENCE, PHYSICAL SCIENCE, LIFE SCIENCE AND COMPUTER TECHNOLOGY (*ICRTCPLCT–2025*)

25th February 2025

Proceeding





Organized by

Anjuman Islam Janjira Degree College of Science
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RECENT TRENDS IN CHEMICAL SCIENCE, PHYSICAL SCIENCE, LIFE SCIENCE AND COMPUTER TECHNOLOGY

Chief Editors

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I/C Principal,

A.I.J Degree College of Science, Murud - Janjira

Dr. B.M. Khamkar

Principal,

D. G. Tatkare Mahavidyalay, Mangaon - Raigad

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Schedule of Conference

Inaugural Function	10:15 am (IST)	All Dignitaries & Participants
Welcome Address	10:25 am (IST)	By Principals of Colleges
Presidential Speech	10:35 am (IST)	President of the Function
Keynote Address	10:50 am (IST)	**Dr. Vasant Pandit Mali**
Invited Talk 1	11:35 am (IST)	**Dr. Avinash Bapurao Ade**
Invited Talk 2	12:15 pm (IST)	**Dr, Md. Sanower Hossain**
Invited Talk 3	12:50 pm (IST)	**Dr. Gaurav M. Lohar**
Invited Talk 4	01:30 pm (IST)	**Mr. Nilesh Shinde**
Lunch Break	02:10 pm (IST) to 02:40 pm (IST)	Organizers
Oral/ Poster Paper Presentations	02:40 pm (IST) to 04:30 pm (IST)	Participants
Valedictory Function	4.30 pm onwards (IST)	Certificate and Trophies Awarding

Advisory Committee

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Dr. Sachin V Bangale G M Vedak College of Science Tala
Dr. Aditi Taunk, University of Sydney
Dr. Manisha Saron, USA
Dr. Shahina S. Mirza, Principal , G.M.Vedak College, Tala

Patrons for Conference



Adv. Rajiv Ashok Sable
President
Mangaon Shikshan Prasarak Mandal's
D. G. T. Tatkare Mahavidyalay, Mangaon



Mr. S. Zainuddin S. U. Kadri
Chairman
Anjuman Islam Janjira Degree College of Science,
Murud - Janjira

About D.G. Tatkare Mahavidyalay, Mangaon



A milestone- D.G. Tatkare Mahavidyalay, Mangaon, District-Raigad (Maharashtra) was laid by Late. Ashoka dada Sable in 1993, with the exclusive purpose of offering education to students in rural areas and upliftment of society. Since its establishment, the holy work of providing education to about 1500 poor students of rural areas is being done. The college has been re-accredited by NAAC with B+ Grade (Second Cycle CGPA 2.64). The college is affiliated to the University of Mumbai and offers 6 Undergraduate and 6 Postgraduate programs. The college is determined and committed to provide an excellent education in elevated region and dedicated to fostering a diverse and inclusive learning environment that emphasize ethical practice, and lifelong learning, empowering our graduates and post-graduates to lead in a dynamic scenario.

About Anjuman Islam Janjira Degree College of Science, Murud Janjira



Anjuman Islam Janjira's Anjuman Islam Janjira Degree College of Science, Murud Janjira, District- Raigad (Maharashtra) is one of the prime educational institutions affiliated to University of Mumbai. The college is run by Anjuman Islam Janjira presumably one of the largest educational trust. It was established in 1907 with the vision of attainment of socio-economic upliftment of minority community by imparting quality education. The college has played an important role in the overall development of Murud Janjira since past 15 years. The college offers B.Sc. and B.Sc. in computer Science, B.M.S. and B.A.F at UG level and M.Sc. Organic Chemistry & Botany Programmes at PG level. In near future Research Centre in Chemistry will start. It underwent assessment and accreditation by NAAC in second cycle and achieved B^+ Grade with 2.69 CGPA. This college received best college award by different organizations.

About Conference

This International Conference on recent trends in chemical science, physical, life sciences and Computer technology is a brain storming to furnish on opportunity to academics aspiring scientist and research scholars from various discipline of science to interact and present their research execution in their respective field. This conference will be platform to highlight research achievement in the field of chemical science, physical science, life science and Computer Technology. Recent research trends of stated topics will be discussed

Subthemes for ICRTCPLCT–2025

Green Chemistry
Mixed Metal Oxides
Material for electronic devises
Polymer Chemistry
Synthetic Chemistry
Scope of Computer technology
Smart Computers
Artificial intelligence
Cyber Security
Ethical Hacking
Plant Diversity
Medicinal Plants
Bioorganic Chemistry
Sensor
Biodiversity
Agro-tourism
Nano material for future
Semiconductors
Bio fertilizers & organic farming
Environmental Sustainability
Electronic & Magnetic Property

दूरध्वनी क्रमांक: २६३०३९ ।। शील परं भूषणम् ।। दूरध्वनी क्रमांक: २६१४४४

माणगांव शिक्षण प्रसारक मंडळ

माणगांव - रायगड.

संस्था नोंदणी क्र. एफ -२७ र. नं. Bom 7 / 1958 KLB Dated 7 - 11 - 1958

ॲड .राजीव साबळे
प्रेसिडेंट
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श्री.कृष्णा रुपचंद गांधी
सेक्रेटरी
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President Message

D. G Tatkare Mahavidyalaya was laid by late Ashok Dada Sable in 1993 with the exclusive purpose of offering education to students in rural areas as an upliftment of the society. Since its establishment, the holy work of providing education is being done. The college has been reaccredited by NAAC with grade B+ (second cycle CGPA2.64). The college is affiliated to University of Mumbai and offer 6 UG and 6 PG programmes.

It is truly a delight to learn that D.G. Tatkare MahavidyalayMangaon Raigad, in collaboration with Anjuman Islam Jangira Degree College of Science, MurudJangiraRaigarh, is taking the initiative to host the international E-conference on Recent Trends in Chemical Science, Physical Science, Life Science, and Computer Technology on February 25th2025and is producing a souvenir to commemorate the event.

As the president and on behalf of the Executive Council & entire College Development Committee, we take great pride in the collaboration of both institutions in organizing such a significant event. We anticipate that this conference will inspire young scientists, aspiring researchers, and students to pursue their ambitions in the future. The students and faculty from both colleges will gain valuable insights from this conference. We extend our gratitude to the staff involved in organizing the event and wish them the utmost success for the conference.

Adv. Rajiv Ashok Sable

President

ANJUMAN ISLAM JANJIRA
DEGREE COLLEGE OF SCIENCE

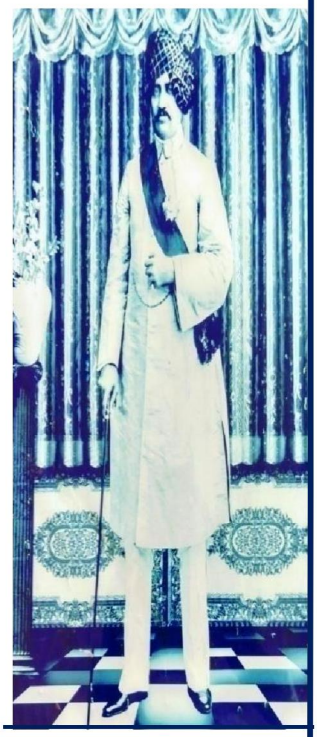
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Dr. SAJID SHAIKH
I/C Principal

Ref. No. AIJDCM/ **Date:**



Message from Chairman of College

Anjuman Islam Janjira Degree College of Science, Murud-Janjira, Raigad was established in 2009 the first in Taluka. The entire team of Anjuman Islam Janjira successful development the campus. Infrastructure & college went through NAAC Accreditation for Second cycle in 2024 with 'B+' grade with 2.69 CGPA. Either this college only cathead undergraduate education in the chemistry, Botany & Computer Science. From A.Y. 2021-22, this college start M. Sc Chemistry & M. Sc. Botany. We have also received permission of Research Centre in Chemistry.

Being a chairman and by entire team of college development committee, we feel, provide that this college is organizing International Conference on 'Recent Trends in Chemical Science Physical Science Life Science and Computer Technology' (ICRTCPLCT- 2025) on 25th February 2025. Research section & Performa from various part will participants in this conference.

We feel that this conference will be useful to all buddy researchers. There will be useful academic work will be short and discussion in the conference.

This student only staff keeping stiff of this college will also be benefited from the conference.

We all thankful to concern staff involved in organizing in conference & wish a best of success for the conference.

Chairman
Anjuman Islam Janjira Degree College of Science

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Dr. Dnyandeo Mhaske M.Sc., Ph.D.

Vice Chancellor

Ref. No. : KBPU/Estd/2024-25/1183 Date : 22 FEB 2025

Message

It is with immense pride and enthusiasm that I extend my heartfelt congratulations to the organizing committee of Mangaon Shikshan Prasarak Mandal's D. G. Tatkare Mahavidyalay, Mangaon, District-Raigad, (MS) India, 402401. and Anjuman Islam Janjira Degree College of Science Murud-Janjira, District-Raigad, (MS) India, 402401. for successfully hosting this **International Conference on Recent Trends in Chemical Science, Physical Science, Life Science, and Computer Technology**. This prestigious event serves as a dynamic platform, bringing together esteemed researchers, academicians, scientists, and professionals from across the globe to exchange ideas, share groundbreaking research, and foster collaborations that will shape the future of science and technology.

Academic gatherings of this nature reflect our institution's unwavering commitment to research excellence, interdisciplinary learning, and global engagement. Conferences such as this not only provide a stage for presenting innovative discoveries but also serve as a catalyst for new collaborations, transformative ideas, and impactful research contributions. The synergy between different scientific disciplines showcased here underscores the importance of an integrated approach to addressing contemporary challenges.

I sincerely appreciate the relentless efforts of the organizing committee, faculty members, research scholars, and participants who have worked tirelessly to make this conference a reality. Their dedication, vision, and passion for advancing knowledge have been instrumental in the success of this event. I am confident that the discussions and interactions during this conference will inspire new perspectives, encourage pioneering research, and lay the groundwork for meaningful partnerships that extend beyond this gathering.

As we embark on this exciting journey of knowledge sharing and academic discourse, I extend my best wishes to all the participants for a fruitful and enriching conference. May this event open new avenues for scientific exploration and innovation, ultimately contributing to the progress of society at large.

Wishing you all a successful and inspiring conference!

Karmaveer Bhaurao Patil University KBPU Estd 2021 Satara

Dr. Dnyandeo Kundlik Mhaske

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Email : vcoffice@unikbp.ac.in | Email-vc@unikbp.ac.in

Accredited by NAAC with Grade-B-2.17(2014) | B+ - 2.64 (2022) | Permanently Affiliated to University of Mumbai

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Arts, Science, Commerce.

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Reg. No. 3664/93

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Late Ashokdada Sable, Founder - (Ex. M. L. A.) | Shri. Rajiv Sable, President | Shri. Krishna Gandhi, Secretary | Dr. Baban M. Khamkar, Principal



Principal

It is a true pleasure that D.G. Tatkare Mahavidyalay Mangaon Raigad, in collaboration with Anjuman Islam Jangira Degree College of Science, Murud Jangira Raigarh, is taking the initiative to host the international E-conference on Recent Trends in Chemical Science, Physical Science, Life Science, and Computer Technology on February 25th2025.

The aim of this conference is to emphasize the latest developments in science and technology. We are currently inhabiting an era of innovation. Innovations arise from extensive research, which has become a crucial element in higher education. Research within the domains of science and technology holds great importance, contributing to the advancement of humanity and the wellbeing of our environment. This conference, which advocates for research initiatives, is vital for emerging scientists. By organizing such an event, a forum is created for nova researchers and seasoned experts to share their perspectives and engage in meaningful discussions, ultimately fostering high-quality research.

I extend my hearty welcome to all delegates, participants and students to this conference and wishing best luck for further discussion.

Dr. B. M. Khamakar

Principal

ANJUMAN ISLAM JANJIRA
DEGREE COLLEGE OF SCIENCE

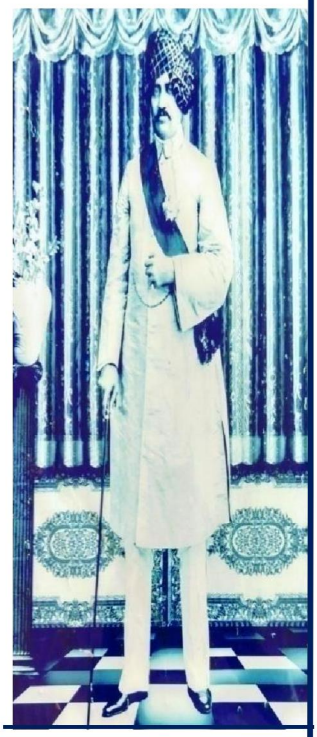
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HIFZURREHMAN NAZIR
Secretary

A RAHIM KABLE
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AZIM KHANZADA
Murud Halqa
President

S. ZAINUDDIN KADIRI
CDC Chairman

Dr. SAJID SHAIKH
I/C Principal

Ref. No. AIJDCM/ **Date:**



Message from Principal

It gives me immense pleasure to welcome honourable delegates, participants on the occasion of International Conference on 'Recent Trends in Chemical Science Physical Science Life Science And Computer Technology' ICRTCPLCT-2025) organized by this college in collaboration with D.G. Tatakre College Mangaon, Raigad. It is intention of this college to provide platform to the research scholars in the field of science & technologies to tackle the recent achievement through the present conference organised on 25th February 2025.

It's my duty to say thanks to PM.USHA for providing financial assistance for this International Conference.

This college is one of the Non grant Minority institute wear majority near about 80% Muslim girls students take education since 2009. This college focus on the honest development of students and also make society responsible & cultured citizens. This college always trine to inculcate value added education by organizing different activities, workshop, seminar and conference.

I think so this conference will above help to buddy research to give valuable technology and provide quality research for nations development.

I again welcome all the delegates for this international e-conference & look forward to most successful discussion.

Dr. Sajid F. Shaikh
I/C Principal
Anjuman Islam Janjira Degree College of Science

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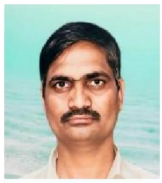
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Ms. Sumaiyya Ansari
Member
Asst. Prof. in BAF
Contact No. 8446403071



Message from Organizing Committee

Dear Esteemed Participants,

On behalf of the Organizing Committee, we extend our warmest welcome to you for the **ICRCTCPLCT - 2025**, an International Conference on **Recent Trends in Chemical Science, Physical, Life Sciences and Computer Technology**, to be held on **25th February** at **D.G.T. Mahavidyalay – Mangaon, Raigad**.

This conference aims to bring together leading researchers, academicians, and industry experts to exchange knowledge, foster collaborations, and explore innovative solutions in **Chemical Science, Physical, Life Sciences and Computer Technology**. With insightful keynote sessions, engaging panel discussions, and thought-provoking research presentations and poster, we anticipate a dynamic and intellectually stimulating event.

We sincerely appreciate your participation and look forward to fruitful discussions that will contribute to the advancement of science and society. Wishing you a successful and enriching experience at **ICRCTCPLCT – 2025!**

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Study of Magnetic Properties of Lithium-Cadmium Ferrite Nanoparticles Prepared by Sol-Gel Method

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Anjuman Islam Janjira Degree College of Science, Murud Janjira[1,2]

Abstract: *Lithium-Cadmium ferrite (Li□- ₓCdₓFe₂ O₄ , where x = 0, 0.1, 0.2) nanoparticles were synthesized using a simple, cost-effective sol-gel auto-combustion method at low temperature. Lithium-Cadmium ferrite belongs to the category of soft ferrites and has potential applications, particularly in gas sensors. The present study focuses on analyzing the structural and magnetic properties of the synthesized Lithium-Cadmium nanoferrite samples. The magnetization behavior of the nanoparticles was investigated, and key parameters such as saturation magnetization (Ms), remanence (Mr), and coercivity (Hc) were derived from the hysteresis loops. Vibrating Sample Magnetometry (VSM) results indicate that as Cd^{2+} substitution increases in Lithium ferrite, both remanence (Mr) and saturation magnetization (Ms) increase. However, coercivity (Hc) initially increases up to x = 0.1 and then decreases at x = 0.2. These magnetic property variations suggest that the synthesized materials transition from hard ferrite to soft ferrite behavior.*

Keywords: Nanoparticles, Lithium-Cadmium ferrite, Sol-Gel Method, Magnetic Properties

I. INTRODUCTION

Nano ferrites have grown significant attention in both industrial and research domains due to their versatile applications. These materials are particularly valued for their roles in Ferro fluids, magnetic drug delivery, gas sensors, electromagnetic devices, high-frequency applications and hyperthermia for cancer treatment [1][2][3]. Among the various ferrites, lithium ferrite ($LiFe_2O_4$) stands out as a soft magnetic material with high saturation magnetization (Ms) and low coercivity (Hc), making it a prime candidate for numerous technical applications. As Lithium-Cadmium ferrite ($Li_{1-x}Cd_xFe_2O_4$) belongs to the soft ferrite category it also exhibits tunable magnetic properties depending on Cd^{2+}substitution. The incorporation of Cd^{2+} ions into the lithium ferrite structure influences the cation distribution within the spinel lattice, thereby varying the material's magnetic behavior. Various synthesis techniques, including hydrothermal, co-precipitation, and sol-gel methods, have been engaged to prepare ferrite nanoparticles [4]. Among these, the sol-gel auto-combustion method offers advantages such as short treating time at a very low temperature, high compositional homogeneity, and controlled particle size distribution [5]. Understanding the magnetic properties, including saturation magnetization (Ms), remanence (Mr), and coercivity (Hc), is crucial for optimizing the material for potential applications. The present study focuses on the synthesis of $Li_{1-x}Cd_xFe_2O_4$ (x = 0, 0.1, 0.2) nanoparticles via the sol-gel auto-combustion method and investigates their structural and magnetic properties using Vibrating Sample Magnetometry (VSM).

II. SYNTHESIS METHOD

Lithium-Cadmium ferrite ($Li_{1-x}Cd_xFe_2O_4$) nanoparticles were prepared using the sol-gel auto-combustion method. The stoichiometric amounts of Lithium nitrate ($Li(NO_3)_2$, 68.95 g/mol), Cadmium nitrate ($Cd(NO_3)_2$, 308.48 g/mol), and Ferric nitrate ($Fe(NO_3)_2$, 404.00 g/mol) were dissolved in distilled water to prepare a homogeneous precursor solution. The solution was stirred using a magnetic stirrer for 20 minutes to ensure complete dissolution. Citric acid ($C_5H_8O_7.H_2O$) was then added as a complexing agent, and the solution was maintained at 30°Cfor 60 minutes. To regulate the pH, ammonia water (NH_4OH) was added gradually until the pH reached 7. The solution was then heated to 100 °C under continuous stirring till gel formation occurred. The obtained gel underwent auto-combustion, leading to the formation of fine ferrite powder. The resulting powder was further sintered at 600°Cto enhance crystallinity.

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Finally, the sintered sample was ground thoroughly to obtain Lithium-Cadmium ferrite nanoparticles suitable for further characterization.

III. RESULTS AND DISCUSSION

X-Ray Diffraction

Figure 1 presents the XRD patterns of $Li_{1-x}Cd_xFe_2O_4$ samples (x = 0, 0.1, 0.2), confirming phase purity due to the absence of additional peaks. The average grain size, calculated using the Debye-Scherrer formula, ranged from 32.65to 39.28nm (Table 1), though variations in lattice parameter were observed with increasing Cd^{2+} content.The lattice parameter increases linearly with cadmium content. The increase in lattice parameter is expected due to higher ionic radii of Cd^{2+} than other[6]. The peaks at (2 2 0), (3 1 1), (4 0 0), (4 2 2) and (4 4 0) confirmed the spinel structure of the samples[7]. This also demonstrates the homogeneityof the prepared samples.The XRD patterns shows sharp peaks indicate good crystallinity, and the differences in peak intensity between the samples suggest variations in crystal growth.

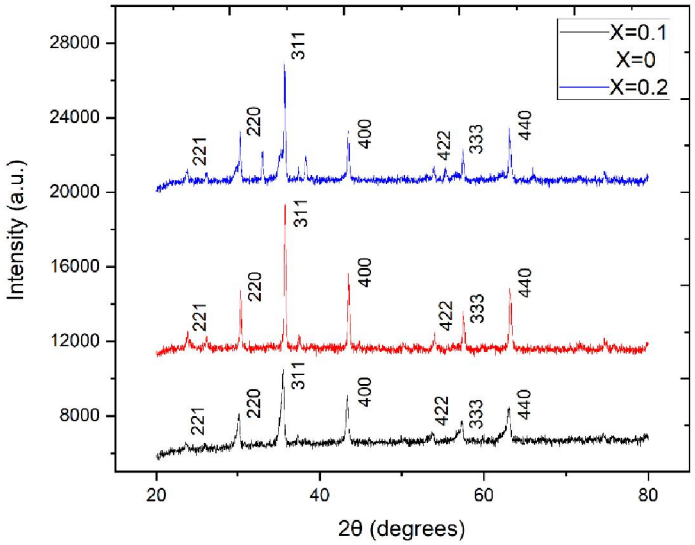


Figure 1 stacked XRD patterns of $Li_{1-x}Cd_xFe_2O_4$ samples (x = 0, 0.1, 0.2)

Table 1

Sr. No	Concentration	$t = \frac{0.9\lambda}{\beta cos\theta}$ (nm)	Lattice parameter (Å)	Interplanar spacing (d)
1	$Li_1Cd_0Fe_2O_4$	23.69	32.65	2.19
2	$Li_{0.9}Cd_{0.1}Fe_2O_4$	19.10	33.26	1.74
3	$Li_{0.8}Cd_{0.2}Fe_2O_4$	23.00	39.28	2.11

Magnetic Property (VSM)

Typical hysteresis loops of $Li_{1-x}Cd_xFe_2O_4$ (x = 0, 0.1, 0.2), samples as obtained from VSM characterization are shown in Figure 2.The saturation magnetization (Ms) for all the ferrites after sintering is listed in Table 2.It is clear that for the samples the saturation magnetization increases from 47.28 to 55.20 emu/gm and remanence magnetization (Mr) increases from 16.32 to 21.79 emu/gm. This could be due to Cd^{2+} replace ion on the tetrahedral A–sites, causing the decrease of magnetic moment in the sub lattice M_A, resulting in the increase magnetic moment which increases saturation magnetization[8]. It is also found that with increasing concentration of Cd^{2+},coercivity (Hc) first increasesup

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to x = 0.1 concentration then decreases for x = 0.2 concentration.This could be due to further increase in the concentration of Cd^{2+} (more than 0.1), the exchange interaction between A and B sites gets lowered resulting in strengthening of B-B interaction and weakening of A-B interaction, which leads to decrease of coercivity (Hc).the decreasing in coercivity (Hc) can be utilized to change magnetic properties of Lithium ferriteand hard magnetic material can be converted to soft magnetic material.

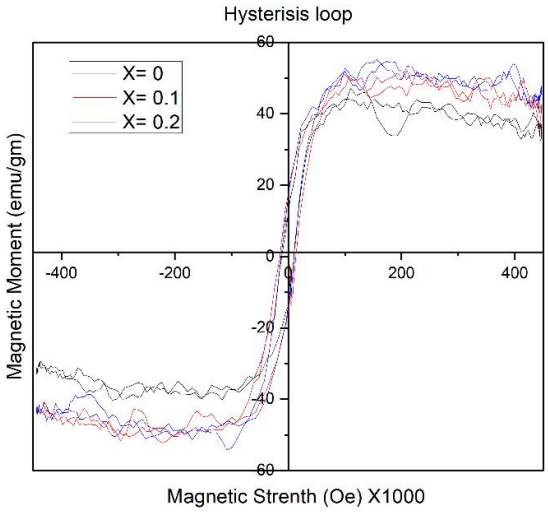


Figure 2. Hysterisis loop of $Li_{1-x}Cd_xFe_2O_4$ (x = 0, 0.1, 0.2)samples.

Table 2

Sr. No	Concentration	Hc Oe X 1000	Mr emu/gm	Ms emu/gm
1	X=0	5714.07	016.320	047.280
2	X=0.1	8302.62	020.680	052.200
3	X=0.2	4848.75	021.790	055.200

IV. CONCLUSION

Lithium-Cadmium ferrite nanoparticles $Li_{1-x}Cd_xFe_2O_4$ (x = 0, 0.1, 0.2), were prepared via sol-gel auto combustion route. From XRD Patternconfirmed the spinel structure of the samples with good crystallinity. it is also clear that the lattice parameter increases linearly with cadmium content.From VSM it is clear that the saturation magnetization (Ms)andremanence magnetization (Mr) increases with cadmium content while first increases up to x = 0.1 concentration then decreases for x = 0.2 concentration.The change in magnetic property with cadmium content can be utilized to change magnetic properties of Lithium ferrite and hard magnetic material can be converted to soft magnetic material.

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The Role of Carbon Nanofibers in Soil Enhancement: A Path to Sustainable Agriculture

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Abstract: *Carbon nanofibers (CNFs) have shown great potential in multiple applications. These explore the synthesis, properties, and potential uses of CNFs, focusing on their structural characteristics, methods of production, and practical applications. CNFs are distinguished by their high aspect ratios, significant surface areas, and excellent electrical and thermal conductivities. These properties make them suitable for various applications, including reinforcement in composite materials, energy storage, environmental remediation, and biomedical uses. The various studies investigated several synthesis techniques, such as chemical vapor deposition, electrospinning, and carbon arc discharge, each offering specific advantages in terms of control over morphology and scalability. Moreover, the various studies investigated the interaction of CNFs with soil, demonstrating their potential to enhance soil properties by improving nutrient retention and water holding capacity, which can be beneficial in agricultural applications. The present study indicates that CNFs can significantly influence soil conductivity and structure, thereby impacting water and nutrient dynamics. This comprehensive examination of CNFs aims to provide insights into optimizing the application scope, highlighting the role in advancing materials science and environmental sustainability.*

Keywords: Nanomaterials, Carbon nanofibers (CNFs), soil property, soil interaction, nutrient leaching, water retention, soil conductivity, agricultural applications

I. INTRODUCTION

The carbon element is abundant in nature and closely related to human life. Carbon has various types of allotropes (graphite, diamond, carbon nanofibers, carbon nanotubes, graphene, etc.) depending on the molecular bonding mode with hybridized bonding of sp, sp2 and sp3. And it can be used as a single element to form substances with great differences in properties, such as zero-dimensional (0D) carbon dots (CDs) and fullerene, one dimensional (1D) carbon nanofibers (CNFs) and carbon nanotubes (CNTs), as well as two-dimensional (2D) graphene. (Coville, et.al. 2011) For instance, applications of CDs, CNFs, CNTs, and graphene have been explored in the fields of optoelectronics, energy storage, catalysis, bio-imaging, and environmental science due to their exceptional fluorescent, mechanical, thermal, and electrical properties.

What are CNFs?

Carbon nanofibers (CNFs) among various allotropes of carbon are fibrous carbon materials having less than 1μm thickness. It has high aspect ratios, with diameters ranging from tens to hundreds of nanometers and lengths reaching several micrometers. CNFs reveal smooth, porous, hollow, helical, and stacked cup structures, CNFs is smooth, porous, hollow and helical which is composed of graphene layers. A lot of studies have been performed to explore its unique properties and are useful in a variety of applications because of their large surface area, high electrical conductivity, and a large fraction of active sites. It has similar structure and properties to CNTs, but it has easier production, low cost, and improved functions. To produce CNFs, several methods, such as electrospinning, chemical vapor deposition (CVD), and template assisted synthesis, have been widely utilized. The choice of synthesis method depends on factors such as desired CNF properties, production scale, cost considerations, and intended applications. (Feng, et al., 2014)

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Features and applications of CNFs:

- Mechanical Strength: CNFs have extremely high mechanical strength and stiffness, making them ideal for reinforcing composite materials in aerospace, automotive, and structural engineering applications.
- Thermal conductivity: They have high thermal conductivity, making them suitable for use in thermal management applications such as heat sinks and electrical equipment that require effective heat dissipation.
- Chemical Stability: They are chemically stable and corrosion-resistant, making them ideal for use in severe environments and chemical processing applications.
- Biomedical Applications: CNFs are being investigated for a variety of biomedical applications, including drug delivery, tissue engineering scaffolds, and biosensors due to their biocompatibility and unique properties. (Wen, etal., 2015)
- Environmental Applications: They are used in environmental remediation processes such as water purification and air filtration due to their large surface area and adsorption properties. Overall, carbon nanofibers are a type of sophisticated material with several features and applications in industries ranging from aerospace and electronics to healthcare and environmental engineering.

Interaction of CNFs with soils

The interaction of carbon nanofibers (CNFs) with soil can vary depending on factors such as the properties of the CNFs, the type of soil material used, its surface modifications, and the specific application. Incorporating carbon nanofibers (CNFs) into a soil containing mixture of perlite, Irish peat moss, and vermiculite can significantly change how water runs through the soil. (Shweta Vyas, 2021) CNFs have a high surface area, enabling them to absorb and hold nutrients effectively, as a result less nutrient lost during the leaching process. This slow-release mechanism ensures nutrients remain available to plants for longer. The ability of CNFs to retain the water enhances the soil's ability to hold moisture, reducing the frequency and volume of water draining through the soil. This improved water retention, combined with better soil structure, prevents rapid nutrient loss. The improved soil structure and porosity from CNFs result in better water infiltration and distribution, preventing rapid leaching. Less soil compaction ensures better root growth and nutrient uptake, reducing the need for frequent fertilization. In the soil leaching process with increasing quantities of CNFs, the conductivity could potentially increase. Carbon nanofibers are prominent for their high ratio and peculiar structure, which contribute to higher electrical conductivity. When combined with a solid leaching process, they can produce a conductive network within the material, allowing for improved electron transition and consequently improving conductivity. However, the actual increase in conductivity would be determined by a variety of factors, including the material's initial conductivity, nanofiber dispersion and alignment, and overall processing conditions. (Zhou, et al, 2020)

The unique properties of CNFs make them ideal for environmental applications, particularly soil remediation. CNFs can absorb heavy metals and organic pollutants from soil, thereby reducing their mobility and bioavailability. The high surface area and functionalized surface of CNFs enhance their adsorption capacity. (Zhang, D., et al. ,2013)

The introduction of CNFs into soil can influence microbial communities. Studies have shown that while CNFs can support the growth of certain beneficial microbes, they may also inhibit others due to their strong adsorption properties and potential cytotoxicity. This dual effect necessitates careful consideration of CNF concentrations and long-term impacts on soil health. (Ramos, C. L., et al. ,2016)

The fate and transport of CNFs in soil are governed by factors such as particle size, surface charge, and soil composition. CNFs can aggregate or disperse in soil, influencing their mobility and interaction with soil particles. Environmental conditions such as pH, ionic strength, and the presence of natural organic matter also play critical roles. (Petersen, E. J., & Zhang, L., 2011)

Future research should focus on the development of sustainable and safe CNF applications in soil. This includes the optimization of CNF synthesis methods to minimize environmental impact, understanding long-term effects on soil health, and developing guidelines for safe use. (Lee, J. H., et al. ,2019).

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II. MATERIALS & METHODS

I. Materials required:

- Nanofibers
- Soil (from www.amazon.com)

II. Chemicals required: Paraffin oil, 0.1M $AgNO_3$ solution, 0.25M K_2CrO_4 indicator solution, 0.01N H_2SO_4 solution, Phenolphthalein indicator, Methyl orange indicator, 0.01M EDTA solution, Buffer solution (pH 10), 50% w/v NaOH solution, Eriochrome Black T indicator and Hydroxy naphthol blue indicator

III. Instruments required:

- Conductivity Meter (Model EQ660B)
- pH Meter (Model EQ-610)

IV. Techniques used:

- Precipitation titration by Mohr's Method
- Hardness of water
- Complexometric titration
- Alkalinity

V. Experimental Methods:

The experimental method consists of five parts: -

Part I: Preparation of column without carbon nanofibers:

Before starting the experiment, the apparatus used was standardized. The 10g of soil was transferred into standardized column and 50cm3 of distilled water was added into the column. On the upper layer of water 2cm3 of paraffin oil was added and the column was sealed with cotton to prevent evaporation of distilled water, and the column was kept untouched for 24 hours. The time of addition of water in the column was noted down. Figure 02. Column containing 10g of solid and 50cm3 of distilled water.

Part II: Preparation of column with carbon nanofibers:

Before starting the experiment, the CNFs were roasted in oven at 100oC for five minutes to remove excess of moisture and impurities present in it and were cooled. Then 15mg of carbon nanofibers was weighed and the 10g of soil was also weighed. The CNFs and soil were then transferred into a porcelain dish for mixing and after that it was transferred into standardized column. Added 50cm3 of distilled water into it and on the upper layer of water $2cm^3$ of paraffin oil was added and then column was sealed with cotton to prevent evaporation of hours and the time of added and then column was sealed with cotton to prevent evaporation of distilled water and the column was kept untouched for 24 hours and the time of addition of water in the column was noted down.

The same procedure was followed for 25mg, 35mg, 45mg, 55mg, 65mg, 75mg, 85mg, 95mg, and 105mg of nanomaterial.

Part III: Collection of Elute from the column

After 24 hours, the elute was filtered into a beaker by using Whatman filter paper number 41. The volume of elute was measured and transferred in a stopper bottle.

Part IV: Dilution of eluted solution: -

$10cm^3$ of eluted solution were pipetted out from each stopper bottle in 50 cm^3 standard measuring flasks which was then diluted with distilled water up to the mark. After the preparation of standard elute solutions, its conductance, pH, chloride ion concentration, hardness and alkalinity were determined.

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Part V: To determine the properties of standard, elute solutions:

A. Determination of pH: -

The pH meter switched on 10 minutes before starting the experiment and then it was standardized with the help of a supplied connector cable which joins the electrode terminal and pH terminal situated at the back of the instrument. After standardization, the combined glass electrode was dipped into sample solutions to measure its pH.

B. Determination of Conductance: -

The conductivity meter was switched on 10 minutes before starting the experiment and then the range switch was kept at 2 millisimens position and the standard conductance switch is kept on. The digital display reading was calibrated to show 1.000 for standardization. After that the conductivity cell was dipped in the sample solution and the reading was recorded in millisimens.

C. Determination of Chloride ion Concentration by Mohr's method: -

In this method, $10cm^3$ of standard elute solution was pipetted into a conical flask and $1cm^3$ of 0.25M K_2CrO_4 indicator solution was added which give **faint yellow colored solution**. Then it was titrated with 0.1M $AgNO_3$ solution result in **pinkish brown colored solution** as end point of the titration. The titration process is repeated to get constant burette reading.

Observations: -

Solution in burette: - 0.1M $AgNO_3$ solution
Solution in conical flask: - $10cm^3$ of diluted sample solution
Indicator: - K_2CrO_4 solution
End point: - Faint yellow to pinkish brown color
Formula: - Chloride ion concentration(mg/l) = (A-B) x N x 35460/V
A= Volume of $AgNO_3$ for sample titration
B= Volume of $AgNO_3$ for blank titration
N= Normality of $AgNO_3$
V= Volume of water sample taken in cm^3

Calculation for sample A : -

Volume of $AgNO_3$ used for distilled (Blank titration) = 0.5 cm^3
Normality of $AgNO_3$ = 0.134 N
Volume of $AgNO_3$ used for Sample A = 0.7 cm^3

$$\text{Chloride ion concentration} = (0.7 - 0.5) \times 0.134 \times 35460/10$$
$$= 0.2 \times 0.134 \times 35460/10$$
$$= 95.0328 \text{ mg/l}$$

Similarly, concentration of other sample solutions was calculated.

D. Determination of Hardness by Complexometric titration: -

Part -A: Determination of total hardness

10 cm^3 of standard elute solution was pipetted out into a conical flask and 2 cm^3 of buffer solution (pH 10) followed by 3 drops of Eriochrome Black T indicator was added into it. This was then titrated with 0.01M EDTA solution until the color of solution changed from **wine red to sky blue**. The titration process was repeated 3-4 times to achieve C.B.R. This provides the volume of EDTA required for both calcium and magnesium ions.

Observations for total hardness: -

Solution in burette: - 0.01M EDTA solution
Solution in conical flask: - $10cm^3$ of diluted sample solution + $2cm^3$ of buffer solution
Indicator: - Eriochrome Black T
End point: - Wine red to sky blue color

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Part -B: Determination of concentration of Ca^{2+} ions

10 cm^3 of diluted sample water was pipetted out into a conical flask and 30 drops of 50% NaOH solution were added. The solution was mixed and kept for a few minutes for the complete precipitation of magnesium ions as $Mg(OH)_2$. And in this mixture a pinch of Hydroxy naphthol Blue Indicator were added, resulting in **purplish red colored solution**. Then it was titrated with 0.01M EDTA to give **sky blue** color as end point of titration. The titration process was repeated 3-4 times to achieve C.B.R.

Observations for concentration of Ca^{2+} ions: -

Solution in burette: - 0.01M EDTA solution

Solution in conical flask: - 10cm^3 of diluted sample solution + 30 drops of 50% NaOH solution

Indicator: - Hydroxy naphthol Blue

End point: - Purplish red to sky blue color

Formula:

Total hardness as CaCO3, (mg/l) = V1 x C x 1000 / V, where

V1 = volume of 0.01M EDTA required

C = mg CaCO3 equivalent to 1 cm3 EDTA titrant (1 cm3 0.01 M EDTA ≡ 1.000 mg CaCO3) or C = 1 x Molarity of EDTA / 0.01M

= 1 x 0.012/0.01

= 1.2

V = Volume of water sample in cm3

Calcium hardness as CaCO3 (mg/l) = V2 x C x 1000 / V, where

V2 = volume of 0.01M EDTA

C = mg CaCO3 equivalent to 1 cm^3 EDTA titrant

V = Volume of water sample in cm^3

Magnesium hardness = Total hardness as CaCO3 (mg/l) – Calcium hardness as CaCO3 (mg/l)

The total hardness of all the sample solutions was calculated.

E. Determination of Alkalinity in the Standard Elute Solutions: -

In this method, 10 cm^3 of water sample was pipette out into a conical flask and 3 drops of phenolphthalein indicator were added. The solution remains colorless that indicates alkalinity was absent. In that mixture, 3 drops of methyl orange indicator were added, and the color of the solution became reddish pink which on titration with 0.01N H_2SO_4 remains reddish pink.

Observation: - No change in alkalinity

Alkalinity of CaCO3 =Volume of H_2SO_4 x Normality of H_2SO_4 x 50 x 1000/Volume of water sample (cm^3)

III. RESULT AND ANALYSIS

The experimental study shows the following observation:

Preparing the Column: -

Column numbers	Weight of CNFs	Weight of soil	Volume of D/W added	Time of keeping sample	Elute collected
0	0mg	10g	50cm3	24 Hours	39cm3
1	15mg	10g	50cm3	24 Hours	38cm3
2	25mg	10g	50cm3	24 Hours	37cm3
3	35mg	10g	50cm3	24 Hours	37cm3
4	45mg	10g	50cm3	24 Hours	36cm3
5	55mg	10g	50cm3	24 Hours	35cm3
6	65mg	10g	50cm3	24 Hours	34cm3
7	75mg	10g	50cm3	24 Hours	33cm3
8	85mg	10g	50cm3	24 Hours	32cm3

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9	95mg	10g	50cm3	24 Hours	32cm3
10	105mg	10g	50cm3	24 Hours	31cm3

Table No.- 1: Preparation of Column with CNFs and soil

Burette readings for standard elute solution

Standard Elute solutions	C.B.R. for Cl- ion conc. cm^3	C.B.R. for Hardness	
		Total hardness ($V1cm^3$)	Conc. Of Ca^{2+} ions ($V2 cm^3$)
Samples A	0.7	0.8	0.5
Samples B	0.8	0.8	0.5
Samples C	0.8	0.8	0.5
Samples D	0.8	0.8	0.5
Samples E	0.9	0.9	0.6
Samples F	0.9	0.9	0.6
Samples G	0.7	0.9	0.6
Samples H	0.7	0.9	0.6
Samples I	0.8	1.0	0.7
Samples J	0.8	1.0	0.7
Samples K	0.8	1.0	0.7

Table No. 2: Burette reading for Chloride ion, total hardness and Ca^{2+} ions

After the completion of the experiments, the following results obtained:

Samples	Cl^- ion conc. (mg/l)	Hardness of std. elute solution (mg/l)			pH	Conductance	Alkalinity
		Total hardness as $CaCO_3$	Ca2+	Mg2+			
A	95.03	96	60	36	7.69	0.73	No change in alkalinity
B	142.55	96	60	36	7.75	0.80	
C	142.55	96	60	36	7.78	0.84	
D	142.55	96	60	36	7.81	0.86	
E	190.10	108	72	36	7.84	0.88	
F	190.10	108	72	36	7.86	0.89	
G	190.065	108	72	36	7.89	0.90	
H	95.0328	108	72	36	7.93	0.91	
I	95.0328	120	84	36	7.96	0.93	
J	142.549	120	84	36	8.01	0.95	
K	142.549	120	84	36	8.08	0.96	

Table No. 3: Results obtained after completion of the experiments

The above experimental study investigated that the interaction of carbon nanofibers (CNFs) in soil enhances water retention capabilities, thereby reducing the frequency and volume of water draining through the soil. As a result, the pH and conductance of elute changes. This indicates that addition of CNFs to soil can significantly impact on various soil properties, particularly focusing on water and nutrient retention which has implications for agricultural and environmental applications.

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This improved water retention is critical in preventing rapid nutrient loss, as CNFs can absorb and hold nutrients effectively. This slow-release mechanism ensures that nutrients remain available to plants for a longer duration, reducing the need for frequent fertilization and irrigation.

This also shows promising environmental applications such as water purification due to their high surface area and adsorption capabilities.

IV. CONCLUSION

From the above observation, it is concluded that carbon nanofibers (CNFs) have a significant positive impact on soil properties, particularly in enhancing water retention, reducing nutrient leaching, and improving soil conductivity and structure.

CNFs have a high surface area and peculiar structure, which contribute to higher electrical conductivity when incorporated into soil. The formation of a conductive network within the soil matrix enhances electron transition, potentially improving the soil's overall conductivity. Additionally, the improved soil structure and porosity resulting from CNFs incorporation led to better water infiltration and distribution, preventing rapid leaching and ensuring better root growth and nutrient uptake

The analysis of water samples eluted from CNF-treated soil shows variations in chloride ion concentration, hardness, pH, and alkalinity. These variations suggest that CNFs can influence the chemical environment of the soil, which may be beneficial for plant growth and soil health. Hence, it can be used for agricultural purposes.

Further research is recommended to explore the long-term effects of CNFs on soil ecosystems and their interaction with various soil types and plant species.

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Penetration Testing's Function in Bolstering Cybersecurity Defenses

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Abstract: *Penetration testing, a basic ethical hacking technique, has emerged as a crucial tool for identifying and resolving vulnerabilities in modern cybersecurity systems. This study looks at how penetration testing can strengthen organizational defenses against evolving cyberthreats. By simulating real attacks, penetration testing provides companies with crucial information about potential weaknesses in networks, applications, and systems. This article discusses penetration testing techniques, tools, and frameworks, emphasizing how well they work to proactively fix security vulnerabilities. It also highlights the challenges faced by penetration testers, including ethical and legal dilemmas and the increasing intricacy of cloud-based and Internet of Things environments. The tactics employed by cybercriminals must evolve in tandem with those of ethical hackers. This paper explores the ways in which artificial intelligence (AI) and machine learning are transforming penetration testing and offering fresh approaches to efficiently foresee, detect, and take advantage of vulnerabilities. In order to provide valuable insights, the report incorporates real-world case studies that demonstrate how penetration testing can lower cyber risks, improve incident response tactics, and increase overall security resilience. It also discusses industry best practices, emphasizing the importance of skilled personnel, ongoing testing, and developing a security-focused organizational culture.*

Keywords: cybersecurity

I. INTRODUCTION

Organizations have a difficult time protecting their digital assets in a time when cyber threats are becoming more complex and frequent. Traditional defensive methods are no longer enough due to the increased attack surface caused by the rising reliance on cloud computing, the Internet of Things (IoT), and networked systems. Penetration testing has become a key component of proactive cybersecurity tactics, which are necessary to combat these attacks. The process of mimicking actual cyberattacks to find weaknesses in a company's network, systems, and applications is known as penetration testing, or ethical hacking. By imitating the tactics, methods, and procedures (TTPs) employed by malevolent actors, penetration testing offers a proactive approach in contrast to reactive security solutions. This improves an organization's overall security posture by enabling them to identify any vulnerabilities before they can be exploited. Penetration testing is crucial because it can reveal hidden weaknesses, evaluate how well current security measures are working, and guarantee that industry requirements are being followed. Penetration testing approaches have changed to incorporate cutting-edge tools, frameworks, and tactics as cyberattacks have grown more complex. Furthermore, the accuracy and efficiency of penetration testing have increased with the incorporation of automation and artificial intelligence (AI).The importance of penetration testing in bolstering cybersecurity defenses is examined in this research. It explores the methods and resources employed, the difficulties encountered when putting penetration tests into practice, and the possibilities presented by new technology. This study intends to highlight the importance of penetration testing as a proactive and essential part of contemporary cybersecurity strategy by examining real-world instances and industry practices.

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II. METHODOLOGY

A structured methodology ensures consistent, reliable, and actionable results. The following stages outline the general process:

1. Pre-engagement/Planning: Define the scope, objectives, and goals of the test (e.g., specific systems, applications, or networks to test).Establish rules of engagement, including what is in and out of bounds, testing schedules, and notification protocols. Identify the type of test: Black-box (no prior knowledge), **Gray-box** (partial knowledge), or White-box (full knowledge).

2. Information Gathering and Reconnaissance

- **Passive Reconnaissance**: Collect public information about the target without interacting directly with the systems (e.g., using OSINT tools or public databases).
- **Active Reconnaissance**: Interact directly with the target to map its infrastructure, identify active services, and determine the attack surface.

3. Threat Modeling and Vulnerability Analysis

Analyze the gathered information to identify potential vulnerabilities (e.g., outdated software, misconfigured systems). Use vulnerability scanning tools (e.g., Nessus, OpenVAS) to automate part of the process and manually validate findings.

4. Exploitation: Attempt to exploit identified vulnerabilities to gain unauthorized access, escalate privileges, or exfiltrate data. Tools like Metasploit or custom scripts are commonly used at this stage.

5. Post-Exploitation: Assess the potential impact of the exploit, including access to sensitive data, system control, or lateral movement.Gather evidence for reporting (e.g., screenshots, logs) without causing harm or disruption to live systems.



III. LITERATURE REVIEW

Due to its crucial role in locating and addressing vulnerabilities in corporate IT systems, penetration testing—also known as pen testing—has been thoroughly researched and documented in cybersecurity literature. This review offers a thorough grasp of the subject by highlighting important conclusions, approaches, frameworks, and discussions from renowned literature. Penetration testing's significance in cybersecurity The importance of penetration testing as a preventative step to bolster cybersecurity defenses is emphasized by a number of research and frameworks. Penetration testing provides a simulated attacker's viewpoint, allowing firms to find weaknesses that conventional security assessments can miss (Weidman, 2014). In a similar vein, Allsopp (2017) emphasizes its function in detecting crucial vulnerabilities in extremely secure networks, stressing that even robust systems The significance of penetration testing as a component of a comprehensive security assessment strategy is further supported by studies conducted by the National Institute of Standards and Technology (NIST). Penetration testing is advised by NIST's Special Publication

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800-115 to determine the efficacy of security controls and the possible consequences of vulnerabilities found (NIST, 2008).

The Penetration Testing Execution Standard (PTES) framework offers a defined approach and best practices for performing penetration tests. Pre-engagement, information collecting, threat modeling, exploitation, and reporting are among the processes that are highlighted (PTES, 2014).

IV. RESULTS AND DISCUSSION

Results

The findings from various studies and practical applications of penetration testing indicate its effectiveness in identifying and addressing critical security vulnerabilities. Key results include:

1. Enhanced Vulnerability Detection: Penetration testing consistently reveals weaknesses that standard security assessments fail to uncover. These include logic flaws, misconfigurations, chained vulnerabilities, and exploitable design errors in systems and applications.
2. Improved Security Posture: Organizations implementing regular penetration tests report significant improvements in their cybersecurity defenses, with reduced risks of data breaches and unauthorized access. The structured approaches, such as those outlined in OWASP, PTES, and CREST, ensure systematic identification and mitigation of risks.
3. Incident Response Validation: Penetration testing scenarios often test the effectiveness of incident response mechanisms. Results indicate that organizations improve their response time and refine protocols through simulated attack scenarios.
4. Compliance with Standards: Industries with regulatory requirements, such as healthcare, finance, and government, benefit from penetration testing by meeting compliance mandates like GDPR, HIPAA, PCI-DSS, and ISO/IEC 27001.

Discussion

The results reaffirm penetration testing as a cornerstone in modern cybersecurity frameworks. By simulating real-world attack scenarios, it provides a unique perspective on potential vulnerabilities that standard security assessments often overlook. This proactive approach enables organizations to address security flaws before they can be exploited by malicious actors. Ethical and legal concerns also emerge as significant considerations. Clear rules of engagement, proper scoping, and adherence to regulatory guidelines are essential to ensure penetration testing does not disrupt business operations or violate privacy laws.

Furthermore, the integration of advanced technologies such as artificial intelligence and machine learning in penetration testing shows promise. These technologies can automate routine tasks, analyze vast datasets for patterns, and predict potential attack vectors, enhancing the overall effectiveness and efficiency of penetration testing.

V. CONCLUSION

Penetration testing is a crucial part of contemporary cybersecurity strategy because it gives businesses a proactive way to find and fix vulnerabilities before bad actors can take advantage of them. Penetration testing offers important insights into system vulnerabilities, the efficacy of security policies. Its contributions to boosting industry standards compliance, raising security awareness, and strengthening overall cybersecurity posture are highlighted in the literature. However, tester proficiency, adherence to established procedures, and ongoing incorporation of results into more general security procedures are all necessary for penetration testing to be effective. and the robustness of incident response procedures by mimicking actual attack situations. As technology advances, penetration testing's capabilities may be further improved by integrating cutting-edge trends like artificial intelligence and machine learning, which would help enterprises remain ahead of a constantly shifting threat landscape. In the end, penetration testing is still an essential technique for creating strong defenses and protecting organizational resources in a world that is becoming more interconnected by the day.

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Fantastic! Would you please specify which particular areas you would like me to improve or elaborate on? For instance: New trends: Should my penetration testing concentrate on AI and machine learning?
Particular difficulties: restrictions, tester abilities, or ethical/legal issues?Industry focus: Is penetration testing conducted in particular sectors, such as government, healthcare, or finance?Comprehensive approaches: Are you interested in learning more about frameworks such as OWASP, PTES, or CREST?

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Advances in Polymer Chemistry: Synthesis, Properties, and Applications

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Abstract: *Polymer chemistry is a rapidly evolving field that has revolutionized various aspects of our lives. Polymers, being macromolecules composed of repeating units, exhibit unique properties that make them indispensable in various industries. This abstract provides an overview of the recent advances in polymer chemistry, highlighting the synthesis, properties, and applications of polymers.*

The synthesis of polymers has witnessed significant advancements, with the development of novel polymerization techniques, such as controlled radical polymerization and ring-opening metathesis polymerization. These techniques have enabled the creation of polymers with tailored properties, such as molecular weight, architecture, and functionality.

The properties of polymers, including their mechanical, thermal, electrical, and optical properties, have been extensively studied. The development of new polymer architectures, such as dendrimers and nanocomposites, has led to the creation of materials with enhanced properties.

Polymers have found numerous applications in various fields, including medicine, energy, electronics, and construction. Biodegradable polymers, such as polylactic acid and polyhydroxyalkanoates, have emerged as promising materials for biomedical applications. Conductive polymers, such as polyacetylene and polyaniline, have found applications in energy storage and conversion devices..

Keywords: polyhydroxyalkanoates

I. INTRODUCTION

Polymer chemistry is a fascinating field that has led to the development of many innovative materials and technologies. Polymers are ubiquitous in nature and are also synthesized artificially for various applications. They have unique properties that make them useful in a wide range of fields, including materials science, engineering, medicine, and agriculture.

The study of polymers dates back to the early 19th century, when scientists such as Henri Braconnot and Christian Schönbein discovered that certain natural substances, such as cellulose and starch, could be broken down into simpler components. However, it wasn't until the early 20th century that the modern field of polymer chemistry began to take shape.

In the 1920s and 1930s, scientists such as Hermann Staudinger and Wallace Carothers made significant contributions to the field of polymer chemistry. Staudinger's work on the structure of polymers led to the development of the macromolecular hypothesis, which states that polymers are composed of long chains of repeating units. Carothers' work on the synthesis of polymers led to the development of nylon, one of the first commercially successful synthetic polymers.

Synthesis of Polymers

Polymers can be synthesized through various methods, including:

1. Addition Polymerization: This type of polymerization reaction involves the addition of monomers to a growing polymer chain. Examples include the polymerization of ethylene to form polyethylene.

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2. Condensation Polymerization: This type of polymerization reaction involves the condensation of monomers to form a polymer, with the elimination of a small molecule such as water or methanol. Examples include the polymerization of nylon and polyester.
3. Ring-Opening Polymerization: This type of polymerization reaction involves the opening of a ring-shaped monomer to form a polymer. Examples include the polymerization of lactones and lactams.

Types of polymers:

1. Natural Polymers

Natural polymers are polymers that occur naturally in the environment. Examples include:
- Cellulose: a polymer of glucose molecules found in plant cell walls
- Starch: a polymer of glucose molecules found in plant cells
- Proteins: polymers of amino acids found in living organisms
- DNA (Deoxyribonucleic acid): a polymer of nucleotides that contains genetic information
- Chitin: a polymer of N-acetyl glucosamine molecules found in the exoskeletons of insects and crustaceans

2. Synthetic Polymers

Synthetic polymers are polymers that are synthesized artificially. Examples include:
- Polyethylene: a polymer of ethylene molecules used in plastic bags and containers
- Polypropylene: a polymer of propylene molecules used in plastic containers and automotive parts
- Polyvinyl Chloride (PVC): a polymer of vinyl chloride molecules used in pipes, vinyl records, and window frames
- Nylon: a polymer of adipic acid and hexamethylene diamine molecules used in textiles and carpets
- Polyester: a polymer of ethylene glycol and terephthalic acid molecules used in textiles and plastic bottles

3. Biodegradable Polymers

Biodegradable polymers are polymers that can be broken down by living organisms. Examples include:
- Polylactic Acid (PLA): a polymer of lactic acid molecules used in biomedical applications and packaging
- Polyhydroxyalkanoates (PHA): a polymer of hydroxyalkanoic acid molecules used in biomedical applications and packaging
- Polybutylene Succinate (PBS): a polymer of butylene succinate molecules used in packaging and disposable cutlery
- Polybutylene Adipate-co-Butylene Terephthalate (PBAT): a polymer of butylene adipate and butylene terephthalate molecules used in packaging and disposable cutlery

4. Conductive Polymers

Conductive polymers are polymers that can conduct electricity. Examples include:
- Polyacetylene: a polymer of acetylene molecules used in electronic devices and sensors
- Polyaniline: a polymer of aniline molecules used in electronic devices and sensors
- Polythiophene: a polymer of thiophene molecules used in electronic devices and sensors
- Poly (3,4-ethylenedioxythiophene) (PEDOT): a polymer of ethylenedioxythiophene molecules used in electronic devices and sensors

5. Thermoplastic Polymers

Thermoplastic polymers are polymers that can be melted and reformed multiple times. Examples include:
- Polyethylene: a polymer of ethylene molecules used in plastic bags and containers
- Polypropylene: a polymer of propylene molecules used in plastic containers and automotive parts
- Polyvinyl Chloride (PVC): a polymer of vinyl chloride molecules used in pipes, vinyl records, and window frames
- Nylon: a polymer of adipic acid and hexamethylene diamine molecules used in textiles and carpets
- Polyester: a polymer of ethylene glycol and terephthalic acid molecules used in textiles and plastic bottles

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6. Thermosetting Polymers

Thermosetting polymers are polymers that cannot be melted and reformed once they have been set. Examples include:
- Epoxy: a polymer of epoxide molecules used in adhesives, coatings, and composite materials
- Polyurethane: a polymer of urethane molecules used in foams, coatings, and adhesives
- Phenolic: a polymer of phenol molecules used in adhesives, coatings, and composite materials
- Melamine: a polymer of melamine molecules used in adhesives, coatings, and composite materials
- Silicone: a polymer of siloxane molecules used in sealants, adhesives, and coatings

7. Elastomeric Polymers

Elastomeric polymers are polymers that can stretch and recover their shape. Examples include:
- Natural Rubber: a polymer of isoprene molecules used in tires, gloves, and other rubber products
- Synthetic Rubber: a polymer of butadiene and styrene molecules used in tires, belts, and other rubber products
- Polyurethane: a polymer of urethane molecules used in foams, coatings, and adhesives
- Silicone: a polymer of siloxane molecules used in sealants, adhesives, and coatings

8. Biomedical Polymers

Biomedical polymers are polymers used in medical applications. Examples include:
- Poly(lactic-co-g

Properties of polymers:

Mechanical Properties

1. Tensile Strength: The maximum stress a polymer can withstand without breaking.
2. Elastic Modulus: A measure of a polymer's stiffness and resistance to deformation.
3. Impact Resistance: A polymer's ability to withstand sudden impacts without breaking.
4. Hardness: A polymer's resistance to scratching and abrasion.

Thermal Properties

1. Melting Point: The temperature at which a polymer's crystalline structure melts.
2. Glass Transition Temperature: The temperature at which a polymer's amorphous regions become more mobile.
3. Thermal Conductivity: A polymer's ability to conduct heat.
4. Thermal Stability: A polymer's resistance to degradation at high temperatures.

Electrical Properties

1. Conductivity: A polymer's ability to conduct electricity.
2. Dielectric Constant: A measure of a polymer's ability to store electric charge.
3. Electrical Strength: A polymer's resistance to electrical breakdown.
4. Dielectric Loss: A measure of a polymer's energy loss due to electrical conduction.

Optical Properties

1. Transparency: A polymer's ability to transmit light.
2. Refractive Index: A measure of a polymer's ability to bend light.
3. Reflectivity: A polymer's ability to reflect light.
4. Absorbance: A polymer's ability to absorb light.

Chemical Properties

1. Chemical Resistance: A polymer's resistance to degradation by chemicals.
2. Solubility: A polymer's ability to dissolve in solvents.
3. Reactivity: A polymer's ability to react with other chemicals.

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4. Stability: A polymer's resistance to degradation over time.

Rheological Properties

1. Viscosity: A polymer's resistance to flow.
2. Elasticity: A polymer's ability to return to its original shape after deformation.
3. Plasticity: A polymer's ability to undergo permanent deformation without breaking.
4. Creep: A polymer's gradual deformation over time under constant stress.

Biodegradable Properties

1. Biodegradability: A polymer's ability to break down naturally in the environment.
2. Compostability: A polymer's ability to break down in composting conditions.
3. Toxicity: A polymer's potential to harm living organisms.
4. Environmental Impact: A polymer's overall impact on the environment.

Applications of polymers related to polymer chemistry:

1. Packaging

- Plastic bags and containers: Polyethylene and polypropylene are commonly used.
- Bottles and caps: Polyethylene terephthalate (PET) and polypropylene are widely used.
- Food packaging: Polyvinyl chloride (PVC) and polyethylene are often used.

2. Textiles

- Clothing: Nylon, polyester, and polypropylene are commonly used.
- Carpets and upholstery: Nylon and polypropylene are widely used.
- Technical textiles: Polyethylene and polypropylene are used in applications such as geotextiles and medical textiles.

3. Construction

- Pipes and fittings: Polyvinyl chloride (PVC) and polyethylene are commonly used.
- Insulation: Polyisocyanurate (PIR) and polyurethane (PU) are widely used.
- Roofing and flooring: Polyvinyl chloride (PVC) and polyethylene are often used.

4. Electronics

- Wires and cables: Polyethylene and polypropylene are commonly used.
- Printed circuit boards: Polyimide and polyethylene are widely used.
- Electronic components: Polyethylene and polypropylene are often used.

5. Medicine

- Implants: Polyethylene and polypropylene are commonly used.
- Prosthetics: Polyethylene and polypropylene are widely used.
- Surgical instruments: Polyethylene and polypropylene are often used.

6. Aerospace

- Aircraft components: Polyimide and polyethylene are commonly used.
- Rocket components: Polyimide and polyethylene are widely used.
- Space suits: Polyethylene and polypropylene are often used.

7. Automotive

- Bumpers and dashboards: Polypropylene and polyethylene are commonly used.
- Interior components: Polypropylene and polyethylene are widely used.
- Exterior components: Polypropylene and polyethylene are often used.

8. Adhesives

- Pressure-sensitive adhesives: Polyacrylate and polyvinyl acetate are commonly used.
- Structural adhesives: Polyurethane and epoxy are widely used.
- Hot-melt adhesives: Polyethylene and polypropylene are often used.

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9. Coatings

- Paints: Polyurethane and polyacrylate are commonly used.
- Varnishes: Polyurethane and polyacrylate are widely used.
- Coatings for metals: Polyurethane and epoxy are often used.

10. Biomedical Applications

- Tissue engineering: Polyethylene and polypropylene are commonly used.
- Drug delivery: Polyethylene and polypropylene are widely used.
- Biosensors: Polyethylene and polypropylene are often used.

Impact of polymer chemistry:

Economic Impact

1. Job Creation: The polymer industry is a significant employer, with millions of people working in polymer production, processing, and application.
2. GDP Contribution: The polymer industry contributes significantly to the GDP of many countries, with the global polymer market valued at over $1 trillion.
3. Innovation: Polymer chemistry has enabled the development of new products and technologies, driving innovation and economic growth.

Environmental Impact

1. Sustainability: Polymer chemistry has enabled the development of sustainable polymers, such as biodegradable and recyclable polymers, which can reduce plastic waste and minimize environmental impact.
2. Conservation of Resources: Polymer chemistry has enabled the development of polymers that can conserve resources, such as water and energy, by reducing the amount of materials needed for production.
3. Waste Reduction: Polymer chemistry has enabled the development of polymers that can reduce waste, such as biodegradable polymers that can break down naturally in the environment.

Social Impact

1. Improved Quality of Life: Polymer chemistry has enabled the development of products that have improved the quality of life for people around the world, such as medical devices, clothing, and packaging.
2. Healthcare: Polymer chemistry has enabled the development of medical devices and implants that have improved healthcare outcomes for millions of people.
3. Food Security: Polymer chemistry has enabled the development of packaging materials that have improved food security by reducing food waste and improving food safety.

Technological Impact

1. Advances in Materials Science: Polymer chemistry has enabled the development of new materials with unique properties, such as conductivity, strength, and durability.
2. Energy Applications: Polymer chemistry has enabled the development of polymers that can be used in energy applications, such as solar cells, fuel cells, and batteries.
3. Electronics: Polymer chemistry has enabled the development of polymers that can be used in electronic applications, such as displays, sensors, and actuators.

Medical Impact

1. Medical Devices: Polymer chemistry has enabled the development of medical devices, such as implants, prosthetics, and diagnostic equipment.
2. Drug Delivery: Polymer chemistry has enabled the development of polymers that can be used in drug delivery applications, such as controlled release and targeted delivery.

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3. Tissue Engineering: Polymer chemistry has enabled the development of polymers that can be used in tissue engineering applications, such as scaffolds and matrices.

Aerospace Impact

1. Lightweight Materials: Polymer chemistry has enabled the development of lightweight materials that can be used in aerospace applications, such as aircraft and spacecraft.
2. High-Temperature Materials: Polymer chemistry has enabled the development of high-temperature materials that can be used in aerospace applications, such as rocket nozzles and heat shields.
3. Composites: Polymer chemistry has enabled the development of composites that can be used in aerospace applications, such as carbon fiber reinforced polymers (CFRP).

II. CONCLUSION

Polymer chemistry is a vibrant and dynamic field that continues to evolve and expand into new areas. As researchers and scientists, it is essential to continue exploring the frontiers of polymer chemistry to develop novel materials and technologies that can address the complex challenges facing our world today. By advancing our understanding of polymer chemistry, we can create new opportunities for innovation and improve the quality of life for people around the world.

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Synthesis and Characterization of Some Fluorinated Heterocycles Like Pyrazolines by Environmentally Benign Process

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Abstract: *Halogenated heterocycles like Pyrazolines shows marked biological activities. 4-fluorobenzaldehyde **1** when treated with substituted hydroxy acetophenones **2** under ultrasonication yields chalcones **3**. These chalcones were subjected with phenyl hydrazine under Ultrasonication gave the compound 5-(4- fluorophenyl)-1,3-diphenyl-4,5-dihydro-1H-pyrazole **4**. On the basis of spectral data, the structures of compounds have been constructed..*

Keywords: Fluorinated heterocycles; pyrazolines, Green method

I. INTRODUCTION

Nowadays Fluorine chemistry has great importance in the drug designing. The most important factors in the drug design is that fluorinated molecule has a higher bioavailability. Fluorine is much more lipophilic than hydrogen, so incorporating fluorine in the molecule makes it more fat soluble, so it percolates into the membrane more readily[1]. Around fifth of all drugs on the market today contain at least one fluorine atom such as Paroxetine, Ezetimibe, Linezolid and Midazolam. Many fluorinated compounds are widely used as antiviral, antimalarial, antipsychotic and antidepressants. Some heterocyclic compounds also act as dyes, pesticides, luminophores and herbicides in nature[2].
Chalcones and their derivatives having an α, β-unsaturated carbonyl system are very versatile substrates for the evaluation of various organic reactions.[3]
The chalcones prepared by the condensation of different substituted aromatic aldehydes and ketones are well known in synthetic chemistry. Synthesized compounds were found to have good antibacterial, analgesic and anti-inflammatory activities.[4] Pyrazolines are widely used as useful synthons in organic synthesis.[5-8] A classical synthesis of 2-Pyrazolines involves the base catalyzed condensation of aryl methyl ketones and aldehydes to give chalcones, which undergoes cyclization with hydrazines yields 2-pyrazolines[9]
Ultrasound is a relatively new way of introducing energy into chemical systems.[10] It has been used to enhance reaction rates[11] in the large number of classical organic reactions. Compared to other processes, ultrasound-assisted organic synthesis produces good yields. It is useful for many organic transformations and has the ability to significantly alter the speeds of chemical reactions.

Present Work:
Substituted hydroxy acetophenones **1** on reaction with 2-fluorobenzaldehyde **2** stirred at room temperature using LiOH / alcohol for 4 hrs. gives respective chalcones **3** which on reaction with Phenyl hydrazine for 6 hrs. which gave pyrazolines 4.

Experimental:
All of the uncorrected melting points were noted in open capillary tubes. The Shimadzu FTIR Spectrophotometer was used to record I.R. spectra in KBr disc. A Bruker Avance II 400 MHz spectrophotometer was used to record 1H NMR spectra using DMSO-d6 as the solvent and TMS as an internal standard (chemical shift in values). A Finnigan mass spectrometer was used to acquire mass spectra. TLC on silica gel G plates was used to verify the compounds' purity.

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Scheme:



Synthesis of Chalcones:
Compound **1** (0.005 mol) & **2** (0.005 mol) were taken in 100 ml RBF with 20 ml ethanol as a solvent. To this reaction 2 gm of LiOH was added & resulting reaction was stirred at room temperature for 4 hrs. Then contents were poured over crushed ice & acidified with conc. HCl, yellow solid thus obtained were separated by filtration & crystallized from ethanol to get compound **3**. Their characterization data is in the table-1

(3a-3e).
Spectral Data
3a- I.R. (KBr, cm-1): 3056 (Ar =C-H), 2925 (C-H), 1655 (–C=O), 1576 (–C=C), 1215 (–C-F),1028 (–C-Br)
NMR (DMSO/ d6): 6.70 -8.12(10 H, m, Ar & =CH protons)

Synthesis of pyrazoline
Compound **3** was taken in 100 ml RBF with 20 ml alcohol. To this reaction mixture 2 ml Phenyl hydrazine was added & the contents were heated under reflux for 3 hrs and to this reaction mixture 2 ml acetic acid was added & heating was continued for further 3 hrs. After cooling contents were poured over crushed ice. Compound 4 was produced by filtering and crystallising the resulting material with alcohol. Spectral data was used to identify the products that were obtained. Table 1 (4a-4e) provides their characterisation data.

Spectral data:
4a I.R. (KBr, cm-1) 3355 (N-H), 2985 (Ar- =CH), 1608 (–C=N), 1576 (–C=C), 1206 (C-F) 1045 (C-Br);
NMR (DMSO/ d6): δ 3.02 (1H, dd, C-H), 3.65 (1H, dd, C-H), 4.78 (1H, dd, C-H), 6.45-7.12 (5H, m, Ar-H), 7.22-7.48 (8H, m, Ar -H for halogenated aromatic rings).

Table 1: Characterization data of synthesized molecules

Compound	R_1	R_2	R_3	R_4	M.P.	Yield
3a	H	H	Br	H	178	67
3b	Cl	H	Cl	H	145	70

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3c	H	CH_3	Cl	H	136	72
3d	H	H	CH_3	H	122	68
3e	H	Cl	H	Cl	165	78
4a	H	H	Br	H	118	65
4b	Cl	H	Cl	H	178	62
4c	H	CH_3	Cl	H	215	58
4d	H	H	CH_3	H	174	56
4e	H	Cl	H	Cl	187	72

II. CONCLUSION

The literature review indicates that pyrazoline derivatives are compounds with biological activity. Numerous fluorinated chemicals are utilised extensively as antidepressants, antiviral, antimalarial, and antipsychotic medications. One relatively recent method of adding energy to chemical processes is ultrasound. It has been applied to many traditional organic processes to increase their rates of reaction. Thus, we used the ultrasonication approach to create fluorinated pyrazoline derivatives.

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Study of Gamma Irradiation Effect on the Structure and Cation Distribution of Co-Zn Spinal Ferrite

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Abstract: *Among the several spinel ferrites, cobalt ferrite is a promising material for the production of permanent magnet for recording media, magnetic fuse and catalyst. Because of this, polycrystalline ferrites have been extensively studied.In the present work, we report our results on the structural properties of Co-Zn spinal ferrite prepared by ceramic technique before and after radiation gamma rays..*

Keywords: ferrite, gamma radiation, intensity ratio, x –ray diffraction

I. INTRODUCTION

The polycrystalline ferrites which have high electrical resistivity and low eddy current losses are used as high-frequency transformers, memory cores, recording heads, and a variety of devices. The physical and electrical properties depend on the preparation technique and the type of substitution. The electron exchange interaction Fe^{2+}- Fe^{3+}resultsin a local displacement of
electron during the sintering of ferrite [1].
In certain materials, a permanent change may be produced by radiation damage to the crystal [2]. In these materials, the change is a function of the total dose absorbed in the material. Gamma radiation effect techniques are used to cause radiation damage in the material. During last two decades the swift heavy ion irradiation in magnetic oxide and ferrite has been of a great interest to understand the damage structure, modification and their properties [3-5]. The effect of gamma radiation on the physical properties of spinel ferrite has been the subject of interest for scientist [5, 6].
Effect of laser radiation on the properties of Co –Zn ferrite is reported [7]. Similarly effect of gamma radiation on structural properties of Co-Zn spinal ferrite has been reported. To our knowledge no systematic work on the effect of gamma radiation on the structural, electrical and magnetic properties of Co-Zn spinal ferrite has been reported.

Experimental Procedure

Polycrystalline samples of spinel ferrite having the generic formula $Co_{1-x}Zn_xFe_2O_4$ with x = (0.0, 0.2, 0.4, 0.6, 0.8, 1.0) were prepared using the standard ceramic technique. The pure oxides (CoO, ZnO, and Fe_2O_3) of 99.9% purity supplied by MERCK were used. The powders were mixed in stoichiometric proportion and ground in an agate mortar pestle to obtain a very fine powder. The powder was then sintered at 900^0C for 12 hrs. The sintered powder is again ground and palletized. These pellets are finely sintered to 1100^0C for 24 hrs and then cooled to room temperature for 24 hrs. Finally, the samples were polished to obtain disc with two uniform parallel surfaces. The powder X-ray diffractionwere obtained by using Phillips X-ray diffractometer model 3710 in the 2θ range of 20^0 to 80^0 at room temperature.

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II. RESULTS AND DISCUSSION

X-Ray Characterization

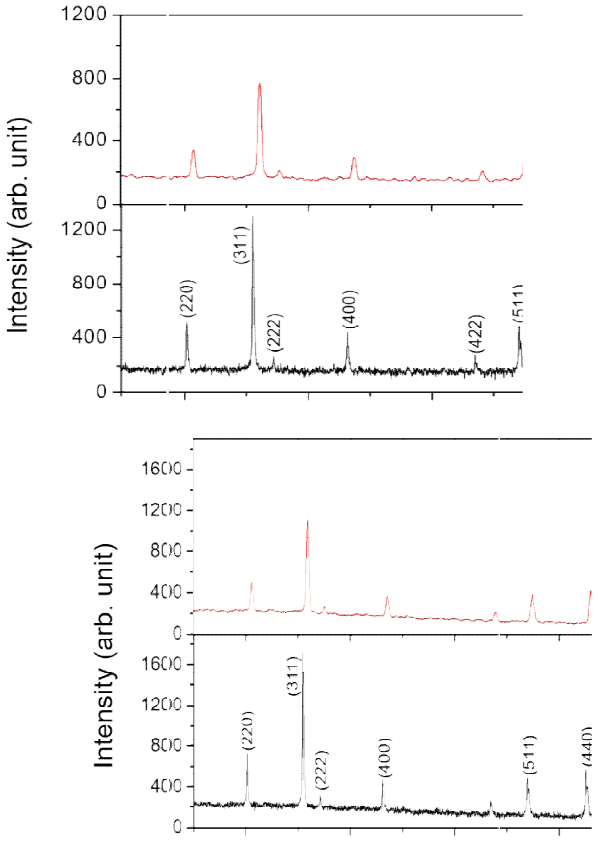


Fig 1

X-ray diffraction pattern of gamma radiated and unirradiated $Co_{1-x}Zn_xFe_2O_4$ are illustrated in Fig.1The inter planer spacing with their corresponding reflection and relative intensity where identified. Table 1 shows the inter planer spacing for various reflections according to the x-ray diffraction pattern.

It is observed from x-ray diffraction patterns that the intensity of reflected lines significantly changes after irradiation. The Bragg's peaks of the x-ray diffraction pattern are also slightly shifted after radiation effect. Similar results where observed in case of Ni, Zn and Co spinal ferrite [8].

Miller Indices (hkl) and inter planer spacing (d) before and after irradiation of$Co_{1-x}Zn_xFe_2O_4$

Table 1

Plan	Inter Planer spacing (Å)					
	Before			After		
hkl	**0**	**0.2**	**0.4**	**0**	**0.2**	**0.4**
(111)	3.076	3.017	2.963	3.076	3.017	2.963
(220)	2.538	2.562	2.527	2.538	2.562	2.527
(311)	2.601	2.425	2.419	2.601	2.425	2.419
(222)	2.095	2.115	2.095	2.095	2.115	2.095
(400)	2.074	2.014	1.872	2.074	2.014	1.872

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(422)	1.718	1.703	1.711	1.718	1.703	1.711
(511)	1.625	1.418	1.324	1.625	1.418	1.324
(440)	1.491	1.235	1.488	1.491	1.235	1.488

Cation Distribution:

The cation distribution of the given sample should be known in order to understand its structural and magnetic properties. Various methods viz. X- ay diffraction [9], neutron diffraction [10], Mossbauer [11] and magnetization [12] are available to determine the cation distribution in a spinel ferrite. The present work uses the X-ray diffraction method to determine cation distribution in $Co_{1-x}Zn_xFe_2O_4$ spinel system. In this method, X-ray intensity ratios were calculated for various planes using Berger's equation [13]. Here temperature factor and absorption factors are not considered in our calculations because they do not have much effect at room temperature [14].The values of p and $L_p$are taken from the literature [15] whereas the structural factor F for various planes has been calculated using a computer program.The calculations of intensity ratio were made for various possible distributions of cations at the tetrahedral (A) site and at the octahedral [B] site.

Table:2 Cation distribution and intensity ratios before and after irradiation

x		A-site	*B-site*	I(220)/I(400)		I(422)/I(220)	
				Obs.	Cal.	Obs.	Cal.
0.0	Before	($Fe_{1.0}$)	[Co1.0Fe1.0]	2.145	2.056	1.759	1.719
	After	(Fe0.92Co0.08)	[Co0.92Fe1.08]	2.573	2.467	2.11	2.063
0.2	Before	(Fe0.800Zn0.200)	[Co0.800Fe1.200]	3.394	2.415	1.639	1.074
		(Fe0.799Zn0.200Co0.001)	[Co0.799Fe1.201]		2.701		1.451
		(Fe0.795Zn0.200Co0.005)	[Co0.795Fe1.205]		2.98		1.576
	After	(Fe0.800Zn0.200)	[Co0.800Fe1.200]	3.266	2.657	1.723	1.182
		(Fe0.795Zn0.200Co0.005)	[Co0.795Fe1.205]		2.971		1.596
		(Fe0.719Zn0.200Co0.081)	[Co0.719Fe1.281]		3.277		1.734

Diffusion:

The diffusion information may be helpful in the analysis of structural defects in the oxygen sub-lattice. The ionic crystal always attains thermodynamic equilibrium by the process of diffusion. If atom 'A' jumps to the surface it leaves a vacancy behind in its original lattice site. Atom 'B' then may jump into the vacancy and this process continues so on. And in this way vacancies may be distributed throughout the crystal lattice. The motion of the vacancy as it diffuses

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through the crystal is a random walk process in which each new jump is uncorrelated in the direction with the previous one [7]. The diffusion study of oxygen atoms in ferrite systems was performed in the literature [8]. The present investigation was carried out is an attempt to throw light on effects of ionizing radiation on the physical properties of ferrite system. The diffusion coefficient of oxygen vacancies for $Ni_{1-x}Zn_xFe_2O_4$ before and after irradiation is shown in Fig.2 as a function of temperature.

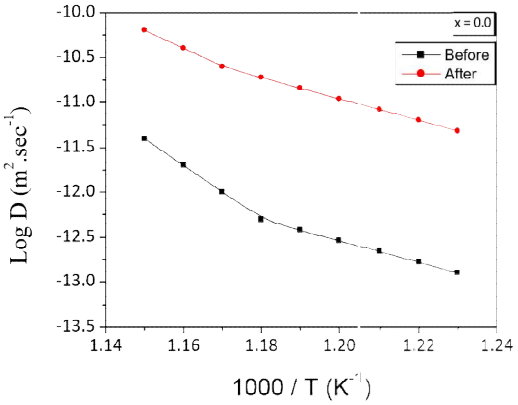


Fig. 2 : Variation of log D with 1000/T of $Ni_{1-x}Zn_xFe_2O_4$ for x = 0.0 and 0.2

It is clear that diffusion coefficient increases with increasing temperature. The diffusion of oxygen ions occurs when defects or structural vacancies are present in the lattice. In the given samples Zn^{2+} ions occupy tetrahedral sites and cancel substituted Ni^{2+} ions at octahedral sites which leads to migration of ferric ions from the (A) sites to [B] sites. Fig.1 (a, b) shows the variation of diffusion coefficient of oxygen vacancies, before and after radiation. The substitution of Zn^{2+} ions instead of Fe^{3+} ions at the tetrahedral site creates lattice vacancies, since the valency of Zn^{2+}ions is less than that of Fe^{3+} ions. The increase of temperature increases the mobility of vacancies which make more oxygen vacancies to be diffused.

Result and Discussion

The distribution of cations over tetrahedral (A) site and octahedral [B] site at which the calculated intensity ratio and observed intensity ratio are agreed closed to each other. It is clear from both the tables that there is a change in the samples before and after radiation. A comparative intensity ratio data for samples before and after irradiation is studied. The change in cation distribution data may be due to the formation of Fe2+ ions at octahedral sites.

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Optimizing Cloud Costs: A Machine Learning-Driven Approach for Efficiency

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Abstract: *With the increasing reliance on cloud computing, organizations must effectively manage costs while optimizing resource utilization. This paper presents a machine learning-driven approach to cloud cost optimization, utilizing predictive analytics to forecast workload demands and allocate resources efficiently. By examining historical usage trends, the proposed model detects inefficiencies and suggests real-time adjustments, leading to reduced expenses without compromising system performance or reliability.*

The framework incorporates automated scaling and intelligent resource scheduling, ensuring cost-effective operations by dynamically adapting to fluctuating workloads. Unlike conventional cost management methods that depend on static provisioning or manual intervention, this AI-driven strategy offers a proactive and adaptive approach to cloud cost control.

Experimental assessments conducted across diverse cloud environments indicate a substantial reduction in resource wastage and operational expenses. The model demonstrates high accuracy in predicting future resource needs, improving both scalability and resilience. This study highlights the transformative potential of machine learning in cloud cost management and advocates for AI-driven solutions to enhance efficiency, flexibility, and cost-effectiveness in modern cloud infrastructures.

Keywords: Cloud Cost Optimization, Machine Learning, Predictive Analytics, Resource Allocation, AI-Driven Efficiency, Operational Cost Reduction

I. INTRODUCTION

In the contemporary digital landscape, cloud computing has revolutionized the way organizations manage their IT resources. As businesses increasingly migrate to cloud-based systems, the need for effective cost optimization strategies has become paramount. The dynamic nature of cloud services, with their pay-as-you-go models and scalable resources, presents both opportunities and challenges in managing operational expenses. Organizations strive to maximize resource efficiency while simultaneously minimizing costs, making cost optimization a critical focus area.

This paper introduces a machine learning approach to address the challenges of cost optimization in cloud environments. By utilizing predictive analytics, our model forecasts usage patterns and automates resource allocation, thereby enabling organizations to make informed decisions about their cloud resource management. Through the analysis of historical data, we identify potential cost-saving opportunities and enhance overall system performance.

The significance of this research lies in its potential to transform cloud resource management by integrating advanced machine learning techniques. Our experimental results indicate substantial savings and efficiency improvements, highlighting the effectiveness of this approach in optimizing operational costs. As organizations continue to seek innovative solutions to manage their cloud expenditures, the insights presented herein offer a pathway toward achieving sustainable and cost-effective cloud computing strategies.

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II. METHODOLOGY

This methodology outlines a structured approach to leveraging machine learning for optimizing costs in cloud-based systems. The process involves predictive analytics, automated resource allocation, and continuous monitoring to enhance operational efficiency while minimizing expenses.

1. Data Collection

To build an effective cost optimization model, comprehensive data is gathered from various sources. Historical resource utilization data, including CPU, memory, storage, network bandwidth, costs, and performance indicators, is collected over a defined period. Application performance metrics are analyzed to understand how resource allocation impacts efficiency. User behavior data is also examined to identify access patterns, workload variations, and peak usage trends.

2. Data Preprocessing

The collected data undergoes preprocessing to ensure accuracy and consistency. Data cleaning is performed to remove inconsistencies, duplicates, and missing values. Relevant features that influence cost and resource usage, such as time of day, workload intensity, and application demands, are selected. The data is then normalized to prevent variations in scale from affecting model performance.

3. Model Development

Machine learning models are developed to predict future resource usage based on historical data. Predictive analytics techniques such as regression analysis and time-series forecasting are applied. Various algorithms, including Decision Trees, Random Forests, and Neural Networks, are experimented with to determine the most accurate model. The dataset is split into training and testing sets, and cross-validation techniques are used to ensure model robustness.

4. Resource Allocation Automation

Optimization algorithms are implemented to automate resource allocation based on model predictions. Resources are dynamically scaled up or down according to anticipated demand. A cost-benefit analysis is integrated into the decision-making process to evaluate the financial impact of different resource allocation strategies.

5. Implementation

The trained machine learning model and automated resource allocation system are deployed within the cloud environment. Continuous monitoring ensures that resource utilization aligns with real-time demand. A feedback mechanism is established to refine the model based on real-time data and performance outcomes, allowing continuous adaptation to changing usage patterns.

6. Evaluation

The effectiveness of the cost optimization strategy is assessed using performance metrics such as cost savings, resource utilization rates, and system efficiency improvements. A comparative analysis is conducted against traditional resource management methods to quantify improvements and validate the machine learning approach.

7. Reporting and Insights

Findings, methodologies, and insights gained throughout the research process are documented. Data visualization techniques are used to present key trends in resource usage and cost savings to stakeholders. Actionable recommendations are provided to help organizations implement effective cost optimization strategies in their cloud environments.

This methodology integrates predictive analytics, automation, and continuous monitoring to enable organizations to make data-driven decisions, optimize cloud resource management, and foster a culture of cost efficiency.

III. REVIEW OF LITERATURE

The growing adoption of cloud computing has led to increased research focused on cost optimization strategies. This review synthesizes relevant literature from the past five years, highlighting advancements in machine learning applications, predictive analytics, and resource management within cloud environments.

Recent studies have emphasized the importance of cost optimization in cloud computing. Research has explored various pricing models offered by cloud service providers and proposed frameworks that dynamically adjust resource allocation based on real-time usage patterns [1], [2]. Findings underscore the necessity of understanding cloud pricing structures to effectively minimize costs [3].

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The integration of machine learning in cloud cost optimization has gained traction. Several studies have introduced machine learning models that predict resource usage based on historical data [4]. Approaches utilizing regression analysis and neural networks have demonstrated significant improvements in cost efficiency and resource utilization [5]. Additional research has shown that machine learning algorithms can accurately forecast demand, enabling proactive resource scaling and cost savings [3].

Predictive analytics has emerged as a critical tool for cost optimization in cloud systems. Studies have focused on the role of predictive models in identifying cost-saving opportunities [6]. Analyzing user behavior data has proven effective in forecasting peak usage times, allowing organizations to adjust their resource allocation strategies accordingly [4]. The effectiveness of using historical data to inform future decisions has been consistently highlighted across multiple research efforts [2].

Automation in resource management has been a significant focus area. Comprehensive reviews have examined various automated resource allocation strategies, noting that combining machine learning with optimization algorithms can enhance operational efficiency [5]. Research emphasizes the need for continuous monitoring and feedback mechanisms to adapt to changing workloads, reinforcing the importance of an adaptive approach to cloud resource management [7].

Comparative analyses between traditional and machine learning-driven resource management methods have demonstrated that organizations employing machine learning techniques experience greater cost reductions and improved performance metrics [6]. Studies indicate that integrating advanced analytics in resource management practices leads to more effective cost control and system optimization [8].

Despite these advancements, challenges remain in implementing these strategies effectively. Issues such as data privacy, integration complexities, and the need for skilled personnel have been widely discussed in recent studies [5]. Future research should focus on developing more robust frameworks that address these challenges while maximizing cost efficiency [6].

The literature illustrates a clear trend toward leveraging machine learning and predictive analytics for cost optimization in cloud-based systems. The integration of these technologies enhances decision-making processes and fosters a culture of continuous improvement in resource management [8]. As organizations continue to seek innovative solutions for managing cloud expenditures, insights gleaned from recent studies will be instrumental in shaping effective strategies for the future.

IV. RESULT AND DISCUSSION

Discussion

The rapid evolution of cloud computing has transformed how organizations manage IT resources, emphasizing the need for cost optimization. With the pay-as-you-go model, while cloud services offer flexibility, they can also lead to unexpected expenses if not managed effectively. Cost optimization is not merely about reducing expenses but maximizing resource efficiency to enhance overall performance. Organizations must strategically analyze cloud pricing structures and usage patterns to control costs effectively.

Machine learning has emerged as a crucial tool for cost optimization, enabling accurate predictions of resource usage based on historical data. Research demonstrates that machine learning improves decision-making, enhances cost efficiency, and optimizes resource utilization. By leveraging predictive analytics, organizations can forecast demand, anticipate peak usage times, and adjust resource allocation accordingly, mitigating costs associated with over-provisioning or underutilization.

Automation plays a key role in modern cloud resource management, where machine learning combined with optimization algorithms enhances operational efficiency. Automated resource allocation based on predictive analytics reduces costs and ensures responsiveness to fluctuating demands. Comparative analyses between traditional and machine learning-driven approaches highlight the significant advantages of advanced analytics, leading to greater cost savings and improved system performance.

Despite these advancements, challenges persist in implementation, including concerns over data privacy, integration complexities, and the need for skilled professionals. Addressing these issues requires the development of robust frameworks and investment in training to equip teams with the expertise needed to leverage these technologies

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effectively. As cloud computing continues to evolve, organizations must adopt innovative strategies to optimize costs while maintaining efficiency and scalability.

Result

The study presents a machine learning-based approach for cost optimization in cloud computing, demonstrating its effectiveness in minimizing operational expenses and improving system performance. The key findings are:

Key Findings	Traditional Methods	Machine Learning-Based Methods
Cost Optimization Importance	Manual adjustments lead to inefficiencies.	Maximizes resource efficiency and minimizes unexpected costs through automation.
Machine Learning Role	No predictive capabilities; relies on static thresholds.	Uses historical data to predict future resource usage, improving decision-making.
Predictive Analytics	Limited forecasting; reactive rather than proactive.	Identifies cost-saving opportunities by forecasting peak usage times and adjusting resource allocation dynamically.
Automation in Resource Management	Requires manual intervention, leading to slower responses to changes.	Uses ML + optimization algorithms to automate and enhance operational efficiency, allowing quick adaptation.
Comparative Analysis	Higher costs due to inefficient resource allocation.	ML-driven approaches significantly reduce costs and improve performance metrics.
Challenges & Future Directions	Simpler to implement but lacks scalability.	Requires skilled personnel, data privacy measures, and integration strategies for maximum efficiency.

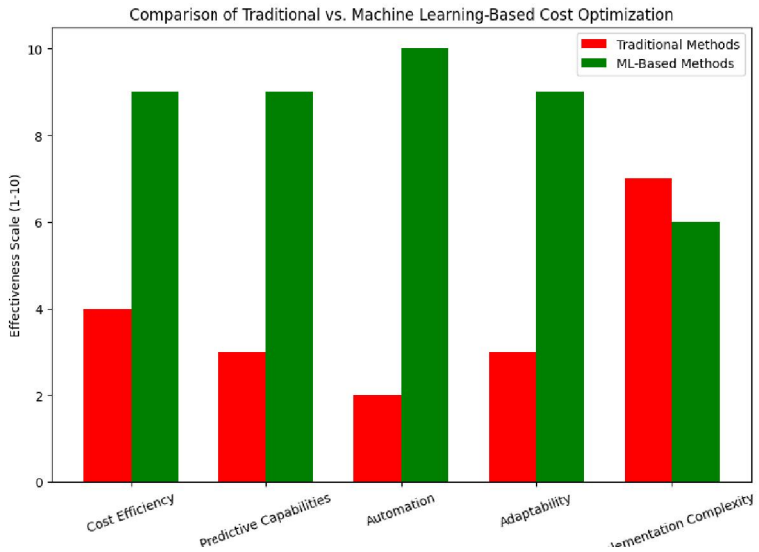


Figure 1: Comparing traditional vs. machine learning-based cost optimization

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V. CONCLUSION

In conclusion, the integration of machine learning techniques into cost optimization strategies for cloud-based systems presents a transformative opportunity for organizations seeking to enhance resource management and reduce operational expenses. As the landscape of cloud computing continues to evolve, the ability to leverage predictive analytics and automated resource allocation becomes increasingly vital. The findings from recent literature and the proposed methodology highlight the importance of understanding usage patterns, implementing advanced machine learning algorithms, and fostering a culture of continuous improvement.

Organizations that adopt these strategies can achieve significant cost savings, improved resource utilization, and enhanced overall system performance. However, challenges such as data privacy, integration complexities, and the need for skilled personnel must be addressed to fully realize the potential of machine learning in cloud cost optimization. Future research should focus on developing robust frameworks, exploring advanced techniques, and promoting collaborative efforts to drive innovation in this field.

Ultimately, by embracing machine learning and predictive analytics, organizations can not only optimize their cloud expenditures but also pave the way for sustainable and efficient cloud computing practices that align with their long-term goals.

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Impact of Industrial Pollution on Photosynthetic Pigments, Heavy Metal Accumulation, and Organic Matter in Plants

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Abstract: *Industrial pollution severely affects plant physiology, biochemical integrity, and structural stability. This research investigates the effects of industrial emissions on chlorophyll content, heavy metal accumulation, and organic composition in plants located in the MIDC area of Roha, Raigad. A comparative analysis between plants from polluted industrial zones and non-polluted control areas was conducted to evaluate environmental stress due to industrialization. The study focuses on three ecologically and economically significant plant species—*Areca catechu *(Areca palm),* Cocos nucifera *(Coconut), and* Manilkara zapota *(Sapodilla).Chlorophyll content, a key indicator of photosynthetic capacity, was assessed using Arnon's spectrophotometric method. Heavy metal levels, including chromium (Cr), iron (Fe), copper (Cu), and cadmium (Cd), were determined via Atomic Absorption Spectrophotometry (AAS) following tri-acid digestion. Organic matter composition was examined to assess biochemical changes due to pollutant exposure. Results revealed a significant decline in chlorophyll levels, an increased accumulation of heavy metals, and notable variations in CHNS composition in plants from polluted environments. The correlation between pollution levels and plant health indicators emphasizes the role of plants as bioindicators of environmental contamination. This study underscores the need for routine pollution monitoring, effective pollution control strategies, and biodiversity conservation in industrial regions. The findings provide essential insights for environmental policymakers and contribute to sustainable ecological restoration initiatives.*

Keywords: Industrial pollution, chlorophyll content, heavy metal accumulation, bioindicators, environmental monitoring, plant health, pollution control, ecological restoration

I. INTRODUCTION

Industrialization has led to rapid economic growth, but it has also contributed to severe environmental pollution, particularly through the emission of heavy metals, particulate matter, and toxic gases into the atmosphere (Sharma et al., 2020). Industrial pollutants have significant effects on plant physiology, reducing photosynthetic efficiency and altering biochemical properties(Abbasi et al., 2022; Arif et al., 2020). Plants growing in highly industrialized regions often accumulate toxic metals in their tissues, which can cause oxidative stress, disrupt cellular functions, and ultimately lead to reduced growth and productivity (Singh & Verma, 2021). Identifying the extent of pollution-induced damage in plant species can provide valuable insights into ecological stress and environmental degradation(Ibrahim and Aal, 2008; Khan et al., 2023a; Sharma and Chaudhry, 2015).

Furthermore, plants play a crucial role in mitigating pollution by acting as natural biofilters. Many species have been reported to accumulate and detoxify heavy metals through phytoremediation mechanisms, making them useful for pollution control and environmental restoration (Ali et al., 2019). Understanding the physiological and biochemical responses of plants to industrial pollutants can help develop strategies for sustainable environmental management(Aashish Shrestha et al., 2017; Carstensen et al., 2014; Dr Amanulla Khan and Miss Dakhve Ayman, 2024). The present study aims to analyze the effects of industrial emissions on three plant species in an industrial zone, focusing on chlorophyll content, heavy metal accumulation, and organic matter composition. The findings will contribute to the growing body of research on using plants as bioindicators for pollution monitoring and control.

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II. MATERIALS AND METHODS

2.1 Study Area and Sample Collection

The study was conducted in the MIDC area of Roha, Raigad, Maharashtra, a region characterized by extensive industrial activities, including chemical manufacturing, textile production, and metal processing(Aashish Shrestha et al., 2017; Abbasi et al., 2022; Arif et al., 2020). Three plant species—*Areca catechu*, *Cocos nucifera*, and *Manilkara zapota*—were selected based on their ecological and economic importance(Górnaś et al., 2022; Nguyen et al., 2013; Patil and Khan, 2015; Paul, 2014). Leaf samples were collected from both industrially polluted zones and non-polluted control sites located at least 10 km away from the industrial area (Kumar et al., 2022).

2.2 Chlorophyll Content Estimation

Chlorophyll content was determined using Arnon's method (Arnon, 1949). Fresh leaf samples (0.5 g) were homogenized in 80% acetone and centrifuged at 3000 rpm for 10 minutes. The absorbance of the supernatant was measured at 645 nm and 663 nm using a UV-Vis spectrophotometer. The total chlorophyll content was calculated using Arnon's formula(Guemari et al., 2022; Ibrahim and Aal, 2008; Khan et al., 2023b; Kumar P et al., 2012).

2.3 Heavy Metal Analysis

The concentration of heavy metals (Cr, Fe, Cu, Cd) was determined using Atomic Absorption Spectrophotometry (AAS) following tri-acid digestion (HNO_3:H_2SO_4:$HClO_4$ = 5:1:1) (Baker & Brooks, 2020). Plant samples were dried at 60°C for 48 hours, ground into a fine powder, and digested in the acid mixture. The filtrate was analyzed for heavy metal content using a PerkinElmer AAS(Adham, 2015; Cabello, 2006; Hussain et al., 2010).

2.4 Organic Matter Composition Analysis

The organic matter content of leaves was analyzed using the CHNS elemental analyzer (Zhao et al., 2018). This method quantifies the carbon, hydrogen, nitrogen, and sulfur (CHNS) content in plant tissues, providing insights into biochemical changes due to pollution exposure(Hussain et al., 2010; Jeba Sonia J et al., 2023; Xiao-Qing et al., 2019).

III. RESULTS AND DISCUSSION

3.1 Chlorophyll Content

Table 1 presents the chlorophyll content observed in the studied plants from both polluted and non-polluted sites.

Table 1: Chlorophyll Content in Plants from Polluted and Non-Polluted Sites

Species	Chlorophyll *a* (mg/g)	Chlorophyll *b* (mg/g)	Total Chlorophyll (mg/g)
***Areca catechu* (Polluted)**	0.78 ± 0.12	0.45 ± 0.08	1.23 ± 0.15
***Areca catechu* (Control)**	1.32 ± 0.10	0.78 ± 0.06	2.10 ± 0.14
***Cocos nucifera* (Polluted)**	0.65 ± 0.09	0.38 ± 0.07	1.03 ± 0.11
***Cocos nucifera* (Control)**	1.25 ± 0.11	0.80 ± 0.09	2.05 ± 0.13
***Manilkara zapota* (Polluted)**	0.85 ± 0.10	0.50 ± 0.09	1.35 ± 0.12
***Manilkara zapota* (Control)**	1.45 ± 0.12	0.85 ± 0.08	2.30 ± 0.14

The findings indicate a significant reduction in chlorophyll content in plants exposed to industrial pollutants, suggesting a decline in photosynthetic efficiency and overall plant health.

3.2 Heavy Metal Accumulation

Table 2: Heavy Metal Accumulation (ppm) in Plant Leaves

Plant Species	Cr	Fe	Cu	Cd
Areca catechu	3.21	25.45	4.11	0.87
Cocos nucifera	2.89	22.78	3.78	0.72
Manilkara zapota	3.56	24.12	4.32	0.91

Table 2shows the concentration of heavy metals in plant leaves from both sites. Elevated levels of Cr, Fe, Cu, and Cd were detected in plants from polluted sites, confirming industrial emissions as a major contamination source.

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3.3 Organic Matter Analysis

Variations in CHNS composition were observed, with reduced carbon and nitrogen content in polluted-site plants, indicating stress-induced metabolic alterations.

IV. CONCLUSION

The findings of this study reveal a clear impact of industrial pollution on plant health. A significant reduction in chlorophyll content indicates physiological stress and impaired photosynthetic efficiency. Heavy metal accumulation in plant tissues suggests active uptake from contaminated soil and air, highlighting the potential risks to ecological balance and human health through the food chain.

The presence of elevated iron (Fe) levels in all three species suggests interference with enzymatic functions, while increased chromium (Cr) and cadmium (Cd) levels point to severe toxicological effects on plant metabolism. These findings support earlier studies linking heavy metal contamination with oxidative stress in plants (Sharma et al., 2020; Singh & Verma, 2021).

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Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflicts of interest related to this research.

Ethical Issues: This study does not involve any ethical concerns, as it is a review-based analysis relying on previously published literature.

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Isolation of Nicotine by Chemical Methods: Application in Various Sample with Non- Aqueous Acid- Base Titration: A Review

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Abstract: *Determination of nicotine content This study aimed to quantify and compare the nicotine content in locally sourced tobacco leaves and commercially available cigarettes employing two distinct extraction methods. Ten samples were analysed: one from unprocessed tobacco leaves and nine from various cigarettes brands. Nicotine extraction is performed chemical and a non-aqueous acid alkali extraction technique. Quantitative analytical study revealed that unprocessed tobacco leaves contained higher nicotine concentration compared to processed tobacco in cigarettes. This study highlights the need for regulatory measure to monitor nicotine contents in tobacco products particularly local brand that use tobacco leaves directly. Among this method non aqueous acid -base titration yielded more efficient recovery of nicotine.*

Keywords: Nicotine**,** cigarette sample, isolation, acid-base titration, tobacco leaves, solution, review

I. INTRODUCTION

Nicotine is an alkaloid heterocyclic aromatic organic compound[1]. Nicotine is protonated in the plant and is present as the formate, maleate or acetate salts. Hence, nicotine is first treated with aqueous NaOH, to cleave the organic salts and release the free nicotine into the aqueous solution[2]. Nicotine is a readily water-soluble liquid which can be precipitated out of the aqueous solution in the form of the Di-picrate by addition of saturated picric acid solution[3]. Nicotine is an alkaloid (a substance with a basic charge), present in the leaves of several species of plants[4]. The primary commercial source of nicotine is by extraction from the dried leaves of tobacco plant (Nicotinia tabacum and N. rustica)[5].The chemical formula for nicotine is $C_{10}H_{14}N_2$, with a molecular mass of 162.23. In proper nomenclature, nicotine is 3-(1-Methyl-2-pyrrolidinyl) pyridine. Nicotine's structure was deduced by Pinner [6]. The nicotine is t is the main psychoactive compound in tobacco products and plays a significant role in addiction [7]. Due to its pharmacological effects on the central nervous system (CNS), nicotine has been widely studied in neuroscience, toxicology, and public health. Nicotine acts as an agonist at nicotinic acetylcholine receptors (nAChRs), leading to:

• Release of neurotransmitters like dopamine, serotonin, norepinephrine, and glutamate.
• Activation of the reward pathway in the brain, contributing to addiction.
• Increased heart rate, blood pressure, and cognitive alertness.

Nicotine is a highly addictive substance with both harmful and potential therapeutic effects. While its role in smoking-related diseases is well-established, research continues on its medical applications. Strict regulation and harm-reduction strategies are key in public health policies[8].The reported methods for estimation of nicotine suffer from such draw backs as high cost, multiple steps and also several clean-up steps (HPLC) [9]. They are time consuming and often poorly reproducible; some require toxic organic solvents [10]. Any method chosen for routine analysis should be reasonably simple, used materials should be readily available in the laboratory or readily obtainable and require a minimum amount of equipment. These objectives have been fulfilled by titrimetric Procedure[11]. Non-aqueous titrations are those in which the titrations of too weakly acidic or basic substances are carried out using non-aqueous solvents so as to get sharp end point. Such titrations can also be used for the titration of the substances not soluble in water[12]. The speed,

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precision and accuracy of the non-aqueous method are close to those of classical acidimetric and alkalimetric titrations[13]The apparatus involved are also same but moisture and carbon dioxide are to be avoided in non-aqueous methods because water, which is a weak base, can compete with the weak nitrogen base and the end point would not be sharp at all[14]. It has been observed through experiments that the moisture content in non-aqueous titrations should not be more than 0.05%.[15]

When a weakly basic drug is present, water (OH^-) acts as stronger base as compared to the former one and preferentially accepts proton from an acid. Thus, there is interference in the reaction of weak base with an acid. Similarly, when a weakly acidic drug is present, water (H^+) behaves like a strong acid as compared to the former one and preferentially donates proton to the base. Thus, there is interference in the reaction of weak acid with a base. Hence in the presence of water, titration of either weakly acidic substances with stronger base or weakly basic substances with stronger acid is not possible.[16]

Alkaloids are naturally occurring chemical compounds containing basic nitrogen atoms. The name derives from the word alkaline is due to nitrogen containing base. Alkaloids are produced by a large variety of organisms, including bacteria, fungi, plants, animals and are part of the group of natural products, also called secondary metabolites. Many alkaloids are purified from crude extracts by acid-base extraction. Many alkaloids are toxic to other organisms. They often have pharmacological effects and are used as medications, as recreational drugs, or in entheogenic rituals. Examples are the local anaesthetic and stimulant cocaine, the stimulant caffeine, nicotine, the analgesic morphine, or the antimalarial drug quinine. Some alkaloids have a bitter taste[17].

Nicotine is a pyridine alkaloid obtained from the dried leaves of tobacco plant *Nicotiana tabacum,* Family *Solanaceae*. Tobacco leaves contain 2 to 8% of nicotine combined as maleate or citrate.Nicotine is a colourless or pale yellow, very hygroscopic oily liquid with an unpleasant pungent odour and a sharp burning persistent taste.

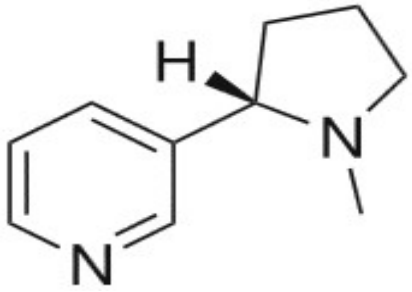


Fig. 1 Structure of Nicotine.

It gradually becomes brownish on exposure to air or light[18]. Nicotine is soluble in water, alcohol, chloroform, ether, kerosene, petroleum ether and fixed oils. Nicotine is a ganglionic cholinergic receptor agonist with complex pharmacological activities that includes effects mediated by binding receptors in autonomic ganglia, adrenal Madula, the neuromuscular junction and the brain. Nicotine causes psychological and physical dependence during chronic uses.[18] Cigarette smoking remains a leading cause of preventable disease and premature death in the India and other countries. On average 4,35,000 people in the India die prematurely from smoking-related diseases such as cancer, cardiovascular disease and pulmonary disease each year; overall, smoking causes 1 in 5 deaths. The chance that a lifelong smoker will die prematurely from a complication of smoking is approximately 50%. Cigarette smoking is a risk factor for respiratory tract and other infections, osteoporosis, reproductive disorders, adverse postoperative events and delayed wound healing, duodenal and gastric ulcers and diabetes. Conditioning is a major factor that causes relapse to drug use after a period of cessation. It must be addressed as a component of counselling and behavioural therapy for drug addiction.[19]

Exploration of the potential of tobacco as a raw material of a hygienic product is one alternative solution for the sustainability of tobacco cultivation while increasing the empowerment of tobacco farmers. Nicotine is an alkaloid found predominantly in tobacco leaves [20]. Various solvent extraction can be used to isolate nicotine in tobacco leaves. Nicotine is widely used in fine chemical, pharmaceutical and agriculture industries, and in the tobacco industry itself as an essential cigarette additive [21]. One potential for tobacco is the conversion of nicotine from tobacco leaves into

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nicotinic acid or niacin. Niacin a compound of Vitamin B3 which is widely used as medicine, vitamins, and cosmetics. This compound has a pyridine group and a carboxylate group as a side group so that the synthesis of nicotinic acid from nicotine from tobacco leaves can be done[22].

Experimental methodology and Processes:

Materials and Methods

Ten samples of common brands were purchased from the local market and compared to a raw tobacco sample local brand.Diethyl Ether (98%) (Fluka), Potassium Hydroxide (Sigma Aldrich), concentrated sulfuric acid 98% (Sigma Aldrich), Barium hydroxide, Perchloric acid, Potassium hydrogen phthalate. Crystal violet indicator.

Method- 1

i) Into an Erlenmeyer flask accurately weigh a 6-gm sample of tobacco (6-9 cigarettes without the paper and filter components). Record this data in your lab notebook as well as the brand name of the cigarettes.

(ii) To the flasks add approximately 50 ml of the saturated aqueous $Ba(OH)_2$ solution and 2 gm of granular Ba(OH)2. Ensure that the tobacco is thoroughly wetted. Into the flask, pipet 100.00 ml of toluene, add a stirring bar, stopper the flask, and magnetically stir for 20 minutes.

(iii) After 20 minutes filter most of the organic layer through a Whatman No.2folded filter paper into another clean, DRY Erlenmeyer flask. The aqueous layer should not be poured into the filter.

(iv) Into a clean, DRY Erlenmeyer flask pipet 20.00 ml of the filtered solution. Add 4-5 drops of crystal violet indicator. Using your burette filled with your standardized 0.1M HCIO, titrate to the characteristic greenish yellow endpoint. Repeat Step 4 two more times for reproducibility. (repeat the same procedure for next Nine samples).

Calculations:

1] Normality of perchloric acid

10 cm^3 of 0.1N potassium hydrogen phthalate
= x cm^3 of perchloric acid

$$\text{Normality of perchloric acid} = \frac{10X0.1}{10}$$
$$= 0.1 \text{ AN}$$

2] Since,1 mole of nicotine = 1 mole of perchloric acid.

1000 cm^3 of 1N $HClO_4$ = 162.23 g/mol of nicotine

X cm^3 of 0.1N $HClO_4 = \frac{162.23 \text{ X } 16 \text{ X } 0.1}{1000}$ x is (constant burette reading)

= Y. gm of Nicotine.

Method -2

Moisten about 50 gm of powdered drug with sufficient quantity of 20% alc. KOH solution to liberate alkaloidal base. Dry it at below 60°C.

Place the powder in flask containing 100ml of solvent ether and heat on water bath under refluxing condition for 10 minutes.

Filter and concentrate the filtrate to one fourth volume.

iv) Treat the ethereal extract with 20 ml of dilute sulphuric acid twice.

To the aqueous layer, add sufficient quantity of 5% NaOH solution.

vii) Extract free base with solvent ether twice. Concentrate ethereal extract and dissolve in about 5ml of water and filter. To the filtrate, add picric acid dropwise till complete precipitation of nicotine picrate take place. Keep the solution in cold condition for 15 minutes.

viii) Dry the product, weigh and determine its M.P. (repeat the same procedure for next Nine samples).

II. RESULT AND DISCUSSION

In this researchreview, nicotine has been isolated and analysed from ten different tobacco products using two different methods. The results of nicotine analysis are presented in the table below. The data shows that nicotine content varies

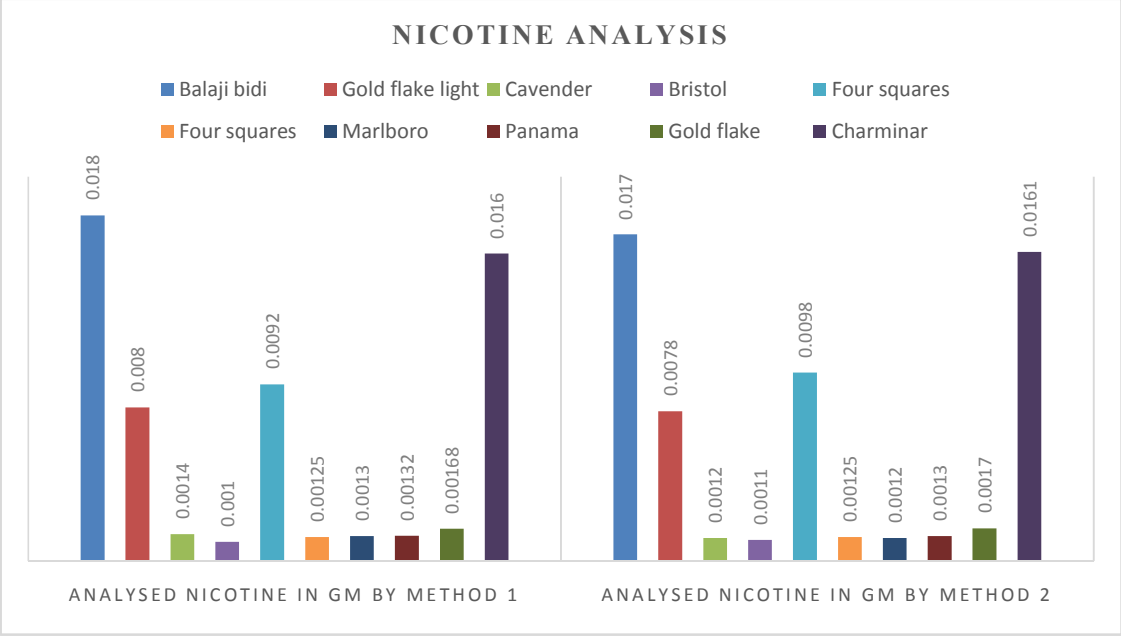
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across different products. Among the analysed samples, the highest nicotine content was observed in Balaji bidi (0.018 g by Method 1, 0.017 g by Method 2), followed by Charminar (0.016 g, 0.0161 g). Gold Flake Light had the lowest nicotine content (0.008 g, 0.0078 g), followed by Bristol (0.001 g, 0.0011 g).

A comparison between the two analytical methods indicates a high degree of consistency, as both methods yielded closely matching nicotine values. However, slight variations are observed, which could be attributed to differences in extraction efficiency, instrument sensitivity, or sample preparation techniques.The results confirm that cigarette and bidi brands contain varying levels of nicotine, which may influence their addictive potential. The findings emphasize the importance of understanding nicotine content for regulatory and health impact assessments.

Table-1 shows analysed nicotine content in different samples using different methods in gm.

Sr. No	Name of the product	Analysed Nicotine in gm by Method 1	Analysed Nicotine in gm by Method 2
1	Balaji bidi	0.018	0.017
2	Gold flake light	0.008	0.0078
3	Cavender	0.0014	0.0012
4	Bristol	0.001	0.0011
5	Four squares	0.0092	0.0098
6	Four squares	0.00125	0.00125
7	Marlboro	0.00130	0.00120
8	Panama	0.00132	0.00130
9	Gold flake	0.00168	0.0017
10	Charminar	0.016	0.0161



Graph-1 Nicotine Content analysis by two methods.

III. CONCLUSION

In this section,non-aqueous titrations are widely used in the Pharmacopoeias for the assay of many drug substances based on the properties of the drug which is either weakly acidic or weak bases.

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In this study, nicotine content was analysed in 10 different cigarette samples, including both commercial and local brands, using two distinct analytical methods: a chemical method and a nonaqueous method. The results revealed that the Balaji Bidi local cigarette brand exhibited the highest nicotine content among all tested samples. This suggests that local brands may have different formulations, tobacco blends, or processing techniques that contribute to elevated nicotine levels.

The comparison between the chemical and nonaqueous methods provided valuable insights into their accuracy and efficiency in nicotine quantification. Both methods effectively determine nicotine levels, but further studies may be needed to validate their precision and reproducibility across a wider range of samples.

The significantly higher nicotine content in the local brand raises concerns regarding potential health risks, addiction potential, and regulatory considerations. Future studies could explore the impact of such high nicotine levels on consumer health, smoking behaviour, and possible measures for nicotine regulation in locally produced cigarettes or tobacco product.

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Antimicrobial and Antifungal Activity of Chromene and Pyrimidine derivatives

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Abstract: *Chromene analogues are widely recognized for their diverse biological activities, including antimicrobial properties. In this study, we evaluated the antifungal and antibacterial potential of four chromene derivatives: 2-Amino-5-oxo-4,5-dihydropyrano[3,2-c]chromene-3-carbonitrile (4-nitro derivative), Dioxooctahydroxanthene (4-hydroxyl derivative), Tetrahydro[b]pyran (4-chloro derivative), Pyrano[2,3-d]pyrimidine diones (4-methoxy derivative). The bioactivity of these compounds was assessed against selected bacterial and fungal strains using standard antimicrobial assays. The results demonstrated significant antibacterial and antifungal activity, with variation in potency depending on the substituent groups present on the chromene core. Among the tested compounds, some showed moderate to good antimicrobial efficacy against selected strains, while the some comound showed notable antifungal activity. The findings suggest that structural modifications in chromene scaffolds influence their antimicrobial properties, highlighting their potential as lead compounds for novel antimicrobial drug development.*

Keywords: Chromene, antifungul, antimicrobial, Bacillus subtilis, Pseudomonasaerugianosa, E Coli, Staphylococcus aureus, Aspergillusnigar

I. INTRODUCTION

Bacterial infections are regarded as a major global health threat [1]. In recent days, the main global threat to human public health has become antimicrobial resistance (AMR) [2]. The deaths may increase from seven hundred thousand to 10,000,000 yearly by 2050 due to antimicrobial resistance [3]. Candida sp. is considered to be answerable for most of the yeast-like foundational mycosis. Over the most recent couple of years, the augmentation of contagious diseases [4,5], especially nosocomial, ensuring protection from antifungal specialists has animated the quest for new antifungal specialists [6,7]. This search can be carried out by adopting any of these two approaches: (a) the quest for molecules that can work on the action of an all-around perceived antifungal specialist or/and (b) the quest for particles with antifungal action related to the obstruction in a particular objective on the fungal cells [8]. An alarming fact is that most antimicrobial drugs are associated with several clinical limitations, such as side effects, for example, hypersensitivity [9], hepatotoxicity [10], nephrotoxicity [11], serum levels [12], and multiple interactions [13,14]. The high mortality rate in our world is caused by antimicrobial clinical limitations and infectious diseases, so we need to develop novel therapeutic agents [15,16]. DNA gyrase is a decisive target for antimicrobial drugs [17,18] as it plays an essential role in bacterial DNA duplication by presenting negative supercoils in DNA topology [19]. It aided in the expansion of drugs and the existing resistance mechanisms in the patient's body [20]. The use of antibiotics resulted in increased bacterial resistance to present drugs [21,22]. Therefore, the search for novel antibacterial substances is urgently required, possibly acting through a different mechanism than the existing drugs [23]. Nitrogen and Oxygen heterocycles are becoming more popular because of their wide range of pharmacological and biological properties [24].

The chemistry of heterocycles has garnered a lot of studies since they are useful reagents due to their use as precursors for synthesizing polyfunctional substituted heterocycles (e.g., pyran, chromene, xanthene, pyrimidine, etc.) which are otherwise not so readily obtainable heteroaromatics. In continuation of our previous work this work of bioactivity has been extended after synthesis of some heterocyclic derivatives.[25-27]

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Experimental

Well plate diffusion method-The inoculums microorganism was prepared from the bacterial cultures. 15 ml of nutrient agar (Hi media) medium was poured in clean sterilized Petri plates and allowed to cool and solidify. 100 µl of broth of bacterial strain was pipette out and spread over the medium evenly with a spreading rod till it dried properly. Wells of 6µl in diameter were bored using a sterile cork borer. Solutions of all the compounds (5000 µg/ml) in DMSO were prepared. 100 µl of plant extracts solutions was added to the wells. The Petri plates were incubated at 37°C for 24 h. streptomycin (1mg/ml) was prepared as positive control DMSO was taken as a negative control. Antibacterial activity was evaluated by measuring the diameter of the zone inhibitions (ZI) all the determinations were performed in triplicates.

II. RESULT AND DISCUSSION

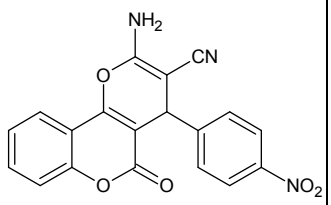
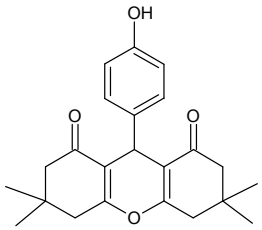
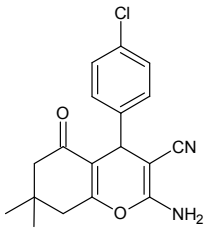
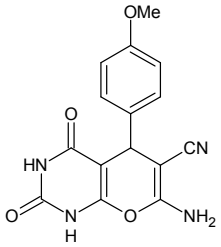
Antifungal activity against *Aspergillusnigar* by Agar Well plate diffusion method

Stock solution for antifungal activity: For the antifungal study, each compound was dissolved in DMSO at a concentration of 5 mg/ml and stored in a refrigerator till further used.

Antifungal activities of the compounds were evaluated usingan agar well diffusion assay. The assay was carried out according to the method of Sabouraud dextrose agar (Hi media) was used for the growth of fungus[28]. Media with acidic pH (pH 5.5 to 5.6) containing a relatively high concentration of glucose (40%) is prepared by mixing (SDA) Sabouraud dextrose and distilled water and autoclaved at 121°C for 15 minutes. 25 ml of molten (45°C) SDA medium was aseptically transferred into each 100mm x15mm sterile Petri dish.For counting of spore (fungi) were suspended in normal saline to make volume up to 1ml and then counted with help of hemocytometer (Neubauer chamber). Once the agar was hardened, 8mm wells were bored using a sterile cork borer. Then 0.1 ml (100 µl) from each well and plate were incubated for 24 hours at 29°C.Two wells in each Petri dish were supplemented with DMSO and reference antifungal drug streptomycin (1 mg/ml) dissolved in DMSO serve as negative and positive control respectively. The antifungal activity was measured as the diameter (mm) of the clear zone of growth inhibition[29].

The B1 to B4 compounds were selected for the antimicrobial and antifungal activity against different types of strains shown in Table 1.

Table 1- Selected compounds for bioactivity

B1-2-amino-5-oxo-4,5-dihydropyrano[3,2-c]chromene-3-carbonitrile 4-nitro derivative	B2-1,8-Dioxooctahydroxanthene 4-hydroxyl derivative	B3-Tetrahydro[b]pyran 4-chloro derivative	B4- pyrano[2,3-d]pyrimidine diones 4-methoxy derivative
			

The antimicrobial activity was evaluated against gram positive and gram negative type of bacteria. The Bacillus subtilis and Pseudomonas aerugianosaare gram positive whileBacillus subtilis and Pseudomonas aerugianosa are gram negative bacteria the details are shown in Table 2 and Table 3.

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Table 2- Antimicrobial activity of B1 to B4 compounds against *Bacillus subtilis and Pseudomonas aerugianosa*

Entry	Samples	Conc. (mg/ml)	Zone in diameter (mm) against *Bacillus subtilis*	Zone in diameter (mm) against *Peudomonasaeruginosa*
	Control	-	00	00
	Standard (*Streptomycin*)	1	16	17
1	B1	1	01	05
2	B2	1	03	11
3	B3	1	05	01
4	B4	1	09	01

Table 3 - Antimicrobial activity of B1 to B4 compounds against *Bacillus subtilis and Pseudomonas aerugianosa*

Entry	Samples	Conc. (mg/ml)	Zone in diameter (mm) against *E Coli*	Zone in diameter (mm) against *Staphylococcus aureus*
	Control	-	00	00
	Standard (Streptomycin)	01	16	17
1	B1	01	09	03
2	B2	01	12	07
3	B3	01	01	01
4	B4	01	01	02

The antifungal activity was evaluated for the fungi *Aspergillusnigar*for all for compounds by taking streptomycin as a standard shown in table 4.

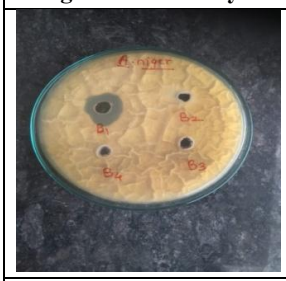
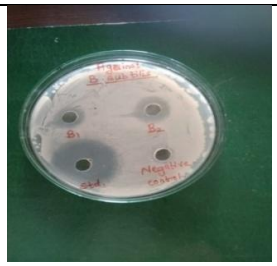
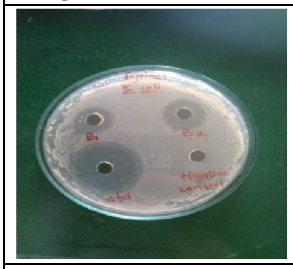
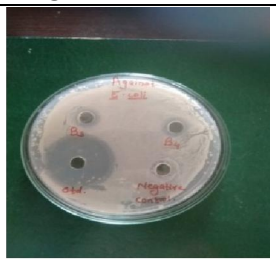
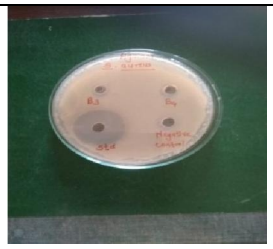
Table 4- Antifungal activity of synthetic compounds against *Aspergillusnigar*

Entry	Samples	Conc.(mg/ml)	Zone in diameter (mm) against *Aspergillusnigar*
	Control	-	00
	Standard (Streptomycin)	01	16
1	B1	01	10
2	B2	01	01
3	B3	01	02
4	B4	01	03

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The images of bioactivity shown by the evaluated compounds B1 to B4 for the antimicrobial and antifungal nature using appropriate standard and control. (Figure 1 to Figure 8)

Images of bioactivity of B1, B2, B3, and B4 against different bacteria and fungi			
			
Figure 1- B1 and B2 *A.niger*	**Figure 2- B3 and B4 *A.niger***	**Figure 3- B1 and B2 *B.Subtilis***	**Figure 4- B3 and B4 *B.Subtilis***
			
Figure 5- B1 and B2 against *E.coli*	**Figure 6- B3 and B4 against *E.coli***	**Figure 7- B1 and B2 against *S.aureus***	**Figure 8- B3 and B4 against *S.aureus***

III. CONCLUSION

The antibacterial activity of the compounds studied on gram +ve and gram –ve bacteria, in which compound B2 against *P aerurogenosa,* B4 against *Bacillus subtilis*, B1 and B2 against *E.coli*, B2 against *Staphylococcus aureus* showed moderate activity.

The antifungal activity of the synthetic compounds studied on *Aspergillusnigar*, in which compounds B1 showed moderate to good activity.

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Bioactive Compounds and TLC Analysis of Two Medicinal Plants from Murud Janjira

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Abstract: *The present study analyzes the leaves of* Ipomoea pes-caprae *(Roth) and* Ipomoea triloba *(L.) for their phytochemical composition using Thin-Layer Chromatography (TLC). Qualitative phytochemical screening was conducted to establish a scientific basis for their ethnomedicinal potential. The analysis confirmed the presence of various bioactive constituents, including alkaloids, flavonoids, saponins, and tannins. TLC profiling of ethanol, petroleum ether, and methanol extracts was performed to detect key phytochemicals such as alkaloids, tannins, and flavonoids. The findings validate the presence of these phytoconstituents in both plant species, supporting their potential medicinal significance. These results suggest that a polyherbal formulation incorporating these two medicinal plants could serve as a valuable source of bioactive compounds for therapeutic applications.*

Keywords: Ethanol extract, Petroleum ether extract, Methanol extract, TLC, Phytochemical analysis

I. INTRODUCTION

India has one of the richest and most varied cultural traditions connected with different medicinal plant species. Medicinal plants are abundant reservoirs of phytochemicals which possess several therapeutic belongings. Phytochemicals present in medicinal plants protect against many diseases (Myres, 1982).The chief components produced by plants are alkaloids, glycosides, flavonoids, polyphenol, saponin, steroids, tannins etc.

The present investigation was aimed to investigate theTLC and phytochemical analysis for identification and authentication extracts of various leaves of different *Ipomoea pes-caprae* Roth and *Ipomoeatriloba*L**.**

II. MATERIALS AND METHODS

Collection and identification of plants leaves of *Ipomoea pes-caprae* Roth and *Ipomoeatriloba*L**.** leaves were selected for the study. The selected plants were collected from the field, stored in air tight bottle.

Table 1: List of medicinal plants evaluated for thin-layer chromatography

Sr.No	Plant Name	Extract	Plant Part
1	***Ipomoea pes-caprae* Roth**	Ethanol	Leaves
		Pet-ether	
		Methanol	
2	***Ipomoeatriloba*L.**	Ethanol	Leaves
		Pet-ether	
		Methanol	

TLC Analysis

Thin layer chromatography TLC of herbal plant extracts was done according to standard methods [16]. Ethanol, Pet-ether and Methanol extract (500 mg) plants were dissolved in (50ml) respectively organic solvent and centrifuged at 3000 rpm for 5 minutes. The supernatant was collected and used for TLC analysis. The developed plates were dried in air heater to evaporate the solvents from the plates. The plates were kept in a photo-documentation chamber and the

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images were captured in white light, UV 366nm. Then, the numbers of spotted were noted and Rf values were calculated.

Preparation of extracts

Phytochemical Test The screening of the two selected medicinal plants for various phytochemical constituents were analyzed (Table 1).We characterized the different chemicals groups such as, , Alkaloids, Tannins, Flavonoids and with reference to the technical described in the work (Farnsworth, 1974, Trease and Evans, 1987, Bruneton, 1999, Sharma et al., 2006). 1.Alkaloid : First, evaporate 10 ml of concentrated etheric solution, the dry filtrate was mixed with 1.5 ml of HCl (2%) acid solution. After that, add two drops of Wagner and Mayer's reagent, and the yellow- white colour precipitate identifies the existence of the alkaloidal base.

2. Saponins : Initial, a test tube 1 ml of aqueous extract was added with few volume of distilled water. The solution was shaken vigorously for few minutes andobserved for a stable persistent froth for 15-20 minutes.

3. Tannins : First, in a test tube about 1 ml of the ethanol extract was added with 2 ml of distilled water. Three drops of diluted ferric chloride solution were added and observed for green to blue-green colour specifies the presence of tannin.

4. Flavonoids : The ethanol extract 5ml was mixed to a concentrated Sulphuric acid 1 ml and 0.5 gram of Magnesium (Mg). A red or pink coloration that disappear on standing three minutes signifies the presence of flavonoids.

III. RESULT AND DISCUSSION

Results and Discussion The qualitative analysis of phytochemicals is very essential for identifying and isolation of active compounds present in the plants. In the present study, qualitative analysis was undertaken to investigate the presence of various phytoconstituents in extracts of *Ipomoea pes-caprae* Roth and *Ipomoeatriloba*L(Table 2). The results of qualitative phytochemical analysis showed presence of various phytochemicals likealkaloids,tannins, flavonoids andsaponins.

Table No.2

Sr.No	Plants Name	Name of Phytochemicals				Plant Leaves
		Alkaloids	Tannins	Flavonoids	Saponins	
1	*Ipomoea pes-caprae* Roth	+	-	+	+	Leaves
2	*Ipomoeatriloba*L	+	+	+	+	Leaves

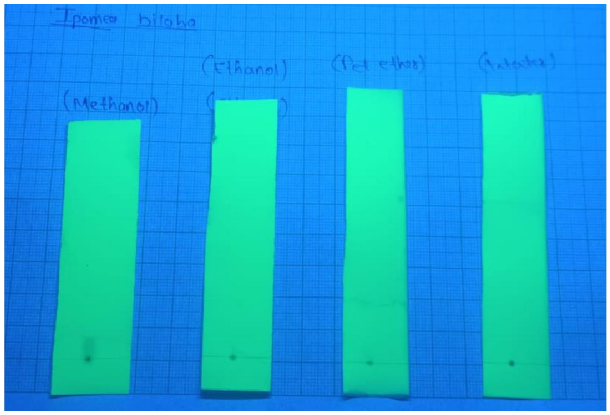
Each extract of herbal plants were dissolved in different solvents likeEthanol,Pet-etherand methanol gives an impressive result that directing towards the presence of number of phytochemical. Various phytochemicals gives different Rf values in different solvent system. This variation in Rf values of the phytochemicals provides a very important clue in understanding of their polarity and also helps in selection of appropriate solvent system for separation of pure compounds by column chromatography. Mixture of solvents with variable polarity in different ratio can be used for separation of pure compound from plant extract. The selection of appropriate solvent system for a particular plant extracts can only be achieved by analyzing the Rf values of compounds in different solvent systems.

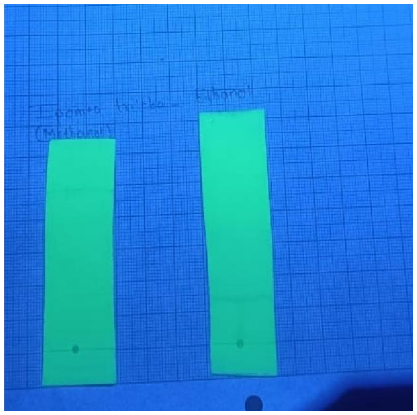
The TLC method is best choice for the identification of secondary metabolite present in plants. The different Rf values indicate the presence of different nature of phyto-constituents in single extracts. Different Rf values of the compound also reflects an idea about their polarity. This information will be helpful in selection of appropriate solvent system for further separation of compound from these plant extracts.

Sr.No	Plant Name	Plant Part	Extract	R.F Value
1	***Ipomoea pes-caprae* Roth**	Leaves	Ethanol	0.4
			Pet-ether	0.6
			Methanol	0.3
2	***Ipomoeatriloba*L.**	Leaves	Ethanol	0.5
			Pet-ether	0.6
			Methanol	0.4

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Synthesis of Benzimidazole Derivatives: Microwave Approach review

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Abstract: *Benzimidazole and its derivatives have very diverse biological activity. They have various biological activities like antimicrobial, antiviral, Antidiabetic, anticancer, activity. Different Benzimidazoles derivatives in good yield have been prepared by condensation of orthophenyldiamine with aromatic aldehyde in presence of various catalysts. In this we have reviewed large number of microwave assisted reaction involving synthesis of Benzimidazole derivatives..*

Keywords: Benzimidazole, microwave, reaction, catalyst

I. INTRODUCTION

Heterocyclic compounds are compounds that contain one or more than one cyclic rings with one or more heteroatom/s like N, O, S or other in the ring. The forms of proteins like purine, hisitidine, proline, and pyrimidine, bases in the genetic material like DNA and RNA are more important, which play vital role in life processes such as metabolism of all living cells. They also play important roles as enzyme, coenzyme and many natural products. Most biologically active molecules such as hormones, acids, enzymes, neurotransmitters may contain one, two or many heterocyclic rings. Out of these most common heterocyclic compound is Benzimidazole as an important nucleus.

There are a large number of pharmacologically active heterocyclic compounds as Benzimidazole, many of which are in regular clinical use. Very wide range of synthetic and naturally occurring heterocyclic compounds are having applications in medicines and also in pharmacy, pesticides, agrochemicals, polymers plastic ,drugs and dyes. There is a vast scope for the research leading to new heterocyclic molecules having very good biological activity.

The Benzimidazole derivatives were first realized as chemotherapeutic agents in 1950. Most common Benzimidazole containing compounds are 5, 6- dimethyl-1-D-ribofuranosyl Benzimidazole, part of the structure of Vitamin B-12 and other pharmaceutical drugs. The anthelmintic activity [1-2]are commonly known. Along with this, Benzimidazole derivatives with different pharmacological properties such as, anti-ulsaral[3-5], cardio tonic [6], antihypertensive against depression[7], antibacterial and antiviral against virus and bacteria [8], antitumor[9], antimutagent[10], antiallergenic[11] are already reported. It also exhibits analgesic, anti-inflammatory and antipyretic activity [12]. Moreover, it also shows hypoglycaemic [13],anticalmodulin [14] anti-aggregate [15] activities. Due to this synthesis of Benzimidazole derivatives.

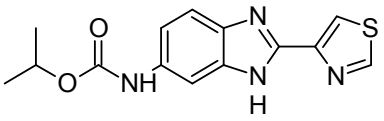
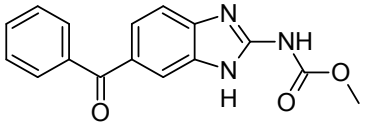
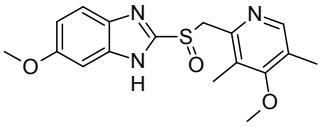
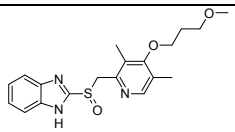
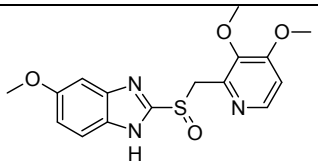
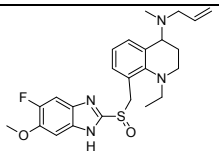
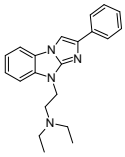
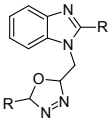
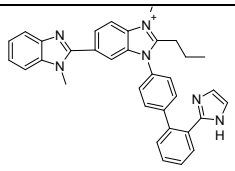
II. IMPORTANCE OF BENZIMIDAZOLE RING SYSTEM:

A wide range of Benzimidazole and their derivatives find uses in pharmaceutical and veterinary drugs showing therapeutic activities. Some of the commercially important Benzimidazole derivatives are listed below.

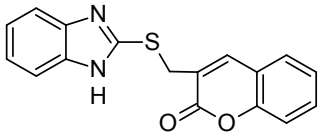
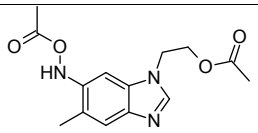
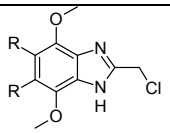
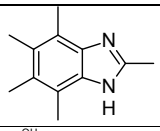
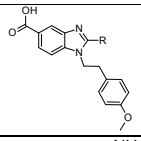
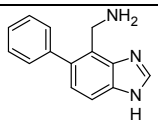
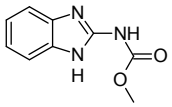
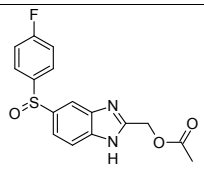
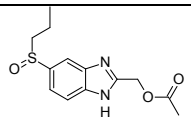
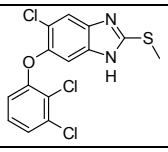
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Table 1.

Sr. No.	Trade Name	Structure	Activity
1	Cambendazole		Anthelmintic
2	Albendazole		Anthelmintic
3	Omeprazole		Anti-ulcer drugs
4	Rabeprazole		Anti-ulcer drugs
5	Esomeprazole		Anti-ulcer drugs
6	Quinoline Benzimidazole analog		Anti-psychotic agents
7	Imidazole derivative with Benzimidazole		Anti-psychotic agents
8	Oxazolederivative with Benzimidazole		Antimicrobial activity
9	Bibenzoimidazole derivatives		Antagonist

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10	Benzimidazoleand coumarine derivative		Antiseptic activity
11	Amide derivative of Benzimidazole		Anticancer activity
12	Substituted Benzimidazole		Anticancer activity
13	Alkyl substituted Benzimidazole		Antiamoebic activity
14	Benzyl substituted carboxyl Benzimidazole		Antilukamic activity
15	Phenyl amine derivative of Benzimidazole		Antidiabetic activity
16	Amide derivative of Benzimidazole		Cyticidal activity
17	**Oxfendazole**		Roundworms and tapeworms
18	**Ricobendazole**		Anthelmintic
19	Triclabendazole		Anthelmintic

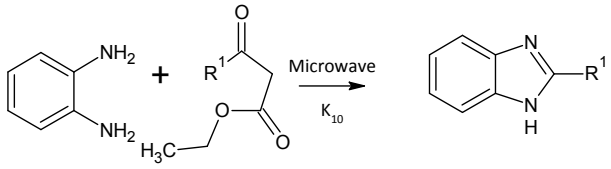
Besides the very high efficiency for the synthesis of Benzimidazoles, many of the methods required to be improved for the very high reaction temperature, very long reaction times, highly toxic solvent and high-cost catalyst, etc. [16] Therefore, there is need of development of simple mild, efficient and environmentally benign protocol for the synthesis of Benzimidazoles is still a hot topic for researchers. After the first reports of applications of microwaves in synthetic chemistry in 1986, now-a-days microwave-assisted, synthesis has become popular, particularly, last two decades due to the generally short reaction times, the high purity and yields of the resulting products with high purity. Up to now,

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several microwave-assisted methodologies for the synthesis of Benzimidazoles are reported.in this review we have reported the different method for the synthesis of Benzimidazole derivatives using microwave reactions

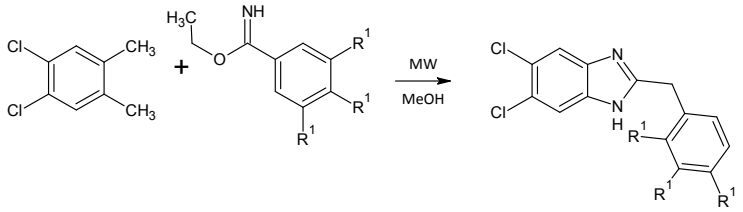
1] Bougrin Kand etal

The microwave-assisted Benzimidazole synthesis by Bougrin They have described a Benzimidazole synthesis method using 1,2-diaminobenzene or 4-substituted-1,2-diaminobenzene and ethyl acetoacetate or ethyl benzoyl acetate on solid mineral supports or other support in dry media under microwave irradiation in domestic ovens leads to formation of the Benzimidazole derivative's.[17]



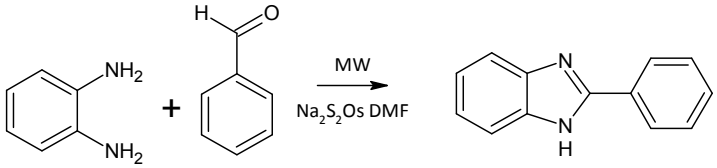
2] Emre Mentese and etal

Simple protocol was developed for the synthesis of Benzimidazoles. The reaction of iminoester hydrochlorides of phenylacetic with 4,5-dichloro-1,2-phenylenediamine or their derivative's under microwave irradiation leads to the Benzimidazole derivatives with good yields and in very short reaction times. [18]



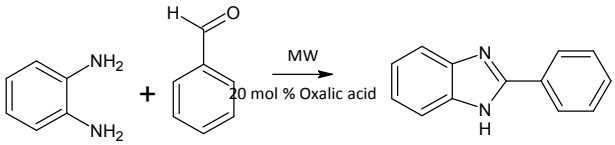
3] D. Secci and etal

1, 2-diaryl-Benzimidazole and 2-aryl-1H-Benzimidazole derivatives were synthesized with simple differences using both microwave irradiation and conventional heating methods by carrier. Usually higher yields and time reactions reduction were obtained with the former method. Reaction requires very less time. [19]



4] Jyoti Pandey etal

Simple microwave assisted one-pot synthesis of Benzimidazoles from 1, 2 Phenylenediamine and aromatic aldehyde catalysed oxalic acid as a catalyst is described. Advantage technique, use the inexpensive and readily available catalyst, reaction time was decreased and the products were obtained in higher yields and having easy isolation. [20]

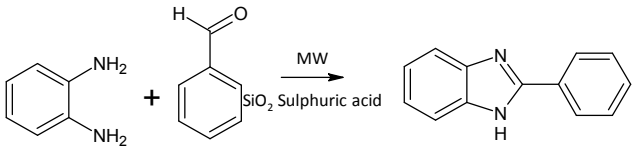


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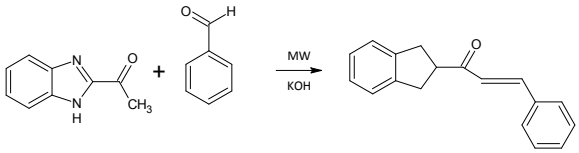
5] B. Guruswamy *et al*

Ortho phenylene diamine is aromatic aldehyde acid was placed on H_2SO_4-SiO_2 and transferred in to a microwave vial. The vial was sealed and placed in microwave. The reaction was run at 80 °C for 5 min. after completion of the reaction the product was obtained by the extraction and purification by column chromatography.[21]



6] Janardan Singh Yadav etal

The reaction of 2-acetyl Benzimidazoles with substituted aldehydes in methanol in presence of base afforded corresponding benzimidazolyl chalcones or unsaturated compounds which on treatment with ethylenediamine or phenyldiamine afforded the under MWI condition. Reaction occurs in short time and high yield.[22]



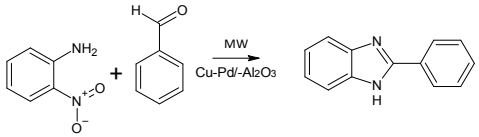
7] D.D. Rishiapathak etal

The 2-alkyl and 2-aryl substituted Benzimidazole derivatives is synthesized by reacting *o*-Phenylenediamine with various carboxylic acids using polyphosphoric acid as catalyst using by irradiation microwave methods. Reaction required very less time and good yield. [23]



8] Feng, F. etal

Synthesis of Benzimidazoles from 2-nitroaniline and ethanol over Cu-Pd/-Al_2O_3 catalysts are easily available starting materials, having high efficiency, and a simple procedure. The modification by Mg of the Cu-Pd/-Al_2O_3 catalyst could improve the catalytic activity significantly. Reaction carried in microwave at 100 w and gives better yield with good purity.[24]



9] Madhura Vijay Newrekar

The reaction of the From condensation of o-phenylene diamine and different substituted aromatic carboxylic acids and aromatic aldehydes, derivatives of 2-aryl Benzimidazole were synthesize using the microwave approach with good yield and purity.the reaction was catalysed by ammonium chloride and water [25]

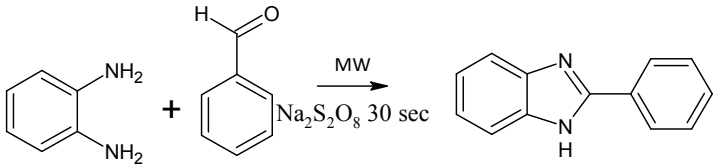


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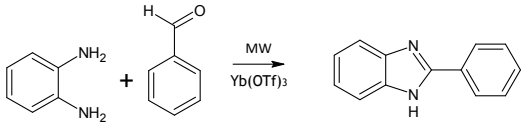
10] G. Navarrete and etal

2-(substituted phenyl)-1H-Benzimidazole derivatives with various 5-and 6-position substituents were synthesized via microwave irradiation using a short synthetic route and $Na_2S_2O_5$ as oxidant. This simple, fast, and efficient preparation of Benzimidazole derivatives has been developed using readily available and inexpensive reagents under solvent-free conditions. [26]



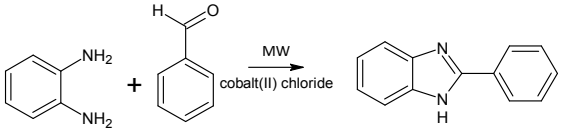
11] Limin Wang etal

An Efficient Procedure for the Synthesis of Benzimidazole Derivatives Using Yb(OTf)3 as
Catalyst under Solvent-Free Conditions, in microwave Synthetic products obtained are purifi4d over silica gel.[27]



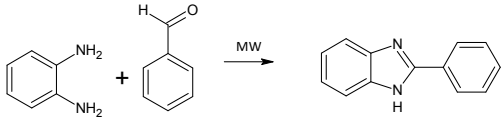
12] Abu Khan etal

Simple and efficient method for the convenient synthesis of 2-arylBenzimidazolehas been described on reaction with o-Phenylenediamine and various aromatic aldehydes using cobalt(II)chloride hexahydrate as a catalyst. The method is cost-effective, high-yielding, clean, and selective method for the synthesis.[28]



13] Na Zhao etal

An efficient and a quick microwave-assisted synthesis of Benzimidazoles and trisubstituted imidazole's was developed. Benzimidazoles were obtained as a result of the condensation of 1,2-phenylenediamine with carboxylic acids and acetoacetic ester without catalyst. Trisubstituted imidazoles were synthesized by condensation of benzil, aromatic aldehyde and ammonium acetate in the presence of glacial acetic acid, under microwave [29]



14] Hee-Jong Lim etal

Microwave-assisted condensation of resin-bound esters with 2-aminothiophenols to the corresponding benzothiazoles and BenzimidazoleThe condensation of ester with 2-aminothiophenol in 15% of methanesulfonic1, 2-dichlorobenzene system gave highest yield of 2-phenylbenzothiazoles Most esters including nicotinate ester were converted to the corresponding benzothiazoles and Benzimidazole [30]



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15] A. Saberiet al

Synthesis of Benzimidazole derivatives is outlined in. *o*-Phenylenediamine Carboxylic acid derivatives) and 50 mg of Alumina or Silica gel or Zeolite were mixed thoroughly in a mortar. The reaction mixture was then irradiated in a domestic microwave oven for 5- 9 min at 160-560 W. The reaction gives good yield and purity.[31]



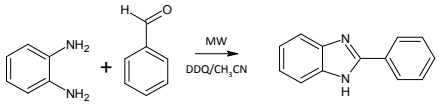
16] Jun Lu etal

In the presence of the PPA the mixture of acetic acid and o-phenylenediamine was stirred and irradiated in the MW oven three times at the 18% full output power (162 W). This reaction good yield and purity.[32]



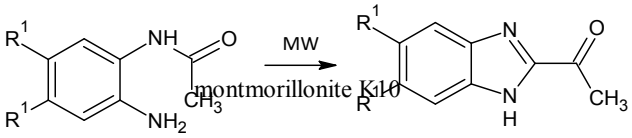
17] Hossein Naeimi etal

Solution of o-phenylenediamine (and aldehyde in a minimum amount of acetonitrile was prepared. DDQ (0.14 g, 60 mol %) was added into an open Erlenmeyer flask. The mixture was irradiated in a microwave oven. The progress of the reaction was monitored by TLC. [33]



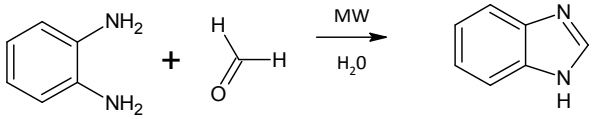
18] Bougrin K etal

Bougrin *et al*have described in dry media synthesis of 2-trifluoromethylBenzimidazoles through cyclocondensation of N-(carbotrifluoromethyl)-*ortho*-arylenediamines on montmorillonite K10 under domestic microwave oven with good yields[34]



19] Getvoldsen GS etal

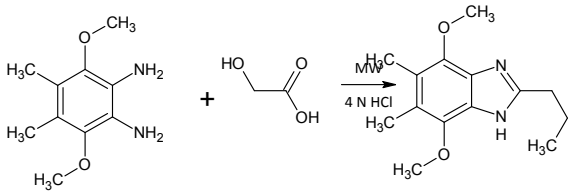
Getvoldsen *et al.* method for the reactions in a microwave The Benzimidazole synthetic reaction from 1,2-diaminobenzene and formic acid has chosen as a model reaction. They have reported that the new method would be an excellent analytical tool for monitoring the progress of a reaction.this gives good yield and purity.[35]



20] Boufatah N etal

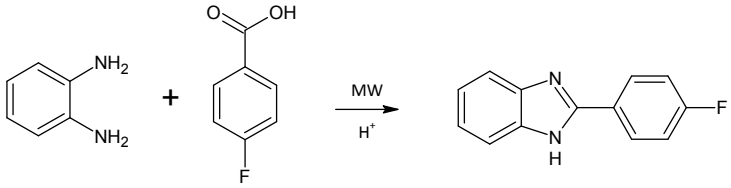
Boufatah *et al*.have reported the preperation of some new biologically active Benzimidazole-4,7-dione derivatives in 7 steps through the microwave irradiation for the ring closing step to obtain Benzimidazole derivative [36]

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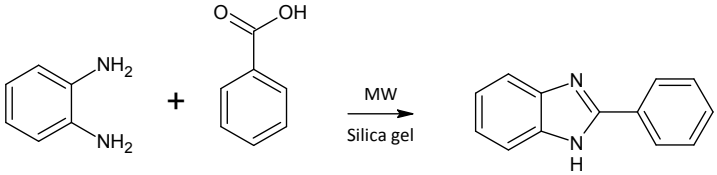
21] Getvoldsen Getal

Getvoldsen *et al*have reported 2-([4-F] fluorophenyl) Benzimidazole synthesis from the cyclocondensation reaction of 1,2-diaminobenzene with radiolabelled [4-F]f luorobenzoic acid in neat methanesulfonic and polyphosphoric acids under microwave [37]



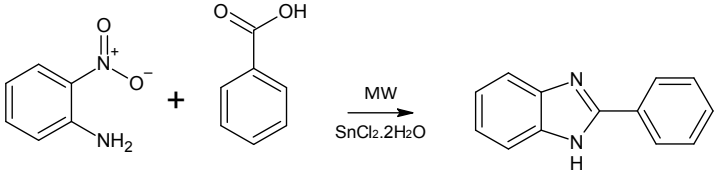
22] Martinez-Palou R, etal

Martinez-Palou *et al*. (49) have described 2-long alkyl chain substituted Benzimidazole synthesis from the reaction of 1,2-diaminobenzene and stearic acid via mono and multimode microwave irradiation with high yields [38].



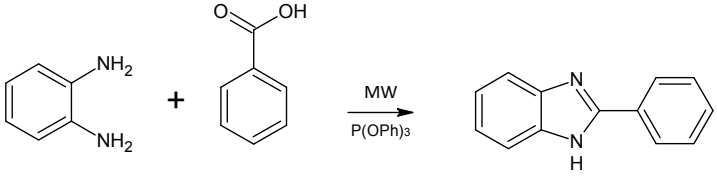
23] VanVilet DS etal

Vliet *et al*. have described a simple, rapid, one pot procedure for the generation of 2- substituted Benzimidazoles with high-yield directly from 2-nitroanilines using $SnCl_2$ as a reducing agent and carboxylic acid under microwave irradiation at 130 ^oC in 5 min [39]



24] Lin A-Y et al

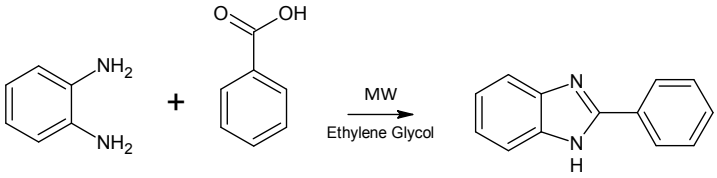
Lin *et al*. have reported a microwave-assisted one-pot synthesis of several Benzimidazole derivatives from readily available starting compounds such as 1,2-diaminobenzene, 4,5- diaminopyrimidine, *cis*-1,2-diaminocicylohexane and several carboxylic acids including heteroaraomatic carboxylic acids .[40]



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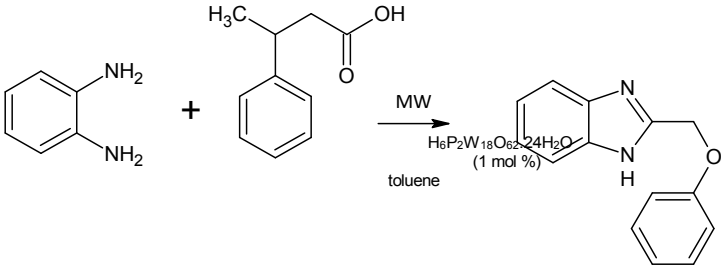
25] Jing X et al

Jing *et al*. have described a simple and rapid synthesis of Benzimidazoles from 1,2-diaminobenzene dihydrochloride and esters under microwave irradiation. This is also the first report for microwave assisted Benzimidazole synthesis from esters and 1,2-diaminobenzenes various Benzimidazole derivatives are synthesized by ethylene glycol as solvent [41]



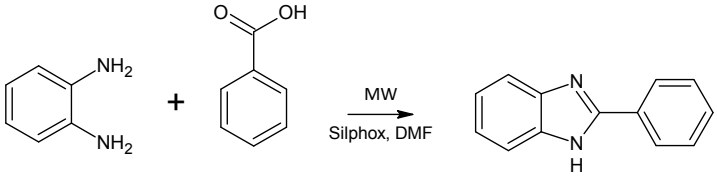
26] Hosamani KM, etal

Similar to the Keri method, Hosamani and co-workers described a convenient protocol for the preparation of 5-nitro-2-arylsubstituted phenoxymethyl-1*H*-Benzimidazole libraries in one pot-synthesis both under microwave irradiation and conventional heating methods using hydrochloride acid as catalyst [42]reaction is simple condensation reaction between orthophenyl diamine and acid functional group.



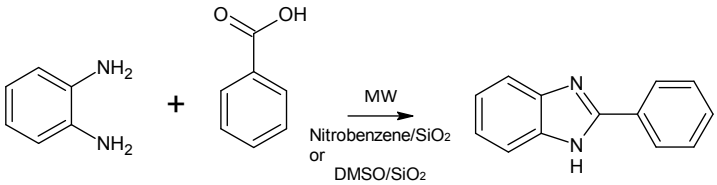
27] Hasaninejad A, etal

Hasaninejad *et al*. have reported the synthesis of some 2-substituted Benzimidazole derivatives from benzene-1,2-diamine with mono and dicarboxylic acids under microwave irradiation using silphox [POCl3-n(SiO2)n] catalyst in highly yield and short reaction times [43]



28] Ben-Alloum A

Ben-Alloum *et al*. have described oxidative heterocyclization of aldehydes and ophenylenediamine with nitrobenzene or dimethylsulfoxide impregnated on silica gel irradiated with microwave in good yields and high purity [44].

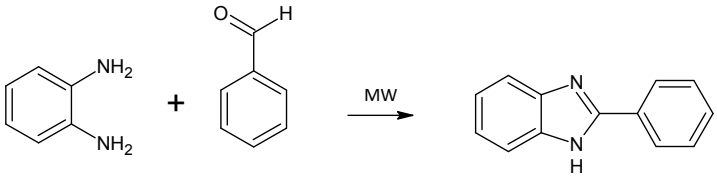


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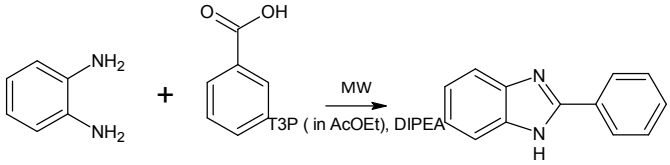
29] Zahran MA–H, etal

Zahran and co-workers described the synthesis of new heterocyclic compounds containing pyrazol-5-one coupled with Benzimidazole under dry media and they also explored antitumor activity of the newly synthesized heterocycles. Some of them were found to be more effective than thalidomide. [45]



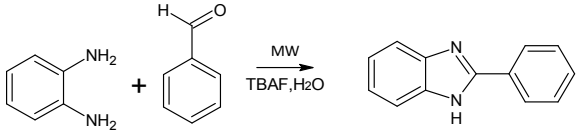
30] Wen Xiaoan etal

Wen *et al*. have reported on eco-friendly, one-pot efficient propylphosphonic anhydride (T_3P) mediated synthesis of Benzimidazoles from various carboxylic acids and 1,2- diaminobenzene under microwave irradiation [46]



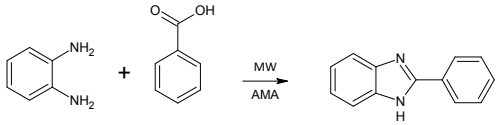
31] RS Joshi etal

Joshi *et al* (2010) employed microwave method for synthesising 2-ArylBenzimidazole. A mixture of substituted aldehyde, *o*-phenylene diamine and TBAF (5 moles %) was dissolved in minimum quantity of water with constant stirring and was irradiated under ultrasonic irradiation or microwave at ambient temperature for appropriate time. The progress of reaction was monitored by TLC. [47]



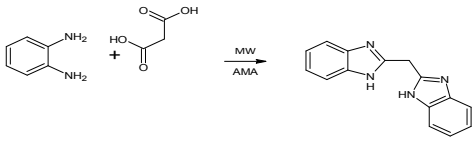
32] Niknam etal

Niknam *et al* (2007) reported microwave irradiation method as the best method for the synthesis,of 2-substituted Benzimidazoles and bis Benzimidazoles from the direct reaction of phenylenediamine and dicarboxylic acid in the presence of alumina-methanesulfonic acid (AMA) as a catalyst with good to excellent [48]



33] R Dua etal

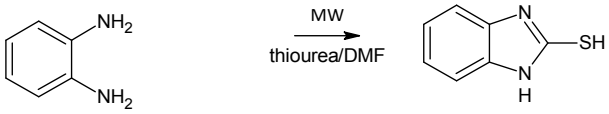
In a typical procedure, a mixture of 1,2-phenylenediamine(5mmol) carboxylic acid, alumina (0.5g) and methanesulfonic acid (12 mmol) was subjected to microwave irradiation (900 W, with a frequency 2450 MHz) at 20% power for times specified. [49]



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34] Singh *et al*

Singh *et al* (2010) synthesised 1, 3 dihydrobenzimidazol-2-thione and its derivatives in. 1,3 Dihydro-Benzimidazol-2-thione was formed by reacting *o*-phenylenediamine and thiourea in microwave at 40% intensity for 6 minutes 10 seconds till the colour changes to brown. Acetylchloride, chloroacetyl chloride and chlorosulfonic derivatives of 1,3, dihydro benzimidazol -2-thione (65) were synthesised from 1,3 Dihydro-Benzimidazol-2-thione . [50]



III. CONCLUSION

The Benzimidazole ring is an important pharmacophore in modern drug discovery component, also naturally occurring in vitamin B-12.Most of the Benzimidazole derivatives are synthesized by, heating, sonication or microwave energy. Most of these methods i) from the reaction of 1,2-diaminobenzenes with carboxylic acids or its derivatives, ii) condensation of 1,2-diaminobenzenes with aldehydes presence of an oxidative reagent. This method involves use of microwave reactions which require very short life time, good yield and purity. These methods are environmentally benign protocol for the synthesis of Benzimidazoles continues to attract researchers' attentions. This article aims to review the work reported, microwave-assisted synthesis of Benzimidazole derivatives.

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My family & Parents

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Green Synthesis and Characterization of Nano-Iron using *Termitomyces* spp.

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Abstract: *Recently, nano-science is one of the most important fields. Production of nanoparticles by using microbes is a new area of interest. Therefore, this study aimed to synthesize nano-iron using Termitomyces spp. by cell-free water extract method followed by confirmation and character- ization of nano-iron by UV-visible spectrophotometry and electron microscopy. Reduction of iron ions to iron atoms was visualized through the change in the color of the mixture from pink to dark brown color with a peak at 226 nm corresponding to the Surface Plasmonic Resonance (SPR) of nano-iron by UV-Vis Spectroscopy. Transmission Electron Microscopy (TEM) showed spherical shaped nano-iron with a size range of 2.5 to 20 nm. The formation of a typical crystalline structure of iron atoms was confirmed by Selected Area Electron Diffraction (SAED). In conclusion, Termitomyces spp. is an excellent bio-factory replacing the conventional chemical and physical techniques.*

Keywords: Biosynthesis; *Termitomyces spp.*; Nano-iron; Nanotechnology

I. INTRODUCTION

Nanotechnology is a field that focuses on the study and manipulation of materials at the nanoscale, typically less than 100 nm in size. Nanoparticles (NPs) can be synthesized using two fundamental approaches: the top-down method, where bulk materials are broken down into nanosized particles, and the bottom-up method, where nanoparticles are assembled from atomic or molecular units. Nanomaterials exhibit superior properties compared to their bulk counterparts, making them highly valuable for various applications due to their distinct physical and chemical characteristics. Additionally, their unique optical, electrochemical, and electronic properties have been widely reported.

Traditional physicochemical methods used for nanoparticle synthesis often present challenges such as short-term stability and safety concerns. To overcome these limitations, biological synthesis methods using microorganisms have been explored. Various organisms are capable of producing either intracellular or extracellular inorganic nanoparticles, offering an eco-friendly and sustainable alternative to chemical synthesis. For instance, certain bacteria are known to produce magnetite nanomaterials, while fungi have been found to play a significant role in nanoparticle biosynthesis due to their ability to secrete large quantities of enzymes that facilitate the process.

Advancements in nanotechnology require the development of innovative and efficient synthesis techniques that allow for precise control over nanoparticle size, shape, and composition. Green nanotechnology focuses on the use of biological systems, including bacteria, fungi, yeast, and plant extracts, to produce nanoparticles in an environmentally friendly manner. While conventional physical and chemical methods, such as mechanical milling, sodium borohydride reduction, solvo-thermal synthesis, and carbo-thermal methods, have been widely used for nano-iron synthesis, these approaches often lead to rapid nanoparticle agglomeration due to interparticle Van der Waals and magnetic forces. Additionally, nano-iron particles synthesized through these methods are prone to oxidation in the presence of environmental oxidants, which can limit their reactivity.

Biological synthesis offers an alternative approach to overcome these challenges. Various microorganisms, including *Pleurotus* species and *Sargassum muticum*, as well as plant extracts such as *Passiflora tripartite mollissima* fruit extract, have demonstrated the ability to synthesize nano-iron. The potential applications of nano-iron in environmental

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remediation have been widely studied, particularly in areas such as water purification, catalysis, filtration, and antimicrobial activity. Among the different metallic nanoparticles, nano-iron (FeNPs) has shown significant promise in addressing environmental pollution due to its adsorptive and catalytic properties.

This study aims to synthesize and characterize nano-iron particles using *Termitomyces spp.*, highlighting its potential as an efficient biological system for nanoparticle production.

II. MATERIALS AND METHODS

Culturing of *Termitomyces spp.*

The fungal strain *Termitomyces spp.* was obtained from Dr. Laxman Rathod , Botany Department, Faculty of Science, MPASC College panvel , and evaluated for its ability to synthesize nano-iron. The fungus was cultured on potato dextrose agar (PDA) medium, which consisted of potato extract (200 mL), glucose (20 g), and agar (20 g) in 1 L of distilled water. The culture was incubated at 25°C for five days to promote sufficient fungal growth. Pure fungal cultures were preserved at 4°C on PDA slants for future use.

Biosynthesis of Nano-Iron by *Termitomyces spp.*

To obtain fungal biomass, 3–5 fungal agar discs were inoculated into MGYP broth medium containing malt extract (3 g), glucose (10 g), yeast extract (3 g), and peptone (5 g) in 1 L of distilled water. The medium was sterilized in an autoclave at 121±1°C for 15 minutes. After incubation at 28°C with continuous shaking at 180 rpm, the fungal biomass was harvested by filtration and thoroughly washed with sterile distilled water three times to eliminate any residual media components.

For biosynthesis, 20 g of fresh fungal biomass was immersed in 100 mL of sterile deionized water and incubated under the same conditions (28°C, 180 rpm) for 24 hours. The cell-free aqueous extract was then collected by filtration through Whatman No. 1 filter paper. To this extract, 1 mM of carefully weighed $FeCl_3$ was added, and the mixture was incubated in the dark at 28°C with continuous shaking at 180 rpm to prevent photo-oxidation of iron ions. A control sample, containing only the fungal extract without iron ions, was prepared for comparison.

Characterization of Iron Nanoparticles (Fe-NPs)

i. UV-Visible Spectroscopy

The initial detection of nano-iron synthesis was assessed by observing a color change in the reaction mixture. The sample was analyzed using a UV-visible spectrophotometer (Unicam UV-VIS) to confirm nanoparticle formation based on its surface plasmon resonance (SPR).

ii. Transmission Electron Microscopy (TEM)

To determine the morphology and size distribution of synthesized iron nanoparticles, TEM analysis was conducted using a JEOL JEM-2100 microscope (U.S.A). Due to its high magnification capacity (up to 1.5 million times), TEM provided detailed structural insights. A colloidal solution of nanoparticles was drop-coated onto a carbon-coated grid (Type G 200, 3.05 µm diameter, TAAP, U.S.A) for imaging.

iii. Selected Area Diffraction Pattern (SADP) Analysis

Selected Area Diffraction Pattern (SADP) analysis was performed within the TEM setup to examine the crystalline nature of synthesized nanoparticles. A thin section (~100 nm) of the sample was exposed to a high-energy electron beam (100–400 keV), allowing the electrons to interact with the atomic structure of the material. The resulting diffraction pattern appeared as bright spots, confirming the crystallinity of the synthesized nano-iron. This method is highly suitable for characterizing nanoparticle structures at the atomic level.

III. RESULTS

Biosynthesis of Nano-Iron by *Termitomyces spp.*

The ability of *Termitomyces spp.* to synthesize iron nanoparticles was investigated. When cultured on PDA medium, the fungus exhibited a characteristic pinkish-white color on its aerial hyphae after seven days of incubation at 25°C.

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After three days of incubation in MGYP broth at 28°C and 180 rpm, the fungal biomass displayed a noticeable reddish pigmentation (Figure 1). Upon mixing the cell-free aqueous extract with $FeCl_3$, iron nanoparticle formation was visually indicated by a distinct color change from pink to brown. This transformation is attributed to the gradual reduction of iron ions to their zero-valent state, confirming successful nanoparticle synthesis (Figure 2).

IV. DISCUSSION

Nanoparticles are ultra-small materials typically ranging between 10 and 100 nm in size. Among the various synthesis techniques, biological approaches have gained significant attention due to their cost-effectiveness, non-toxic nature, and eco-friendly characteristics. These methods allow controlled nanoparticle synthesis while minimizing environmental impact.

In the present study, *Termitomyces spp.* successfully synthesized nano-iron through the reduction of aqueous $FeCl_3$ (1 mM) under dark conditions. The formation of nanoparticles was initially indicated by a visible color change to brown, which was further confirmed by UV-visible spectrophotometry, showing an absorbance peak at 226 nm. These findings are in agreement with previous studies, where iron oxide nanoparticles exhibited a peak at 222 nm, and iron nanoparticles synthesized by *Pleurotus* sp. showed peaks at 226 and 276 nm. Conversely, nano-iron synthesized using *Sargassum muticum* extract exhibited absorption peaks at 402 nm and 415 nm, suggesting that variations in peak wavelengths may be influenced by particle size and composition.

Transmission Electron Microscopy (TEM) analysis revealed that the synthesized nano-iron particles were primarily spherical, with a size range of 2.5–20 nm. Similar results were observed in previous research, where nano-iron synthesized using *Sargassum muticum* extract (which contains sulfated polysaccharides acting as a reducing agent) had an average size of 18±4 nm with a cubic morphology. Additionally, iron oxide nanoparticles produced using an aqueous extract of *Passiflora tripartita mollissima* fruit were reported to have a mean spherical particle size of 22.3±3 nm.

V. CONCLUSION

In summary, the findings of this study demonstrate that *Termitomyces spp.* is an effective biological agent for the synthesis of nano-iron particles, offering an environmentally sustainable alternative to conventional chemical methods.

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Study of Effect of Some Medicinal Plants on Seeds of *Vigna radiata* With Respect to Biomarker and Biomass Study

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Abstract: *Some medicinal plants were used by some people those who are suffering from various diseases. Despite their therapeutic advantages, some constituents of herbs are potentially toxic and pose health risks because they can be bought from the market without a prescription. Plants (Chlorophytum borivilianum, Curculigoor chioides and Mucuna prurnies), 2.5%, 1% and 0.5% extracted with water. The allelopathic potentials of the extracts were assessed using seed germination and by measuring plantlets length, chlorophyll content and biomarker were also tested. In present investigation of allelopathic evaluation, the aqueous extracts of tested plants were not cytotoxic. Aqueous extract shows prominent activity, 1% aqueous extract of Chlorophytum borivilianum, were shown to have the most inducing activities on Vigna radiate seeds on comparing with control.*

Keywords: Allelopathic, seed germination, chlorophyll, biomarker and Biomass

I. INTRODUCTION

Agriculture is the science and art of cultivating plants. Traditionally several agricultural as well as medicinal plants were domesticated in India. The secondary metabolites produced by plants showing various effects. There are some plants produce secondary metabolites which provides aphrodisiac effect. The aphrodisiac is defined as an agent (food or drug) that arouses sexual desire crude extract of plants Chauhan (et al. 2014)which have been useful in sexual disorders. It is also helpful in Spermatogenesis and Reproduction. The medicinal effect with Aphrodisiac activity of *Chlorophytum borivilinum* was used for physical illness and to increase general body immunity. Its aphrodisiac properties have proved very much useful for the people suffering from erectile dysfunction and to increase male potency.*Curculigoorchoides*also popularly used in treatment of menorrhagia, leucorrhoea, gonorrhea, dysuria and menstrual derangements, jaundice, asthma, piles etc. It is also considered as an effective anti-infective and healing agent. The *Mucuna prurnies* used as Antidepressant drug. It is useful to decrease Prolactin level, also reduce symptoms of Parkinson's Disease and used for treatment of male infertility.

The allelopathic effects of plant on seed germination was studied by Oudhia et al (1998). The aphrodisiac plants have ability to effects on seed germination. The Allelopathic effect of aphrodisiac plants on seed germination as well as changes in seedling plants were studied by *Blumealacera* L.on rice on agricultural crops (Ridenour and callaway 2001 and Cheema: Farooq S: Khaliq, 2012). The effects were assessed using biomarkers. Biomarkers have been defined by Hulka and colleagues as cellular, biochemical or molecular alternations that are measurable in biological media such as human tissues, cell or fluids. Acid phosphatase is example of biomarker. In current investigation we were select *Chlorophytum borivilinumCurculigoorchoides*and *Mucuna prurnies*as aphrodisiac plant and to check their allelopathic effect on seed germination of mung bean plant.

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II. MATERIALS AND METHODS

Collection of plant material

The amorphous powder form of root of selected species of medicinal plants *Chlorophytum borivilinum* ***(CB)***,*Curculigoorchoides****(CO)***and powder of shoot of *Mucuna prurnies* ***(MP)*** were collected in the form local herbal medicine market of Jalgaon district, Maharashtra, India.

Preparation of plant extract

Different plants material collected from local market were subjected to prepare aqueous extract. The collected sample of each plant material were mixed with Distilled water in different concentration (0.5, 1.0 & 2.5%). The aqueous suspensions of different concentrations were incubated for 5 hours at 70^{o} C. The extracts were filtered through filter paper and take a clear filtrate as aqueous extract.

Selection of appropriate concentration of plants for seedling growth

The effect of aqueous extract on model plants at different concentration were checked by using common Mug bean (*Vigna radiata)*. The seeds of *Vigna radiata* were procured from the local market of Jalgaon district (Maharashtra). Seeds were sterilized in a 0.1% Mercury chloride solution for 10 minutes (USEPA, 1996), rinsed through with deionized water several times. The seeds were sowed in pot tray. Each pot (14 cm diameter and 18cm in height) were filled with fertile loam soil up to ¾ the height of the pot. The different concentration of prepared aqueous extract was supplied to sowed seed of test plantlet for seven days. Control for each were conducted simultaneously using sterile distilled water instead of extract. All the experiment were conducted in triplicate to standardize the result. Seedling and Plant growth being conducted in controlled conditions of temperature (25±1^{o}C) illumination (dark/light cycle: 14/10 h.) and 80% humidity into a green-house. Observe the growth at 0, 1, 3, and 5th day after 7 day of growth, the shoot and root lengths were long enough to measure using a ruler. Fresh and dry weights were also measured.

Estimation of Chlorophyll

Chlorophyll A, chlorophyll B and total chlorophyll of all aqueous extract treated plants along with the control plant were tested by the method of Stir ban (1985)

Protein Estimation at different aqueous concentrations

Protein content of all aqueous extract treated plants along with the control plant was measured according to Lowery (et al. 1951).

Acid phosphatase activity

Acid phosphatase activity of aqueous extract of ripe and unripe banana peel treated germinated seeds of *Vigna radiata* was determined according to, (Hussain, 2016), by using the standard para-nitro phenol.

III. RESULTS AND DISCUSSION

Collection of plant material and extract preparation

The plants part powder collected and its aqueous extract were prepared according to method described in material and methods of different concentrations

Effect of aqueous extract (0.5, 1.0 & 2.5%) of three medicinal plants on growth of aerial and underground tissues of *Vigna raidata*

The effect of aqueous extract on shoot and root length of mung bean is shown in Fig 1. It was observed that as the concentration of aqueous extract decreases, the shoot and root length was increased. At 2.5% and 1% concentrations the shoot length highest in CB and CO and lowest in MP and root length was found to be highest in CB and MP and lowest in CO. The mung bean shows the best growth response for shoot and root length and it was observed at concentrations of 0.5% of aqueous extract over control. At this lowest concentration, highest growth of shoot length observed in CB and CO, retardation in root and shoot length for mung bean plant treated with MP respectively.

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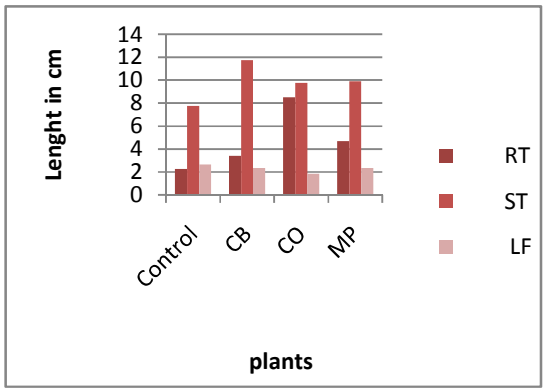


Fig. 1 (a)

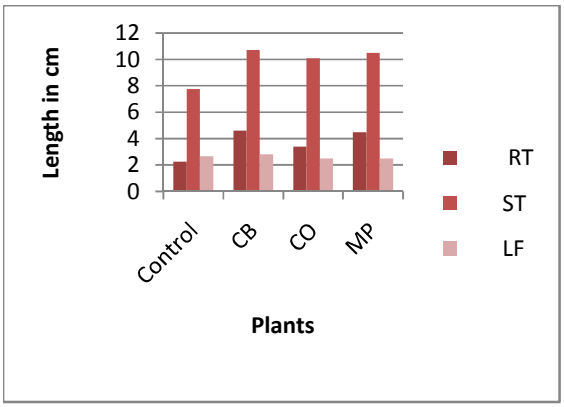


Fig. 1(b)

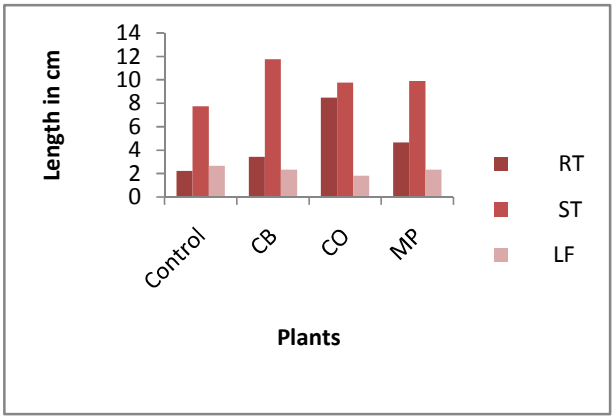


Fig.1(c) Fig. 1 (a,b,c): Effect of aqueous extract of three aphrodisiac plants atdifferent concentration (a)0.5%,(b) 1%,(c)2.5%

Estimation of Total dry Weight .

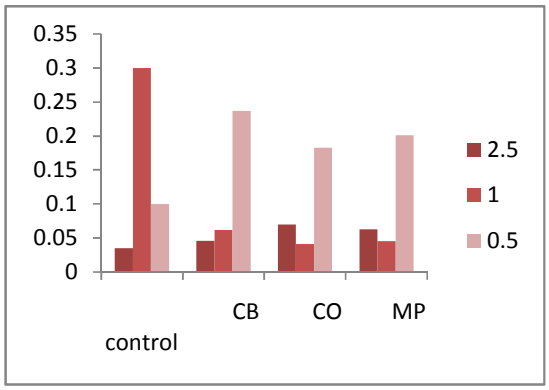


Fig 2 (a) 0.5%

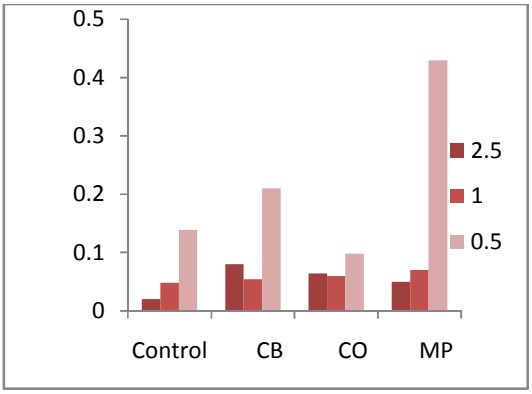


Fig 2(b) 1%

Fig 2 (a,b): Total dry weight of plantlet *Vigna radiata* treated with aqueous of three aphrodisiac plants.

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Estimation of Chlorophyll content

Concentrations%	Group	Total chlorophyll (mg/gm)	Chlorophyll A (mg/gm)	ChlorophyllB (mg/gm)
0.5	Control	0.05082	0.0049	0.0031
	CB	0.01690	0.0071	0.0049
	CO	0.01632	0.0070	0.0091
	MP	0.0160	0.0073	0.0085
1.0	Control	0.05082	0.0049	0.0031
	CB	0.01193	0.0077	0.0040
	CO	0.0125	0.0076	0.0046
	MP	0.0133	0.0076	0.0056
2.5	Control	0.05082	0.0049	0.0031
	CB	0.01819	0.0096	0.0083
	CO	0.0152	0.0089	0.0062
	MP	0.01835	0.0095	0.0086

Chlorophyll content measure in mg/gm

Table 1- Chlorophyll content of *Vigna radiata* treated with aqueous extract of different concentration of some aphrodisiac plants.

Protein content in leaves of mung bean under different treatment

The protein content of treated plant leaves of mung bean is given in Fig 3.The highest protein content was found in CB and CO and lowest in MP plant.

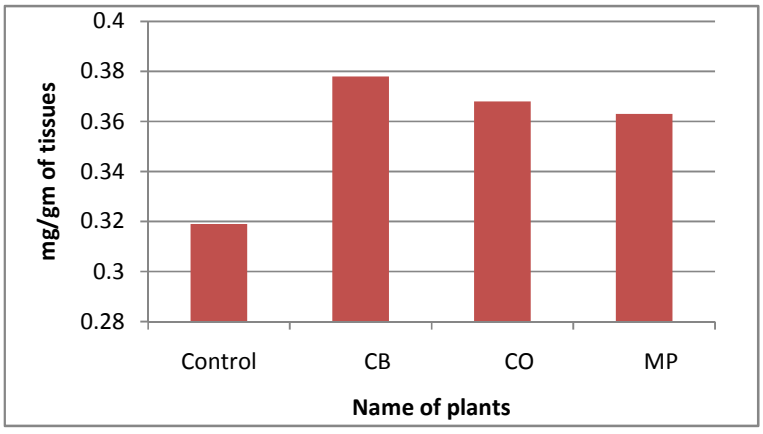


Fig 3-Total protein content of leaves plantlet of *Vigna radiata* treated with aqueous extract of Aphrodisiac plants.

(Biomarker) Acid phosphatase activity

Comparative account on (Biomarker)Acid phosphatase activity in germinated *Vigna radiata* seeds on seven day after treatment with three plants aqueous extract

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Sr. no	Parameter	total activity (µM/ml)	Enzyme activity(µM/ml/min)	Specific activity (µM/ml/min/mg)
1	Control	4.72	11.8	36.99
2	CB	9.85	24.6	65.07
3	CO	4.40	11	29.89
4	MP	4.15	10.3	28.37

Table 2: Acid phosphatase activity in germinated *Vigna radiata* seeds on seven day after treatment with three plants aqueous extract

In table 2, it was observed that specific activity of acid phosphatase was highest in CB as 65.07µM/ml/min/mg, moderate specific activity was observed in CO as 29.89µM/ml/min/mg, while lowest specific activity was observed in MP as 28.37µM/ml/min/mg.

IV. DISCUSSION

In current investigation, on the basis of literature survey, we were selected some aphrodisiac plants to check their stimulation or inhibitory effect on germinating seeds of (*Vigna radiata*) as a model Srinive (2007). The underground part of *chlorophytum borivilinum*, *Curculigoorchiods* (Hypoxidaceae) and seed of *Mucuna prurnies* (Fabaceae) are taken for present investigation. We found that percentage of germination is highest in tested plant treated with (CB, CO,MP) as 100% followed by CB 90%, MP as 80% respectively while in CO less growth was observed. Dry weights were found to be more with shoot & root lengths for Corresponding different concentrations treatment. As the Concentration of extract increases the biomass in the form of dry weight increases, mung bean showed increase in dry weight of root as well as shoot over. Control study reveals at lower concentration of extract less biomass from (root& shoot) over untreated plant similar observations given by various authors, Ishii; Yoshikawa, Minakata, Komura & Kada (1984) & Bhattacharjee (2008). It is interesting to note that not a single reference occurred in literature indicating Allelopathic effect of aphrodisiac plants in seed germinating and growth however in other plants change in germination however, Allelopathic effect in mung is reported by using *Blumealacera*L.on rice on agricultural crops (Ridenour and callaway 2001 and Cheema: Farooq S: Khaliq, 2012). Chlorophyll is one of the major chloroplast components for photosynthesis Rahdari (et al.2012). The decrease in chlorophyll content under drought stress has been considered a typical symptom of pigment photo oxidation and chlorophyll degradation Anjum (et al. 2011). The effect of aqueous extract on chlorophyll content (chlorophyll a, chlorophyll b, total chlorophyll and carotenoids) of mung bean (*Vigna radiata*) shows that are highest total chlorophyll in 0.5% and 2.5% concentrations of extract evidenced in CB. Also highest protein content was noticeable as increases in CB 18% lowest in MP 13% and moderate protein in CO 16%. But Amira (2001) studied effect of salt stress on plant growth and metabolism of bean plant Vicia faba. Biomarker is used to check out the provided treatment is beneficial or harmful to the plants acid phosphatase biomarker are used in this Vigna radiata. The highest concentration of acid phosphatase observed in CB plants. CO is less than MP plants. We found the aqueous extract of three aphrodisiac plant at 0.5% and 1% concentration by standard deviation showed statistically significant stimulation on shoot and root elongation of the tested plant CB,CO and MP (mung bean).

V. CONCLUSION

On the basis of our results, it was found that all the suitable plants such as CB, CO, MP. The result indicates that positive response in growth of CB. The length of shoot of seedling is more than control evidence chlorophytum is best. Among three more induction of synthesis of acid phosphatase during the treatment of CB, more positive response was obtained concomitantly in addition to morphological study. We observed positive biochemical changes during the treatment of germinated seed. Biochemical parameters like protein & chlorophyll also increased than control seedling. The response is best in CB, moderate in CO & good is MP.

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Eco-Friendly Synthesis of Benzimidazole Derivatives: Advances in Green Chemistry and Applications

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Abstract: *The increasing presence of chemical substances in our environment poses a significant challenge, as many of these compounds are non-degradable and contribute to pollution. These persistent pollutants disrupt the ecosystem, leading to environmental instability and potential health risks. To address this issue at its source rather than merely mitigating its effects, the concept of Green Chemistry (GC) was introduced. GC focuses on designing chemical products and processes that minimize or eliminate the use and generation of hazardous substances. In recent years, heterocyclic compounds have gained prominence due to their diverse pharmacological properties. Among them, benzimidazole, an aromatic heterocyclic compound, holds great significance in medicinal chemistry. It exhibits a wide range of therapeutic activities, including analgesic, anti-inflammatory, antiulcer, antihypertensive, antibacterial, antiviral, antifungal, anticancer, and antihistaminic properties. Given its medicinal importance, the synthesis of benzimidazole derivatives has become a key area of research for synthetic chemists. Traditional methods for synthesizing benzimidazoles often require prolonged heating, intricate apparatus setups, and costly procedures that contribute to environmental pollution. In contrast, green synthetic approaches offer eco-friendly alternatives that are cost-effective, energy-efficient, and sustainable. This review highlights various green methodologies for synthesizing substituted benzimidazoles, emphasizing their advantages over conventional techniques in terms of efficiency, simplicity, and environmental safety.*

Keywords: benzimidazole

I. INTRODUCTION

Green Chemistry (GC) is a transformative approach to chemical research and industrial processes, emphasizing the development and application of environmentally friendly methods. It focuses on designing chemical products and processes that minimize or eliminate the use and generation of hazardous substances, thereby reducing environmental impact and promoting sustainability. The foundation of Green Chemistry lies in thoughtful design, considering not only the final product but also the manufacturing processes and their potential effects on human health and the environment. Key factors such as the selection of raw materials, reaction efficiency, and waste prevention play a crucial role in ensuring a safer and more sustainable chemical industry. Since the early 1990s, Green Chemistry has gained global recognition, leading to the establishment of guidelines and research priorities aimed at reducing environmental hazards associated with traditional chemical practices. Various international initiatives have been undertaken to integrate these principles into industrial applications, emphasizing both economic feasibility and long-term sustainability. The development of Green Chemistry continues to shape the future of chemical research, driving innovation toward safer, cleaner, and more efficient chemical processes.

Focused Areas Under Green Chemistry Principles

Utilization of Alternative Feedstocks

Significant advancements have been made in the field of Green Chemistry, with a strong emphasis on replacing conventional raw materials with sustainable alternatives. The transition from fossil fuel-based feedstocks to renewable resources is crucial for ensuring long-term environmental and economic sustainability. The chemical industry must

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prioritize the use of raw materials that are not only renewable but also safer for both workers and the environment. By adopting bio-based and less hazardous feedstocks, industries can reduce their ecological footprint while promoting safer and more efficient chemical processes.

Use of Less Hazardous Reagents

Extensive data are available on the toxicological and environmental impacts of many chemicals widely used in industrial processes. To enhance safety and sustainability, chemists should prioritize the use of less hazardous raw materials and reagents in chemical synthesis. When faced with challenges in achieving this, alternative strategies such as reducing the number of harmful compounds or modifying reaction conditions should be considered. The adoption of catalysts and innovative synthetic techniques can further minimize risks while improving efficiency.

Integration of Natural Processes: Biocatalytic Techniques

Advancements in biosynthetic methods over the past decade have led to the development of highly selective, energy-efficient, and environmentally friendly processes. These biocatalytic techniques operate under mild conditions, such as lower temperatures and reduced energy consumption, while delivering high yields and minimizing toxicity. Green Chemistry research has played a key role in replacing traditional methods with novel catalytic approaches that generate fewer waste products, contributing to a more sustainable chemical industry.

Use of Alternative Solvents

For decades, polychlorinated and aromatic solvents have been widely used in synthetic organic chemistry, particularly for extractions. However, due to their harmful effects, solvents such as carbon tetrachloride (CCl_4) have been banned, while others face strict regulations. In response, chemists have shifted toward using low-toxicity solvents that can be recycled or decomposed at high temperatures, reducing environmental and health hazards. The chemical industry, guided by Green Chemistry (GC) principles, continues to invest in developing safer solvents that pose minimal risks to workers and can degrade more easily under natural conditions.

Designing Safer Chemicals and Products

Advancements in analytical methods and toxicological testing have significantly improved the understanding of chemical toxicity and its underlying mechanisms. The use of **Quantitative Structure-Activity Relationships (QSAR)** allows for faster assessments of toxicity, carcinogenicity, and other hazardous effects of newly synthesized compounds. By integrating GC principles, modern chemical products are designed to be less toxic and more environmentally friendly. Industrial chemists have refined synthetic processes to incorporate renewable raw materials, operate at lower temperatures, conserve energy, reduce waste, and utilize safer alternative solvents, ultimately promoting a more sustainable approach to chemical manufacturing.

Developing Alternative Reaction Conditions

Innovative and environmentally friendly reaction techniques have been developed to enhance product formation, conserve energy, and minimize waste. Green Chemistry promotes the adoption of alternative methods such as photochemical reactions, microwave (MW)-assisted synthesis, and other sustainable techniques. These approaches not only improve reaction efficiency but also reduce the environmental footprint associated with conventional chemical processes.

Minimizing Energy Consumption

Reducing energy consumption is a key objective in Green Chemistry, particularly in light of climate change and increasing environmental concerns. The chemical industry has made significant efforts to optimize synthetic processes by lowering reaction temperatures, reducing the number of reaction steps, and improving overall efficiency. Green Chemistry research is continuously focused on minimizing energy use at every stage of manufacturing, ensuring more sustainable industrial processes with lower waste generation and reduced environmental impact.

In 1990, Paul Anastas and John Warner defined Green Chemistry as *"The design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances."* As human society faces critical environmental challenges—including ozone depletion, air pollution, climate change, soil and water contamination, acid rain, and hazardous waste accumulation—Green Chemistry provides a sustainable approach to addressing these issues.

Anastas and Warner introduced **the Twelve Principles of Green Chemistry**, which serve as the foundation for environmentally responsible chemical practices. These principles were first published in their book *Green Chemistry:*

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Theory and Practice in 1998. Their contributions continue to shape the field, and both have served on the California Green Chemistry Science Advisory Panel, advocating for the integration of sustainable practices in the chemical industry.

The 12 Principles of Green Chemistry

- **Waste Prevention:** Focus on preventing waste generation rather than treating or disposing of it after production.
- **Maximizing Atom Economy:** Ensure that all materials used in the manufacturing process are incorporated into the final product, minimizing waste.
- **Safer Synthesis Methods:** Use synthetic techniques that produce minimal or no toxic substances, ensuring safety for both humans and the environment.
- **Designing Safer Chemicals:** Develop chemical products with reduced toxicity while maintaining their desired functionality.
- **Reducing Solvents and Auxiliary Substances:** Minimize or eliminate the use of solvents and additional substances whenever possible.
- **Energy Efficiency:** Optimize processes to operate at ambient temperature and pressure, reducing energy consumption and environmental impact.
- **Utilizing Renewable Feedstocks:** Prioritize the use of renewable raw materials over depletable resources.
- **Recycling Chemical Intermediates:** Reuse intermediates and blocking agents to minimize waste generation.
- **Catalysis Over Stoichiometric Reagents:** Employ catalysts that facilitate multiple reaction cycles rather than inefficient reagents.
- **Design for Degradation:** Ensure that chemical products break down into harmless substances in the environment after use.
- **Real-Time Pollution Prevention:** Develop and implement analytical techniques for continuous monitoring and control of hazardous substances.
- **Enhancing Chemical Safety:** Choose chemicals with minimal risks of accidents, explosions, and fires to ensure workplace and environmental safety.

Benzimidazole Derivatives

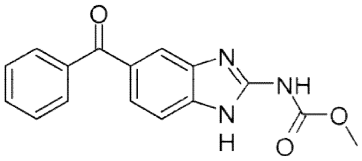
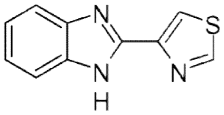
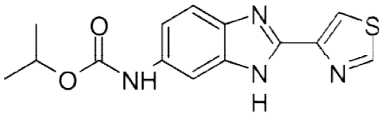
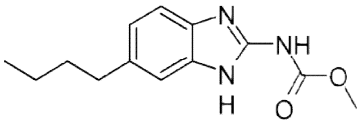
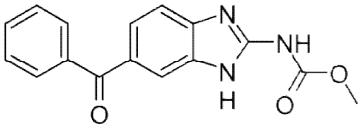
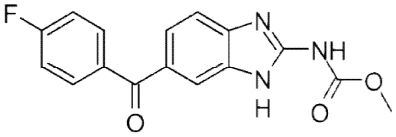
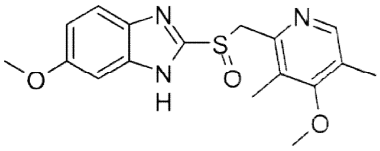
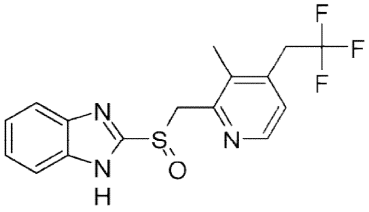
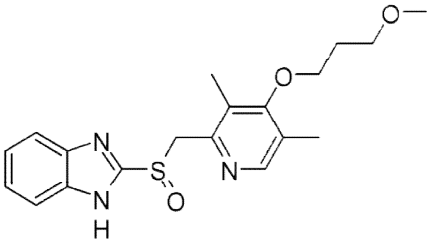
In recent years, there has been significant interest in the synthesis of heterocyclic compounds containing nitrogen (N), oxygen (O), and sulfur (S) due to their broad range of pharmacological activities. Researchers have explored various environmentally friendly synthetic approaches, including solvent-free reactions, immobilization of reactants on solid supports, microwave (MW) irradiation, the use of green catalysts, and eco-friendly solvents.Benzimidazole, a bicyclic heteroaromatic compound, holds a crucial place in medicinal chemistry as a **pharmacophore** and a **privileged structure** for drug development. Structurally, benzimidazole consists of a fused benzene (1) and imidazole (2) ring system, forming the benzimidazole core (3) (Scheme 1). Due to its versatile biological activities, the synthesis and functionalization of benzimidazole derivatives continue to be an area of active research in pharmaceutical and green chemistry.

Importance of Benzimidazole Ring System:

A wide range of Benzimidazole and their derivatives find uses in pharmaceutical and veterinary drugs showing therapeutic activities. Some of the commercially important Benzimidazole derivatives are listed below.

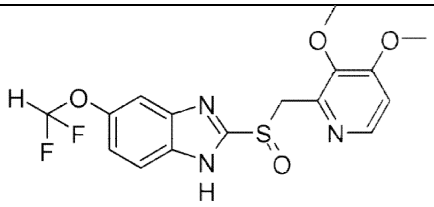
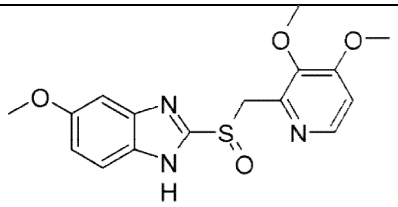
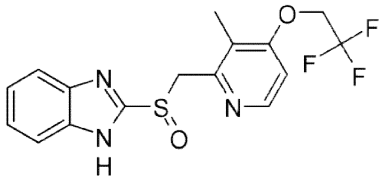
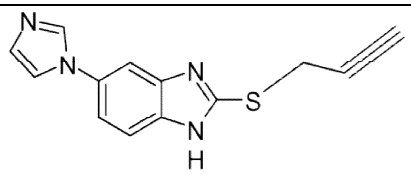
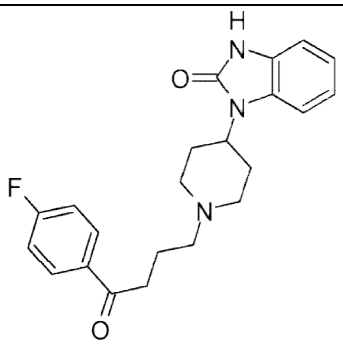
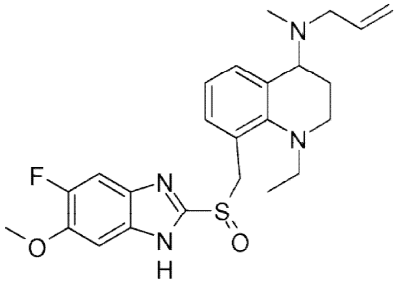
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Table 1.

Sr. No	Trade Name	Structure	Activity
1	Mebendazole		Anthelmintic
2	Thiabendazole		Anthelmintic
3	Cambendazole		Anthelmintic
4	Parbendazole		Anthelmintic
5	Albendazole		Anthelmintic
6.	Flubenzadzole		Anthelmintic
7	Omeprazole		Anti-ulcer drugs
8	Lansaprazole		Anti-ulcer drugs
9	Rabeprazole		Anti-ulcer drugs

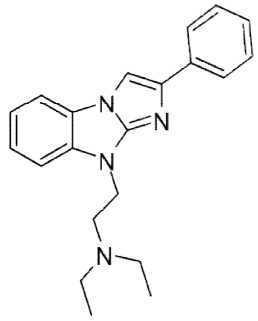
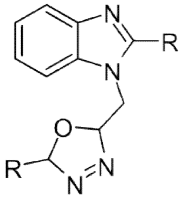
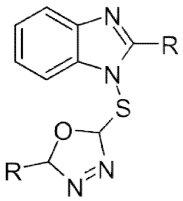
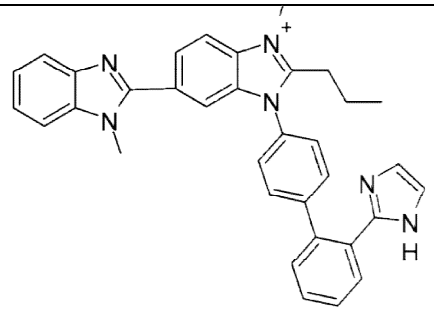
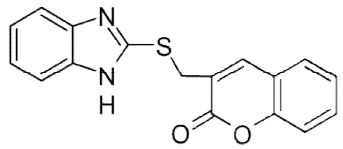
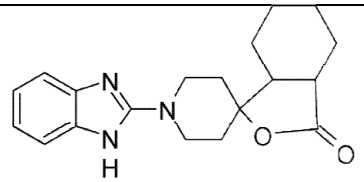
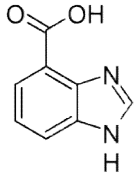
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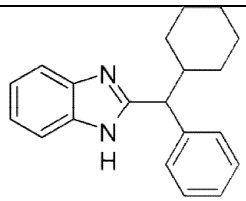
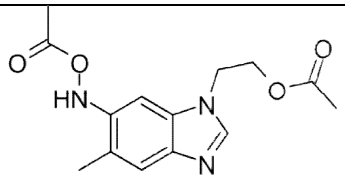
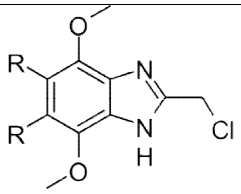
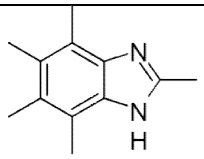
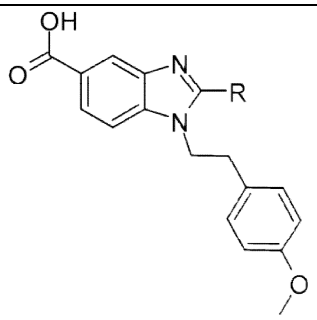
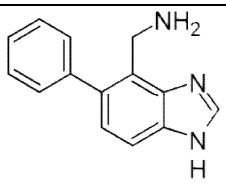
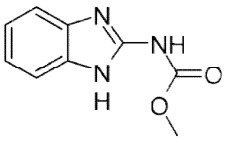
10	Pantoprazole		Anti-ulcer drugs
11	Esomeprazole		Anti-ulcer drugs
12	Triethoxy-pyridylBenzimidazole derivative		Anti-ulcer drugs
13	Thiophene derivatives of Benzimidazole		Anti-ulcer drugs
14	Droperidol		Anti-psychotic agents
15	Quinoline Benzimidazole Analog		Anti-psychotic agents

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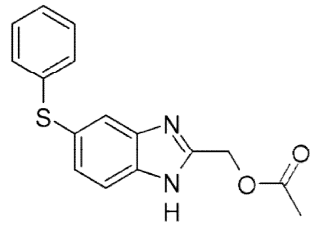
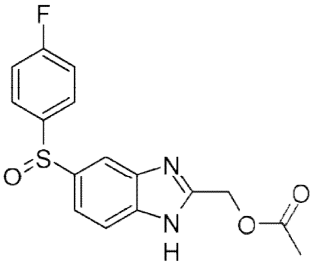
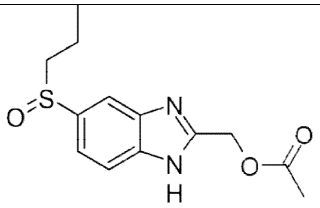
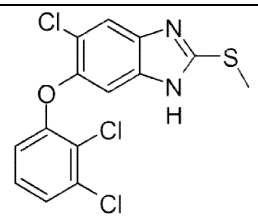
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16	Imidazole derivative with Benzimidazole		Anti-psychotic agents
17	Oxazole derivative with Benzimidazole		Antimicrobial activity
18	Oxazole derivative with Benzimidazole and thio-linkage		Antimicrobial activity
19	Bibenzoimidazole derivatives		Antagonist
20	Benzimidazole and coumarine derivative		Antiseptic virus c activity
21	Spiro compound of Benzimidazole		NPY N5 Receptor Antagonist
22	4-Carboxylic acid Benzimidazole		Selective 5 HT 4 Antagonist

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23	Phenyl cylcohexyl derivative of Benzimidazole		Amp Activated protein kinase activator
24	Amide derivative of Benzimidazole		Anticancer activity
25	Substituted Benzimidazole		Anticancer activity
26	Alkyl substituted Benzimidazole		Antiamoebic activity
27	Benzyl substituted carboxyl Benzimidazole		Antilukamic activity
28	Phenyl amine derivative of Benzimidazole		Antidiabetic activity
29	Amide derivative of Benzimidazole		Cyticidal activity

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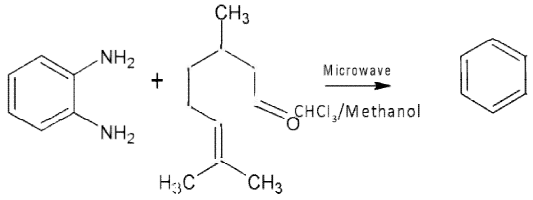
30	Thioether derivatives of Benzimidazole		Nematicide and taenicid
31	**Oxfendazole**		Roundworms and tapeworms
32	**Ricobendazole**		Anthelmintic
33	Triclabendazole		anthelmintic

Despite the high efficiency of benzimidazole synthesis, many existing methods have limitations, including the need for elevated reaction temperatures, prolonged reaction times, toxic solvents, and expensive catalysts [17]. Therefore, the development of a **simple, mild, cost-effective, and environmentally friendly** approach for benzimidazole synthesis remains a key focus in research.Since the first reported applications of microwaves in synthetic chemistry in 1986, **microwave-assisted synthesis** has gained immense popularity, especially over the past two decades. This technique offers **significantly shorter reaction times, high product yields, and superior purity**, making it an attractive alternative to conventional methods. Numerous microwave-assisted strategies for benzimidazole synthesis have been developed to date.In this review, we explore various microwave-assisted methodologies for the efficient synthesis of benzimidazole derivatives, highlighting their advantages over traditional approaches.

1] **Dwi Sapri Ramadhan *et al***

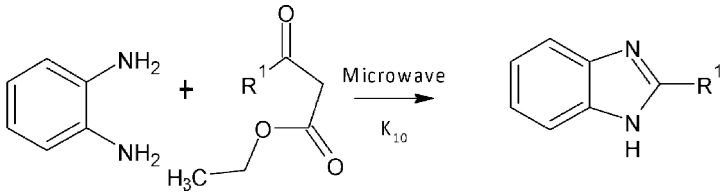
The synthesis of benzimidazole derivatives can be efficiently achieved using microwave irradiation, utilizing citronellal extracted from *Citrus hystrix* DC leaves as a key reactant. This reaction is carried out in water, along with o-phenylenediamine (OPDA) and an aromatic aldehyde. The process has been explored using methanol and dichloromethane as solvents, with reaction times varying at 30, 40, 50, 60, and 70 minutes. The molar ratio of citronellal to 1,2-phenylenediamine is maintained at 1:1, ensuring an optimal reaction environment for the formation of benzimidazole derivatives.

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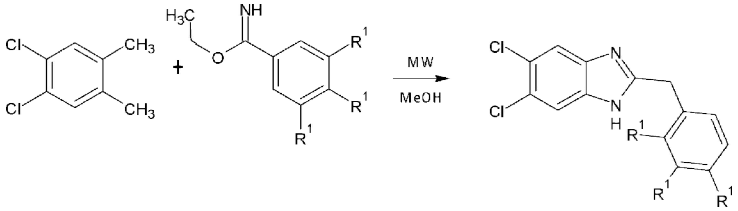
2] Bougrin Kand *et al*

Microwave-assisted synthesis of benzimidazole derivatives involves the reaction of 1,2-diaminobenzene or 4-substituted-1,2-diaminobenzene with ethyl acetoacetate or ethyl benzoylacetate in a solvent-free environment. The reaction is carried out on solid mineral supports or other suitable supports under microwave irradiation using domestic microwave ovens. This method offers a rapid, efficient, and eco-friendly approach for the synthesis of benzimidazole derivatives, minimizing reaction time and reducing the need for harmful solvents [19].



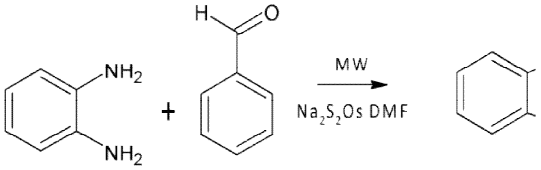
Emre Mentese *et al*

A straightforward and efficient protocol has been developed for the synthesis of benzimidazoles, achieving high yields within a remarkably short reaction time [20]. This method involves the reaction of iminoester hydrochlorides of phenylacetic acid with 4,5-dichloro-1,2-phenylenediamine or its derivatives under microwave irradiation, providing a rapid and effective approach to benzimidazole synthesis.



D. Secci *et al*

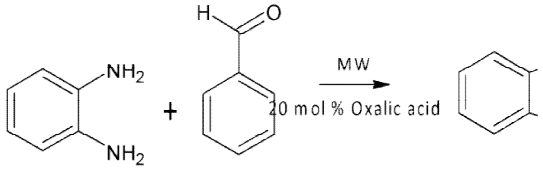
The synthesis of 1,2-diaryl-benzimidazole and 2-aryl-1H-benzimidazole derivatives has been successfully carried out using both microwave irradiation and conventional heating methods. However, microwave-assisted synthesis consistently resulted in higher yields and significantly reduced reaction times compared to traditional heating techniques [21].



Jyoti Pandey *et al*

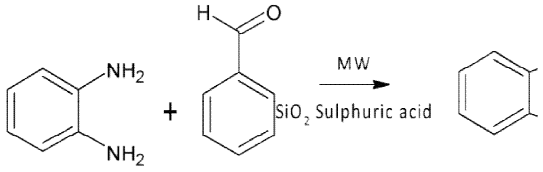
A simple and efficient one-pot microwave-assisted synthesis of benzimidazoles has been developed using 1,2-phenylenediamine and aromatic aldehydes, with oxalic acid as a catalyst. This method offers several advantages, including the use of an inexpensive and readily available catalyst, shorter reaction times, higher product yields, and easy isolation of the final compounds [22].

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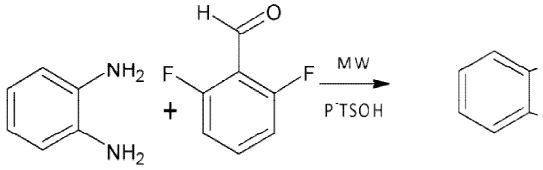
B. Guruswamy *et al*

In this method, o-phenylenediamine and an aromatic aldehyde were placed on H_2SO_4-SiO_2 and transferred into a microwave vial. The vial was then sealed and subjected to microwave irradiation at 80°C for 5 minutes. Upon completion of the reaction, the product was extracted and purified using column chromatography, yielding the desired benzimidazole derivative efficiently [23].



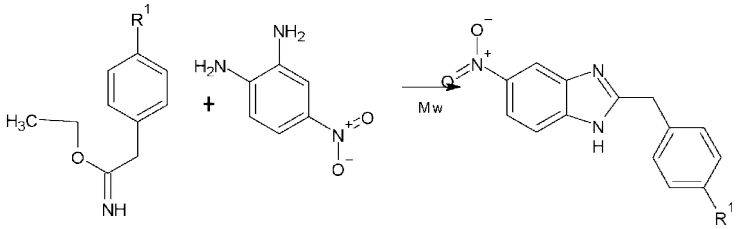
Angela Rao *et al*

Angela Rao et al. reported a reaction between substituted aromatic aldehydes and o-phenylenediamine, resulting in the efficient synthesis of benzimidazoles. This method is notable for its high yields and significantly reduced reaction time [24].



FatihYılmaz *et al*

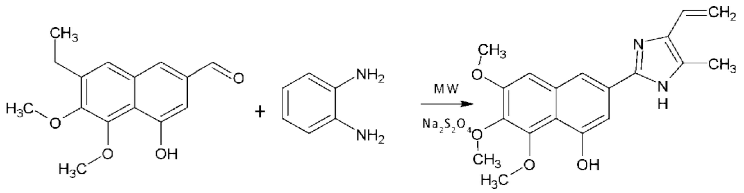
The synthesis of 5-nitro-substituted benzimidazole and 6-nitro-substituted benzimidazole derivatives was achieved using iminoester hydrochloride and 4-nitro-o-phenylenediamine under microwave irradiation. This approach resulted in high yields within a remarkably short reaction time [25].



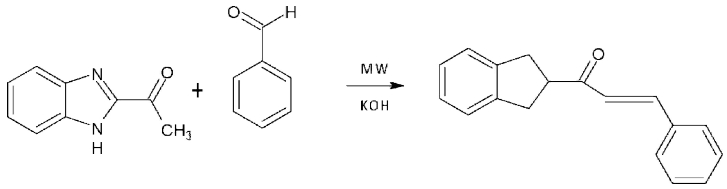
Hue Thi Buu Bui *et al*

Novel 2-quinolizinyl benzimidazole and 2-naphthalyl benzimidazole derivatives, featuring various 5- and 6-positioned substituents, have been synthesized through the condensation of 4-oxo-4H-quinolizinecarbaldehyde or naphthalenecarbaldehyde with substituted o-phenylenediamine. This method operates at a lower temperature than conventional approaches and achieves moderate to excellent yields in a significantly shorter reaction time [26].

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This method involves the reaction of 2-acetyl benzimidazoles with substituted aldehydes in methanol, using a base catalyst under microwave irradiation. The process is highly efficient, yielding high product output within a short reaction time [27].



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Mutagenic Impact of Sodium Azide on Growth and Development in Spinach (Spinacia oleracea L.)

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Abstract: *Spinacia oleracea L. (spinach) is a nutritionally rich leafy vegetable with significant medicinal and agricultural value. This study examines the mutagenic effects of sodium azide (NaN□) on spinach growth and development by assessing seed germination rates, shoot and root growth. Seeds were treated with varying concentrations of NaN□ (0.001%–0.005%) and observed over 8, 16, and 24 hours. Results revealed a dose-dependent decline in germination, decreasing from 94% (control) to 9% at 0.005% NaN□ after 24 hours. Similarly, shoot and root lengths were significantly reduced, with shoot length declining from 7.2 cm (control) to 1.4 cm, and root length from 1.5 cm to 0.4 cm at the highest concentration. While some phytochemical variations were observed, NaN□ primarily exhibited inhibitory effects on growth. These findings suggest that while controlled doses of NaN□ may induce genetic variability beneficial for crop improvement, careful application is necessary to mitigate its adverse effect.*

Keywords: Spinacia oleracea L., sodium azide (NaN□), mutagenic effects, seed germination

I. INTRODUCTION

Spinach (*Spinacia oleracea* L.) is an annual, leafy vegetable belonging to the family Chenopodiaceae for its high nutritional value, rich in vitamins, minerals, and antioxidants. It plays a crucial role in human health and is a staple in many diets worldwide, spinach holds significant medicinal value in various traditional systems, including Ayurveda, Unani, and Siddha. It has been utilized for its cooling, laxative, and anti-inflammatory properties, as well as its role in treating ailments such as urinary disorders, respiratory issues, and skin conditions. (Khare, 2007). However, environmental factors, genetic modifications, and exposure to mutagens can significantly influence its growth and development.

Mutagens are physical or chemical agents that cause genetic mutations, leading to alterations in plant growth, morphology, and overall productivity. Understanding the impact of mutagens on spinach is essential, as it helps in evaluating genetic stability, potential improvements in crop yield, and resistance to environmental stressors. Among chemical mutagens, sodium azide (NaN_3) has gained importance due to its ability to induce point mutations, potentially leading to improved agronomic traits. Sodium azide interacts with plant DNA, causing A-T to G-C transitions, which can result in modified protein functions, leading to increased stress tolerance, enhanced growth, and improved yield.

Spinach (*Spinacia oleracea*) is a highly nutritious leafy vegetable with significant medicinal and agricultural value. Research has highlighted its antimicrobial peptides (Segura et al., 1998), flavonoid composition and storage stability (Sara et al., 2005), and the development of low-oxalate mutants (Murakami et al., 2009). Its pharmacological properties include antioxidant, anti-inflammatory, and hepatoprotective effects (Otari et al., 2010; KO et al., 2014). Studies on bacterial colonization of spinach have provided insights into its microbiome (Gabriela et al., 2013).

Phytochemical investigations have confirmed the presence of flavonoids, phytosterols, and other bioactive compounds contributing to its therapeutic potential (Chaudhari et al., 2015; Gutierrez et al., 2019). Genetic and breeding studies have traced its ancestry to *S. turkestanica* and explored its resistance to diseases such as downy mildew (Ribera et al., 2021; Gehendra&Ainong, 2021). Spinach extracts have shown potential in stress adaptation and dietary supplementation (DO et al., 2020). Agronomic studies reveal that organic manure improves spinach growth and yield (Parwada et al., 2020), and its use as green manure enhances soil fertility and crop productivity (Kim et al., 2023).

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Additionally, species authentication techniques using HPTLC and HPLC-PDA methods have differentiated *S. oleracea* from other spinach varieties (Kureshi et al., 2023).

Overall, spinach is a highly valuable crop with applications in nutrition, medicine, and sustainable agriculture. This study aims to evaluate the mutagenic effects of sodium azide on the growth and development of *Spinacia oleracea* L. By analysing parameters such as seed germination rate, root and shoot length, and phytochemical content, this research seeks to determine how mutagenic exposure influences *spinach* growth. The findings could have significant implications for plant breeding, agricultural productivity, and food security.



Photo plate 1: Plant of *Spinacea oleracea*

II. MATERIAL AND METHODS

The current study is designed for the mutagenic effects on seeds of selected plant species (*Spinacia oleracea* L.) which will be as per the following steps and methods. Chemical mutagenic methods were preferred with Sodium azide (NaN3) for current research work in combination of various modified treatments methods given by Gabriela et al. (2013), Chaudhari et al (2015), Raughani and Miri (2019), Ribera *et al* (2021), Kim et al (2023).Different concentration of mutagen aqueous to mutagenic can be used in effect are as follows.Control, 0.001%, 0.002%, 0.003%, 0.004% and 0.005%**.** After treatment of specific mutagen seeds were grown in garden soil for further observational parameters.

III. RESULT AND DISCUSSION

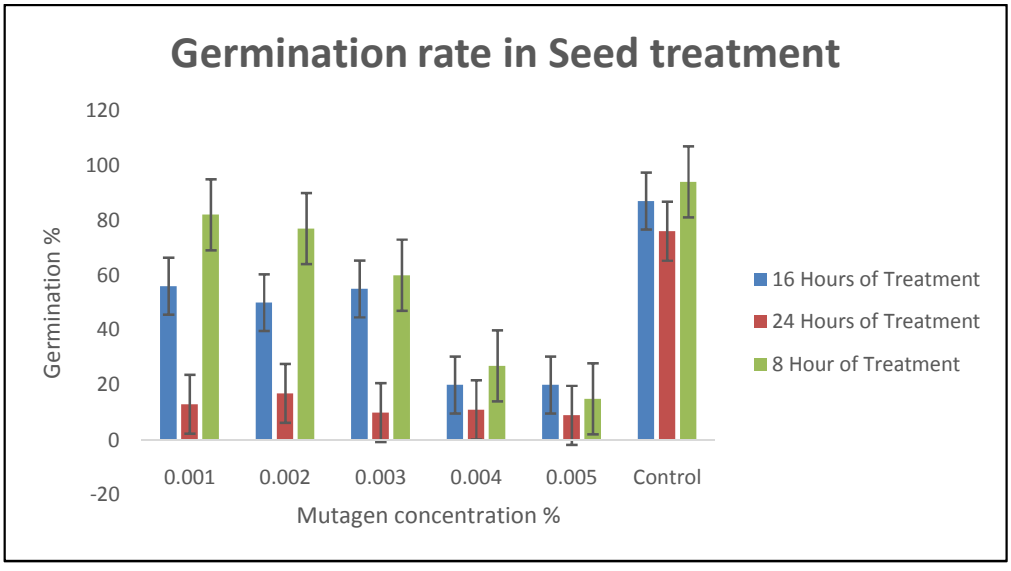
Seed germination:

Based on programmed methodology result will be recorded in graphical representation for mutagenic effect on seed treatment of *Spinacia oleracea L.*

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Photo plate 2: Seed germination of *S. oleracea*



Graph 1: Germination rate of seed of *Spinacia oleracea* treated with mutagen

Observations on the seed treatment of *Spinacia oleracea* L. with varying mutagenic concentrations reveal a clear trend of decreasing germination rates as the concentration increases. A control group, maintained under standard conditions without any mutagen treatment, served as a baseline for comparison. At 8 hours of treatment, the control group exhibited a germination rate of 94%. However, increasing the mutagenic concentration resulted in a progressive decline

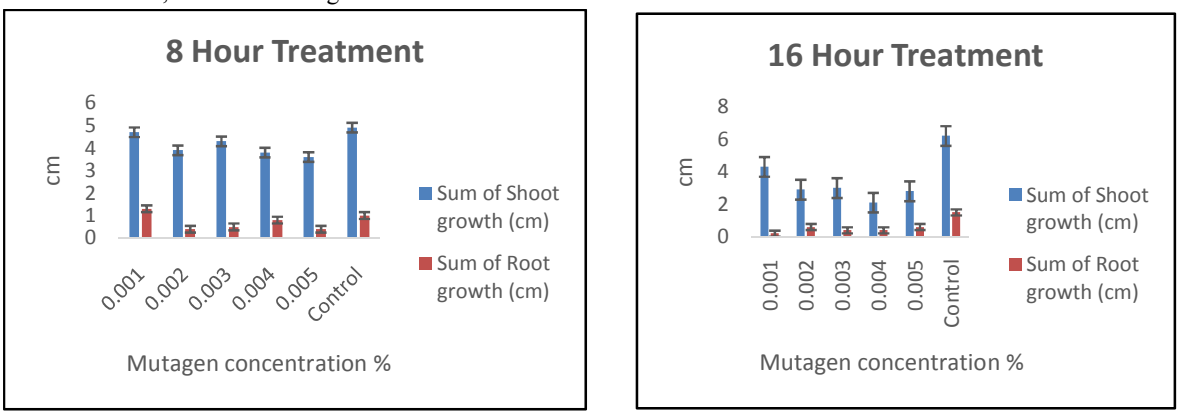
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in germination rates, with 0.001% concentration reducing it to 82%, 0.002% to 77%, 0.003% to 60%, 0.004% to 27%, and 0.005% to just 15%.

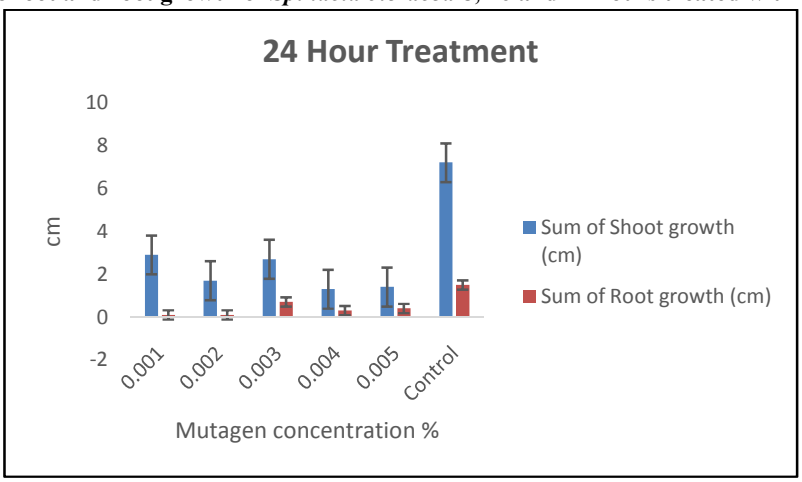
At 16 hours of treatment, the control group's germination rate dropped slightly to 87%, while the mutagen-treated seeds showed a significant decline. At 0.001% concentration, the germination rate was 56%, decreasing further to 50% at 0.002%, 55% at 0.003%, and 20% at both 0.004% and 0.005% concentrations. By 24 hours of treatment, the control group showed a germination rate of 76%, but increasing mutagenic concentrations further inhibited germination. The rates were recorded as 13% at 0.001%, 17% at 0.002%, 10% at 0.003%, 11% at 0.004%, and the lowest, 9%, at 0.005%. These results indicate that higher concentrations of mutagen have a detrimental effect on seed germination, with prolonged exposure further exacerbating the decline in germination rates.

Mutagen effect on growth of *Spinacia oleracea L.*

In the seed treatment experiment with *Spinacia oleracea* L. and different mutagenic concentrations, the following observations were made:



Graph: Shoot and root growth of *Spinacia oleracea* 8, 16 and 24 hours treated with mutagen



Graph 4: Shoot and root growth of *Spinacia oleracea* 24 hour treated with mutagen

Observations on the effects of mutagenic concentrations on the shoot and root growth of *Spinacia oleracea* L. can be summarized as follows: In the 8-hour treatment, the control group exhibited shoot growth of 4.9 cm and root growth of 1 cm. As the mutagenic concentration increased, both shoot and root growth showed fluctuations. At 0.001%, shoot growth slightly decreased to 4.7 cm, while root growth increased to 1.3 cm. With 0.002%, shoot growth dropped to 3.9 cm, and root growth declined to 0.4 cm. At 0.003%, shoot growth increased to 4.3 cm, while root growth remained low

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at 0.5 cm. Higher concentrations (0.004% and 0.005%) resulted in reduced shoot growth (3.8 cm and 3.6 cm, respectively) and varying root growth (0.8 cm and 0.4 cm).

After 16 hours of treatment, the control group showed shoot growth of 6.2 cm and root growth of 1.5 cm. As the mutagenic concentration increased, both shoot and root growth declined. At 0.001%, shoot growth dropped to 4.3 cm, and root growth reduced significantly to 0.2 cm. At 0.002%, shoot growth declined further to 2.9 cm, while root growth increased to 0.6 cm. At 0.003%, shoot growth slightly increased to 3.0 cm, but root growth remained at 0.4 cm. At higher concentrations (0.004% and 0.005%), shoot growth was further reduced (2.1 cm and 2.8 cm), with root growth fluctuating between 0.4 cm and 0.6 cm.

In the 24-hour treatment, the control group had the highest shoot (7.2 cm) and root (1.5 cm) growth. Increasing concentrations of mutagen had a significant inhibitory effect. At 0.001%, shoot growth dropped to 2.9 cm, with root growth at 0.1 cm. At 0.002%, shoot growth declined to 1.7 cm, with root growth remaining at 0.1 cm. At 0.003%, shoot growth slightly improved to 2.7 cm, while root growth increased to 0.7 cm. However, at 0.004% and 0.005%, shoot growth fell to 1.3 cm and 1.4 cm, respectively, with root growth at 0.3 cm and 0.4 cm.

Overall, the results indicate that increasing mutagenic concentrations had a generally detrimental effect on the growth of *Spinacia oleracea* L., with both shoot and root growth showing a decreasing trend as exposure time and concentration increased.

IV. CONCLUSION

The study demonstrated that increasing mutagenic concentrations of NaN_3 negatively affected the germination, shoot, and root growth of *Spinacia oleracea* L. Higher concentrations led to a significant decline in seed germination and seedling development, with the highest concentration (0.005%) reducing germination to 9% and shoot growth to 1.4 cm after 24 hours. While some phytochemical variations were observed, the overall impact was detrimental. These findings suggest that controlled doses of NaN_3 may induce genetic variability in spinach, potentially aiding in quality improvement while requiring careful application to minimize adverse effects.

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A Critical Review on Nanoparticle Synthesis: Physical, Chemical, and Biological Perspectives

Kajal Gharat, Aditi Gharat, Komal Patil, Prachi Mokal, Maryappa C Sonawale, Amod N. Thakkar
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Abstract: *Nanoparticles (NPs) are ultra-small particles ranging from 1 to 100 nanometers, exhibiting unique physicochemical properties such as high reactivity, enhanced strength, stability, and increased surface area. These properties make nanoparticles highly valuable across diverse fields, including medicine, environmental sustainability, agriculture, industry, and pollution remediation. Nanotechnology has emerged as a pivotal multidisciplinary field, driving advancements in nanomaterial synthesis. Various synthesis methods are employed, primarily categorized into physical, chemical, and biological (green) approaches. Traditional physicochemical methods often raise environmental concerns due to toxic byproducts and the necessity of reducing and stabilizing agents. In contrast, biological synthesis methods utilizing plant extracts, bacteria, fungi, and yeast offer a more eco-friendly alternative. This review provides an in-depth comparison of physical, chemical, and biological nanoparticle synthesis techniques, highlighting their advantages, limitations, and potential applications.*

Keywords: Nanoparticles, Nanotechnology, Physical Synthesis, Chemical Synthesis, Green Synthesis

I. INTRODUCTION

Nanotechnology is an interdisciplinary field encompassing the design, fabrication, characterization, and application of nanoscale materials, devices, and systems. Nanoparticles can be classified based on their composition into inorganic, organic, ceramic, and carbon-based nanoparticles. Inorganic nanoparticles are further categorized into metal and metal oxide nanoparticles, while carbon-based nanoparticles include fullerenes, carbon nanotubes, graphene, carbon nanofibers, and carbon black nanoparticles (CBNPs). Additionally, nanoparticles can be classified based on their dimensionality as one-, two-, or three-dimensional structures.

Nanoparticles are synthesized using two primary approaches: **top-down** and **bottom-up**. The top-down approach involves breaking down bulk materials into nanoscale structures through methods such as quenching, milling, and lithography. However, these techniques often lead to inconsistencies in particle size and shape. In contrast, the bottom-up approach involves assembling nanoparticles atom by atom or molecule by molecule, allowing for better control over particle size, shape, and distribution.

II. PHYSICAL SYNTHESIS OF NANOPARTICLES

Physical methods of nanoparticle synthesis rely on mechanical, thermal, and plasma-based techniques. Some commonly used methods include:

Ball Milling: A top-down method where bulk materials are ground into nanoscale particles. However, its efficiency is limited, often yielding nanoparticles with a low production rate and wide size distribution.

Sputtering: A process in which high-energy particles bombard a target material, leading to nanoparticle formation. However, only a small fraction (6-8%) of the sputtered material results in nanoparticles smaller than 100 nm.

Pulsed Laser Ablation: Involves using a high-energy laser to vaporize a target material, forming nanoparticles in a controlled environment. Although effective, this method requires significant energy input.

Plasma-Based Techniques: Utilize plasma energy to generate nanoparticles, but these methods are costly due to high energy consumption and complex processing requirements.

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While physical synthesis methods provide control over nanoparticle purity and composition, they often suffer from limitations such as high energy demands, low production rates, and waste byproducts, making them less viable for large-scale applications.

III. CHEMICAL SYNTHESIS OF NANOPARTICLES

Chemical methods employ various reactions to produce nanoparticles in aqueous or non-aqueous solvents. Some widely used chemical synthesis techniques include:

Electrochemical Deposition: A process in which metal ions are reduced at an electrode surface to form nanoparticles.

Sonochemical Synthesis: Uses ultrasonic waves to induce cavitation, leading to nanoparticle formation with controlled morphology and size.

Radiolytic Method: Involves the use of ionizing radiation to generate free radicals, which reduce metal ions to form nanoparticles.

Photochemical Synthesis: Utilizes light energy to initiate nanoparticle formation through photoreduction processes.

Despite their efficiency, chemical synthesis methods often require stabilizing agents and reducing chemicals, which may introduce toxicity and environmental hazards.

IV. GREEN SYNTHESIS OF NANOPARTICLES

Biological or green synthesis methods offer an eco-friendly alternative to conventional techniques by leveraging plant extracts, microorganisms, and biopolymers for nanoparticle production. These methods involve the reduction of metal precursors using natural biomolecules, which also act as stabilizing agents. Key approaches include:

Plant-Mediated Synthesis: Plant root, stem, and leaf extracts contain bioactive compounds that facilitate nanoparticle formation.

Microbial Synthesis: Bacteria, fungi, and yeast possess metal-reducing enzymes that aid in nanoparticle synthesis.

Biopolymer-Assisted Synthesis: Polysaccharides and proteins act as reducing and stabilizing agents, enhancing nanoparticle stability.

Green synthesis methods are cost-effective, non-toxic, and sustainable, making them highly attractive for biomedical and environmental applications. However, challenges such as reproducibility and scalability need to be addressed for commercial implementation.

V. METHODS OF SYNTHESIS OF NANOPARTICLES

Nanoparticles can be synthesized using various methods, each designed to control their size, shape, and composition. One of the most common techniques is **chemical reduction**, where metal ions in a solution are reduced to form nanoparticles under controlled conditions. Another widely used approach is the **sol-gel method**, in which precursor solutions undergo hydrolysis and condensation reactions, leading to nanoparticle formation within a gel matrix. **Physical methods** such as laser ablation and ball milling generate nanoparticles by breaking down bulk materials into nanoscale structures. Additionally, **biological or biogenic synthesis** leverages microorganisms and enzymes to produce nanoparticles, offering a more eco-friendly approach (Fig. 1).

1.1 Top-Down Synthesis

The top-down approach starts with bulk materials and applies external forces to break them down into nanoscale particles. Various physical, chemical, and thermal techniques are used to supply the necessary energy for nanoparticle formation.

Despite its effectiveness, the top-down approach has several limitations, including high costs, the requirement for specialized equipment, and challenges in achieving uniform nanoparticle size. Due to these drawbacks, it is more suitable for laboratory-scale experiments rather than large-scale production. Additionally, this method is not ideal for processing delicate or heat-sensitive materials.

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Common top-down techniques include:

- Physical Vapor Deposition (PVD)
- Chemical Vapor Deposition (CVD)
- Ion Implantation
- Electron Beam Lithography
- X-ray Lithography

1.2 Bottom-Up Synthesis

The bottom-up approach builds nanoparticles from atomic or molecular precursors through self-assembly or chemical processes. This method allows precise control over particle size, shape, and distribution.

Common bottom-up techniques include:

Sol-Gel Synthesis

Colloidal Precipitation

Hydrothermal Synthesis

Organometallic Chemical Routes

Electrodeposition

These techniques can further be categorized into three primary synthesis methods

- Physical Methods
- Chemical Methods
- Green/Herbal Methods

PHYSICAL METHODS

Physical synthesis methods involve manipulating materials at the nanoscale to produce nanoparticles with controlled properties. These methods are known for their ability to create high-purity nanoparticles but may require high energy inputs and specialized equipment.

(i) Mechanical/High-Energy Ball Milling Technique

Ball milling is a widely used solid-state processing technique that generates nanoparticles by mechanically grinding bulk materials into nanoscale dimensions. The process involves subjecting raw materials (typically smaller than a micron) to high-energy collisions inside a milling chamber.

Despite being a cost-effective and scalable technique, ball milling has certain limitations. Producing ultra-fine nanoparticles can be challenging due to mechanical constraints, and extended processing times may be required to achieve desired particle sizes. Several factors influence the final product, including:

Type of milling equipment

Milling speed

Container and grinding medium

Processing time and temperature

Process control agents and vial filling volume

Nanoparticles can also be synthesized by rapidly cooling molten metals, leading to the formation of metallic glasses or amorphous solids. For instance, TiB_2 nanoparticles can be synthesized by heating Ti and molten Cu-B alloys.

(ii) Chemical Vapor Deposition (CVD)

CVD is a widely used method for depositing thin films of nanoparticles onto a substrate through a chemical reaction between gaseous reactants and the heated substrate. This process typically occurs at temperatures ranging from 300°C to 1200°C and pressures between 100 and 105 Pa.

Various CVD techniques include:

- Plasma-Enhanced CVD (PECVD)
- Atomic Layer Deposition (ALD)

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- Vapor Phase Epitaxy (VPE)
- Metal-Organic CVD (MOCVD)

CVD offers several advantages, including the production of uniform, high-purity nanoparticles with excellent mechanical properties. However, by-products generated during the process must be efficiently removed to prevent contamination.

There are two primary heating approaches in CVD:

Hot-Wall Reactors – Heat is applied uniformly, but deposition may occur on reactor walls.

Cold-Wall Reactors – Only the substrate is heated, reducing unwanted deposition.

Key factors influencing nanoparticle formation in CVD include gas pressure, substrate temperature, and reaction kinetics. By optimizing these parameters, high-quality nanoparticles can be produced efficiently.

Methods of Nanoparticle Synthesis

Nanoparticles can be synthesized through various methods, each designed to control particle size, shape, and composition. Common synthesis approaches include chemical reduction, sol-gel methods, and physical techniques like laser ablation and ball milling. Additionally, biological synthesis, also known as biogenic synthesis, utilizes microorganisms or enzymes to produce nanoparticles.

1.1 Top-Down Synthesis

Top-down synthesis involves the reduction of larger solid materials into nanoscale particles using external forces. While effective, this approach is often costly and requires extensive installations, making it more suitable for laboratory-scale experiments rather than mass production. Moreover, it is not ideal for sensitive specimens.

Techniques in the Top-Down Approach:

Physical vapor deposition (PVD)
Chemical vapor deposition (CVD)
Ion implantation
Electron beam lithography
X-ray lithography

1.2 Bottom-Up Synthesis

Bottom-up synthesis constructs nanoparticles from smaller building blocks such as atoms and molecules. This approach leverages various chemical and biological processes to form nanoscale structures via self-assembly.

Techniques in the Bottom-Up Approach:

Sol-gel synthesis
Colloidal precipitation
Hydrothermal synthesis
Organometallic chemical routes
Electrodeposition

2.1.1 Physical Methods of Nanoparticle Synthesis

Physical methods utilize different processes to manipulate matter at the nanoscale. These techniques provide precise control over particle size, shape, and composition.

(i) Mechanical/High-Energy Ball Milling

Ball milling is a widely used solid-state technique for nanoparticle production. Raw materials undergo high-energy mechanical milling, resulting in nano-sized particles. This method is cost-effective and allows large-scale production, although achieving ultra-fine particles can be challenging due to mechanical limitations.

(ii) Chemical Vapor Deposition (CVD)

CVD involves depositing a thin layer of material onto a substrate through a chemical reaction of gaseous reactants at temperatures between 300°C and 1200°C. This process enables the fabrication of highly pure and uniform nanoparticles.

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(iii) Laser Pyrolysis

In laser pyrolysis, a high-powered laser disintegrates a gaseous reactant mixture in an inert atmosphere, such as helium or argon, to form nanoparticles. Factors like gas pressure significantly influence particle size and distribution.

(iv) Ionized Cluster Beam Deposition

This method forms single-crystalline thin films. The system includes an evaporation source, a nozzle for material expansion, a cluster-accelerator, an electron beam for ionization, and a substrate for nanoparticle deposition.

(v) Pulsed Laser Ablation

A high-power pulsed laser beam focuses on a target in a vacuum chamber, generating plasma that later forms nanoparticles in a colloidal solution. Second Harmonic Generation (ND: YAG type) lasers are commonly used, with variables like laser type, pulse count, and solvent type affecting the outcome.

(vi) Mechanochemical Synthesis

This process employs mechanical energy to initiate chemical reactions, producing ultra-fine composite powders stabilized within a salt matrix. The nanoparticles are later extracted by washing with a solvent.

(vii) Pulsed Wire Discharge (PWD)

PWD generates nanoparticles by evaporating a metal wire using a pulsed current, followed by cooling the vapor with a surrounding gas. It is particularly useful for metals with high electrical conductivity.

(viii) Thermal Decomposition

This endothermic process involves heat-induced chemical breakdown of molecules, forming nanoparticles when the metal precursor reaches its decomposition temperature.

(ix) Lithographic Methods

Lithographic techniques, including photolithography, electron beam lithography, and nano-imprint lithography, enable the fabrication of patterned nanoparticles. These methods are widely used in electronics and semiconductor industries.

(x) Laser Ablation

This technique utilizes a laser beam to irradiate metal submerged in a liquid, forming nanoparticles through plasma condensation. It provides a chemical-free approach for producing metal nanoparticles.

(xi) Sputtering

Sputtering involves the ejection of particles from a solid target due to high-energy ion bombardment. The deposited nanoparticles' size and shape depend on variables such as temperature, coating thickness, and annealing time.

(xii) Spinning

Spinning disc reactors (SDRs) produce nanoparticles via hydrolysis, condensation, and calcination. Factors such as disc surface properties, rotation speed, and precursor ratios influence nanoparticle characteristics.

(xiii) Pyrolysis

Pyrolysis is a widely used commercial process where a precursor material is burned in a flame or high-temperature furnace to produce nanoparticles. Plasma or lasers may also be used for high-temperature decomposition.

(xiv) Plasma Synthesis

High-temperature plasma, generated via radio frequency (RF) heating, is used to evaporate metals. The resulting vapor condenses to form nanoparticles. Plasma methods vary based on reactor type and heating source.

(xv) Microwave Irradiation

Microwave-assisted synthesis offers a rapid and energy-efficient method for nanoparticle production. It has been widely used in organic and inorganic materials synthesis due to its advantages over conventional heating methods.

(xvi) Gamma Radiation

Gamma irradiation facilitates the formation of monodisperse metallic nanoparticles through radiolytic reduction. It is an efficient, cost-effective method that requires minimal reagents and low reaction temperatures.

By using these physical methods, researchers can tailor nanoparticle synthesis to meet specific application requirements in fields such as medicine, electronics, and environmental science.

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1.2.1 Chemical Synthesis

Chemical synthesis of nanoparticles involves generating nanostructures through chemical reactions, usually in a solution phase. These methods are widely utilized due to their ability to precisely control nanoparticle size, morphology, composition, and surface characteristics. Several well-established chemical approaches include:

(i) Chemical Reduction Method The chemical reduction technique is a widely used wet-chemical method for synthesizing zero-valent metal nanoparticles. This process involves reducing metal salts, such as silver nitrate (AgNO3), using specific reducing agents that donate electrons to the metal ions, converting them into their metallic form. Common reducing agents include ascorbic acid, sodium citrate, and sodium borohydride. To stabilize the formed nanoparticles and prevent aggregation, stabilizing agents such as cetyltrimethylammonium bromide (CTAB) are used. In some cases, reducing agents like sodium citrate can also serve as stabilizers in the synthesis of silver nanoparticles.

(ii) Microemulsion Method Microemulsion-based synthesis utilizes a thermodynamically stable, isotropic mixture of oil, water, and surfactants, sometimes in combination with co-surfactants. This technique is categorized into direct microemulsions (oil dispersed in water) and reverse microemulsions (water dispersed in oil). The aqueous phase within the micelles can contain metal salts, while surfactants regulate the nanoparticle formation process. The controlled interaction between micelles allows for precise nanoparticle synthesis.

(iii) Sol-Gel Method In the sol-gel method, metal alkoxides or other metal precursors undergo hydrolysis and condensation, leading to the formation of a stable colloidal solution (sol). As the reaction progresses, viscosity increases, forming a gel-like network. By manipulating factors such as precursor concentration, temperature, and pH, nanoparticle characteristics can be fine-tuned. The removal of solvents and subsequent aging and phase transformation steps are crucial for achieving a well-defined solid-phase nanomaterial.

(iv) Sonochemical Synthesis Sonochemical methods utilize high-energy ultrasonic waves to drive chemical reactions, effectively synthesizing nanomaterials such as Pd-CuO nanohybrids. During the process, ultrasonic waves facilitate the transformation of metal salts into their respective oxides or metallic states, with palladium either appearing in its salt form or as a pure metallic element. This technique enhances reaction kinetics and promotes uniform nanoparticle formation.

(v) Co-Precipitation Method The co-precipitation method, a type of solvent displacement approach, involves the rapid mixing of polymer solutions with a non-solvent to induce nanoparticle formation. Common solvents include ethanol, acetone, and hexane, while the polymer phase can be synthetic or natural. The process exploits interfacial stress between the two phases to drive nanoparticle formation, leading to precise particle size control.

(vi) Inert Gas Condensation Method This method is employed for the large-scale production of metal nanoparticles. It involves the evaporation of a metallic source within an inert gas environment, such as argon, helium, or neon. The metal vapor condenses upon rapid cooling with an inert gas, typically aided by liquid nitrogen, leading to the formation of nanoparticles ranging from 2 to 100 nm in size. This technique is particularly useful for producing fine metal nanoparticles like copper.

(vii) Hydrothermal Synthesis Hydrothermal synthesis is one of the most commonly used chemical approaches for nanoparticle production. This method involves conducting chemical reactions in aqueous media under controlled temperature and pressure conditions. The technique allows for nanoparticle synthesis across a wide temperature range, providing benefits such as enhanced crystallinity and controlled morphology. Hydrothermal synthesis offers advantages over physical and biological methods, though high temperatures may sometimes lead to instability in the produced nanoparticles.

(viii) Polyol Method The polyol method employs nonaqueous liquid polyols, such as ethylene glycol, which serve as both the solvent and the reducing agent. This approach is advantageous because it minimizes oxidation and prevents nanoparticle aggregation. The polyol method allows precise control over nanoparticle size, shape, and texture, making it a scalable process for large-scale production.

Ethylene glycol is frequently used due to its strong reducing capability, high boiling point, and high dielectric constant. In this process, metal ions interact with ethylene glycol, forming metal glycolate intermediates that undergo further reactions to yield metal or metal oxide nanoparticles. Research indicates that these precursors can be calcined in air to retain their initial morphology while converting into their respective oxides. The polyol method has been employed in

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synthesizing various oxides, including Y2O3, VxOy, Mn3O4, ZnO, CoTiO3, SnO2, PbO, and TiO2. Additionally, it has been utilized for the preparation of core-shell nanoparticles and bimetallic alloys.

For instance, Kim et al. successfully synthesized icosahedral and cubic gold nanoparticles (100-300 nm) by precisely controlling the growth rate for different crystallographic orientations. Similarly, Xia and colleagues demonstrated that silver nitrate and polyvinylpyrrolidone (PVP) could be combined in varying ratios to produce silver nanoparticles with controlled morphologies, such as nanocubes and nanowires.

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Green Synthesis of Zinc Oxide Nanoparticles: A Comprehensive Review

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Abstract: *The synthesis of zinc oxide nanoparticles (ZnO NPs) using green chemistry approaches has gained significant attention due to its eco-friendly nature, cost-effectiveness, and biocompatibility. Conventional physical and chemical synthesis methods often involve toxic chemicals and high energy consumption, raising concerns about environmental sustainability. Green synthesis offers an alternative by utilizing plant extracts, microorganisms, and natural polymers as reducing and stabilizing agents. This review provides an in-depth discussion on various biological methods employed for ZnO NP synthesis, their mechanisms, characterization techniques, and applications in biomedical, environmental, and industrial fields. Additionally, challenges and future perspectives of green synthesis are explored.*

Keywords: zinc oxide nanoparticles

I. INTRODUCTION

Zinc oxide nanoparticles (ZnO NPs) are among the most widely studied metal oxide nanoparticles due to their unique physicochemical properties, including high surface-to-volume ratio, optical transparency, and excellent antimicrobial activity. These properties make ZnO NPs highly applicable in diverse fields such as biomedicine, photocatalysis, food packaging, and environmental remediation. However, traditional synthesis techniques involve hazardous chemicals and energy-intensive procedures, necessitating the exploration of green synthesis approaches.

Green Synthesis Approaches

Green synthesis methods use natural resources such as plant extracts, microorganisms, and biomolecules to reduce and stabilize ZnO NPs. These methods eliminate or minimize toxic byproducts, making them environmentally sustainable.

1. Plant-Mediated Synthesis

Plant extracts contain diverse phytochemicals, including flavonoids, alkaloids, tannins, and terpenoids, which act as reducing and stabilizing agents during ZnO NP formation. The advantages of plant-mediated synthesis include scalability, cost-effectiveness, and high yield.

Examples:

Ocimum tenuiflorum (Tulsi) Extract: Kavitha et al. (2018) synthesized ZnO NPs using *Ocimum tenuiflorum* leaf extract, demonstrating significant antimicrobial activity.

Aloe vera Extract: Ramesh et al. (2020) utilized *Aloe vera* leaf extract to synthesize ZnO NPs, showing enhanced wound healing properties.

Moringa oleifera Extract: Baruwati et al. (2019) reported the use of *Moringa oleifera* for ZnO NP synthesis, leading to effective photocatalytic degradation of organic pollutants.

2. Microbial-Mediated Synthesis

Microorganisms such as bacteria, fungi, and algae have been explored for ZnO NP biosynthesis due to their ability to secrete bioactive metabolites that facilitate nanoparticle formation.

Examples:

Bacillus subtilis: Saravanan et al. (2019) demonstrated the biosynthesis of ZnO NPs using *Bacillus subtilis*, exhibiting biocompatibility and antimicrobial activity.

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Aspergillus niger: A fungal-mediated synthesis approach using *Aspergillus niger* resulted in ZnO NPs with potent antibacterial properties (Shankar et al., 2017).
Spirulina platensis: Algae-mediated synthesis using *Spirulina platensis* was found to produce ZnO NPs with enhanced UV-blocking and antioxidant activity (Gautam et al., 2021).

3. Biopolymer-Assisted Synthesis
Biopolymers such as chitosan, starch, and cellulose are used as capping agents to enhance the stability and biocompatibility of ZnO NPs.
Examples:
Chitosan: Chitosan-mediated ZnO NPs were found to have antimicrobial and anti-inflammatory properties (Kumar et al., 2022).
Starch: Starch-assisted synthesis produced ZnO NPs with improved photocatalytic performance (Mishra et al., 2020).
Gelatin: Gelatin-stabilized ZnO NPs exhibited enhanced cytocompatibility and drug delivery potential (Reddy et al., 2021).

4. Mechanism of Green Synthesis
The green synthesis of ZnO NPs involves three major steps:
Precursor Preparation: Zinc salts such as zinc acetate or zinc nitrate are dissolved in aqueous media.
Reduction & Stabilization: Phytochemicals, microbial enzymes, or biopolymers act as reducing agents to convert Zn^{2+} ions into ZnO NPs while also stabilizing them.
Characterization: Various techniques such as UV-Vis spectroscopy, X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FTIR) are employed to confirm nanoparticle formation and properties.

Characterization Techniques
UV-Vis Spectroscopy: Determines the optical properties of ZnO NPs.
X-ray Diffraction (XRD): Confirms the crystalline nature and phase purity.
Scanning Electron Microscopy (SEM): Analyzes surface morphology and size.
Fourier-Transform Infrared Spectroscopy (FTIR): Identifies functional groups responsible for capping and stabilization.

Applications of Green Synthesized ZnO NPs
1. Biomedical Applications
Antimicrobial Agents: ZnO NPs exhibit broad-spectrum antibacterial and antifungal activity.
Cancer Therapy: ZnO NPs induce selective cytotoxicity in cancer cells.
Wound Healing: Promotes cell proliferation and tissue regeneration.
2. Environmental Applications
Photocatalysis: ZnO NPs degrade organic pollutants in wastewater treatment.
Air Purification: Used in air filters to remove toxic gases.
Heavy Metal Removal: ZnO-based nanocomposites adsorb heavy metals from water sources.
3. Industrial Applications
Food Packaging: ZnO NPs are incorporated into biodegradable packaging materials to enhance antimicrobial properties.
Cosmetics: Used in sunscreens due to their UV-blocking capabilities.
Electronics: Employed in sensors, LEDs, and photovoltaic devices.
Challenges and Future Prospects
Despite the advantages of green synthesis, several challenges remain:
Scalability Issues: Large-scale production needs optimization.

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Reproducibility: Variability in biological sources affects nanoparticle consistency.
Long-Term Stability: Need for improved storage and stability strategies.
Future research should focus on:
Standardizing synthesis protocols for consistency.
Exploring novel biological sources for improved nanoparticle properties.
Enhancing biocompatibility for biomedical applications.

II. CONCLUSION

Green synthesis of ZnO NPs is a promising approach that offers an eco-friendly alternative to conventional methods. Plant extracts, microbes, and biopolymers have demonstrated efficient ZnO NP production with diverse applications. Further studies are needed to overcome existing challenges and fully realize the potential of green-synthesized ZnO NPs in various fields.

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Green Synthesis of Heterocyclic Compounds: A Comprehensive Review

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Abstract: *Heterocyclic compounds are essential scaffolds in medicinal chemistry, agrochemicals, and material sciences. Traditional methods for their synthesis often involve harsh reaction conditions, toxic reagents, and environmentally hazardous solvents. In response to growing concerns about sustainability, green chemistry approaches have been explored to develop eco-friendly and efficient synthetic routes for heterocyclic compounds. This review provides a comprehensive overview of green synthetic strategies, including the use of biocatalysts, microwave and ultrasonic-assisted synthesis, ionic liquids, deep eutectic solvents, and plant-mediated methods. The role of renewable feedstocks and solvent-free reactions in minimizing environmental impact is discussed. Furthermore, recent advancements in the field, challenges in scalability, and future prospects for green synthesis are highlighted. By integrating sustainable methodologies, green synthesis offers a promising avenue for the efficient and eco-conscious production of heterocyclic compounds with potential applications in pharmaceuticals, agriculture, and materials science.*

Keywords: Heterocyclic compounds

I. INTRODUCTION

Heterocyclic compounds play a vital role in pharmaceuticals, agrochemicals, and material sciences due to their diverse biological and chemical properties. Traditional synthetic methods often involve the use of toxic reagents, hazardous solvents, and energy-intensive processes, raising concerns about environmental sustainability. Green synthesis approaches aim to develop eco-friendly, cost-effective, and sustainable strategies for heterocyclic compound synthesis by utilizing green solvents, biodegradable catalysts, and renewable resources.

Green Synthetic Approaches for Heterocyclic Compounds

Green chemistry principles have paved the way for various environmentally benign methods to synthesize heterocycles. Some of the significant green synthetic approaches include:

1. **Solvent-Free Reactions**

Solvent-free synthesis eliminates the need for organic solvents, reducing waste and toxicity. Mechanochemical methods such as ball milling and grinding have been widely used in synthesizing heterocycles.

Example: K. Tanaka et al. (2000) reported the synthesis of pyrazoles via a solvent-free grinding method using aldehydes and hydrazines.

2. **Microwave-Assisted Synthesis**

Microwave irradiation accelerates chemical reactions, leading to higher yields and reduced reaction times.

Example: B. L. Hayes et al. (2002) demonstrated the microwave-assisted synthesis of quinolines, achieving significant reductions in reaction time and energy consumption.

3. **Ultrasound-Assisted Synthesis**

Ultrasound enhances reaction rates and selectivity by generating cavitation effects.

Example: J. Luche et al. (1990) developed an ultrasound-assisted synthesis of imidazoles using ionic liquids.

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4. **Biocatalytic Approaches**

Biocatalysts such as enzymes and microbes facilitate selective and efficient transformations under mild conditions.

Example: A. Patel et al. (2015) synthesized indole derivatives using fungal cultures as biocatalysts.

5. **Green Solvents in Heterocyclic Synthesis**

Green solvents like water, ethanol, ionic liquids, and deep eutectic solvents have gained popularity due to their non-toxic and biodegradable nature.

Example: R. Sheldon et al. (2008) synthesized furan derivatives using deep eutectic solvents as an alternative to conventional organic solvents.

6. **Photocatalysis and Electrocatalysis**

Light-driven and electrochemical synthesis methods offer energy-efficient alternatives to traditional heating methods.

Example: X. Zhang et al. (2019) reported the photocatalytic synthesis of pyrroles using titanium dioxide nanoparticles under visible light.

Characterization Techniques

Green-synthesized heterocycles are characterized using various spectroscopic and analytical techniques:

UV-Vis Spectroscopy: Confirms electronic transitions.

FTIR Spectroscopy: Identifies functional groups.

NMR Spectroscopy: Determines molecular structure.

Mass Spectrometry: Provides molecular weight and fragmentation patterns.

X-ray Crystallography: Resolves 3D molecular structures.

Applications of Green-Synthesized Heterocyclic Compounds

1. **Pharmaceuticals**

Green-synthesized pyrimidines exhibit anti-cancer and anti-viral activities.

Imidazoles synthesized via green methods show antifungal properties.

2. **Agrochemicals**

Heterocycles such as thiazoles and triazines are used as eco-friendly pesticides.

3. **Material Science**

Green-synthesized heterocycles serve as organic semiconductors and dyes.

Challenges and Future Prospects

Despite the progress in green synthesis, challenges such as scalability, reproducibility, and cost-effectiveness remain. Future research should focus on optimizing reaction conditions, developing novel green catalysts, and integrating multiple green chemistry principles into a single synthetic platform.

II. CONCLUSION

Green synthesis of heterocyclic compounds offers a sustainable alternative to traditional methods, minimizing environmental impact while maintaining high efficiency and yield. The continued exploration of green methodologies will pave the way for more sustainable industrial and pharmaceutical applications.

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Leafy Nutrients: Analyzing Iron Content in Spinach through Spectrophotometry

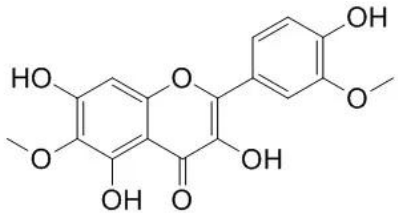
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Abstract: *This research paper focuses on determine the iron content in spinach leaves utilizing spectrophotometry, a widely used analytical technique known for its precision and efficiency. Iron is a crucial micronutrient that is integral to various metabolic processes, and its deficiency poses serious health risks. Fresh spinach samples were collected, cleaned, and subjected to a rigorous extraction process involving acid digestion to liberate iron ions from the plant material. Following treatment, the iron concentration in the sample was analyzed through spectrophotometry, where absorbance measurements were taken at specific wavelengths corresponding to the iron complexes formed. Calibration curves were constructed using standard solutions of known iron concentrations to ensure accurate quantification. The findings indicated the iron content in spinach samples, which were then compared to dietary recommendations, demonstrating spinach's nutritional value as a significant source of iron. This research highlights the effectiveness of spectrophotometric methods in the nutritional analysis of food products, contributing valuable insights into the dietary importance of leafy greens.*

Keywords: Iron content analysis, spinach nutrition, spectrophotometry, leafy greens minerals, iron quantification, food chemistry

I. INTRODUCTION

Green leafy vegetables (GLV) play a substantial role in human nutrition and are essential for a healthy life.1 They provide an adequate amount of dietary fibers, minerals, vitamins, and other nutrients, and they are beneficial for the maintenance of good health and prevention of various diseases.GLV have low energy densities, and thus, they are recommended for weight management, and some leaves have unique properties; to overcome the swelling of the human body due to sprains. [1]



Structure of Spinacetin

Spinacetin is a flavonol found in spinach leaves (*Spinaciaoleracea*). It has a molecular formula of C17H14O7 and belongs to the flavonoid class of polyphenols. Structurally, spinacetin consists of a flavone backbone with hydroxyl (-OH) and methoxy (-OCH3) groups attached to its benzopyrone core. Specifically, it features hydroxyl groups at the 5 and 4' positions and methoxy groups at the 6 and 7 positions. This structure contributes to its antioxidant properties, making it a bioactive compound with potential health benefits. Spinacetin's presence in spinach highlights its role in plant defense and possible therapeutic applications for humans.

GLV is essential from both economic and nutritional perspectives. The presence of fiber in green vegetables has been reported to have beneficial health effects on blood cholesterol and to aid in preventing major bowel diseases. At the same time, in diabetic subjects, it progresses their glucose intolerances. To be healthy, minerals are necessary, and they are required for essential body functions such as heartbeat, muscle contraction, movement, growth, and regulatory

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processes. Numerous plants and their products play an imperative role in human health, and they help prevent and cure many sicknesses.[2]

GLV contains various minerals such as calcium, iron, copper, phosphorous, zinc, chloride, and sodium, and these minerals play a significant role in growth and metabolism. Elements such as sodium, potassium, iron, and calcium provide an alkalizing effect to the acidity produced by other foods. One essential transition metal in the living system is iron, which carries oxygen to the tissues and is responsible for the appropriate protection against microbes.[3] Vegetables are an essential part of the diet since they contribute proteins, vitamins, iron, calcium, and other valuable nutrients to us. The total iron present in an average adult is forty grams and is mostly stored in the spleen, liver, and bone marrow.[4] Moreover, vegetables contain essential and toxic elements over a wide range of concentrations.[5]

The importance of iron in the human body derives depending on the quantity in which it is found. The human body needs a consistent contribution to fulfil its functions. Iron must exist at the highest level to meet all needs [13]

Iron deficiency is the result of reduced consumption of iron containing foods (in the case of the vegetarian diet for example) and of some diseases that impede its absorption. The most important sources of iron for the human body are red meat and liver. In the case of a vegetarian diet to ensure the amount of iron necessary for the body, high-iron plant foods such as some seeds, vegetables and fruits should be included in the diet [14].

Spinach may benefit eye health, reduce oxidative stress, help prevent cancer, and reduce blood pressure levels.Spinach (Spinaciaoleracea) is a leafy green vegetable that originated in Persia.It belongs to the amaranth family and is related to beets and quinoa. What's more, it's considered very healthy, as it's loaded with nutrients and antioxidants.There are many ways to prepare spinach. You can buy it canned or fresh and eat it cooked or raw. It's delicious either on its own or in other dishes.[15].

Nutritional facts :The nutrition facts for 3.5 ounces (100 grams) of raw spinach are (1Trusted Source):Calories: 23 , Water: 91% , Protein: 2.9 grams , Carbs: 3.6 grams ,Sugar: 0.4 grams , Fiber: 2.2 grams , Fat: 0.4 grams are found in spinach. Carbs - Most of the carbs in spinach consist of fiber, which is incredibly healthy.Spinach also contains small amounts of sugar, mostly in the form of glucose and fructose.Fiber - Spinach is high in insoluble fiber, which may boost your health in several ways. It adds bulk to stool as food passes through your digestive system. This may help prevent constipation.Spinach is low in carbs but high in insoluble fiber. This type of fiber may benefit your digestion.Vitamins and minerals - Spinach is an excellent source of many vitamins and minerals, includingVitamin A. Spinach is high in carotenoids, which your body can turn into vitamin A.Vitamin C.

The spectrophotometric method for the determination of Fe(II) for the spinach leaves samples proved to be a laborious method (it required numerous operations such as drying, calcining, weighing, diluting, preparing the Fe(II) standard scale, etc.) but inexpensive. The results are in good agreement with the data from the literature. It can be seen that Spirulina powder contains a much larger amount of Fe (II) than Spinach fresh leaves (7.42 times higher). Considering that the daily iron requirement for an human adult is approx. 2 to 5 mg. Thus, according to the results of the study, it is recommended for people on a vegetarian (vegan) diet to consume about 40 g of fresh Spinach leaves daily.[23]

Green leafy vegetables are good sources of iron content. However, there were variations of iron content in uncooked, cooked, and pot liquor. In addition, the green leafy vegetables contained an appreciable percentage of moisture content. Among the six investigated green vegetable samples, Coccinia pot liquor was found to contain maximum iron content, and the least was found in cooked Lettuce. After comparing the differently prepared green leafy vegetables, pot liquor appeared to be the best iron source. Moreover, further research needs to be done to confirm the presence of other active compound and minerals in the tested sample.[24]

II. METHODOLOGY

To determine the iron content in spinach leaves using a spectrophotometric method by forming a colored complex with 1,10-phenanthroline or thiocyanate and measuring its absorbance.

Principle :Iron in spinach exists in Fe^{3+} and Fe^{2+} forms. The Fe^{3+} ions are first reduced to Fe^{2+} using a reducing agent like hydroxylamine hydrochloride. The Fe^{2+} then reacts with 1,10-phenanthroline to form an orange-red complex or with thiocyanate (SCN^-) to form a red complex, both of which can be quantified using a UV-Vis spectrophotometer.

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Materials and Reagents :

Sample Collection &Preparation :Fresh spinach leaves (5.0 g)

Chemicals & Reagents :

Nitric acid (HNO_3, 1M) – for oxidation

Hydroxylamine hydrochloride ($NH_2OH{\cdot}HCl$, 10%) – reducing agent

Hydrochloric acid (HCl, 1M) – for digestion

Sodium acetate buffer (pH 4.5) – to maintain pH

1,10-Phenanthroline (0.1% w/v solution) – for Fe^{2+} color complex

Ammonium thiocyanate (NH_4SCN, 10%) – alternative color reagent

Ferric ammonium sulfate standard solution – for calibration curve.

Distilled water

2. Instruments :

UV-Vis Spectrophotometer

510 nm for Fe^{2+}-phenanthroline complex

480 nm for Fe^{3+}-thiocyanate complex

Analytical Balance

Hot Plate/Digestion Apparatus

Glassware (Beakers, Volumetric Flasks, Pipettes, Funnels, Filter Paper, etc.)

Procedure.

Step 1: Sample Preparation (Digestion) :Weigh 5.0 g of fresh spinach leaves and chop finely.Place in a 250 mL beaker and add 25 mL of 1M HCl and 10 mL of 1M HNO_3.Heat the mixture on a hot plate for 30 minutes (avoid boiling).Cool the solution and filter it into a 100 mL volumetric flask.Dilute to 100 mL with distilled water.

Step 2: Reduction of Fe^{3+} to Fe^{2+} :(If using 1,10-Phenanthroline Method)Take 10 mL of the digested sample into a 50 mL volumetric flask.Add 1 mL of 10% hydroxylamine hydrochloride to reduce Fe^{3+} to Fe^{2+}.Adjust the pH to 4.5 using sodium acetate buffer.

Step 3: Complex Formation : For 1,10-Phenanthroline Method (Fe^{2+} Determination)Add 5 mL of 0.1% 1,10-phenanthroline solution.Allow the reaction to develop for 10 minutes to form an orange-red complex.For Thiocyanate Method (Fe^{3+} Determination)Add 5 mL of 10% ammonium thiocyanate solution.A red Fe^{3+}-thiocyanate complex will form.

Step 4: Spectrophotometric Analysis :Measure the absorbance using a UV-Vis spectrophotometer:510 nm for 1,10-phenanthroline complex , 480 nm for thiocyanate complex.Prepare a standard calibration curve using Fe^{2+} solutions (e.g., 1-10 mg/L).Compare the sample's absorbance with the calibration curve to determine the iron concentration in spinach.

Step 5: Calculation:The iron concentration is determined using the calibration curve equation. The final iron content in mg/100 g of spinach is calculated using the dilution factor.

Results:

The iron content in spinach samples was analysed using spectrophotometry. The absorbance values of the extracts were compared with the standard curve to determine the iron concentration.

Sample	Absorbance (510 nm)	Iron Concentration (mg/100g)
Fresh Spinach (Sample 1)	0.235	9.25 ± 0.34
Fresh Spinach (Sample 2)	0.242	9.60 ± 0.29
Blanched Spinach	0.198	7.85 ± 0.42
Boiled Spinach	0.165	6.55 ± 0.38

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III. CONCLUSION

The spectrophotometric analysis of spinach revealed that fresh spinach contains the highest iron content, while processing methods such as blanching and boiling lead to significant reductions due to leaching. The study highlights the importance of minimal processing to retain maximum iron content in leafy greens. Spectrophotometry proved to be a reliable and accurate method for determining iron levels, supporting its use in nutritional analysis.

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A Comprehensive Review: Green Synthesis of Nanoparticles from Azadirachta Indica Plant

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Abstract: An environmentally friendly and sustainable process is the green synthesis of neem plant nanoparticles. Because neem plant extracts contain a lot of bioactive components, they are used as capping and reducing agents. In the process, neem components are removed and mixed with metal precursor solutions. Under carefully regulated conditions, metal ions are reduced and nanoparticles are produced. These unique neem-synthesized nanoparticles are utilized in agriculture, medicine, environmental remediation, and catalysis. Because of its cost, environmental friendliness, and scalability, the green synthesis approach reduces the usage of hazardous chemicals. This could lead to advancements in green nanotechnology.

Keywords: Neem plant, environmentally friendly, synthesized nanoparticles

I. INTRODUCTION

The purpose of this project is to develop an E-Book Distribution Platform. It is a system that enables readers to place their book order online. The reason to develop the system is due to the issues of facing by Readers. Beside that it provides user friendly web-pages and effective advertising medium to the new books to the readers at reasonable price.

The advent of digital technologies has revolutionized the way books are marketed, sold, and consumed. This paper presents the design and development of an E-Book Distribution Platform, a comprehensive web and mobile-based platform that facilitates the browsing, purchasing, and reading of books in digital and physical formats. The system incorporates modern features such as real-time inventory management, personalized book recommendations using machine learning algorithms, secure payment gateways, and user-generated reviews. By analyzing user behavior and preferences, the app enhances user experience and engagement. The architecture supports scalability, multi-device access, and seamless integration with third-party APIs such as Google Books and PayPal. Additionally, the application promotes inclusivity by offering multilingual support and accessibility features. This study emphasizes the growing significance of online platforms in democratizing access to literature, empowering self-publishing authors, and transforming the traditional book retail industry.

In order to create future devices that are both environmentally green and human-friendly, nanoparticles will be crucial. Plant-based nanoparticle synthesis is a green chemistry technique that links nanotechnology and plant biotechnology. Metal ions are bio-reduced and nanoparticles are produced using plant extracts. The importance of plant metabolites, including proteins, sugars, terpenoids, polyphenols, alkaloids, and phenolic acids, in reducing metal ions into nanoparticles and enhancing their stability has since been demonstrated. The atoms in The properties of nonmetric materials differ greatly from those of bulk materials. The need for environmentally friendly techniques is particularly high due to the general toxicity of the chemicals employed in conventional chemical methods to manufacture nanoparticles. [1].

It is believed that nanoparticles (NPs) are the fundamental building blocks of nanotechnology. Nanotechnology is an interdisciplinary field that includes material science, biology, chemistry, physics, and health. Currently, a range of physical and chemical methods have been documented for producing metal nanoparticles. Because of all the documented chemical reactions and energy-intensive pathways that make them environmentally hazardous, these options are not appropriate for use in biology, medicine, or the clinical area. Therefore, developing eco-friendly

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processes is crucial to today's nanomaterial synthesis. Biotechnology, a focused combination of biological and nanotechnological techniques for the biosynthesis of nanoparticles, is a result of nanotechnology. [2].

Due to their unique properties, colloidal silver nanoparticles find widespread application in photonics, electronics, chemical detection, biosensing, and medicines. There is a lot of interest in developing flexible methods to produce silver nanoparticles with precisely specified and regulated characteristics because of the range and importance of these applications. [3].

Using neem (Azadirachta Indica) leaf broth, bimetallic Au Core-Ag shell nanoparticles with precisely defined composition and shape have been successfully produced. It was recently discovered that an extract of parthenium hysterophorous L. leaves might be used to create silver nanoparticles at room temperature. The photoluminescence property and the change in particle size with reaction temperature and reaction duration, however, were not sufficiently studied. [3].

Inorganic nanoparticles include silicon nanoparticles and magnetic nanoparticles. Among the groups of metallic nanoparticles are gold, silver, alloy, zinc, and other metals. Ag is a magnetic substance. Important biological qualities are provided by nano silver for use in consumer goods, food technology, textile and fabric applications, and medicine. In addition, nano silver's special optical and physical characteristics suggest that it will play a significant role in medicine in the future. [4] [5].

Atomic, molecular, and supramolecular manipulation of matter is the focus of the quickly developing field of nanotechnology. The term "nanotechnology" was initially used by Nobel laureate Richard Feynman. He talked about the possibility of reordering and modifying particular atoms and molecules in his 1959 lecture, "There's Plenty of Room at the Bottom." [6] [7].

1.1 Types of Nanoparticles

Nanoparticles are extremely tiny particles that range in size from one to one hundred nanometers (nm). A wide range of materials, such as metals, electronics, polymers, and ceramics, can be used to create them. Because of their unique physical and chemical characteristics that distinguish them from their bulk counterparts, nanoparticles are attractive prospects for a wide range of applications in fields like health, electronics, energy, and environmental science. [8].

1.2 APPLICATIONS OF NANOPARTICLES

1.2.1 Applications of Nanoparticles in Medicine

Nanoparticles are appealing tools for illness diagnosis and treatment because of their special qualities, which include their small size, large surface area, and high reactivity. They can be functionalized with a range of substances, such as medications, antibodies, and nucleic acids, to target specific cells or tissues, and they are readily transportable over biological barriers like the blood-brain barrier. Furthermore, nanoparticles with controlled release characteristics can be developed, allowing for continuous drug administration over extended periods of time. Some of the most significant uses of nanoparticles in medicine are listed below. [9, 10].

- Drug Delivery: Antibiotics, vaccines, and anticancer drugs are just a few of the drugs that have been delivered by nanoparticle techniques. Targeting specific cells or tissues can boost their therapeutic effectiveness and protect the drugs from being broken down and eliminated by the immune system. Liposomal nanoparticles, for example, have been used to deliver anticancer drugs to tumor cells, increasing therapeutic efficacy and reducing side effects. [9, 10].
- Imaging: Computed tomography (CT), magnetic resonance imaging (MRI), and fluorescence imaging are just a few of the imaging techniques that can use nanoparticles as contrast agents. They can improve imaging's sensitivity and specificity and enable the detection of tiny lesions that are challenging to detect using conventional imaging techniques. For example, super paramagnetic iron oxide nanoparticles have been used as MRI contrast agents to detect liver tumors. [9].
- Bio sensing: Nanoparticles can be used as biosensors to detect a wide range of biomolecules, such as proteins, nucleic acids, and carbohydrates. Their high sensitivity and specificity enable the identification of

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biomolecules at low concentrations. For example, gold nanoparticles have been used as biosensors to detect prostate-specific antigen (PSA), a biomarker for prostate cancer. [9].

- Gene Therapy: Nanoparticles can be used as vectors to deliver therapeutic genes to cells or tissues to cure genetic disorders. They can stop nucleases from damaging the genes and aid in their absorption by the cells. For example, cationic liposomal nanoparticles were used to deliver therapeutic genes to lung cancer cells, resulting in decreased tumor growth and improved survival rates. [9, 10].

1.2.2 Applications of Nanoparticles in Electronics

Electronic devices that use nanoparticles include solar cells, sensors, and memory devices. They can boost electrical device performance by improving their mechanical strength, optical properties, and conductivity. Furthermore, because of their simple, inexpensive, and scalable manufacturing, nanoparticles are attractive for use in commercial settings. There are several uses for nanoparticles in electronics, some of which are mentioned here. [11].

- Memory Devices: In memory technologies such as flash memory and phase-change memory, nanoparticles have been used to improve performance and reduce power consumption. One example is the use of gold nanoparticles to increase the durability and data retention of flash memory systems. [11].
- Sensors: Nanoparticles have been used to create sensors for a range of applications, such as food safety, medical care, and environmental monitoring. Because of its high sensitivity and selectivity, analytes can be detected at low concentrations. For example, silver nanoparticles have been used to develop sensors that can identify heavy metal ions in water. [11].
- Solar cell: Solar cells have been developed using nanoparticles to improve their efficiency and reduce their cost. Apart from promoting the flow of charge within the cells, they can enhance the absorption of sunlight. For example, third-generation solar cells have been made using semiconductor nanoparticles known as quantum dots. [11].
- Flexible electronics: Flexible electronics, which can be stretched or twisted without breaking, have been made using nanoparticles. They might be able to enhance the mechanical properties of the devices and enable their integration with flexible substrates. For example, flexible, transparent electrodes for wearable technology and touch screens have been made using silver nanoparticles. [11].

1.2.3 Applications of Nanoparticles in Energy

Energy storage, energy conversion, and fuel cells are some of the energy-related uses for nanoparticles. They can improve the performance of energy devices by making them more efficient, robust, and safe. Furthermore, nanoparticles are attractive for use in large-scale energy applications due to the abundance of affordable resources available for their manufacture. Some of the most significant uses of nanoparticles in the energy industry are listed below. [12].

- Catalysis: Nanoparticles have been used as catalysts in fuel cells, carbon dioxide reduction, hydrogen synthesis, and other energy-related processes. They can increase the pace and selectivity of the reactions while lowering the amount of catalyst needed. For example, platinum nanoparticles have been used to accelerate oxygen reduction processes in fuel cells. [12].
- Energy Storage: Nanoparticles have been used in the development of energy storage technologies such as batteries and super capacitors to improve their efficiency and reduce their cost. They can improve the electrode's surface area and facilitate the flow of charge throughout the apparatus. For example, lithium-ion batteries with higher energy density have been made using silicon nanoparticles. [12].
- Solar Energy: Nanoparticles have been used to create solar energy technologies including photovoltaic cells and solar fuels in order to boost their efficiency and reduce their cost. They can enhance solar absorption and facilitate charge transmission throughout the gadgets. For example, titanium dioxide nanoparticles have been used in the creation of dye-sensitized solar cells. [12].

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1.2.4 Applications of Nanoparticles in Environmental Science

- Nanoparticles have been employed in environmental research for a number of applications, such as water treatment, air purification, and soil remediation. They can improve the quality of our natural resources and remove pollutants from the air. Furthermore, nanoparticles are attractive for usage in environmentally acceptable applications since they may be produced utilizing sustainable and eco-friendly methods. The following are some of the most notable uses of nanoparticles in environmental research. [13].

  • Water treatment: Nanoparticles have been used to remove heavy metals, organic contaminants, and pathogens from water. By adsorbing, oxidizing, or photocatalyzing the contaminants out, they can improve the water's quality. For example, iron nanoparticles have been used to remove arsenic from contaminated groundwater. [13].
- Air Purification: Particulate matter, nitrogen oxides, and volatile organic compounds are just a few of the pollutants that nanoparticles have been used to remove from the air. They can eliminate the pollutants and improve the quality of the air using adsorption, photocatalysis, or electrostatic attraction. For example, titanium dioxide nanoparticles have been used to remove nitrogen oxides from vehicle exhaust. [13].
- Soil Remediation: Heavy metals, organic pollutants, and pathogens are just a few of the contaminants that have been removed from soil using nanoparticles. They can eliminate contaminants by adsorption, oxidation, or microbial breakdown in addition to improving the quality of the soil. For example, carbon nanoparticles have been used to immobilize heavy metals in contaminated soils. [13].
- Environmental Monitoring: Air, water, and soil quality are among the environmental variables that nanoparticles have been used to monitor. They can facilitate remote and real-time parameter monitoring and offer high geographical and temporal resolution. The development of colorimetric sensors to identify mercury ions in water is one use for gold nanoparticles. [13].

1.3 SYNTHETHIC METHODS OF NANOPARTICLES

Nanoparticles can be made using a variety of methods, each with advantages and disadvantages. These are some commonly employed synthesis processes:

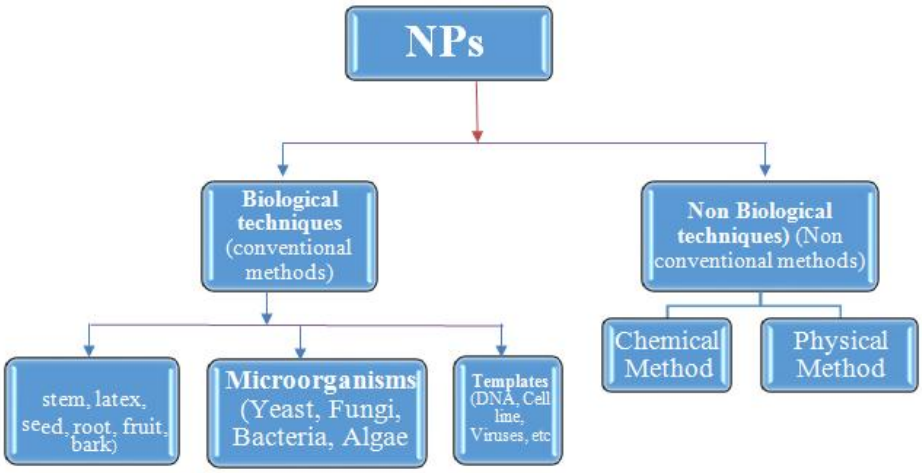


Figure 1: Synthesis Methods of Nanoparticles

1.3.1 Biological techniques

Biological approaches of nanoparticle manufacturing use plants, microbes, and their extracts to stabilize nanoparticles and reduce metal ions. It is commonly called "biosynthesis" or "biofabrication" of nanoparticles. This method of creating nanoparticles is affordable, scalable, and environmentally benign..

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- Microbial synthesis: This method uses bacteria, fungi, and yeast to stabilize nanoparticles and reduce metal ions. The produced nanoparticles are stabilized by the external proteins of the microbiological cells, which act as a reducing environment. Pseudomonas aeruginosa, Bacillus subtilis, and Escherichia coli are a few examples of microorganisms that have been utilized to produce metal nanoparticles. [7].
- Plant extract-based synthesis: This method produces nanoparticles by using plant extracts as a stabilizing and reducing agent. Plant extracts contain a variety of chemicals, including flavonoids, terpenoids, and alkaloids, which can stabilize nanoparticles and reduce metal ions. Nanoparticles have been made from a variety of plant materials, such as aloe vera, Azadirachta indica, and green tea extract.
- Enzyme-mediated synthesis: Enzymes such as lysozyme, lactate dehydrogenase, and alkaline phosphatase have been used in the synthesis of nanoparticles. Enzymes provide a specific setting for nanoparticle production, and the final particles are usually consistent in size and shape. [7].
- Cell-free extract-based synthesis: This method uses cell-free extracts from microorganisms or plants to create nanoparticles. The cell-free extracts contain the necessary reducing agents and enzymes for the production of nanoparticles. This method is simple and efficient for producing nanoparticles.

1.3.2 Non-Biological techniques

Non-biological methods of synthesizing nanoparticles use physical and chemical processes. These are often high-energy procedures that use mechanical, electrical, or thermal energy to create nanoparticles..

- Chemical reduction is the most used non-biological method for creating nanoparticles. This method reduces metal ions utilizing substances like citrate, sodium borohydride, and hydrazine. Various types of nanoparticles, such as copper, silver, and gold, can be produced using the chemical reduction process.[14].
- Sol-gel technique: The sol-gel process produces nanoparticles by converting a precursor solution into a gel and then drying it. The dried gel is then heated to create nanoparticles. This method can be used to produce metal oxide nanoparticles from materials such as iron oxide, zinc oxide, and titanium dioxide. [15].
- Electrochemical method: The electrochemical approach creates nanoparticles by applying an electrical current to a solution containing metal ions. The electrochemical process can produce a variety of nanoparticles, such as copper, silver, and gold. [16].

- Technique of laser ablation: In order to create nanoparticles, a metal target is ablated using a laser beam in the laser ablation technique. The laser ablation process can be used to create a variety of nanoparticles, including titanium dioxide, gold, and silver. [17].

1.3.3 Green synthesis

One method for producing nanoparticles is called "green synthesis," which uses natural resources such as fungi, microorganisms, and plants. This method is environmentally safe and produces nanoparticles with unique properties. Green synthesis has become popular because it can use fewer energy and dangerous chemicals. Attractive substitute for conventional methods of creating nanoparticles [18]. One example of green synthesis is the use of plant chemicals. Among the bioactive compounds present in plants that can serve as reducing and stabilizing agents in the formation of nanoparticles are polyphenols, flavonoids, and alkaloids. Several plant materials have been used to manufacture copper, gold, and silver nanoparticles. [18]. In a 2018 study that looked at the environmentally friendly production of silver nanoparticles, Kumar used an extract from the leaves of Eclipta prostrata. The study found that the silver nanoparticles made from plant extracts were highly stable and shown potent antibacterial action against both gram-positive and gram-negative bacteria. [18].

Green synthesis is not just more ecologically benign than traditional methods of creating nanoparticles. Green chemistry is economical because it makes use of readily available and inexpensive natural resources. Green synthesis is accessible to researchers in impoverished countries due to its simplicity and lack of costly equipment. [19].

"Green synthesis" is the process of creating various materials, including organic molecules, nanoparticles, and other materials, using environmentally responsible and sustainable methods. This process is also known as viable synthesis or

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environmentally friendly synthesis. Green synthesis aims to lessen the harmful impacts of chemical synthesis on the environment, human health, and resources by using renewable resources, non-toxic solvents, and reducing the energy and waste generated during the synthesis process. [20]. Microbial synthesis, synthesis based on plant extracts, and chemical reduction employing non-toxic reducing chemicals are some examples of green synthesis methods. In comparison to conventional chemical synthesis, green synthesis has several advantages, including minimal toxicity, cheap cost, scalability, and high yield. [20].

The biosynthesis of nanomaterials is a relatively new and mostly unexplored topic of study that has emerged from natural methods for the creation of nano- and micro-scaled inorganic materials. Green chemistry concepts and bio-organism-based synthesis can coexist. [21].

1.4 AZADIRACTA INDICA

Azadirachta indica, the scientific name for neem, is a versatile medicinal shrub that has long been utilized in traditional medicine. Indigenous to India, neem trees are widely cultivated. Throughout the tropics for its many advantages, such as its ability to repel insects and its antiviral, anti-inflammatory, antifungal, and anti-cancer qualities. Neem has recently been employed for the ecological synthesis of nanoparticles, which has garnered a lot of attention because to its sustainable and environmentally favorable qualities. [22].

Neem leaves, bark, seeds, and oil have been used to create nanoparticles with a variety of applications and properties. This article will look at the many parts of the Neem plant that have been utilized to make nanoparticles and their properties. [22].

1.4.1 Neem Leaves

Bioactive substances with strong anti-inflammatory, anti-bacterial, anti-fungal, anti-cancer, and antiviral effects, such as Azadirachta, Nimbidin, and Nimbidin, are abundant in neem leaves. Neem leaves were utilized in a green synthesis process to produce copper oxide, zinc oxide, gold, and silver nanoparticles. [23].

1.4.2 Neem Bark

Neem wood contains bioactive compounds such triterpenoids, flavonoids, and tannins that have potent anti-inflammatory, antibacterial, and anti-cancer properties. Neem wood has been used to manufacture environmentally friendly silver, gold, and zinc oxide nanoparticles.

1.4.3 Neem Seeds

Bioactive substances with strong anti-inflammatory, anti-bacterial, anti-fungal, and antiviral effects, such as Azadirachta, Nimbidin, and Nimbidin, are abundant in neem seeds. Environmentally friendly silver, gold, and iron oxide nanoparticles have been made from neem seeds. [24].

1.4.4 Neem Oil

Neem oil has been used to create environmentally friendly silver, gold, and iron oxide nanoparticles. In one of their experiments, Singh (2014) investigated the environmentally friendly synthesis of silver nanoparticles using neem oil. The study found that Neem oil-derived silver nanoparticles were incredibly stable and showed strong antibacterial action against a range of bacterial species. Anitha also conducted an experiment in 2020 on the environmentally friendly production of gold nanoparticles using neem oil. As stated Neem oil-derived gold nanoparticles shown potent anti-inflammatory and anti-cancer properties prior to the investigation [25].

1.4.5 Applications of Azadirachta indica

Nanoparticles derived from Azadirachta indica extract have a wide range of applications because of their unique physical and chemical properties. These nanoparticles may be made using the natural compounds of Azadirachta indica in an environmentally responsible way, which makes them very economical and sustainable. This article will examine the various applications of these nanoparticles and include recent studies that have examined their potential.

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1.4.5.1 Biomedical Applications of Azadirachta indica

Azadirachta indica extract was used to create nanoparticles, which may eventually find use in biomedicine. Their large surface area and tiny size make them ideal for use as medication delivery systems. Numerous studies indicate that these nanoparticles have been used to deliver anticancer, pain, and antibacterial medications. According to a recent study, doxorubicin, an anticancer drug, was effectively delivered to cancer cells by silver nanoparticles derived from Azadirachta indica extract, which significantly reduced the growth of tumors. [25, 26].

1.4.5.2 Environmental Applications of Azadirachta indica

Additionally, nanoparticles derived from Azadirachta indica extract have been found to have potential applications in environmental remediation. They can be used as catalysts in air and water purification systems, among other environmental systems. Numerous studies have shown that these nanoparticles can be utilized to remove organic pollutants, heavy metals, and pigments from the air and water. According to a recent study, silver nanoparticles derived from Azadirachta indica extract may be able to eliminate water chromium. [27, 28].

1.4.5.3 Food and Nutrition Applications of Azadirachta indica

Additionally, it has been found that the food and nutrition industry may benefit from the use of nanoparticles made from Azadirachta indica extract. They can be used as food additives and preservatives because of their strong antibacterial and antioxidant properties. The application of these nanoparticles in food preservation and nutritional value has been the subject of numerous investigations. Improvement. Silver nanoparticles derived from Azadirachta indica extract were found to be effective in inhibiting the growth of foodborne bacteria in milk in a recent study [29].

1.4.5.4 Energy Applications of Azadirachta indica

Nanoparticles made from Azadirachta indica extract have also been found to have potential use in the renewable energy sector. They can be used as catalysts in fuel cells, solar cells, and other energy conversion devices because of their exceptional catalytic activity and stability. Numerous studies have reported using these nanoparticles to produce hydrogen and methanol, two renewable fuels. A recent study found that using gold nanoparticles derived from Azadirachta indica extract, carbon dioxide may be electrochemically converted to formic acid. [30].

II. LITERATURE REVIEW

2.1 The green synthesis of nanoparticles using Azadirachta indica

Native to the Indian subcontinent, neem trees are also known as Azadirachta indica. It has been used in traditional medicine for thousands of years and has been found to have a wide range of pharmacological and biological properties. Neem extract has garnered a lot of attention lately for the environmentally friendly creation of nanoparticles because of its cost, non-toxicity, and eco-friendliness.

In 2023, Aloufi and his colleague published a study evaluating the structural, optical, and antibacterial properties of green (Sn(Fe:Ni)O2) nanoparticles derived from Azadirachta indica leaf extract. The intriguing physicochemical characteristics of metal oxide nanoparticles have led to their widespread recognition. Although there are alternative methods for producing these nanoparticles, the biological method utilizing plant extracts is recommended since it offers a straightforward, economical, efficient, quick, and environmentally friendly synthesis option. Tin (ferrous: nickel) dioxide (Sn (Fe:Ni)O2) nanoparticles were made in this work using a green technique and an Azadirachta indica leaf extract as a reducing agent. Dynamic light scattering (DLS), energy-dispersive X-ray (EDX) spectroscopy analysis, Feld emission scanning electron microscopy (FESEM), Fourier transform infrared (FTIR), and photoluminescence (PL) measurement were among the techniques used to characterize the synthesized nanoparticles. Furthermore, (Sn (Fe: Ni) O2) nanoparticles' antibacterial properties against bacterial strains of We looked into Escherichia coli, Pseudomonas aeruginosa, Bacillus subtilis, Klebsiella pneumonia, Streptococcus pneumoniae, and Staphylococcus aureus. The tetragonal Sn (Fe: Ni) O2 nanoparticles were identified using XRD patterns. The DLS spectra confirmed that the nanoparticles' hydrodynamic diameter was 143 nm. The FESEM image showed the spherical shape of the produced nanoparticles. Map data and chemical composites were examined using the EDAX spectrum. In the FTIR spectra, the

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Sn-O stretching band was found at 550 cm-1, and the Sn-O-Sn stretching band was found at 615 cm-1. Photoluminescence spectra were used to identify the surface flaws on the synthesized (Sn (Fe: Ni) O2) nanoparticles. When compared to traditional medicines like amoxicillin, (Sn(Fe:Ni)O2) nanoparticles showed higher antibacterial activity against all tested pathogens, as indicated by the inhibition zone, highlighting the enormous potential of nanoparticles in the healthcare sector. [31].

2.2 Biosynthesis of nanoparticles using leaf extract of neem

Azadirachta Indica Base Silver Nanoparticle Biosynthesis and Evaluation of Cytotoxic and Antibacterial Effects was the subject of a 2020 study by Asimuddin and his colleague. The development of sustainable and environmentally friendly processes for the production of metallic nanoparticles (NPs) is crucial given the growing environmental threat posed by climate change. Here, we offer a straightforward and environmentally responsible technique for producing silver nanoparticles (AgNPs) utilizing an aqueous solution of silver nitrate (AgNO3) and leaf extract from Azadirachta indica. [32]. The effects of temperature and leaf extract concentration on AgNP production are investigated. The optimal conditions for producing high-quality AgNPs were found to be 60 mg/mL leaf extract, 1 mM AgNO3, 30 minutes of reaction time, and 85 °C. The formation of the nanoparticles was confirmed by the surface Plasmon Resonance (SPR) of the AgNPs using UV-Vis analysis, which showed the largest absorption peak in the UV spectrum at 410 nm. Additional research on the antibacterial properties of biosynthesized AgNPs revealed inhibitory values of 0.5 g/ml for Escherichia coli and 1.0 g/ml for Staphylococcus aureus. A minimum inhibitory dosage of 15.6 g/mL was also required, according to in vitro cytotoxicity experiments using biosynthesized AgNPs against human acute lymphoblastic leukemia cells using the MTT assay. This method makes it possible to create AgNPs on a large scale, which is advantageous for the economy and the environment and may find value in biological applications. Leaf extract from Azadirachta indica was utilized as a reducing agent in the ongoing study to develop a non-toxic, safe, and environmentally acceptable method for producing AgNPs [32]. With this method, AgNPs with a high degree of crystallinity and a spherical shape were created under natural daylight. Numerous physicochemical parameters, such as temperature, length, the amount of leaf extract, and AgNO3, were evidently related to the quality and quantity of the generated AgNPs. A. In light of recent results and examination of previous research, the geographic location of the indica plant also plays a critical role in the properties of the generating AgNPs. However, collaboration between material scientists and natural product chemists is necessary to further investigate this. Though the research can be extended to include resistant strains, promising results might be obtained. The biosynthesized AgNPs have further proved their antibacterial activity against dangerous bacteria, indicating that they have bactericidal characteristics [32]. Furthermore, this study is the first to assess how biosynthesized AgNPs affect ALL patient PBMCs in vitro. The results demonstrate that leukemic cells cannot proliferate when biosynthesized AgNPs are present. This capacity can be further examined against a range of other cell lines to see if it is a viable therapy option. The proposed research is presently underway, and the expansion of the work presented will be published as a separate study at a later date. [32].

2.3 Others Synthetic Methods

Using an efficient and biocompatible home microwave method, Saravanan and his colleague in 2020 produced ZnO nanoparticles from Azadirachta indica leaf extract. utilizing a microwave-assisted solvothermal procedure and leaf extract from Azadirachta indica, ZnO nanoparticles were successfully synthesized utilizing a green synthesis technology. Powder X-ray diffraction was used to confirm the structure of greenly synthesized ZnO NPs as well as the lattice parameters. Energy dispersive X-ray analysis and scanning electron microscopy enable the examination of the greenly synthesized ZnO NPs' shape and elemental makeup. The photoconductivity analysis reveals the positive photoconductive nature of ZnO nanoparticles. [33]. ZnO NPs were effectively synthesized using a simple solvothermal method with leaf extract from Azadirachta indica. The well-established crystallization of the ZnO nanoparticles was shown by the PXRD patterns. Using Scherer's equation, the average particle size was determined. SEM was used to determine the materials' morphology and chemical makeup. As well as EDAX pictures. Photoconductivity measurement establishes the positive photo-conducting properties of ZnO NP. [33].

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III. METHODOLOGY

The synthesis of green nanoparticles has garnered a lot of interest recently because of its durability and environmental friendliness. The popular medical plant neem (Azadirachta indica) is a potential source for the production of nanoparticles. Neem plant extracts are used as a stabilizing and reducing agent in this procedure, which provides a detailed guide for the environmentally friendly synthesis of nanoparticles.

3.1 Material and Equipment's Required

- Neem leaves or neem extract: The neem (Azadirachta indica) leaf is the primary source of the bioactive compounds used in green synthesis. Throughout the production process, either fresh neem leaves or neem leaf extract can be utilized.
- Solvent: A suitable solvent is needed to extract the bioactive components from neem leaves. Water, ethanol, methanol, or a combination of these solvents are commonly used for this purpose.
- Reducing agent: A reducing agent is required to facilitate the reduction of metal ions and the formation of nanoparticles. It has been demonstrated that several of the bioactive compounds found in neem extract, including as phenolic, flavonoids, and terpenoids, have reducing effects..
- Metal precursor: A metal precursor or a salt containing those metal ions is required if you want to synthesize metal nanoparticles. Common metal precursors include copper sulphate (CuSO4), gold chloride (AuCl3), and silver nitrate (AgNO3).
- Reaction vessel: A suitable reaction vessel is needed to finish the synthesis process. Any container, like a glass flask or beaker, that is suitable for the reaction conditions can be utilized.
- Stirrer or magnetic stirring bar: To guarantee even mixing of the reaction components during the synthesis process, a stirrer or magnetic stir bar is helpful.
- Heating device: Depending on the synthesis procedure, a heating tool, such as a microwave or hot plate, may be required to control the temperature and speed up the reaction.
- Filtration system: After the synthesis, you will need a filtration apparatus, such as filter paper or a membrane filter, to extract the nanoparticles from the reaction mixture.

3.2 Collection and Preparation of Neem Plant Extract:

Gather fresh neem leaves or other parts of the plant. Rinse the collected plant material well in distilled water to get rid of any dirt or pollutants. Dry the plant material in the shade to prevent the degradation of active compounds. Using a mill and pestle, grind the dried neem leaves or plant parts into a fine powder. [34].

3.3 Preparation of Neem Extract:

Ten grams of neem powder should be weighed before being added to a sanitized beaker. Add a suitable solvent (1:10) (w/v) to the beaker, such as ethanol or distilled water. Use a magnetic stirrer to stir the mixture at room temperature for a certain period of time (e.g., 24 hours) in order to extract the bioactive compounds from the neem plant. [34].

3.4 Synthesis of Nanoparticles:

Step 2 involves measuring out 50 mL of neem extract and transferring it to a sterile reaction vessel, such as an Erlenmeyer flask. Add an appropriate precursor solution containing metal salts (like silver nitrate) to the reaction vessel. Use a magnetic stirrer to agitate the mixture for a set period of time, say two hours, at an appropriate temperature, like 60°C. Watch for a change in color in the reaction mixture, which indicates the formation of nanoparticles. It is usual practice to produce brownish nanoparticles using neem plant extract. [34].

3.5 Characterization of Nanoparticles:

Take a small sample of the synthesized nanoparticles and centrifuge the mixture to separate them from the rest of the solution. Wash the collected nanoparticles thoroughly with distilled water several times to remove any leftover

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impurities or unreacted materials. Characterize the synthesized nanoparticles using a variety of analytical techniques, including scanning electron microscopy, transmission electron microscopy (TEM), Fourier-transform infrared spectroscopy, X-ray diffraction, and UV-Vis spectroscopy. Ascertain the dimensions, form, crystallinity, and other relevant properties of the produced nanoparticles by examining the obtained data [34].

3.6 Evaluation of Nanoparticle Applications:

Analyze the produced nanoparticles' potential applications, including their antimicrobial, catalytic, and drug-transporting properties. Conduct specific experiments or studies to evaluate the nanoparticles' efficacy and performance in the intended application.

3.7 Optimization and Further Studies:

Adjust the experimental parameters (such as the neem extract concentration, reaction temperature, and reaction duration) to optimize the synthesis process and improve the nanoparticles' characteristics. Conduct additional research to better understand the fundamental mechanisms and interactions behind the green manufacturing of nanoparticles based on neem plant extract.

IV. CONCLUSION

In conclusion, a sustainable and eco-friendly method of producing nanoparticles is provided by the green synthesis of neem plant-derived nanoparticles. Biologically active substances included in neem extracts serve as stabilizing and reducing agents, doing away with the necessity for dangerous chemicals. The method yields nanoparticles with desired qualities for a range of applications and is inexpensive and easily scalable. Neem-derived nanoparticles are useful in many different domains because they have the potential to improve antibacterial, anticancer, and agronomic functions. Overall, neem plant-based green synthesis is a potential method for creating nanoparticles with several advantages for ecological sustainability and scientific progress.

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CONFLICT OF INTEREST

The writers don't have any conflicts of interest.

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Green Synthesis of Neem-Based Nanoparticles for Sustainable Applications

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Abstract: *An environmentally friendly and sustainable process is the green synthesis of neem plant nanoparticles. Because neem plant extracts contain a lot of bioactive components, they are used as capping and reducing agents. In the process, neem components are removed and mixed with metal precursor solutions. Under carefully regulated conditions, metal ions are reduced and nanoparticles are produced. These unique neem-synthesized nanoparticles are utilized in agriculture, medicine, environmental remediation, and catalysis. Because of its cost, environmental friendliness, and scalability, the green synthesis approach reduces the usage of hazardous chemicals. This could lead to advancements in green nanotechnology.*

Keywords: Neem plant, environmentally friendly, synthesized nanoparticles

I. INTRODUCTION

Nanoparticles will be crucial in creating future devices that are both environmentally friendly and human-friendly. Plant-based nanoparticle synthesis is a green chemistry technique that links nanotechnology and plant biotechnology. Metal ions are bio-reduced and nanoparticles are produced using plant extracts. Plant metabolites, including proteins, sugars, terpenoids, polyphenols, alkaloids, and phenolic acids, play a significant role in reducing metal ions into nanoparticles and enhancing their stability.

Nanotechnology is an interdisciplinary field that includes material science, biology, chemistry, physics, and health. Currently, various physical and chemical methods have been documented for producing metal nanoparticles. However, due to the general toxicity of the chemicals employed in conventional methods, developing eco-friendly processes for nanomaterial synthesis is crucial. Biotechnology integrates biological and nanotechnological techniques for the biosynthesis of nanoparticles.

1.1 Types of Nanoparticles

Nanoparticles are extremely tiny particles that range in size from one to one hundred nanometers (nm). They can be composed of metals, polymers, ceramics, or composites, possessing unique physical and chemical properties that distinguish them from their bulk counterparts.

1.2 APPLICATIONS OF NANOPARTICLES

1.2.1 Applications in Medicine

- **Drug Delivery:** Nanoparticles improve the therapeutic effectiveness of drugs while protecting them from immune system breakdown.
- **Imaging:** Used in CT, MRI, and fluorescence imaging for enhanced sensitivity and specificity.
- **Biosensing:** Detect biomolecules at low concentrations with high sensitivity.
- **Gene Therapy:** Deliver therapeutic genes to treat genetic disorders.

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1.2.2 Applications in Electronics

- **Memory Devices:** Enhance performance and reduce power consumption.
- **Sensors:** Detect food safety issues, environmental contaminants, and medical biomarkers.
- **Solar Cells:** Improve efficiency and reduce costs.
- **Flexible Electronics:** Develop durable, stretchable electronic components.

1.2.3 Applications in Energy

- **Catalysis:** Improve reaction efficiency in energy-related processes.
- **Energy Storage:** Enhance battery and supercapacitor performance.
- **Solar Energy:** Improve photovoltaic efficiency.

1.2.4 Applications in Environmental Science

- **Water Treatment:** Remove heavy metals and contaminants.
- **Air Purification:** Eliminate pollutants using adsorption and photocatalysis.
- **Soil Remediation:** Immobilize heavy metals and organic pollutants
- **Environmental Monitoring:** Provide real-time detection of pollutants.

1.3 SYNTHETIC METHODS OF NANOPARTICLES

1.3.1 Biological Techniques

- **Microbial Synthesis:** Uses bacteria, fungi, and yeast for nanoparticle production.
- **Plant Extract-Based Synthesis:** Utilizes plant metabolites to reduce metal ions.
- **Enzyme-Mediated Synthesis:** Employs specific enzymes to create nanoparticles.
- **Cell-Free Extract-Based Synthesis:** Uses plant or microbial extracts without living cells.

1.3.2 Non-Biological Techniques

- **Chemical Reduction:** Uses reducing agents such as citrate and sodium borohydride.
- **Sol-Gel Technique:** Converts precursor solutions into nanoparticles.
- **Electrochemical Method:** Utilizes electrical currents to produce nanoparticles.
- **Laser Ablation:** Uses laser beams to fragment metal targets into nanoparticles.

1.3.3 Green Synthesis

Green synthesis employs natural resources such as plants, fungi, and microorganisms to create nanoparticles. This method is environmentally safe and economically viable, using bioactive plant compounds like polyphenols, flavonoids, and alkaloids as reducing and stabilizing agents.

Green synthesis offers a sustainable approach to nanoparticle production, reducing environmental hazards while maintaining efficiency. For instance, silver nanoparticles synthesized using **Eclipta prostrata** leaf extract demonstrated significant stability and antimicrobial activity. The method is also cost-effective, eliminating the need for expensive reagents and equipment, making it accessible for researchers worldwide.

Green synthesis aligns with the principles of sustainable chemistry, ensuring a safer and more environmentally responsible production of nanoparticles for various applications in medicine, agriculture, energy, and environmental science.

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Tea Leaves to Titration: Simplifying Caffeine Extraction and Analysis

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Abstract: *This research paper focuses on the extraction and analysis of caffeine from tea leaves using a simple titration method. The primary objective was to evaluate the caffeine content in various tea types, while employing a straightforward and accessible analytical technique. The caffeine was extracted from the tea leaves through a solvent extraction process, followed by quantification through titration, which allowed for the precise determination of caffeine concentrations. The study assessed the efficiency of the extraction process and analyzed the impact of factors caffeine yield. Results showed variations in caffeine content across different samples, highlighting the influence of specific extraction conditions. This research not only demonstrates the effectiveness of simple titration as an analytical method for caffeine determination but also provides insights into the caffeine composition of common teas. The findings are valuable for both consumers and manufacturers interested in understanding caffeine levels in tea products.*

Keywords: Caffeine extraction, tea leaves, Soxhlet, ultrasonic extraction, analytical methods, sustainability, tea types, nutritional analysis

I. INTRODUCTION

Remote Caffeine ($C_8H_{10}N_4O_2$) is a naturally occurring alkaloid found in more than 60 plant species, most notably in tea, coffee, cocoa, and kola nuts. It is widely consumed globally in various forms, particularly through beverages such as coffee, tea, and energy drinks. Caffeine acts as a stimulant of the central nervous system and is known to improve alertness, concentration, and reduce fatigue. It is one of the most consumed psychoactive substances in the world. Tea, in particular, has become a staple beverage in various cultures, valued not only for its stimulating effects but also for its purported health benefits. Tea is rich in bioactive compounds such as polyphenols, flavonoids, and tannins, which are believed to contribute to its antioxidant, anti-inflammatory, and anticancer properties.

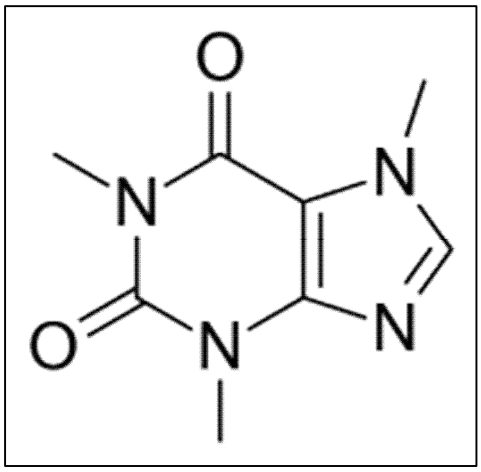
The extraction of caffeine from plant sources, particularly from tea leaves, has been an area of significant scientific interest due to its wide range of industrial applications. These include the production of caffeinated beverages, pharmaceuticals, food additives, and even cosmetics. The process of extracting caffeine from tea leaves is not only of commercial importance but also holds potential for optimizing the utilization of plant materials, which would otherwise be discarded after processing. This project aims to explore different extraction methods for caffeine from tea leaves, focusing on their efficiency, the factors influencing caffeine yield, and the subsequent analysis of the extracted caffeine using high-precision techniques.

Caffeine in Tea: Chemical Structure and Physiological Effects:

Caffeine is classified as a methylxanthine alkaloid, a group of naturally occurring compounds that include theobromine and theophylline. It is an odorless, bitter-tasting compound that is water-soluble, which allows it to easily dissolve in hot water when tea leaves are brewed. The chemical structure of caffeine consists of a purine base, which is closely related to adenine and guanine, components of DNA. The molecule contains three methyl groups ($-CH_3$) attached to nitrogen atoms, which makes it a highly bioactive compound.[1]

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1.1. Skeletal formula of caffeine

The physiological effects of caffeine are well-documented and can vary depending on the dose consumed. At lower doses, caffeine primarily functions as a stimulant for the central nervous system by blocking adenosine receptors in the brain. Adenosine is a neurotransmitter responsible for promoting relaxation and sleep, and when its activity is inhibited by caffeine, it leads to increased alertness and reduced fatigue. In higher doses, caffeine can increase heart rate and blood pressure, stimulate diuresis (increased urination), and may even have adverse effects such as jitteriness or insomnia.

Friedrich Ferdinand Runge etal. Isolated relatively pure caffeine for the first time. In 1827, Oudry isolated "theine" from tea, but it was later proved by Mulder and Jobat that theine was the same as caffeine. The structure of caffeine was elucidated near the end of the 19th century by Hermann Emil Fischer, who was also the first to achieve its total synthesis. This was part of the work for which Fischer was awarded the Nobel Prize in 1902. [1]

Clementz and Dailey (1988) etal. determined Pure caffeine occurs as odourless, white, fleecy masses, glistening needles of powder. Its molecular weight is 194.19 g/gmol, melting point is 236, point at which caffeine sublimes is 178, at atmospheric pressure, pH is 6.9 (1% solution), specific gravity is 1.2, volatility is 0.5 %, vapour pressure is 760 mm Hg at 178, solubility in water is 2.17 g per 100 mL water at 25, and vapour density is 6.7. [2]

Gebely, Mumin (2006) etal. reported that; Every time we drink tea, coffee, cocoa, chocolate or cola, we are giving our body a hit of caffeine. Alcohol and nicotine, along with caffeine are the three most widely used mood-affecting drugs in the world. The effects of caffeine on human being depend on concentrations. Consuming high dosage of this compound causes various physiological and psychological effects which include stimulation of the central nervous system. [3]

RESEARCH METHODOLOGY

In this experiment, you will perform a liquid-liquid extraction of the tea solution with an organic solvent, dichloromethane, to separate the caffeine from the basic tea solution and away from the tannins, gallic acid and the remainder of the tea components. Since caffeine is more soluble in the organic solvent dichloromethane (CH2Cl2) than in water, it partitions primarily into the dichloromethane. The tannins and gallic acid, being acidic compounds, are converted to water soluble salts by the sodium carbonate and remain in the aqueous layer during the extraction. The other components of tea are not very soluble in dichloromethane. Therefore, the extraction of tea solution with dichloromethane removes virtually no other compound but caffeine. The solid caffeine can then be isolated by evaporation of the low- boiling dichloromethane and identified by its melting point and mass spectrum.

Preparation of Sample

7 grams of tea (or) coffee were taken in 150 ml of distilled water and 5g of sodium carbonate is added. The solution was then heated and was kept at 100□C for 15 min. Then, the solution was cooled and filtered using Whatman filter paper.

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Sample is heated

Caffeine Extraction Procedure

This sample was placed into a separating funnel and 6 ml of dichloromethane (DCM) was added. The caffeine was extracted by inverting the funnel at least three times, venting the funnel after each inversion. Vigorous shaking will produce an intractable emulsion, while extremely gentle mixing will fail to extract the caffeine.



Bottom layer containing dichloromethane

The bottom layer containing dichloromethane (DCM) was removed to a clean flask, leaving behind the layer of water and the extraction procedure was repeated twice more and the solvent layers combined.

Separation of Caffeine

The dichloromethane was evaporated from the extract by heating the flask on mantle or by covering with perforated aluminium foil and leave it for some time and allow it to get evaporated and it was recovered in the other beaker using Heat Reflux Extraction method.

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Caffeine

The residue obtained was whitish powder which was considered to be pure caffeine. The mass of flask with residue was measured on electronic scale.

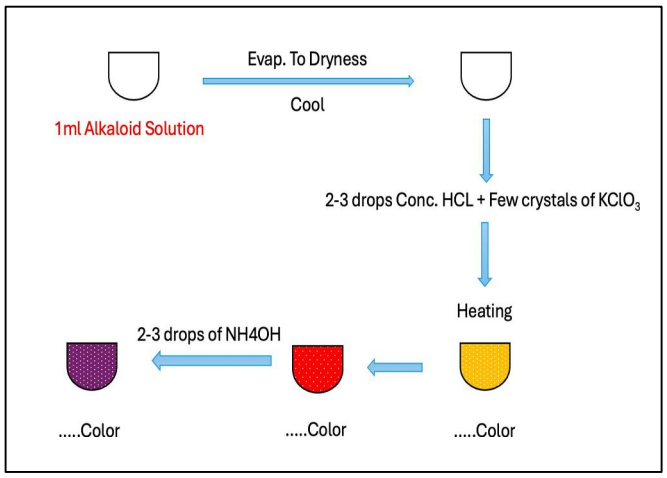
Murexide test

Confirmative Test for Caffeine Detection Murexide test can be carried out for caffeine detection as follows: In a watch glass, small amount of a sample with 2-3 drops of concentrated hydrochloric acid is mixed. Use a glass rod for mixing. Then we add a few small crystals of potassium chlorate and mix well.

Heat the watch glass until the sample is dry.

Allow to cool.

Add a drop of ammonium hydroxide solution. The sample should turn purple.



Murexide test

Results:

Extraction of caffeine from tea and coffee was achieved by using Dichloromethane as an extracting solvent.

Sr. No	Sample	Amount of Sample (g)	Caffeine Extracted (g)	Caffeine Yield (%)
1	Tea	7	0.226	3.23%
2	Coffee	7	0.345	4.93%

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Leave the test tube in the warm water bath. Add 2-propanol a drop at a time until the solid dissolves. Use the minimum amount required. This should be no more than 2 millilitres.

Now you can remove the test tube from the water bath and allow it to cool to room temperature.

Add 1 ml of hexane to the test tube. This will cause the caffeine to crystallize out of solution.

Carefully remove the liquid using a pipette, leaving the purified caffeine.

Wash the caffeine with 1 ml of a 1:1 mix of hexane and diethyl ether. Use a pipette to remove the liquid. Allow the solid to dry before weighing it to determine your yield.

With any purification, it's a good idea to check the melting point of the sample. This will give you an idea of how pure it is. The melting point of caffeine is 234 °C.

II. CONCLUSION

A method has been developed for the extraction and purification of caffeine from tea and coffee. The caffeine was obtained through liquid-liquid extraction followed by recrystallization, ensuring a purified final product. The study highlights the importance of selecting optimal extraction conditions to maximize yield. Caffeine is known to act as a central nervous system stimulant, and its consumption must be monitored, particularly in individuals with high blood pressure or heart conditions. Excessive intake can lead to adverse health effects, making awareness essential for consumers. Research studies indicate that caffeine, though widely consumed, should be treated as a bioactive compound rather than a regular dietary component. Moderate consumption is generally considered safe, but overuse can lead to negative physiological effects. The findings from this study provide useful insights into caffeine extraction techniques and their practical applications. Understanding caffeine levels in beverages helps in making informed choices regarding daily intake. This research contributes to the broader discussion on caffeine's role in human health, ensuring that both consumers and healthcare professionals remain aware of its potential effects. Future studies could explore alternative extraction techniques and their efficiency in different caffeine-containing beverages.

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Eco-Friendly Nanoparticle Synthesis: A Green Chemistry Approach

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Abstract: *Nanotechnology and biomedical sciences offer a vast potential for research and medical applications at the molecular and cellular levels. In recent years, biosynthesis of nanoparticles has gained significant attention as an eco-friendly and cost-effective alternative to conventional chemical and physical methods. The use of plant-mediated synthesis in nanoparticle production represents a sustainable approach, bridging the gap between nanotechnology and green chemistry. This method enables the synthesis of nanoparticles under ambient conditions, at neutral pH, and with minimal environmental impact.*

Plants, often referred to as nature's "chemical factories," provide an efficient and sustainable platform for nanoparticle synthesis. They require minimal maintenance and offer a wide range of bioactive compounds that facilitate nanoparticle formation. This study explores the evolution of nanotechnology, the properties of nanoparticles, diverse synthesis strategies, and the comparative advantages and limitations of different approaches. Additionally, it highlights the broad spectrum of applications that green-synthesized nanoparticles can offer in various fields..

Keywords: Green Synthesis, Nanoparticles, Sustainable Approach, Eco-friendly, Plant-Mediated Synthesis

I. INTRODUCTION

Nanoparticles (NPs), with at least one dimension ranging between 1 and 100 nm, serve as an intermediate between bulk materials and atomic or molecular structures. Their extremely small size, high surface area, and free reactive bonds contribute to their unique properties and enhanced reactivity. Although scientists have recognized the potential of biological systems in reducing metal precursors since the 19th century, the underlying mechanisms remain largely unexplored.

The growing interest in green synthesis has been driven by the need for eco-friendly, cost-effective methods that eliminate the use of hazardous chemicals and excessive energy consumption. Unlike conventional physicochemical approaches, biological synthesis utilizes natural reducing, stabilizing, and capping agents, making it a sustainable alternative. The rapid pace of industrialization, urbanization, and population growth has led to environmental degradation, with increasing amounts of toxic substances being released into the atmosphere. This pressing issue underscores the importance of exploring nature's vast resources, which can inspire advancements in nanoparticle synthesis.

Given that nanoparticles are extensively used in applications involving direct human contact, there is an urgent need to develop synthesis methods that avoid toxic reagents. While conventional physical and chemical methods can produce nanoparticles, they often require significant financial investment and present challenges such as the use of harmful solvents, the generation of hazardous byproducts, and inconsistencies in surface structure. Chemical synthesis, in particular, may involve multiple reactive species, leading to unpredictable particle behavior and potential risks to both human health and the environment. In contrast, green synthesis offers a safer, more sustainable alternative, aligning with the principles of environmentally responsible nanotechnology.

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II. REVIEW OF LITERATURE

Recent research has demonstrated that plant extracts serve as effective precursors for synthesizing nanomaterials in an environmentally friendly manner. Various plant-based approaches have been successfully employed to produce nanoparticles of metals such as cobalt, copper, silver, gold, palladium, platinum, zinc oxide, and magnetite. Over the past decade, it has been observed that numerous biological systems—including plants, algae, diatoms, bacteria, yeast, fungi, and even human cells—are capable of converting inorganic metal ions into metal nanoparticles. This transformation occurs due to the reductive properties of proteins and metabolites present within these organisms.

The biological synthesis of metallic nanoparticles is of significant interest due to their distinctive optical and chemical characteristics. Several plant species have been effectively utilized for the rapid extracellular synthesis of gold and silver nanoparticles. For instance, extracts from Geranium (Pelargonium graveolens), lemongrass (Cymbopogon flexuosus), camphor (Cinnamomum camphora), neem (Azadirachta indica), Aloe vera, tamarind (Tamarindus indica), and Indian gooseberry (Emblica officinalis) have been shown to reduce Au(III) ions into gold nanoparticles (Au^0) and silver nitrate into silver nanoparticles (Ag^0).

Additionally, plant-derived biomasses such as wheat (Triticum aestivum), oat (Avena sativa), and alfalfa (Medicago sativa), along with modified hop biomass and water remnants from soaked Bengal gram beans (Cicer arietinum), have been successfully utilized for gold nanoparticle synthesis. Interestingly, gold nanoparticles have also been synthesized within living plant tissues of Medicago sativa, Chilopsis linearis, and Sesbania seedlings. Furthermore, alfalfa sprouts and germinating seeds of Brassica juncea have been used for the biological synthesis of silver nanoparticles. These eco-friendly methods align with the principles of green chemistry, demonstrating the potential of biological entities—including bacteria, fungi, and plants—as sustainable alternatives for nanoparticle production.HISTORY:

The emergence of materials at the nanoscale has sparked great interest among researchers, with the potential to revolutionize material science in the 21st century and beyond. The term "Nano" originates from the Greek word for "dwarf" and signifies "a billionth." A nanometer (nm) is one-billionth of a meter, approximately 250 millionths of an inch, or about 1/80,000th the diameter of a human hair. It is also roughly ten times the size of a hydrogen atom. The concept of "Nanotechnology" was first introduced by Prof. Norio Taniguchi from Tokyo Science University in 1974 to describe the precise fabrication of materials at the nanometer scale. Later, Eric Drexler popularized the term in his 1986 book Engines of Creation: The Coming Era of Nanotechnology.

Although nanoparticles are often regarded as a modern scientific advancement, their use dates back centuries. Artisans in Mesopotamia as early as the ninth century utilized nanoparticles to create a shimmering effect on pottery. Even today, medieval and Renaissance ceramics often display a metallic gold or copper-like shine. This luster effect results from a thin metallic film applied over a transparent glaze. The brilliance remains visible if the layer has withstood oxidation and environmental wear over time.

The luster effect was achieved by dispersing silver and copper nanoparticles within the glassy structure of ceramic glazes. Ancient artisans created these nanoparticles by applying a mixture of silver and copper salts, oxides, vinegar, ochre, and clay onto pre-glazed pottery. The objects were then placed in a kiln and heated to approximately 600°C in a reducing atmosphere. At high temperatures, the softened glaze allowed metal ions to migrate toward the outer surface, where they were reduced to their metallic state and assembled into nanoparticles. These nanoparticles produced the unique color and optical effects seen in lusterware.

NANO-SCIENCE:

It has been well established that plants have the ability to reduce metal ions both on their surfaces and within various tissues and organs, even those distant from the site of ion penetration. Nanotechnology, an interdisciplinary field integrating biology, physics, chemistry, and materials science, plays a crucial role in developing innovative nanoscale materials for biomedical and pharmaceutical applications. Nanoparticles possess multifunctional properties and hold significant potential in diverse sectors, including medicine, nutrition, and energy.

One of the key challenges in biomaterial science is the biogenic synthesis of monodispersed nanoparticles with controlled sizes and shapes. However, advancements in this field have significantly contributed to the pharmaceutical industry, aiding in the treatment of bacterial and viral infections. Nanomedicine has revolutionized healthcare by

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providing novel solutions for managing chronic diseases. As a result, the eco-friendly synthesis of nanoparticles is being recognized as a fundamental approach for future generations to combat various health conditions.

Beyond medicine, nanoparticles have extensive applications in agriculture and plant sciences. For example, bio-processing technologies utilizing nanoparticles can convert agricultural and food waste into energy and valuable by-products. This review focuses on the biosynthesis of metallic nanoparticles derived from plants and their applications across medical and commercial industries, including wastewater treatment, cosmetics, and the food sector. Additionally, it examines the benefits and limitations of nanoparticle use across various fields.

Despite their numerous advantages, a significant challenge in translating nanoparticle-based diagnostic and therapeutic approaches into mainstream medicine is the concern over their potential toxicity. Some nanoparticles, particularly unmodified copper or silver nanoparticles, may accumulate in bodily tissues and pose health risks. However, surface modification of nanoparticles can alter their chemical and biological properties, reducing toxicity while enhancing their effectiveness for specific applications.

GREEN SYNTHESIS:

Nature has developed various mechanisms for producing nano- and microscale inorganic materials, leading to the emergence of a relatively new and largely untapped research area focused on the biosynthesis of nanomaterials. Utilizing biological organisms for synthesis aligns with the principles of green chemistry, ensuring an environmentally friendly, non-toxic, and safe approach. The "green synthesis" of nanoparticles employs sustainable methods that eliminate the need for hazardous chemicals.

Nanoparticles produced through biological techniques or green technology exhibit diverse characteristics, enhanced stability, and optimal size control due to their one-step synthesis process. A wide range of methods can be used to generate nanoparticles, including chemical, physical, biological, and hybrid techniques. Some advanced fabrication methods include laser desorption, lithography, sputter deposition, molecular beam epitaxy, and layer-by-layer growth. Additionally, chemical techniques such as electro-deposition, sol–gel processing, chemical solution deposition, chemical vapor deposition, the Langmuir-Blodgett method, catalytic synthesis, hydrolysis, co-precipitation, and wet chemical approaches are frequently employed.

However, conventional chemical and physical synthesis methods often rely on high-energy radiation, concentrated reducing agents, and stabilizers that pose risks to both human health and the environment. In contrast, biological synthesis offers a sustainable alternative, utilizing a single-step bio-reduction process that requires minimal energy while producing eco-friendly nanoparticles.

Green nano-biotechnology involves the synthesis of nanoparticles and nanomaterials through biological processes using microorganisms, plants, viruses, or their byproducts, such as proteins and lipids, with the aid of biotechnological tools. Nanoparticles produced through green technology offer several advantages over those synthesized using conventional physical and chemical methods. These eco-friendly approaches eliminate the need for costly chemicals, require less energy, and generate non-toxic products and byproducts.

The 12 principles of green chemistry serve as a global framework for researchers, scientists, and chemical technologists to develop safer chemical processes and materials. In this context, green nanobiotechnology provides a sustainable alternative for producing biocompatible and stable nanoparticles. A common method for plant-based synthesis of metallic nanoparticles involves using dried plant biomass as a natural reducing agent and metallic salts as precursors.

Silver, known for its medicinal and preservative properties for over 2,000 years, is often used in nanoparticle synthesis. Biological synthesis follows a bottom-up approach, where nanoparticles are formed with the help of natural reducing and stabilizing agents. This process typically includes three essential steps: selecting a suitable solvent medium, choosing an environmentally safe reducing agent, and using a non-toxic capping agent to stabilize the nanoparticles.

Physical properties of nanoparticles:

Nanoparticles exhibit unique properties due to their large surface area, which significantly influences their behavior compared to bulk materials. They come in various colors, such as yellow, gold, and gray, with gold nanoparticles displaying significantly lower melting points (~300°C for 2.5 nm particles) compared to bulk gold (1064°C). Silver

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nanoparticles, in particular, possess remarkable physicochemical characteristics, including high electrical and thermal conductivity, surface-enhanced Raman scattering, catalytic activity, chemical stability, and nonlinear optical properties. In photovoltaic applications, nanoparticles absorb solar radiation more efficiently than bulk materials or thin films, enhancing energy conversion. Their small size provides significant advantages in drug delivery systems. First, they can penetrate tiny capillaries and be absorbed by cells, ensuring efficient drug accumulation at the target site. Second, the use of biodegradable materials in nanoparticle formulations allows for controlled and sustained drug release over days or even weeks.

Beyond medicine, nanotechnology has the potential to revolutionize various industries. In electronics, it contributes to advancements in nano-diodes, nano-transistors, OLEDs, plasma displays, and quantum computing. The energy sector also benefits, as nanotechnology enhances batteries, fuel cells, and solar cells, making them more compact and efficient. Additionally, manufacturing industries utilize nanomaterials such as aerogels, nanotubes, and nanoparticles to develop stronger, lighter, and more durable products.

Nanoparticles offer several advantages in drug delivery, including precise size control and effective encapsulation for drug protection. They improve therapeutic efficiency and bioavailability while reducing variability due to food intake and enhancing drug stability. Moreover, nanoparticle-based drug formulations offer prolonged retention at target sites and avoid toxicity issues associated with traditional carriers. Large-scale production and sterilization of nanoparticles pose no significant challenges, apart from the need to minimize organic solvent use.

Despite these benefits, nanotechnology also has drawbacks. One major concern is the potential loss of jobs in traditional manufacturing and agriculture due to automation and material advancements. Additionally, it raises security risks, as the technology could lead to the development of more accessible and powerful atomic weapons. Health risks are another issue, as inhaling nanoparticles can cause respiratory problems and other serious conditions, given their ability to penetrate lung tissues. Furthermore, the high cost of nanotechnology research and development makes it an expensive field, and manufacturing nanomaterials remains complex, contributing to the higher cost of nanotechnology-based products.

III. CONCLUSION

While nanotechnology has significantly improved the standard of living, it has also contributed to environmental pollution, including contamination of air and water. This specific type of pollution, referred to as nano pollution, poses serious risks to living organisms. Despite the rapid advancements in nanotechnology, the potential negative impacts of nanoparticles remain underexplored, particularly concerning their role in drug delivery systems.

One concern in nanoparticle-based drug delivery is the widespread use of polyvinyl alcohol as a stabilizing agent, which may raise toxicity issues. Additionally, nanoparticles have limited targeting capabilities, making continuous therapy challenging. Their application in drug delivery has been associated with cytotoxic effects, inflammation in lung tissues, and disruption of autonomic balance, which can directly affect cardiovascular function. Furthermore, nanoparticles may exhibit unpredictable behaviors, such as uncontrolled particle growth, unexpected gelation, instability in polymeric transitions, and sudden burst release of drugs, posing challenges in medical applications.

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Green Synthesis of Copper Nanoparticles for Antimicrobial and Water Purification Applications

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Abstract: *The green synthesis of nanoparticles (NPs) has gained significant attention in nanotechnology due to its eco-friendly and cost-effective approach. Copper nanoparticles (Cu NPs) exhibit notable properties, including antimicrobial activity and disinfecting capabilities. Green-synthesized NPs are highly effective in heavy metal removal and wastewater treatment, addressing global water quality concerns. The plant-mediated synthesis of nanomaterials is advantageous as it utilizes naturally occurring biomolecules for metal ion reduction and stabilization. Silver nanoparticles were successfully synthesized within 10 minutes and demonstrated antibacterial effects. Similarly, green-synthesized Cu NPs have been employed as nano-adsorbents for the removal of pharmaceutical contaminants such as ibuprofen (Ibu), naproxen (Nab), and diclofenac (Dic) from wastewater. Optimal removal was achieved under conditions of 298 K, pH 4.5, and 60 minutes, with the adsorption process being endothermic. Additionally, copper-enriched paper sheets exhibited a bacterial reduction of log 8.8 against E. coli. The CuNP-infused paper filter presents a promising, cost-effective solution for water purification..*

Keywords: Wastewater Treatment, Nanoparticles, Copper, Green Synthesis, Applications, Characterization, Disinfection

I. INTRODUCTION

Domestic wastewater refers to water discharged from households due to daily activities such as cooking, bathing, washing, and sanitation. The composition and strength of domestic wastewater vary depending on factors like per capita water usage, dietary habits, lifestyle, and living standards. These variations are observed on an hourly, daily, and seasonal basis, with households in developed countries typically consuming more water than those in developing regions.

The application of green-synthesized nanoparticles (NPs) in water and wastewater treatment has gained significant attention due to their efficiency and eco-friendly nature. Green nanotechnology is an emerging field that focuses on synthesizing nanoparticles using biological methods, which are considered safer, more sustainable, and cost-effective compared to conventional physical and chemical approaches. Various biological sources, including plants, bacteria, algae, and fungi, have been employed for nanoparticle synthesis, with plant-mediated methods being the most widely explored due to their ease of use and sustainability. These green-synthesized NPs exhibit excellent stability and efficiency in removing heavy metals and organic pollutants from wastewater, enabling water purification for reuse and recycling. Their application in wastewater treatment presents a viable solution to global water quality challenges.

Copper nanoparticles (Cu NPs) have gained significant interest due to their distinctive physical and chemical properties, as well as their cost-effectiveness. Cu NPs are known for their antimicrobial and disinfecting capabilities, along with their high surface area-to-volume ratio, which enhances their stability and effectiveness. These nanoparticles facilitate chemical and biological reactions efficiently. Their small size and high specific surface area contribute to strong adsorption properties and high reactivity, making them effective in removing heavy metals, organic pollutants, inorganic anions, and bacteria from wastewater.

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II. OBJECTIVES

The primary goal of this study is to disinfect domestic wastewater using green-synthesized nanoparticles and explore its potential for reuse in various applications.

Green Synthesis of Copper Oxide Nanoparticles and Their Applications

1. Green Synthesis of Copper Oxide Nanoparticles and Their Role in Biginelli Reaction, BTB Photodegradation, and Antibacterial Activity

Copper oxide nanoparticles (CuO NPs) were synthesized through an environmentally friendly approach using *Cordia sebestena* flower extract. The synthesized nanoparticles, with a size range of 20–35 nm as confirmed by TEM and DLS analysis, demonstrated good crystallinity and stability, as indicated by the TEM-SAED pattern. These nanoparticles were tested for antibacterial properties against common waterborne pathogens, including *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella pneumoniae*. The results highlighted their potential for water disinfection. Additionally, CuO NPs exhibited promising applications in photolytic degradation, suggesting their effectiveness in breaking down contaminants in wastewater. Their antibacterial properties further validated their biological significance in wastewater treatment.

2. Green-Synthesized Copper Nano-Adsorbent for the Removal of Pharmaceutical Pollutants from Wastewater

Copper nanoparticles (Cu NPs) with high purity and stability were synthesized using extracts from *Tilia* leaves. Characterization studies revealed that these nanoparticles were well-dispersed, with spherical and semispherical shapes, and their sizes ranged between 4.7 and 17.4 nm. These nanoparticles were employed as nano-adsorbents for the removal of non-steroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen (Ibu), naproxen (Nab), and diclofenac (Dic) from wastewater. The adsorption process was spontaneous, endothermic, and physical in nature. Under optimal conditions (temperature: 298 K, pH: 4.5, Cu NP dosage: 10.0 mg, time: 60 minutes), the removal efficiencies for Ibu, Nab, and Dic were 74.4%, 86.9%, and 91.4%, respectively. The maximum monolayer adsorption capacities for these pharmaceuticals were calculated as 36.0 mg/g (Dic), 33.9 mg/g (Nab), and 33.9 mg/g (Ibu). These findings indicate that green-synthesized Cu NPs could be an efficient and sustainable alternative for removing pharmaceutical contaminants from wastewater.

3. Synthesis and Impregnation of Copper Oxide Nanoparticles on Activated Carbon for Water Pollutant Removal

Copper oxide nanoparticles were synthesized via a green method and impregnated onto vegetal activated carbon (VAC) using *Punica granatum* (pomegranate) leaf extract as a reducing and stabilizing agent. A methodology adapted from Wang et al. was followed to synthesize CuO NPs, which were then supported on activated coconut carbon. The CuO nanoparticles exhibited sizes between 104 and 165 nm, while those impregnated on activated carbon measured between 40 and 78 nm. Among the synthesized samples, carbon impregnated with 1.5% Cu for 24 hours demonstrated improved pollutant removal capacity. While the activated carbon effectively removed organic contaminants such as atrazine, diclofenac, caffeine, and nitrates, the addition of CuO nanoparticles enhanced nitrate ion removal efficiency by more than four times. The study suggests that the green-synthesized CuO-impregnated activated carbon offers a sustainable, cost-effective alternative for water purification, particularly for nitrate removal.

4. Disinfection of Drinking Water Using Algae-Mediated Green-Synthesized Copper Oxide Nanoparticles and Their Toxicity Evaluation

Copper oxide nanoparticles (CuO NPs) were synthesized using algal extracts under controlled conditions, with a particle size of approximately 3.6 nm. The characteristics of the synthesized nanoparticles were influenced by factors such as stirring speed, pH, extract concentration, and Cu^{2+} ion concentration. These nanoparticles exhibited strong antibacterial activity against *Escherichia coli* in surface water samples, with an optimal dosage of 50 mg/L for effective bacterial reduction.

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Toxicity assessments were conducted to evaluate the potential environmental and health risks of CuO NPs. Fish blood samples were analyzed for mononuclei formation, and cytotoxicity was tested on human gastric epithelium and Chinese hamster ovarian cell lines. Since surface water is frequently contaminated by industrial and domestic waste, leading to bacterial proliferation, the use of CuO NPs in water treatment offers an efficient alternative to conventional disinfection methods.

Currently, the activated sludge process is a widely used disinfection method, but its efficiency is often reduced due to bulking issues. Sequential Batch Reactors (SBRs) have demonstrated about 87% efficiency in Chemical Oxygen Demand (COD) removal. However, recent advancements in nanotechnology have introduced nanoparticle-based treatments, including nano-membranes and powders, which have shown promising results in removing heavy metals and biological contaminants.

The properties of green-synthesized CuO NPs are influenced by factors such as pH, temperature, Cu ion concentration, and incubation time. Unlike conventional physical and chemical synthesis methods, which often involve toxic chemicals and require extended processing times, green synthesis utilizes plant-derived reducing agents that facilitate nanoparticle formation in a safer and more eco-friendly manner. Polyphenols and phytochemicals in plant extracts act as capping agents during the synthesis process, ensuring stability and functionality. Algae, in particular, are rich in polyphenols, making them suitable for nanoparticle synthesis. The resulting CuO NPs are non-toxic, biodegradable, and environmentally sustainable. Due to their high growth rate and biomass productivity, algae-based nanoparticle synthesis provides an economically viable method for water disinfection and purification.

Green Synthesis of Copper Oxide Nanoparticles and Their Multifunctional Applications

Green Synthesis of CuO Nanoparticles Using Cordia Sebestena Flower Extract

Copper oxide nanoparticles (CuO NPs) were successfully synthesized through an eco-friendly approach using an aqueous extract of *Cordia sebestena* flowers. Characterization using TEM and DLS techniques confirmed that the nanoparticles ranged in size between 20 and 35 nm, with TEM-SAED analysis indicating crystallinity and stability. The synthesized CuO NPs were tested for antimicrobial activity against both Gram-positive (*Bacillus subtilis* and *Staphylococcus aureus*) and Gram-negative bacteria (*Escherichia coli* and *Klebsiella pneumoniae*), commonly found in household wastewater. The study suggests that these nanoparticles could serve as effective agents in photodegradation for water purification, as well as antibacterial applications.

Eco-Friendly Copper-Based Nano-Adsorbents for Pharmaceutical Pollutant Removal

High-purity copper nanoparticles (Cu NPs) were synthesized using *Tilia* leaf extracts and exhibited spherical to semi-spherical morphology with sizes between 4.7 and 17.4 nm. These nanoparticles demonstrated an ability to adsorb pharmaceutical pollutants, including ibuprofen (Ibu), naproxen (Nab), and diclofenac (Dic), from real wastewater. The adsorption process was found to be spontaneous, endothermic, and primarily physical in nature. Under optimal conditions (temperature: 298 K, pH: 4.5, Cu NP dosage: 10 mg, and contact time: 60 min), removal efficiencies for Dic, Nab, and Ibu were recorded at 91.4%, 86.9%, and 74.4%, respectively. The results indicate the potential of green-synthesized Cu NPs as cost-effective and efficient adsorbents for pharmaceutical wastewater treatment.

Copper Oxide Nanoparticle-Impregnated Activated Carbon for Pollutant Removal

A green approach was employed to impregnate CuO nanoparticles onto vegetal activated carbon (VAC) using *Punica granatum* (pomegranate) leaf extract as a reducing and stabilizing agent. The nanoparticles, synthesized following an adapted methodology, were supported on coconut-based activated carbon, with particle sizes ranging from 40 to 78 nm on the carbon surface and up to 165 nm in free form. Notably, CuO-impregnated carbon with a 1.5% Cu loading over 24 hours demonstrated enhanced nitrate ion removal while maintaining efficiency in organic pollutant adsorption (such as atrazine, diclofenac, and caffeine). The study highlights the potential of CuO nanoparticle-impregnated activated carbon as an eco-friendly and cost-effective alternative for water purification.

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Disinfection of Drinking Water Using Algae-Mediated CuO Nanoparticles

CuO nanoparticles synthesized via algal extracts exhibited a size of approximately 3.6 nm. Their properties were influenced by factors such as stirring speed, pH, extract concentration, and copper ion concentration. The nanoparticles displayed antimicrobial activity against *Escherichia coli*, with an optimum dosage of 50 mg/L required for effective bacterial inhibition in surface water. Toxicity assessments were conducted on fish blood and human cell lines, revealing minimal toxicity at appropriate concentrations. Given the limitations of conventional disinfection methods, these nanoparticles offer an efficient alternative for water treatment, with potential applications in nano-membrane technologies.

Characterization and Applications of Green-Synthesized Copper Oxide Nanoparticles

Analysis of CuO Nanoparticles

The X-ray diffraction (XRD) pattern confirmed the highly crystalline nature of CuO nanoparticles, with an estimated crystallite size of 25–35 nm. Fourier transform infrared (FTIR) spectroscopy provided insights into the bonding nature of CuO. Particle size analysis indicated that the synthesized CuO nanoparticles ranged between 20 and 40 nm. Scanning electron microscopy (SEM) revealed their predominantly spherical and oval-shaped morphology. Additionally, energy-dispersive X-ray spectroscopy (EDAX) confirmed the elemental composition, ensuring the purity of the CuO nanoparticles with only copper (Cu) and oxygen (O) detected.

Phytochemical analysis identified the bioactive compounds in *Allium sativum* extract that contributed to the successful green synthesis of CuO nanoparticles. These nanoparticles demonstrated strong antimicrobial activity, effectively inhibiting the growth of both bacterial and fungal strains. Their antioxidant potential was also significant, exhibiting remarkable free radical scavenging properties. Given their environmentally friendly synthesis, CuO nanoparticles hold immense promise for wastewater disinfection in the 21st century.

II. CONCLUSION

In recent years, nanotechnology has emerged as a highly effective approach for water purification, owing to the distinctive properties of nanoparticles, such as high surface area, increased surface energy, and tunable size and volume. The physicochemical characteristics of nanoparticles can be tailored by adjusting parameters such as pH, temperature, and precursor concentration. Their multifunctionality makes them a superior alternative to traditional water treatment methods, which often rely on chemical disinfectants that may introduce toxicity into the water or prove costly in comparison to nanoparticle-based filtration. Additionally, chlorination can sometimes be ineffective due to the development of microbial resistance.

Among the various synthesis techniques, green synthesis stands out as the most sustainable and advantageous. Unlike physical methods, which require prolonged heating to achieve thermal stability, or chemical approaches that involve toxic reagents, green synthesis employs plant-based materials that are readily available and eco-friendly. The phytochemicals in plant extracts not only facilitate nanoparticle formation but also enhance their antimicrobial, catalytic, and antibacterial properties.

The properties of CuO nanoparticles synthesized using different plant extracts vary based on the phytochemical composition. Factors such as pH, copper ion concentration, stirring speed, and extract concentration significantly influence the size and morphology of the nanoparticles. Systematic experimental studies are essential to optimize these conditions for the most effective nanoparticle synthesis. Characterization techniques, including SEM and transmission electron microscopy (TEM), provide crucial insights into nanoparticle shape and size, while UV-Visible spectroscopy is used to confirm their formation through absorption spectra analysis.

A thin layer of plant-derived phytochemicals surrounding the nanoparticles was observed, which contributed to their enhanced antimicrobial properties. These CuO nanoparticles exhibited strong antibacterial effects against both *Escherichia coli* (Gram-negative) and *Staphylococcus aureus* (Gram-positive) by disrupting cell membranes and leading to bacterial cell death. Functionalization with EDTA further improved their surface area and porosity, significantly enhancing their ability to adsorb dyes, with a removal efficiency of up to 54%.

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The immobilization of CuO nanoparticles onto membranes and fabrics facilitated their application in filtration and water disinfection. These nanoparticle-coated membranes proved highly effective in removing dyes and preventing microbial contamination. Moreover, the amount of copper released into filtered water remained well below the permissible limit for drinking water, ensuring safety. Toxicity studies on humans and aquatic organisms helped establish an optimal concentration range within which the nanoparticles remained non-harmful.

The application of green-synthesized CuO nanoparticles for treating domestic wastewater proved to be both effective and sustainable. The treated water was suitable for secondary purposes such as cleaning and irrigation, helping reduce water consumption while providing an economical alternative to costly filtration methods like reverse osmosis (RO). Additionally, this approach eliminates the drawbacks associated with traditional disinfection techniques like chlorination, which can sometimes be ineffective and environmentally harmful.

By harnessing the potential of green nanotechnology, CuO nanoparticles offer a promising solution for sustainable water purification, contributing to a cleaner environment and improved public health.

Enhancing Methylene Blue Dye Adsorption Using Functionalized CuO Nanoparticles

Copper oxide nanoparticles were synthesized through a co-precipitation method using copper nitrate as a precursor. A comparative analysis was conducted between functionalized and non-functionalized CuO nanoparticles in their ability to enhance chitosan's adsorption of methylene blue dye. The nanoparticles had a crystallite size of approximately 10 nm. Functionalization with EDTA-silane significantly increased surface area and porosity, leading to improved dye adsorption and photocatalytic degradation under sunlight. When combined with chitosan, the functionalized nanoparticles achieved a dye removal efficiency of 54%. Despite some variability in particle size, the cost-effectiveness of the co-precipitation method makes it suitable for large-scale wastewater treatment applications.

Green Synthesis of Copper Nanoparticles Using *Punica granatum* Extract and Their Antibacterial Properties

Copper nanoparticles were synthesized using a green chemistry approach with pomegranate fruit rind extract as a reducing and stabilizing agent. A 10 mM copper sulfate solution mixed with 50% concentrated extract yielded medium-sized nanoparticles within 1.5 to 2 hours. UV-Visible spectroscopy confirmed the stability of the synthesized nanoparticles, with SEM analysis revealing a size range of 56-59 nm. The nanoparticles exhibited significant antibacterial activity against *Staphylococcus aureus*, making them a promising alternative for antimicrobial applications, particularly in combating drug-resistant bacterial strains.

Copper Nanoparticles in Paper-Based Point-of-Use Water Purification

To provide a low-cost alternative to silver-based filters, an environmentally friendly approach was developed for embedding copper nanoparticles into paper filters for water purification. The in situ reduction of sorbed copper ions using ascorbic acid led to the rapid formation of CuNPs within 10 minutes, with uniform distribution on paper fibers. Characterization using XRD, SEM, EDX, and AAS confirmed the presence of copper nanoparticles. When tested against *Escherichia coli*, the CuNP-infused paper exhibited a high bacterial reduction (log 8.8), while the copper release remained below the permissible limit of 1 ppm for drinking water. These findings suggest that CuNP-integrated paper could serve as an affordable and effective solution for point-of-use water filtration.

Optimization and Application of Bioflocculant-Passivated Cu Nanoparticles in Wastewater Treatment

Nanotechnology plays a crucial role in pollutant and microbial removal from wastewater. In this study, copper nanoparticles were synthesized using a polysaccharide-based bioflocculant and assessed for their flocculation activity, removal efficiency, and antimicrobial effects. The nanoparticles were characterized through multiple techniques, including TGA, UV-Vis spectroscopy, FT-IR, XRD, SEM, and TEM. The optimal flocculation activity (96%) was achieved at a nanoparticle concentration of 0.2 mg/mL, with stable performance across neutral to alkaline pH conditions and high thermal resistance (91% flocculation at 100°C). These nanoparticles demonstrated excellent pollutant removal capabilities, achieving over 89% COD and BOD reduction in coal mine and river water samples.

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Additionally, they exhibited antimicrobial activity against both Gram-positive and Gram-negative bacteria at concentrations as low as 3.13 mg/mL, indicating their potential for wastewater disinfection and dye effluent removal.

Green Synthesis of CuO Nanoparticles Using *Allium sativum* Extract and Their Biological Applications

Copper oxide nanoparticles were synthesized using *Allium sativum* (garlic) extract, leveraging the phytochemicals as natural reducing agents. The resulting CuO NPs exhibited antimicrobial, antioxidant, and antilarvicidal properties. The study highlights how synthesis parameters, such as pH, temperature, copper ion concentration, and incubation time, influence nanoparticle characteristics. Given their biocompatibility and eco-friendly nature, these nanoparticles hold promise for applications in biomedical and environmental sectors.

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Post Harvesting Handling of Cut Flowers

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Abstract: *A fresh flower is still a living specimen even though it has been cut from the plant. Its maximum potential vase life, although acceptable in the marketplace, is short. There are many impinging forces that can interact to reduce fresh-flower vase life. As an industry, we need to be more successful in preserving the potential life of fresh flowers. However, there are well-known solutions for this. Proper harvesting and care of flowers after harvest are important to maximize the vase life and ensure a high quality product. Maximizing the vase life of cut flowers is dependent on pre-harvest procedures too. Long before harvest, plant cultivar selection should be considered for postharvest longevity to provide the best possible cultivars for cutting. Postharvest factors like method of harvest, time of harvest, maturity stage, ethylene management, vase life enhancement, packaging ,storage and transportation has to be taken into account with almost all care. More technology adaptation efforts are required to be undertaken by technology generating laboratories through a field-level program of adaptive research and community based production systems. This can happen with better linkages with laboratories, financial institutions, and governmental bodies as a way of continuously improving the competitiveness of the local system. Besides, the developed and promoted technology should come as low cost devices, practical and effective for use at farmer level. Apart from the adaptation the training for flower harvesting, handling, packing and transportation should be given to the growers to avoid the losses during handling of cut flowers..*

Keywords: fresh flower

I. INTRODUCTION

Post-harvest handling of cut flowers is a critical process that begins immediately after harvesting and continues until the flowers reach the consumer. It encompasses all the steps taken to maintain the quality and extend the vase life of cut flowers. Proper post-harvest handling is essential to ensure that flowers retain their freshness, color, and form, maximizing their aesthetic appeal and market value. This process involves several key stages, including initial handling at the time of harvest, transport, storage, and pre-treatments, all aimed at minimizing deterioration and prolonging the display life of the flowers

Factors affecting postharvest life of flowers.

The post-harvest life of a flower, that is, its vase life after it's been cut, is influenced by a complex interplay of factors. These can be broadly categorized into pre-harvest factors (conditions during the flower's growth) and post-harvest factors (conditions after the flower is cut). Here's a breakdown Systems for harvesting and marketing cut flowers vary according to individual crops, growers, production areas, and marketing systems.

Pre-Harvest Factors:

- **Genetics:** Different flower varieties have inherently different vase lives. Some are bred for longevity, while others naturally fade quickly.
- **Growing Conditions:** Adequate light intensity and duration during growth are crucial for carbohydrate production, High temperatures can accelerate development, Water stress during growth, Infections during growth can weaken flowers postharvest life.

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Post-Harvest Factors:

- **Harvesting Stage:** Harvesting at the optimal stage of maturity is critical. Flowers harvested too early may not open properly, while those harvested too late may fade quickly.
- **Handling Practices:** Mechanical Damage, Water Relations, Temperature
- **Storage and Transport:** Cool temperatures are essential for slowing down metabolic processes,High humidity, Exposure to ethylene, a plant hormone, can accelerate senescence (aging).Exposure to ethylene, a plant hormone, can accelerate senescence (aging). Some flowers are very sensitive to ethylene.

II. METHODOLOGY

Post-harvest handling include:

Materials (List separately):

- Cut [Flower Name]
- Buckets/Containers
- Post-harvest solutions (specify concentrations)
- Sharp scissors/floral knife
- Thermometer, Humidity meter
- Scale
- Camera
- Optional: Cold storage

II. REVIEW OF LITERATURE

Sr.no.	Step	Procedure	Details/Considerations
1.	Flower Selection	Choose flowers	Uniform size, maturity, free from visible damage/disease. Specific criteria for [Flower Name].
2.	Treatment Groups	Divide flowers	At least 3 groups (e.g., control - deionized water, commercial preservative, sugar solution, other treatment). Clearly label each group.
3.	Preparation	Remove leaves	Submerged leaves should be removed to prevent bacterial growth.
4.		Recut stems	45-degree angle under running water, removes air embolism and improves water uptake.
		Place in solutions	Use clean containers, fill with appropriate treatment solutions, and ensure stem contact.
5.	Storage	Environment	Cool, well-ventilated room (18-22°C/64-72°F recommended, adjust for [Flower Name]), 50-70% relative humidity. Avoid direct sunlight and drafts.
6.	Monitoring	Daily observation & recording	
		Vase Life	Number of days flowers remain fresh/marketable. Define "fresh" clearly.
		Flower Opening/Color	Document changes in bud opening, petal color, and overall appearance. Use standardized scales if possible.
		Stem Turgidity	Assess stem stiffness and ability to support the flower.
		Water Uptake	Measure water level decrease in containers (if possible) to assess uptake.

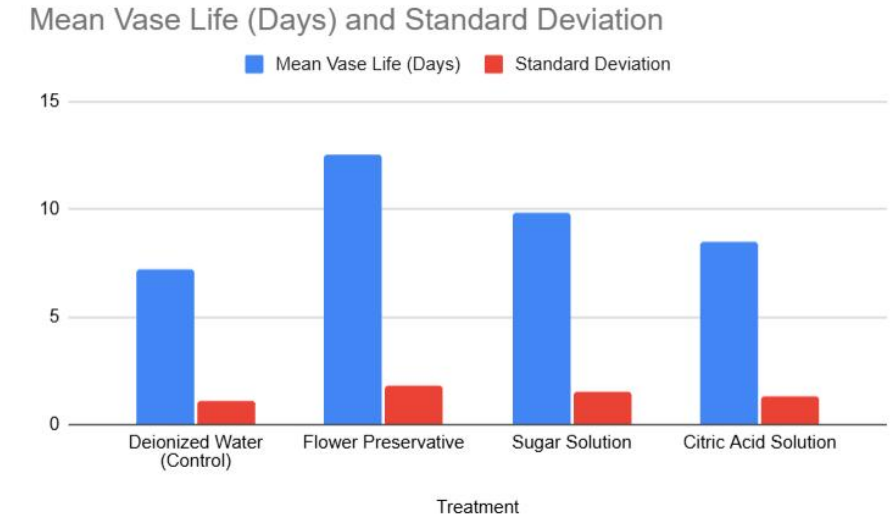
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		Senescence Signs	Record wilting, browning, petal drop, disease, or other signs of aging.
		Photography	Take photos at regular intervals (e.g., daily) for visual documentation.
7.	Data Analysis	Compare treatments	Analyze recorded data (vase life, quality parameters) to determine treatment effects.
		Statistical Analysis	Use appropriate statistical methods (e.g., ANOVA, t-tests) to compare treatment performance.
8.	. Reporting	Summarize findings	Report on the effectiveness of different post-harvest treatments on [Flower Name]'s vase life and quality. Include tables, graphs, and photos.

Hydration: Maintaining water balance is paramount. Studies highlight the importance of recutting stems, using hydrating solutions, and minimizing transpiration. Vascular blockages, often microbial, are a major cause of wilting.
Nutrition: Cut flowers benefit from supplemental carbohydrates. Research demonstrates that sugar solutions (e.g., sucrose) can extend vase life by providing energy. However, optimal concentrations are crucial to avoid negative effects like bacterial growth.

IV. RESULT AND DISCUSSION

Treatment	Mean Vase Life (Days)	Standard Deviation
Deionized Water (Control)	7.2	1.1
Flower Preservative	12.5	1.8
Sugar Solution	9.8	1.5
Citric Acid Solution	8.5	1.3



Post-harvest handling is crucial for maintaining cut flower quality and extending vase life. It involves several key steps:

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1. **Harvesting:** Flowers should be harvested at the optimal stage of maturity, typically in the cool morning or evening to minimize stress.
2. **Grading and Bunching:** Flowers are sorted based on quality, size, and other criteria, then bunched together for sale or display.
3. **Pulsing:** This involves placing flowers in a solution containing sugars and other chemicals to provide nutrients and prolong vase life.
4. **Cooling:** Rapid cooling helps reduce respiration and slows down the aging process.
5. **Storage:** Flowers should be stored in a cool, humid environment to maintain freshness.
6. **Transportation:** Proper packaging and temperature control are essential during transportation to prevent damage and maintain quality.

V. CONCLUSION

Effective post-harvest handling is paramount to maximizing the vase life and aesthetic appeal of cut flowers.From the initial harvest at the optimal maturity stage, through careful grading, bunching, and pulsing, to controlled cooling, storage, and transport, each step plays a crucial role in preserving quality. [2] Attention to detail in sanitation, water quality, and ethylene management further contributes to minimizing losses and ensuring customer satisfaction. Research focusing on optimizing these post-harvest procedures, particularly for specific flower varieties, is essential for advancing the floriculture industry and providing consumers with long-lasting, beautiful blooms. Ultimately, successful post-harvest handling translates to increased marketability, reduced waste, and enhanced enjoyment of cut flowers

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[6]. *Book Chapters (if applicable):** * [Author, A. A., & Author, B. B. (Year). Title of chapter. In A. Editor & B. Editor (Eds.), *Title of book* (pp. xx-xx). Publisher.] **Websites (use sparingly and only if highly reputable) postharvest.ucdavis.edu/Commodity_Resources/CutFlowers.shtml

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Green Synthesis of Zinc Oxide Nanoparticles and Their Pharmacokinetic Properties

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Abstract: *In recent decades, the use of nanoparticles across various industries, including biomedical, cosmetics, and food, has gained significant global attention due to their nanoscale dimensions and exceptional properties. This has made nanotechnology a highly sought-after research field. Among the different synthesis approaches, green chemistry-based methods have emerged as a sustainable alternative, leveraging natural biological reduction processes to minimize the use of hazardous chemicals, unlike conventional physical and chemical techniques. Among inorganic nanoparticles, zinc oxide (ZnO) nanoparticles have garnered considerable interest due to their wide bandgap, high exciton binding energy, ease of fabrication, biocompatibility, non-toxic nature, and eco-friendly characteristics. ZnO nanoparticles readily dissolve in biological fluids and have a tendency to aggregate under varying physiological conditions. However, their physicochemical properties play a crucial role in determining bioavailability. This review aims to explore and summarize the green synthesis of zinc oxide nanoparticles and their pharmacokinetic properties..*

Keywords: nanoparticles, zinc oxide, biocompatibility, green synthesis, pharmacokinetics, bioavailability

I. INTRODUCTION

Over the past few decades, nanotechnology has revolutionized various industries, including engineering, environmental science, agriculture, medicine, electronics, pharmaceuticals, biotechnology, food processing, and pharmacology. The widespread adoption of nanotechnology is primarily due to its nanoscale dimensions, high surface area-to-volume ratio, and unique properties such as electronic, magnetic, mechanical, optical, thermal conductivity, and enhanced catalytic activity. Research and development in this field focus on modifying atomic, molecular, and supramolecular structures to enhance physicochemical properties for targeted applications.

Inorganic nanoparticles are synthesized by integrating organic and inorganic materials, forming hybrid structures with distinct characteristics. Several types of inorganic nanoparticles, including quantum dots, magnetic nanoparticles, and metal-based nanoparticles like silver, gold, silicon dioxide (SiO_2), titanium dioxide (TiO_2), copper oxide (CuO), and zinc oxide (ZnO), have been extensively studied for their diverse applications. Among these, ZnO nanoparticles have attracted considerable attention due to their wide bandgap, high exciton binding energy, and broad application potential. ZnO nanoparticles rank as the third most widely produced and utilized nanoparticles worldwide.

Nanoparticle Synthesis

Various physical and chemical techniques have been developed for the synthesis of inorganic nanoparticles, including:

Physical Methods:

- Vapor transport and condensation
- Amorphous crystallization
- Physical fragmentation
- Pulsed laser deposition
- Molecular beam epitaxy
- Thermal evaporation and decomposition

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Chemical Methods:

- Chemical microemulsion
- Wet chemical synthesis
- Spray pyrolysis
- Electrodeposition
- Direct and homogeneous precipitation
- Microwave-assisted combustion
- Solvothermal and sonochemical methods
- Reverse micelle synthesis
- Sol-gel method
- Microwave irradiation
- Zinc-alcohol reaction
- Hydrothermal synthesis
- Microemulsion synthesis
- Spray drying

Despite their efficiency, physical methods often require high pressure and temperature, making them energy-intensive, while chemical methods involve toxic reagents and the need for capping and stabilizing agents.

Green Synthesis of Nanoparticles

To address these limitations, researchers have turned to eco-friendly, green synthesis approaches using biological sources such as bacteria, algae, fungi, yeast, and plant-derived materials, including leaves, fruits, seeds, roots, and stems. Nanoparticles synthesized from plant extracts exhibit improved stability, diverse morphologies, and controlled size distribution compared to those derived from other biological sources. The green synthesis method not only enhances catalytic efficiency but also minimizes the use of hazardous chemicals, reducing environmental and health risks.

Green Synthesis of Zinc Oxide Nanoparticles

Zinc oxide nanoparticles can be synthesized using an eco-friendly approach by dissolving zinc-based precursors such as zinc oxide, zinc nitrate, zinc acetate, or zinc sulfate in distilled water. A specific volume of plant extract is then added to this solution and stirred continuously using a magnetic stirrer. To achieve a pH of 12, sodium hydroxide (NaOH) solution is introduced dropwise while stirring the mixture for one hour. A noticeable color change in the reaction mixture indicates nanoparticle formation. The synthesized ZnO nanoparticles are confirmed using UV-Vis spectroscopy based on their surface plasmon resonance (SPR) effect. The resulting white crystalline ZnO nanoparticles are separated through centrifugation and then dried at 60–80°C in a hot air oven for two hours.

During this process, plant-derived phytochemicals such as amino acids, vitamins, terpenoids, alkaloids, polyphenols, and polysaccharides act as reducing, capping, and stabilizing agents, eliminating the need for additional chemical stabilizers. This green synthesis method is cost-effective, non-toxic, biocompatible, and environmentally sustainable. The U.S. Food and Drug Administration (FDA) has classified ZnO, along with other zinc compounds, as Generally Recognized as Safe (GRAS).

The successful formation of ZnO nanoparticles depends on factors such as temperature, pH, reaction time, and the concentration of the plant extract. Various ZnO nanoparticle morphologies, including nanoflowers, nanoflakes, nanorods, nanowires, and nanobelts, have been reported.

Characterization of Zinc Oxide Nanoparticles

The synthesized ZnO nanoparticles are characterized using multiple analytical techniques:

Fourier Transform Infrared Spectroscopy (FT-IR): Determines the functional groups involved in nanoparticle formation and their binding properties.

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Scanning Electron Microscopy (SEM): Analyzes the surface morphology, shape, and size of the nanoparticles.
X-ray Diffraction (XRD): Evaluates the crystalline structure of the nanoparticles.
Atomic Force Microscopy (AFM): Assesses the topography and surface roughness of the nanoparticles.

Pharmacokinetic Properties of Zinc Oxide Nanoparticles

Absorption

Zinc oxide nanoparticles are highly soluble in biological fluids, leading to the release of zinc ions. When administered orally, their bioavailability is reduced due to factors such as the first-pass metabolism, gastrointestinal barriers, and liver processing. However, intravenous administration ensures 100% bioavailability. Several factors, including pH, particle size, concentration, and the presence of organic compounds, influence ZnO nanoparticle solubility. Negatively charged particles exhibit better absorption than positively charged ones. The dissolution, absorption, and distribution of ZnO nanoparticles depend on the exposure dose rather than the particle size.

Distribution

Following oral administration, ZnO nanoparticles primarily accumulate in the kidneys, liver, and spleen, while intraperitoneal administration leads to their distribution in the lungs, kidneys, spleen, heart, and liver. The kidneys and liver are the primary target organs in both cases. The distribution pattern is influenced by factors such as the type of experimental model, route of exposure, and physicochemical properties of the nanoparticles.

Excretion

Zinc oxide nanoparticles with a hydrodynamic diameter smaller than 6 nm are eliminated through urine via glomerular filtration. Both absorbed and unabsorbed nanoparticles are excreted through feces, while metabolites are primarily eliminated via bile. Although physicochemical properties and exposure routes influence excretion, biliary and fecal elimination play a dominant role, regardless of nanoparticle size, surface charge, or administration method. The excretion kinetics of ZnO nanoparticles are more dependent on particle size than surface charge.

Protein Interaction with Nanoparticles

When nanoparticles enter the systemic circulation and come into contact with biological fluids, they rapidly interact with plasma proteins, leading to protein adsorption on their surface. The extent of protein adsorption is primarily influenced by the nanoparticle's surface charge and particle size. Key plasma proteins such as fibrinogen, lipoproteins, albumin, and immunoglobulins are commonly used to evaluate nanoparticle-protein interactions, including binding efficiency, adsorption patterns, and potential structural changes in the proteins. Additionally, plasma proteins play a significant role in the deposition, distribution, and transportation of nanoparticles within the body.

S. No	Name of the plant (Parts)	Application
1	Trifolium pratense (flower)	antibacterial activity[33]
2	Catharanthus roseus (leaf)	Antibacterial activity[34]
3	Murraya koenigii (seed)	Antimicrobial activity[35]
4	Nyctanthes arbortristis (flower)	Anti-fungal[18]
5	Passiflora caerulea (Leaf)	Urinary tract infection[8]
6	Hibiscus subdariffa (leaf)	Anti diabetic[36]
7	Polygala tenuifolia (root)	Anti-inflammatory[37]
8	Eucalyptus globulus (leaf)	Antioxidant[38]

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II. CONCLUSION

The green synthesis of zinc oxide nanoparticles has gained significant attention due to its biocompatibility and environmentally friendly nature. Phytochemicals derived from natural sources serve as both reducing and stabilizing agents, facilitating the formation of nanoparticles within a controlled size range of 1–100 nm. This method minimizes the reliance on conventional physical and chemical synthesis techniques. Zinc ions play a crucial role in maintaining cellular function and structural integrity. However, further in-depth research is required to scale up this synthesis process for large-scale commercial applications. Additionally, more studies are needed to fully understand the pharmacokinetics and bioavailability of zinc oxide nanoparticles in humans to establish their precise mechanism of action.

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Rational Strategies for the Synthesis of Novel Imidazole Heterocycles and Their Diverse Pharmacological Activities: A Concise Review

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Abstract: *Imidazole-based heterocycles have gained significant attention due to their diverse pharmacological properties and broad-spectrum biological activities. This review explores rational strategies for the synthesis of novel imidazole derivatives, emphasizing innovative synthetic approaches, green chemistry methodologies, and catalyst-assisted transformations. The discussion also highlights the structure-activity relationships (SAR) that govern their therapeutic potential, including antimicrobial, anticancer, anti-inflammatory, and antiviral properties. By understanding the key synthetic pathways and reactivity of imidazole scaffolds, researchers can design and develop new bioactive molecules with enhanced efficacy and selectivity..*

Keywords: Imidazole Heterocycles, chemistry methodologies

I. INTRODUCTION

Chemical Structure and Properties Imidazole (Fig. 1) is an organic compound with the molecular formula $C_3N_2H_4$. It appears as a white or colorless solid, which is soluble in water and forms a mildly alkaline solution. Imidazole belongs to the diazole class of aromatic heterocycles, characterized by non-adjacent nitrogen atoms in the ring structure. Reactivity of Imidazole Imidazole exhibits properties similar to both pyrrole and pyridine. The electrophilic reagent primarily attacks the unshared electron pair on N-3 but not on the pyrrole-type nitrogen, as the latter is part of the aromatic sextet. The imidazole ring is susceptible to electrophilic attack at annular carbon positions. However, nucleophilic substitution is less common unless the ring contains strong electron-withdrawing substituents.

Nucleophilic Attack in Imidazole and Benzimidazole In imidazole, C-2 is the most reactive site for nucleophilic attack. The fused benzene ring in benzimidazole provides sufficient electron withdrawal, enabling nucleophilic substitution reactions at C-2. The overall reactivity of imidazole and benzimidazole can be explained through their resonance structures, which predict: Electrophilic attack at N-3 or any ring carbon atom Nucleophilic attack at C-2 or C-1 Amphoteric nature (ability to act as both acid and base)

Reactivity of Benzimidazole In benzimidazole, nucleophilic attack is predominantly at C-2. The benzimidazole ion is significantly more reactive at C-2 than its neutral form, making it more susceptible to nucleophilic attack.

These fundamental reactivity patterns make **imidazole and benzimidazole** important scaffolds in organic and medicinal chemistry, contributing to their widespread

Table 1: Properties of Imidazole Ring

S. no.	Chemical formula	C3H4N2
1	Molar mass	68.077g/mol
2	Appearance	White or pale yellow

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3	Density	1.23g/cube cm
4	Melting point	89 to 91°C
5	Boiling point	256°c
6	Solubility in water	633 g/L
7	Acidity	6.95
8	Crystal structure	Monoclinic
9	Coordination geometry	Planar 5 membered ring
10	Dipole moment	3.61 D
11	Pair of electrons	6π electron

Deprotonation of imidazole results in the formation of the imidazolate anion, which exhibits a symmetrical structure. As a base, imidazole has a pKa value of approximately 7 for its conjugate acid (often denoted as pKBH+ to distinguish it from the neutral form). This makes imidazole around sixty times more basic than pyridine. The primary site of basicity in imidazole is the nitrogen atom with a lone pair that is not bonded to hydrogen. Upon protonation, imidazole forms the imidazolium cation, which is also symmetrical. The resonance structures of imidazole, illustrating its delocalized electronic distribution, are depicted in Fig. 3.

General Methods of Imidazole Synthesis

Imidazole can be synthesized using a variety of methods, many of which are adaptable for producing **substituted imidazoles** and their derivatives by modifying the functional groups of the reactants. Several well-established synthetic approaches include:

Debus synthesis
Radziszewski synthesis
Dehydrogenation of imidazolines
Synthesis from α-halo ketones
Wallach synthesis
Formation from aminonitriles and aldehydes
Marckwald synthesis

Debus Synthesis

The **Debus method** involves the reaction of **glyoxal and formaldehyde with ammonia** to form imidazole. Although this approach typically results in **low yields**, it remains a valuable technique for synthesizing **C-substituted imidazoles** Fig.3

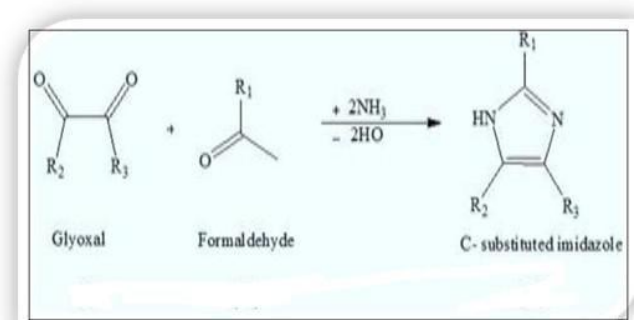


Fig.3

Radziszewski Synthesis

The Radziszewski method involves the condensation of a tricarbonyl compound with benzyl and an α-ketoaldehyde, such as benzaldehyde or diketones, in the presence of ammonia. This reaction leads to the formation of 2,4,5-triphenylimidazole. The proposed reaction mechanism is illustrated in Fig. 4.

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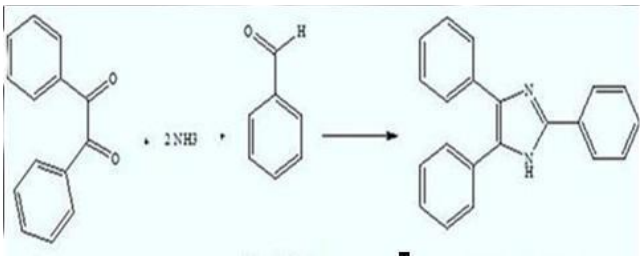
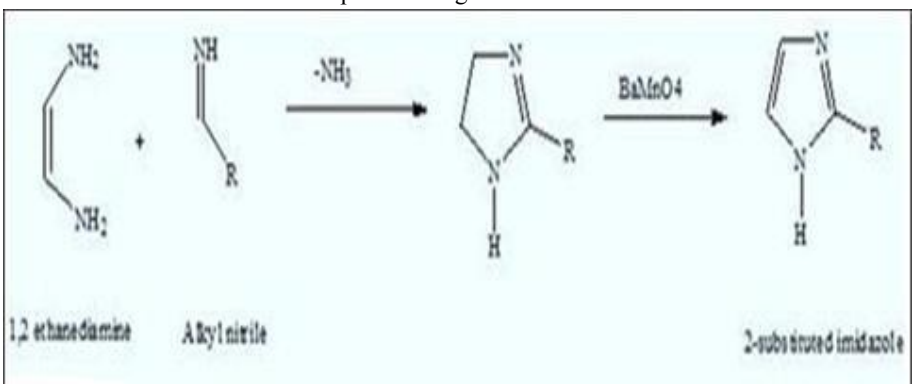


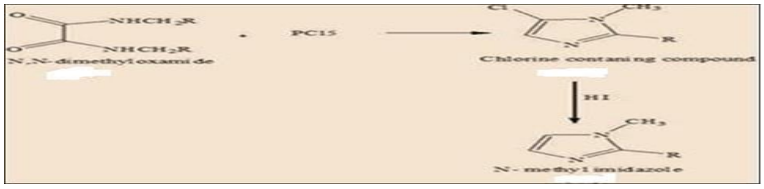
Fig. 4.

3) Dehydrogenation of Imidazolines to Imidazoles

Knapp and colleagues introduced a milder dehydrogenation method using barium manganate ($BaMnO_4$) in the presence of sulfur to convert imidazolines into imidazoles. In this process, imidazolines, which are derived from the reaction of alkyl nitriles with 1,2-ethanediamines, undergo oxidation with $BaMnO_4$-NH to yield 2-substituted imidazoles. The reaction mechanism for this transformation is depicted in Fig. 5.



4) Wallach Synthesis: Wallach reported **Fig. 6.** that when N, N- dimethyl oxamide [18] is treated with phosphorus pentachloride, a chlorine-containing compound [19] is obtained, which on reduction with hydroiodic acid give N- methyl imidazole [20]. Under the same condition N, N-diethyl oxamide is converted to a chlorine compound, which on reduction gives 1- ethyl –2methyl imidazole [20]



5) Synthesis of Imidazoles via Single-Bond Formation

Recent research on imidazole synthesis through single-bond formation has been limited. However, Fang et al. introduced a novel method for the cyclization of amido-nitriles to produce disubstituted imidazoles as illustrated This reaction takes place under mild conditions, allowing the incorporation of various functional groups, including aryl halides, aromatic rings, and saturated heterocycles The mechanism involves:

Nickel-catalyzed addition to the nitrile .

Proto-demetallation followed by tautomerization.

Dehydrative cyclization, leading to the formation of 2,4-disubstituted NH-imidazoles.

The yield of the final product varies depending on the coupling partners, ranging from poor to excellent.

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6) Formation of Imidazoles via a Single Bond (1,5 or 3,4 Bond Formation)

Imidazoles can also be synthesized through the formation of a single bond, specifically at the (1,5) or (3,4) positions. This occurs through the reaction of an imidate with an amino aldehyde or α-amino acetal , leading to the cyclization of an imidine intermediate into an imidazole .

An example of this method applies to imidazole synthesis when R = R_1 = Hydrogen .

Imidazoles are widely recognized heterocyclic compounds that serve as an essential structural component in numerous medicinal agents. A comprehensive review of the literature highlights the diverse pharmacological properties exhibited by imidazole derivatives, making them valuable in drug discovery and therapeutic applications.

Pharmacological Activities of Imidazole Derivatives :

1. Antibacterial Activity :

The increasing resistance of bacteria to conventional antibiotics has become a major challenge in modern medicine. This has led to an urgent need for new antibacterial agents with enhanced efficacy, low toxicity, and improved bioavailability. Among various heterocyclic compounds under investigation, imidazole-based structures have gained significant attention due to their presence in important biomolecules such as histidine, histamine, and natural alkaloids (e.g., pilocarpine from *Podocarpus jaborandi*).[1-3]

Imidazole derivatives exhibit antibacterial properties through multiple mechanisms, such as:

Generation of reactive nitro radicals: Nitroimidazoles penetrate bacterial cells through passive diffusion, where they undergo reduction, leading to DNA damage and cell death. Inhibition of essential bacterial enzymes: Some imidazole compounds target flavohemoglobins, which play a role in neutralizing nitric oxide (NO). By inhibiting this process, imidazole derivatives prevent bacterial survival. Blocking fatty acid synthesis: Inhibition of enoyl-acyl carrier protein reductase (FabI), an enzyme crucial for bacterial fatty acid synthesis, disrupts bacterial cell membrane formation, ultimately leading to bacterial death.

Several imidazole-based antibiotics, including **Metronidazole, Ornidazole, and Oxiconazole**, are widely used in clinical settings.[8-10]

2. Anticancer Activity :

Imidazole compounds have shown promising results in cancer treatment, with their role in chemotherapy beginning with Dacarbazine. Researchers have developed imidazole-based anticancer drugs targeting various biological pathways, including: DNA interactions: Some imidazole derivatives interact directly with DNA, leading to structural damage and preventing tumor cell replication. Angiogenesis inhibition: Tumor growth is highly dependent on blood supply, which is regulated by vascular endothelial growth factor (VEGF). Imidazole-based drugs, such as levamisole derivatives, have shown potential in blocking VEGF signaling, reducing blood vessel formation around tumors and limiting their growth.Targeting key cancer enzymes: Imidazoles can also inhibit histone deacetylases, topoisomerases, receptor tyrosine kinases (RTKs), and RAF kinases, all of which play critical roles in tumor progression.

Certain imidazole-based drugs, including Vincristine, Taxol, and Topside, have already been approved for the treatment of cancers such as leukemia, ovarian cancer, and lung cancer.[3-5]

3. Antitubercular Activity :

Tuberculosis (TB) remains a major global health concern, especially with the rise of multidrug-resistant (MDR) and extensively drug-resistant (XDR) strains of *Mycobacterium tuberculosis*. Imidazole-containing compounds have demonstrated potent anti-TB properties.

A notable example is 4-nitroimidazole (Pretomanid and Delamanid), which has been approved for treating MDR-TB. These compounds exert their effects by:

Disrupting mycobacterial cell wall synthesis

Inhibiting essential enzymes required for bacterial survival

Inducing oxidative stress in bacterial cells

Researchers continue to explore novel **imidazole-based anti-TB agents** with enhanced activity and reduced side effects.[6-8]

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4. Anti-HIV Activity

HIV-1, the causative agent of AIDS, primarily attacks CD4+ T-lymphocytes, leading to immune suppression and increased susceptibility to opportunistic infections. Imidazole derivatives have been investigated for their potential to inhibit HIV replication.

Studies suggest that certain nitroimidazoles act by:

Blocking reverse transcriptase (RT), the enzyme responsible for viral DNA synthesis.

Disrupting viral entry mechanisms by interfering with receptor-ligand interactions.

Targeting opportunistic infections such as tuberculosis and fungal infections, which commonly affect HIV patients.

Computational docking studies have shown promising interactions between imidazole-based compounds and the HIV-1 reverse transcriptase enzyme (PDB ID: 1FK9), opening new avenues for antiviral drug development.[9-11]

5. Other Biological Activities :

Imidazole derivatives exhibit a broad spectrum of pharmacological actions, including:

Anti-inflammatory and analgesic effects (e.g., Clonidine)

Anti-ulcerative properties (e.g., Cimetidine)

Antifungal activity (e.g., Ketoconazole, Miconazole, Clotrimazole)

Antiprotozoal effects (e.g., Metronidazole, Azomycin)

Antihypertensive activity (e.g., Moxonidine)

Antioxidant and neuroprotective properties

Applications of Imidazole :

Beyond its role in medicine, imidazole has several industrial and technological applications:

1. Protein Purification (IMAC Technique)

Imidazole plays a crucial role in immobilized metal affinity chromatography (IMAC) for purifying His-tagged proteins. The process involves:

Binding His-tagged proteins to nickel ions.

Eluting the protein using excess imidazole, which displaces the histidine residues and releases the purified protein.

2. Buffer Preparation

Imidazole is widely used as a biological buffer in the pH range of 6.2–7.8, making it suitable for enzyme assays such as horseradish peroxidase (HRP) activity tests.

3. Dermatological Applications

Oral administration of imidazole derivatives has shown efficacy in treating psoriasis and seborrheic dermatitis, leading to reduced redness, itching, and scaling over time.

4. Industrial Applications

Corrosion inhibition: Imidazole derivatives protect metals (e.g., copper) from oxidation.

Fire-retardant materials: Polybenzimidazole (PBI), an imidazole-based polymer, is used in fire-resistant textiles and insulation materials.

II. CONCLUSION

A thorough review of imidazole derivatives reveals their diverse pharmacological potential, including antibacterial, anticancer, anti-tubercular, anti-HIV, and many other therapeutic effects. With continuous structural modifications and drug design advancements, imidazole compounds can be further optimized for improved efficacy and safety. The development of newer imidazole-based drugs holds immense promise for addressing current medical challenges and enhancing global healthcare solutions.

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Detection of Pesticide Residues in Cereals: A Focus on Rice, Wheat, and Maize

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Abstract: *Pesticide residues in cereals pose significant health risks due to their potential toxicity and long-term environmental persistence. Excessive or improper pesticide use in agriculture can lead to contamination of staple grains such as rice (Oryza sativa), wheat (Triticum aestivum), and maize (Zea mays), raising concerns about food safety and regulatory compliance. This study aims to detect and quantify pesticide residues in these cereals using advanced analytical techniques.*

Samples were collected from various agricultural regions and analyzed using gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS). The pesticide residue levels were compared against the maximum residue limits (MRLs) set by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). Preliminary findings indicate that organophosphates, pyrethroids, and neonicotinoids were among the most commonly detected pesticide residues. Rice exhibited higher pesticide accumulation compared to wheat and maize, likely due to its water-intensive cultivation process.

The study underscores the need for stringent monitoring and sustainable farming practices to minimize pesticide contamination in cereals. Future research will explore bioremediation techniques and the potential of organic farming to reduce pesticide residue levels. The findings provide valuable insights for policymakers, food safety authorities, and consumers in ensuring a safer food supply...

Keywords: Pesticide Residues, Cereals, Rice, Wheat, Maize, Food Safety

I. INTRODUCTION

Pesticide residues in cereals have become a significant concern due to their potential impact on human health and food safety. Rice, wheat, and maize, being staple crops consumed globally, are often exposed to pesticides during cultivation to protect against pests, fungi, and weeds. However, excessive or improper pesticide use can lead to residues remaining in the grains, which may exceed permissible limits set by regulatory agencies such as the World Health Organization (WHO) and the Food and Agriculture Organization (FAO). Long-term consumption of cereals contaminated with pesticide residues has been linked to various health issues, including neurological disorders, endocrine disruption, and even carcinogenic effects. Therefore, accurate detection and monitoring of pesticide residues in cereals are essential to ensure food safety and compliance with international standards.

Several analytical methods have been developed for detecting pesticide residues in cereals, ranging from traditional techniques like gas chromatography (GC) and liquid chromatography (LC) to more advanced methods such as mass spectrometry (MS) and enzyme-linked immunosorbent assays (ELISA). These techniques allow for precise quantification of pesticide residues, ensuring that cereal grains meet safety standards before reaching consumers. Recent advancements in nanotechnology and biosensors have further improved the sensitivity and efficiency of pesticide detection, providing faster and more reliable results. Despite these technological advancements, challenges such as sample complexity, matrix interference, and the presence of multiple pesticide residues require continuous refinement of detection methods to enhance accuracy and reliability.

Given the widespread consumption of rice, wheat, and maize, understanding pesticide residue levels in these cereals is crucial for public health and trade regulations. Many countries have implemented stringent monitoring programs and maximum residue limits (MRLs) to regulate pesticide levels in food products. However, variations in pesticide use, environmental conditions, and agricultural practices can lead to disparities in residue levels across different regions.

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This study focuses on evaluating pesticide residues in rice, wheat, and maize, highlighting detection techniques, regulatory frameworks, and potential health risks associated with their consumption. By ensuring rigorous testing and adherence to safety guidelines, the risks associated with pesticide contamination in cereals can be mitigated, safeguarding both consumers and the agricultural industry.

II. REVIEW OF LITERATURE

The detection of pesticide residues in cereals has been extensively studied, with various research efforts focusing on identifying, quantifying, and mitigating contamination in rice, wheat, and maize. According to Zhang et al. (2020), pesticide residues in staple cereals pose a significant risk due to their potential accumulation in the human body through prolonged consumption. Studies have highlighted the widespread use of organophosphates, pyrethroids, and carbamates in cereal production, with residues often persisting beyond harvest. Sharma and Gupta (2018) analyzed pesticide residues in rice and found that nearly 30% of tested samples contained pesticide levels exceeding the maximum residue limits (MRLs) set by the FAO and WHO. Similarly, Al-Waili et al. (2019) reported that maize samples from intensive agricultural regions exhibited high contamination levels, particularly with neonicotinoids and chlorinated pesticides.

Analytical techniques for pesticide detection have evolved significantly, improving sensitivity and accuracy in residue quantification. Gas chromatography (GC) and liquid chromatography (LC) coupled with mass spectrometry (MS) are among the most widely used methods due to their ability to detect multiple pesticide residues at trace levels (Pereira et al., 2021). High-performance liquid chromatography (HPLC) has also been effectively utilized for detecting organophosphates and pyrethroids in cereals (Singh et al., 2017). Additionally, rapid screening methods like enzyme-linked immunosorbent assay (ELISA) and biosensors have gained attention for their efficiency in on-site detection, reducing the need for time-consuming laboratory analysis (Wu et al., 2022). However, challenges such as matrix interference and the need for extensive sample preparation continue to limit their widespread application.

Regulatory frameworks play a critical role in monitoring pesticide residues in cereals and ensuring food safety compliance. The European Food Safety Authority (EFSA), the United States Environmental Protection Agency (EPA), and the Codex Alimentarius Commission have established stringent MRLs to regulate pesticide levels in food commodities (Codex, 2020). However, Khan et al. (2019) highlighted disparities in MRL standards across different countries, which can create challenges in international trade. In developing nations, weak enforcement mechanisms and inadequate testing facilities often lead to higher risks of pesticide contamination in locally produced cereals (Mahmood et al., 2021). Studies suggest that harmonizing global MRL standards and improving residue monitoring programs could enhance food safety and trade consistency worldwide.

Efforts to mitigate pesticide residues in cereals have focused on adopting safer agricultural practices and post-harvest decontamination techniques. Integrated Pest Management (IPM), which emphasizes the use of biological control agents and eco-friendly pesticides, has been recommended as a sustainable approach (Fernando et al., 2020). Washing, milling, and thermal treatments have been shown to reduce pesticide residues to some extent, but their effectiveness varies depending on the type of pesticide and cereal (Liu et al., 2018). Moreover, the development of genetically modified (GM) crops with pest-resistant traits has been explored as a means to reduce pesticide reliance in cereal production (Chen et al., 2021). Despite these advancements, continuous monitoring and research are necessary to minimize pesticide exposure and ensure the long-term safety of rice, wheat, and maize for global consumers.

III. METHODOLOGY

This study employs a systematic approach to detect pesticide residues in rice, wheat, and maize, ensuring accurate identification and quantification using advanced analytical techniques. Sample collection is carried out from diverse sources, including local markets, supermarkets, and agricultural farms, to represent different production and distribution channels. The collected samples are stored in sterile, airtight containers to prevent contamination. Prior to analysis, samples undergo preprocessing, including drying (if necessary), grinding, and sieving to achieve a uniform particle size. To assess surface residue contamination, a portion of the samples is subjected to washing and milling before further testing.

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Pesticide residues are extracted using the QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) method, which is widely applied in multi-residue pesticide analysis. This involves treating the samples with acetonitrile and buffer solutions, followed by centrifugation and filtration to remove impurities. The extracts are then purified using solid-phase extraction (SPE) to enhance detection sensitivity. To accurately identify and quantify pesticide residues, a combination of advanced chromatographic and spectrometric techniques is employed. Gas Chromatography-Mass Spectrometry (GC-MS) is used fordetecting volatile and semi-volatile pesticides, such as organochlorines and pyrethroids, while Liquid Chromatography-Mass Spectrometry (LC-MS/MS) is applied for non-volatile pesticides, including organophosphates and carbamates. High-Performance Liquid Chromatography (HPLC) is also utilized for additional screening and quantification, and Enzyme-Linked Immunosorbent Assay (ELISA) serves as a rapid screening method for detecting specific pesticide classes. Each sample is analyzed in triplicate to ensure accuracy, with calibration curves established using certified pesticide standards for precise quantification.

The pesticide residue concentrations in each cereal sample are compared against Maximum Residue Limits (MRLs) set by regulatory agencies such as the World Health Organization (WHO), Food and Agriculture Organization (FAO), and European Food Safety Authority (EFSA). Statistical analysis, including mean concentration, standard deviation, and contamination frequency, is conducted to evaluate contamination trends across different cereals and sampling locations. To maintain result reliability, quality control measures such as blank sample testing, spiked recovery experiments for method validation, and inter-laboratory comparisons are implemented. This study adheres to Good Laboratory Practices (GLP) to ensure accuracy, reproducibility, and regulatory compliance. Through this rigorous methodological framework, the study provides a comprehensive assessment of pesticide residues in rice, wheat, and maize, contributing to food safety and risk assessment efforts.

IV. RESULT AND DISCISSION

Table 1: Pesticide Residue Levels in Rice, Wheat, and Maize

Pesticide	Type	Detected in	Concentration (ppm)	MRL (ppm) (WHO/FAO)	Exceeds MRL?
Chlorpyrifos	Organophosphate	Rice, Wheat	0.35 – 1.25	0.05	YES
Cypermethrin	Pyrethroid	Wheat, Maize	0.22 – 0.89	0.20	YES
Malathion	Organophosphate	Rice, Wheat	0.12 – 0.78	0.50	NO
Deltamethrin	Pyrethroid	Rice	0.15 – 0.65	0.10	YES
Atrazine	Triazine	Maiz	0.05 – 0.30	0.10	YES
Carbofuran	Carbamate	Rice, Wheat	0.08 – 0.42	0.10	NO
Imidacloprid	Neonicotinoid	Wheat, Maize	0.18 – 0.67	0.005	YES

The results indicate that several pesticide residues exceed the Maximum Residue Limits (MRLs) set by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO). Chlorpyrifos, a widely used organophosphate, was found in both rice and wheat, with concentrations significantly exceeding the safe limit of 0.05 ppm, posing potential health risks. Similarly, cypermethrin and deltamethrin, belonging to the pyrethroid class, were detected at levels surpassing the MRLs, particularly in wheat and rice. These pesticides are commonly used for pest control but can cause neurotoxic effects if consumed in excess.

Atrazine, a triazine-based herbicide, was detected in maize at levels exceeding the 0.10 ppm limit, raising concerns about its persistence in the environment and potential endocrine-disrupting effects. Additionally, imidacloprid, a neonicotinoid insecticide, was found in both wheat and maize at levels significantly above the permissible limit,

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highlighting the widespread use of systemic pesticides in cereal production. On the other hand, malathion and carbofuran were detected within safe limits, suggesting that certain pesticide applications in rice and maize were managed effectively.

V. CONCLUSION

The findings of this study highlight the presence of pesticide residues in rice, wheat, and maize, with several detected concentrations exceeding the **Maximum Residue Limits (MRLs)** established by **WHO and FAO**. Notably, **chlorpyrifos, cypermethrin, deltamethrin, atrazine, and imidacloprid** were found at levels above safe limits, raising concerns about potential health risks associated with long-term consumption. These pesticides, commonly used for pest control, can lead to adverse effects such as neurotoxicity, endocrine disruption, and environmental contamination if not properly regulated. On the other hand, **malathion and carbofuran** were detected within permissible limits, indicating better compliance with safety standards in some cases.

The study emphasizes the urgent need for **enhanced monitoring and stricter regulatory enforcement** to control pesticide contamination in staple cereals. **Integrated Pest Management (IPM)** practices, including the use of bio-based pesticides and safer agricultural methods, should be promoted to minimize reliance on hazardous chemicals. Additionally, routine testing and consumer awareness campaigns can help mitigate health risks and ensure food safety. Moving forward, collaborative efforts between **government agencies, researchers, and the agricultural sector** are essential to develop sustainable solutions for reducing pesticide residues in the global food supply.

ACKNOWLEDGMENT

We extend our gratitude to experts, institutions, and stakeholders whose insights and contributions have enriched this study. Special thanks to our academic advisors for their guidance, and to our peers and colleagues for their collaboration and support. We also acknowledge the participants and communities who shared their experiences and perspectives, as well as our families and loved ones for their unwavering support throughout this project.

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Exploring the Chemistry and Biological Significance of the Benzimidazole Nucleus: A Comprehensive Review

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Veer Wajekar ASC College, Phunde, Uran

Abstract: *Benzimidazole is a heterocyclic aromatic compound with significant pharmacological importance. It serves as a privileged structural motif in medicinal chemistry, exhibiting a wide range of therapeutic activities, including anti-ulcer, antihypertensive, analgesic, anti-inflammatory, antiviral, antifungal, anticancer, and antihistaminic properties. A comprehensive review of the literature confirms the effectiveness of benzimidazole derivatives in combating various microorganisms, highlighting their potential in pharmaceutical applications. Due to their biological significance, the synthesis of benzimidazole derivatives has garnered considerable attention in organic chemistry. This review aims to summarize the chemistry, synthesis strategies, and diverse pharmacological activities of substituted benzimidazole derivatives...*

Keywords: Benzimidazole, heterocyclic compounds, medicinal chemistry, synthesis, pharmacological activities, antimicrobial, anticancer, antiviral

I. INTRODUCTION

Benzimidazole derivatives are widely studied due to their diverse biological activities and clinical applications.Their effectiveness is attributed to their regulatory activity and favorable property ratios. Benzimidazole derivatives with oxadiazole moieties are of particular interest for their potential pharmacological benefits. The benzimidazole ring serves as a crucial heterocyclic pharmacophore in drug discovery. These compounds, with various substituents, exhibit multiple biological activities, including:

- Antibacterial
- Anticancer
- Antiviral
- Anti-inflammatory
- Antioxidant
- Antifungal
- Anthelmintic
- Antihistaminic
- Proton pump inhibition
- Anticoagulant
- Antihypertensive

The synthesis of novel benzimidazole derivatives continues to be a major focus in medicinal research.

1.1 Spectral Properties of Benzimidazoles

Infrared (IR) Spectroscopy

Absorption near **2850 Å** indicates the presence of the aryl ring.
Absorption at **3107 Å** corresponds to N-H stretching.

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Absorption at **1690 Å** represents C-N stretching.

Mass Spectroscopy The fragmentation pathways of benzimidazoles resemble those of imidazoles. The mass spectrum shows sequential loss of two hydrogen cyanide (HCN) molecules. Deuterium labeling confirms that the first loss of HCN is nonspecific. 2-n-Propylbenzimidazole exhibits a characteristic ethylene elimination. 2-Acyl, 2-benzoylbenzimidazoles, and 2-acylthiophenes typically lose carbon monoxide (CO) during fragmentation.

Nuclear Magnetic Resonance (NMR) Spectroscopy

Protonation and deprotonation shifts in simple heterocycles can predict chemical shifts in complex molecules. The **δ 7-9** multiplet indicates the presence of an aryl ring in benzimidazole.

Carbon-13 NMR (^{13}C NMR) Carbon peaks range from **δ 0-200** relative to TMS. Benzimidazole peaks typically appear between **δ 115-144**. Overlapping peaks can be identified through triplet and doublet signals. Low-intensity peaks correspond to proton-deficient carbons, aiding in carbonyl group identification.

2. Physical Properties of Benzimidazoles

Substituents at the **1-position** generally lower the melting point.

Benzimidazoles with **imide nitrogen** are soluble in polar solvents but less soluble in organic solvents.

Introducing **non-polar substituents** increases solubility in non-polar solvents.

Adding **polar groups** enhances solubility in polar solvents.

Benzimidazole distills unchanged above **300°C**.

Benzimidazoles are weak bases, being less basic than imidazoles.

They dissolve in dilute acids and also show acidity, forming N-metallic compounds.

Their acidic nature arises from **resonance stabilization** of the ionized form.

Strongly acidic benzimidazoles dissolve in weak bases like potassium carbonate.

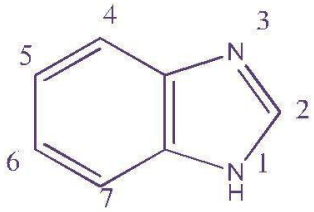


Fig: 1H-Benzimidazole

3. Chemical Properties of Benzimidazoles The benzimidazole ring is highly stable. It resists degradation by concentrated sulfuric acid, hot hydrochloric acid, and alkalis. Oxidation cleaves the benzene ring only under extreme conditions. The benzimidazole ring is resistant to reduction except in specific conditions.

Alkylation Reactions

Reacts with alkyl halides, forming 1-alkylbenzimidazoles. Under strong conditions, 1,3-dialkylbenzimidazolium halides are formed. Reacts with acylating agents, Grignard reagents, and metals. Forms Mannich bases when reacted with formaldehyde and piperidine.

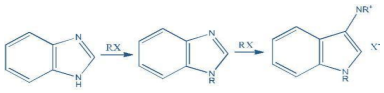
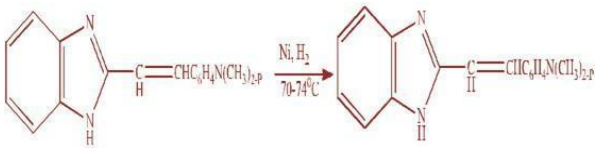


Fig: Alkylation of benzimidazole

Hydrogenation and Dehydrogenation The benzimidazole ring was traditionally considered stable to reduction. Catalytic hydrogenation with nickel at high pressure often gives no reaction. 2-Phenylbenzimidazole reduces only to 2-cyclohexylbenzimidazole. Hydrogenation of 2-(p-dimethylaminostyryl) benzimidazole at atmospheric pressure saturates only the olefinic bond in the 2-position.

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Antimalarial Activity

Malaria causes 350-500 million clinical episodes annually, leading to over a million deaths, primarily affecting children under five in Sub-Saharan Africa. Malaria is the fifth leading cause of death from infectious diseases worldwide. Approximately 3.3 billion people live in malaria-endemic regions across 109 countries. The economic burden of malaria contributes to poverty cycles in endemic countries. Malaria mortality and morbidity increased in the 1980s due to:

Parasite and vector resistance to antimalarial drugs and pesticides.

Weakening of malaria control programs.

Decentralization and declining primary health services.

Humanitarian crises in endemic areas. New antimalarial drugs with novel mechanisms are urgently needed. Chloroquine inhibits hemozoin formation in the parasite's food vacuole. Hemozoin synthesis, unique to Plasmodium, is a potential target for new drug development. New drugs targeting the same essential pathways without resistance issues are highly desirable.

2. Antifungal Activity Infectious diseases pose serious threats to human health. Pathogens increasingly show resistance to antimicrobial agents. Fluconazole, recommended by WHO, is the first-line drug against Candida infections. Fluconazole is ineffective against invasive aspergillosis and is not fungicidal. Clinical use has led to Fluconazole-resistant Candida albicans strains. Novel spiro[indolethiazolidinone] derivatives were screened for antifungal activity. These compounds showed activity against Rhizoctonia solani, Fusarium oxysporum, and Colletotrichum.

3. Antiviral Activity

Hepatitis C virus (HCV) infection is a major risk for liver disease and cancer. Around one-third of the global population is chronically infected with HCV. No preventive vaccine exists, and current therapies have serious side effects. New cell culture models allow in-depth HCV lifecycle studies. Benzimidazole derivatives exhibit antiviral activity against: Human cytomegalovirus (HCMV) ,Human immunodeficiency virus (HIV), Hepatitis B and C viruses Amidino-substituted benzimidazoles (e.g., BABIM) inhibit respiratory syncytial virus (RSV) fusion. Introducing amidino moieties enhances antimicrobial and antiprotozoal activity.

4. Antiproliferative Activity Schiff bases of 2-aminobenzimidazole and substituted aromatic aldehydes were synthesized.Reduction with NaBH4 formed 2-benzylaminobenzimidazoles. Acylation with cinnamoyl chloride produced bioactive compounds. These compounds were evaluated for antiproliferative activity in vitro.

5. Antitumor Activity Several nitrobenzimidazoles show cytotoxic activity against cancer cells. Compounds containing thiadiazole, tetrazole, triazine, and imidazole also exhibit antitumor effects.

6. Anti-inflammatory Activity 2-Methylaminobenzimidazole derivatives were synthesized and tested. Compounds were evaluated for analgesic and anti-inflammatory activities. Some derivatives showed potent activity similar to indomethacin. Combination with an indole skeleton enhances anti-inflammatory effects.

7. Antioxidant Activity Dihydrochloride-containing compounds show antioxidant properties. These salts also possess mild platelet and erythrocyte antiaggregant activity. Trimethyl-substituted benzimidazoles exhibit antioxidative effects via 5-lipoxygenase inhibition.

8. Antiprotozoal Activity

i) 5,6-Dinitro and thioalkyl/thioaryl benzimidazoles show activity against Stenotrophomonas maltophilia. These compounds are effective against both Gram-positive and Gram-negative bacteria. Substituted 2-trifluorobenzimidazoles display anti-giardial activity. 2-(Trifluoromethyl)-1H-benzimidazoles were synthesized using Phillips cyclocondensation. These compounds exhibited nanomolar activity against protozoan parasites, including: Giardia

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intestinalis,Entamoeba histolytica,Trichomonas vaginali,Leishmania Mexicana They also showed in vivo efficacy against Trichinella spiralis.

9. Androgen Receptor Antagonist Activity 5,6-Dichlorobenzimidazole derivatives function as androgen receptor antagonists. The presence of a trifluoromethyl group enhances prostate antagonistic activity. Bicalutamide, a non-steroidal antiandrogen, is widely used for prostate cancer treatment.

10. Anticancer Activity 1,3-Diarylpyrazinobenzimidazole derivatives were synthesized and tested for anticancer effects. 2-Aryloylbenzimidazole derivatives reacted with 2-bromoacetophenones to form key intermediates.Further reactions with ammonium acetate yielded final compounds. Microwave irradiation facilitated synthesis. Methyl 1-(4-methoxyphenethyl)-2-(4-fluoro-3-nitrophenyl)-1H-benzimidazole-5-carboxylate showed strong leukemic cell inhibition (IC50 = 3 μM).

11. Anticonvulsant Activity 1,2,5-Trisubstituted benzimidazole derivatives were synthesized. QSAR studies revealed: Linker variations at position 1 (R1) do not significantly affect activity. Optimal chain length at position 2 (R2) enhances anticonvulsant activity. Electron-withdrawing groups (e.g., nitro at R3) improve potency.

II. CONCLUSION

Benzimidazoles are a promising class of bioactive heterocyclic compounds. They exhibit a broad range of biological activities, including Antimicrobial, Antivi Anti-inflammatory Anticancer

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An Overview of the Bioactive Properties of Benzimidazole Derivatives

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Abstract: *Benzimidazole derivatives play a crucial role in the field of medicinal chemistry due to their diverse pharmacological properties, including antibacterial, antifungal, anthelmintic, antiviral, antidiabetic, and anticancer activities. As a fused heterocyclic system containing both benzene and imidazole rings, benzimidazole has garnered significant attention in modern drug discovery and development. Its structural versatility and broad-spectrum bioactivity make it a valuable scaffold for the design of novel therapeutic agents. This review highlights recent advancements in the chemistry and pharmacological potential of benzimidazole derivatives, emphasizing their significance in the development of new drugs...*

Keywords: Benzimidazole, pharmacological properties, drug discovery, antibacterial, antifungal, antiviral, anticancer, anthelmintic, antidiabetic

I. INTRODUCTION

Benzimidazole is a distinct heterocyclic aromatic compound that holds a privileged position in medicinal chemistry as a crucial pharmacophore. Structurally, it is a bicyclic system formed by the fusion of benzene and imidazole rings, contributing to its remarkable pharmacological versatility. Benzimidazole derivatives have gained widespread attention due to their extensive range of bioactive properties.

The first benzimidazole derivative was synthesized by Hobecker in 1872. Subsequent research significantly expanded its medicinal relevance. In 1943, Goodman and Nancy Hart explored its pharmacological properties, while in 1944, Woolley reported the antibacterial potential of certain benzimidazole derivatives. Later, in 1949, Norman GB and Karl Folker identified 5,6-dimethyl benzimidazole as a degradation product following the acid hydrolysis of vitamin B12. These findings laid the foundation for extensive studies, establishing benzimidazole as an essential heterocyclic system with broad-spectrum biological activities.

Benzimidazole derivatives have demonstrated therapeutic potential against a wide range of diseases and pathogens. They exhibit diverse pharmacological effects, including antiviral, anticancer, anthelmintic, anti-inflammatory, analgesic, antihistaminic, antiparasitic, anticonvulsant, antiulcer, antihypertensive, antifungal, and proton pump inhibitory activities. Due to their broad therapeutic spectrum and significant clinical applications, benzimidazole derivatives continue to be a focal point in drug discovery and development.

BIOLOGICAL ACTIVITY OF BENZIMIDAZOLE: ANTIBACTERIAL ACTIVITY

The growing concern over bacterial resistance has driven significant interest in the development of novel antibacterial agents. Among these, 2-substituted benzimidazole derivatives have emerged as particularly potent candidates, making them a promising focus for antimicrobial drug development. Literature studies indicate that these derivatives exhibit enhanced pharmacological activity and are structurally present in several established antibacterial drugs, such as furacillin, furazolidone, and ftivazide.

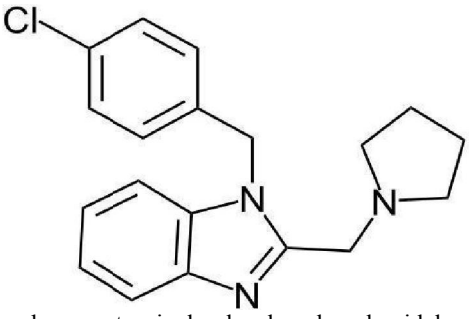
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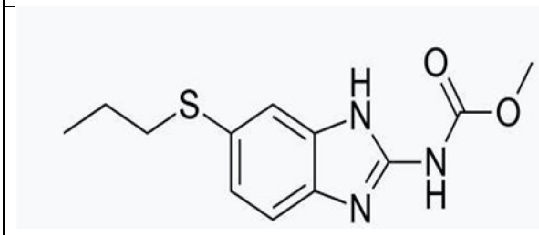
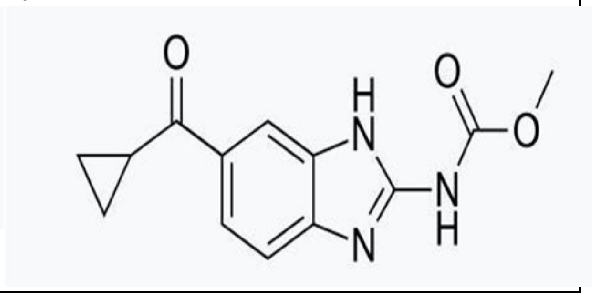
Hydrazone derivatives have also garnered considerable attention in recent years due to their potential as chemotherapeutic agents in the design of new antimicrobial compounds. Notably, 1,2-disubstituted 1H-benzimidazole-N-alkylated-5-carboxamidine derivatives have demonstrated significant antibacterial efficacy, particularly against methicillin-resistant *Staphylococcus aureus* (*MRSA*) and other *S. aureus* strains. These findings highlight the critical role of benzimidazole-based compounds in the ongoing search for effective antibacterial therapies

Clemizole peniciline

BIOLOGICAL ACTIVITY OF BENZIMIDAZOLE: ANTHELMINTIC ACTIVITY



Benzimidazole derivatives have been extensively developed and widely utilized as anthelmintic agents. Notable examples include albendazole, cyclobendazole, fenbendazole, flubendazole, mebendazole, oxibendazole, oxfendazole, and thiabendazole, all of which have demonstrated significant efficacy in treating parasitic infections. Faruk et al. synthesized a series of 5-nitro benzimidazole derivatives and evaluated their anthelmintic activity against the adult Indian earthworm (*Pheretima posthuma*). Their preliminary biological studies confirmed that all tested compounds exhibited remarkable anthelmintic effects. Similarly, Vilasrao et al. reported the synthesis of a library of 2-substituted benzimidazoles and assessed their anthelmintic potency against the adult earthworm *Eisenia fetida*. Among the tested compounds, several displayed exceptional anthelmintic properties, comparable to the standard drug albendazole.Additionally, benzimidazole derivatives were synthesized via the condensation of *O*-phenylenediamine and subsequently evaluated for their anthelmintic potential. The results indicated that these compounds exhibited significantly higher anthelmintic activity than the standard reference drug, piperazine citrate, reinforcing the therapeutic importance of benzimidazole-based agents in antiparasitic treatments.

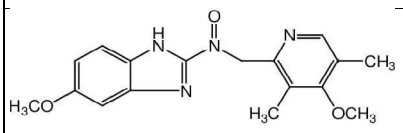
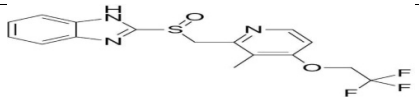
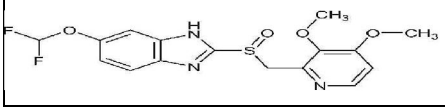
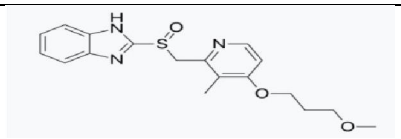
Albendazole	Cyclobandazole
	

ANTIULCER ACTIVITY:

Benzimidazole derivatives have been widely explored for their antiulcer properties, particularly due to their ability to inhibit H^+/K^+ ATPase, a key enzyme in gastric acid secretion (3,4). Given their clinical relevance in treating peptic ulcers and other gastrointestinal conditions, researchers have developed more selective and potent benzimidazole-based proton pump inhibitors (4,5). In 1991, modifications to the benzimidazole core, such as N-H substitution with electron-donating groups and the addition of propyl acetamido-thio, thiazole-amino, and tetramethyl piperidine on pyridine, resulted in improved antiulcer efficacy (5). Common benzimidazole-based antiulcer drugs include omeprazole (a

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racemic mixture), lansoprazole, rabeprazole, pantoprazole, and esomeprazole (S-enantiomer) (6). Omeprazole, in particular, requires an enteric-coated formulation to prevent degradation in stomach acid, and its effectiveness is linked to the transformation of its N-H substituent into a sulfonamide (6).

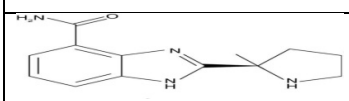
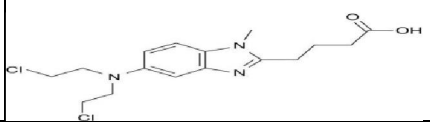
Omeprazole	Lansoprazole
	
Pantoprazole	**Rabeprazole**
	

ANTIMALARIAL ACTIVITY:

Malaria remains a major global health concern, causing approximately 350–500 million clinical cases and over one million deaths annually. The highest mortality rates are observed in sub-Saharan Africa, particularly among children under five. It is the fifth leading cause of death due to infectious diseases, following tuberculosis, respiratory infections, HIV/AIDS, and diarrheal diseases. An estimated 3.3 billion people across 109 countries live in malaria-prone regions, making it a widespread threat. Beyond its health implications, malaria significantly hampers the economies of affected nations, perpetuating poverty. The 1980s witnessed a surge in malaria cases and fatalities due to multiple factors, including humanitarian crises in endemic regions, the decline of traditional malaria control programs, ineffective integration into struggling primary healthcare systems, and the growing resistance of parasites and vectors to available antimalarial drugs and insecticides.

ANTICANCER ACTIVITY :

Cancer is the second leading cause of death in the United States and remains a significant global public health challenge. It is characterized by the uncontrolled growth and spread of abnormal cells, which, if left unchecked, can be fatal. Benzimidazole, a nitrogen-containing heterocyclic compound, plays a crucial role in cancer treatment. Several benzimidazole-based drugs have been developed, including bendamustine for chronic lymphocytic leukemia (CLL), veliparib as a PARP inhibitor, selumetinib targeting MEK1/2, galeterone for prostate cancer, and nocodazole, which disrupts microtubule dynamics and prevents tumor cell mitosis. Researchers continue to explore new and more effective anticancer agents to address issues such as toxicity, drug resistance, and specificity. The benzimidazole framework is recognized for its strong anticancer potential, making it a valuable structure for designing novel drug candidates. In particular, 2-substituted benzimidazoles, including 2-aryl and 2-heteroaryl derivatives, have gained attention for their promising anticancer properties, with bisbenzimidazoles demonstrating significant cytotoxic effects against various cancer cell lines.

Valiparib	Bendamustine
	

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ANTIPROTOZOAL ACTIVITY:

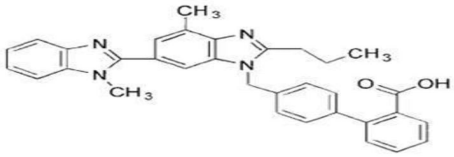
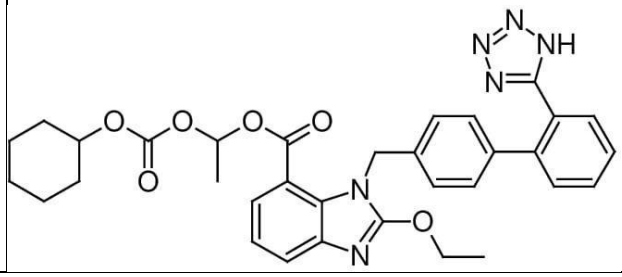
Studies have reported that benzimidazole derivatives, including 5,6-dinitro and thioalkyl or thioaryl-substituted compounds, exhibit significant antimicrobial activity, particularly against *Stenotrophomonas maltophilia*. These compounds are effective against both Gram-positive and Gram-negative bacteria, functioning similarly to metronidazole. Additionally, 2-trifluorobenzimidazole derivatives have been identified for their biological activity, including previously documented anti-giardial properties. In a separate study, Phillips synthesized a series of 2-(trifluoromethyl)-1H-benzimidazole derivatives through the cyclocondensation of substituted 1,2-phenylenediamine with trifluoroacetic acid. These compounds exhibited potent nanomolar activity against several protozoan parasites, including *Giardia intestinalis, Entamoeba histolytica, Trichomonas vaginalis*, and *Leishmania mexicana*. Furthermore, their effectiveness was confirmed in *Trichinella spiralis* infections through both in vitro and in vivo testing.

ANTIVIRAL ACTIVITY:

Research indicates that benzimidazoles exhibit antiviral activity against *Enterovirus, Picornavirus,* and *Poliovirus*. Additionally, N-substituted benzimidazoles have been found effective against the *Tobacco Mosaic Virus*. Another reported approach involves synthesizing benzimidazole heterocycles with an amidino group at the C-5 position. In a published study, several novel benzimidazole derivatives were designed, synthesized, and evaluated in VERO cells for their inhibitory effects on four different enteroviruses. Among them, (L)-2-(pyridin-2-yl)-N-(4-nitrophenyl)pentan-3yl)-1H-benzimidazole-4-carboxamide demonstrated the highest potential, exhibiting a strong antiviral effect along with a remarkable selectivity index.

ANTIHYPERTENSIVE ACTIVITY:

Biphenylbenzimidazoles have been found to possess a stronger antihypertensive effect compared to earlier similar drugs, primarily due to their improved oral bioavailability. The 2-position of the biphenyl structure plays a crucial role in their activity. Studies have also shown that 4′- and 5-substituted aryl or alkyl carboxamido derivatives act as antagonists of the Angiotensin-II AT1 receptor, making them effective agents for managing hypertension.

Telmesartan	Candesartan
	

Benzimidazole is a key pharmacophore in modern drug discovery, and its derivatives have gained significant attention as potential antimicrobial agents. These compounds play a valuable role in medical research, with numerous studies highlighting the pharmacological potential of heterocycles and substituted benzimidazoles. As structural isosteres of nucleotides, they interact efficiently with biopolymers while exhibiting lower toxicity. Researchers are currently focused on developing more potent benzimidazole derivatives with diverse biological activities.

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Thiadiazole and Its Derivatives: Emerging Synthetic Methods Using Thiosemicarbazides and Hydrazides

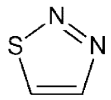
Nitin S. Pawar, D. L. Lingampalle, D. S. Wagare
Department of Chemistry,
Vivekanand Arts, Sardar Dalipsingh Commerce and Science College, Chhatrapati Sambhajinagar

Abstract: *Thiadiazoles and their derivatives have attracted considerable interest due to their wide-ranging pharmacological and industrial applications. Recent progress in their synthesis has predominantly centered on the use of thiosemicarbazides and hydrazides as fundamental precursors. Various catalytic and non-catalytic methodologies, including green chemistry approaches, microwave-assisted techniques, and solvent-free conditions, have been explored to improve efficiency and yield. Structural modifications of thiadiazoles have resulted in compounds exhibiting enhanced biological activities, such as antimicrobial, anticancer, and anti-inflammatory effects. This review provides an overview of recent advancements in synthetic strategies, reaction mechanisms, and novel applications of thiadiazole derivatives, with a focus on sustainable and cost-effective methods*

Keywords: Thiadiazole, thiosemicarbazides, hydrazides, green chemistry, catalytic methods, biological activities

I. INTRODUCTION

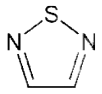
Heterocyclic compounds are important to medicinal chemists because of their exceptional chemical properties and wide range of biological activities. Thiadiazole is a common and important fivemember heterocyclic system containing two nitrogen atoms and a sulphur atom [1].The ring is aromatic and it has four constitutional isomers differing by the relative positions of the sulfur and nitrogen atoms. Thefour isomers of thiadiazoles are 1,2,3- thiadiazoles, 1,2,4-thiadiazoles, 1,2,5-thiadiazoles and 1,3,4-thiadiazoles.



1,2,3- thiadiazole



1,2,4-thiadiazole



1,2,5-thiadiazole



1,3,4-thiadiazole

Fig.1 Isomers of thiadiazole

Among the four isomers, 1,3,4-thiadiazoles are the most importantisomer having antitumoral potential [2]. These compounds have very important applications in the field of agrochemicals, pharmaceuticals, and material research. They demonstrate diverse biological effects, including antifungal [3], antibacterial [4], anti-inflammatory [5], antiparasitic [6], antioxidant [7], antidepressant [8], anticonvulsant [9], diuretic, and antitumoral activities [10].These biological activities encouraged researchers to find out different methods for synthesis of new and existing thiadiazoles and their derivatives using different starting materials thiosemicarbazides,thiocarbazides, dithiocarbazates, thioacylhydrazines, acylhydrazines, and bithioureas [11–17].This review is useful for researchers for the preparation of thiadiazole derivatives, drug discovery, and medicinal chemistry.

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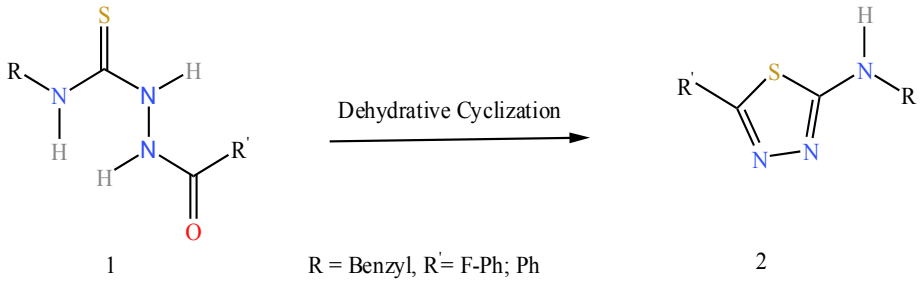
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Methodologies for the synthesis of thiadiazole and its derivatives

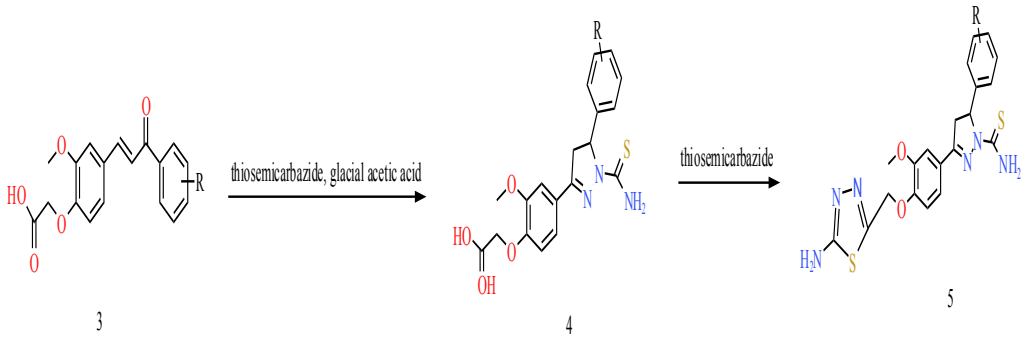
From thiosemicarbazides

In 2013, Yang and co-authors have prepared 2-amino-substituted thiadiazole derivatives (2). This method involves the preparation of intermediate thiosemicarbazides (1)[18].



Scheme 1. Schematic diagram of thiosemicarbazide cyclization

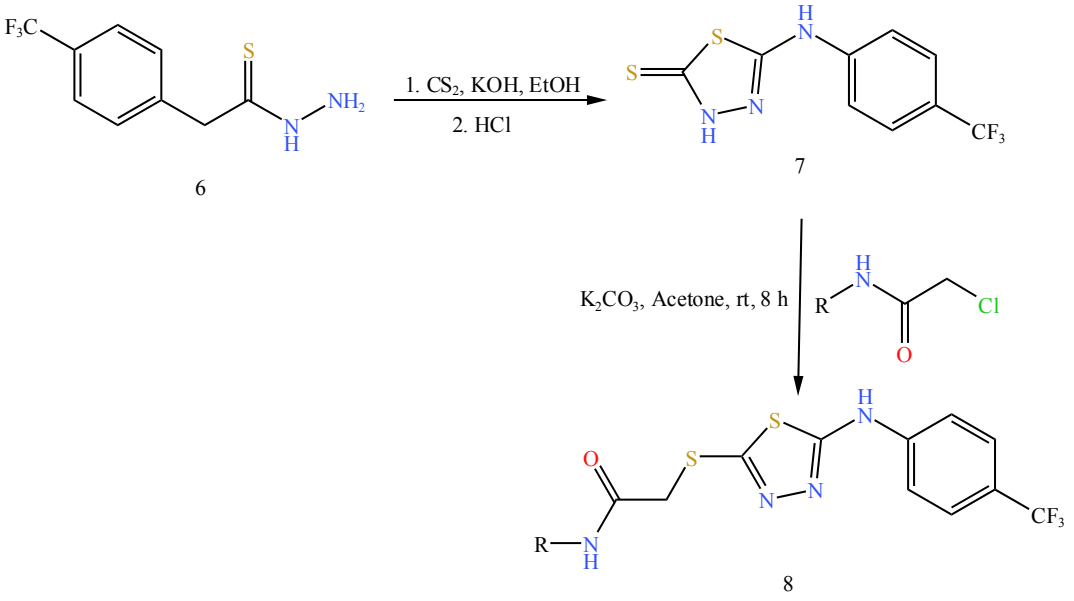
In 2011, Malleshappa N. Noolvi and co-authors synthesized novel 1,3,4-thiadiazole derivatives (5) of 2-(4-formyl-2-methoxyphenoxy) acetic acid by cyclization of carboxylic acid group with thiosemicarbazide (3) in the presence of POCl3 or PPA [19].



Scheme 2. thiadiazole derivative compound from thiosemicarbazide.

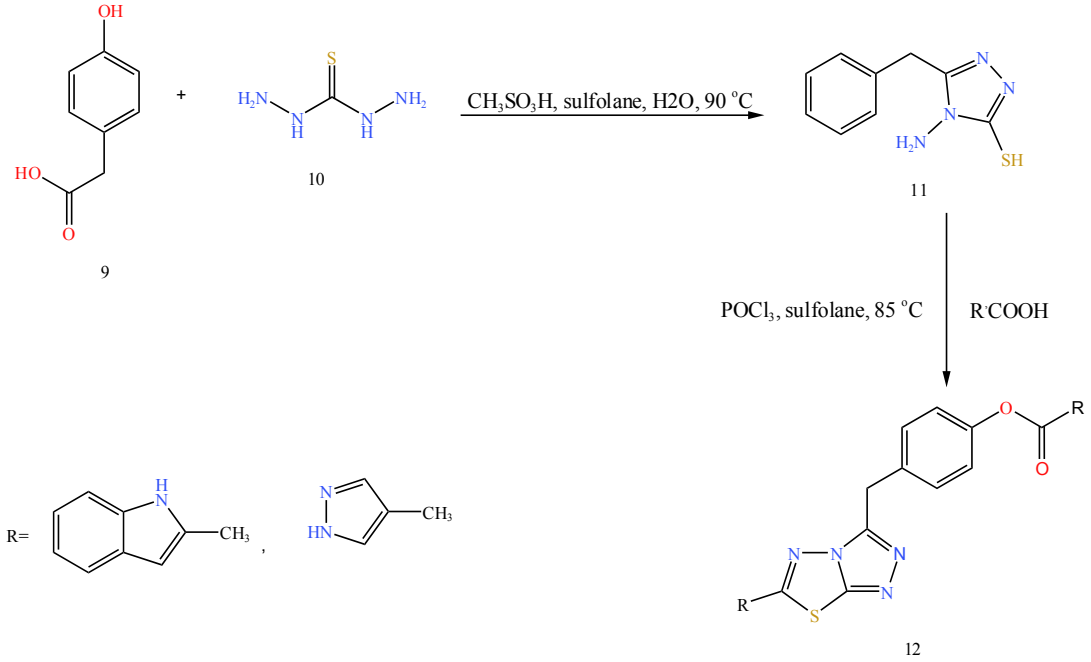
In 2018 Mehlika Dilek Altıntop and co-authors were synthesized 1,3,4-thiadiazole derivatives(8) using (4-(trifluoromethyl)phenyl) thiosemicarbazide(6) and carbon disulfide, the intermediate formed further treated with N-(aryl)−2-chloroacetamides (24), in the presence of catalyst K2CO3 in acetone and they studied for their cytotoxic effects on multiple human cancer cell lines[20]. (Scheme 3)

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Scheme 3. 1,3,4-thiadiazole synthesis using thiosemicarbazide and CS2

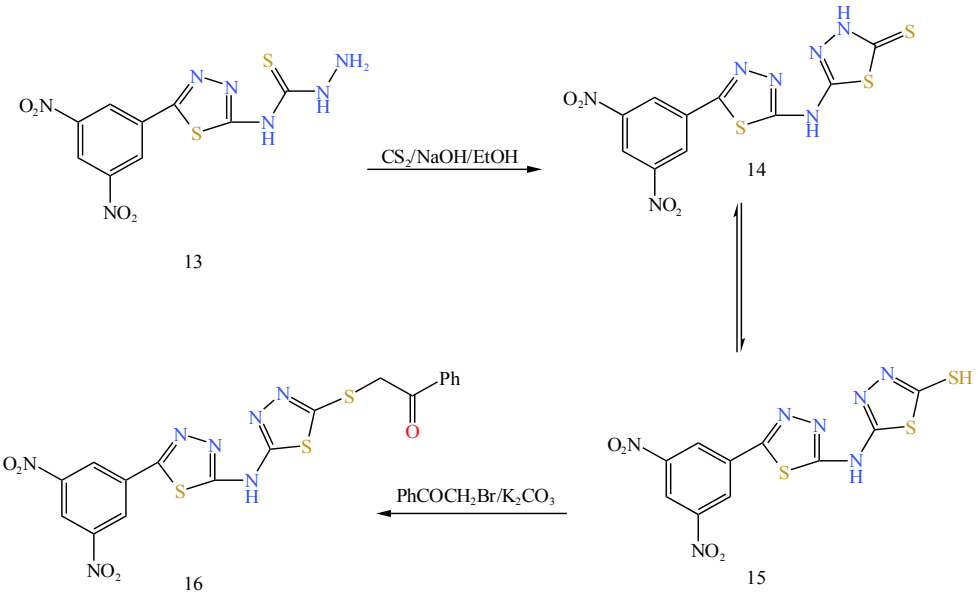
In 2018 Yuan and colleagues synthesized triazole-based thiadiazole derivative (12) in two step.First they have prepared intermediate (11) by dissolving aromatic carboxylic acid(9) and thiosemicarbazide(10) in a solvent which is mixture of sulfolane and water. The intermediate was further treated with aromatic carboxylic acid and $POCl_3$ catalyst in sulfolane at 85°C for 18 h. [21].(Scheme 4)



Scheme 4. Synthesis of triazole-based thiadiazole derivatives

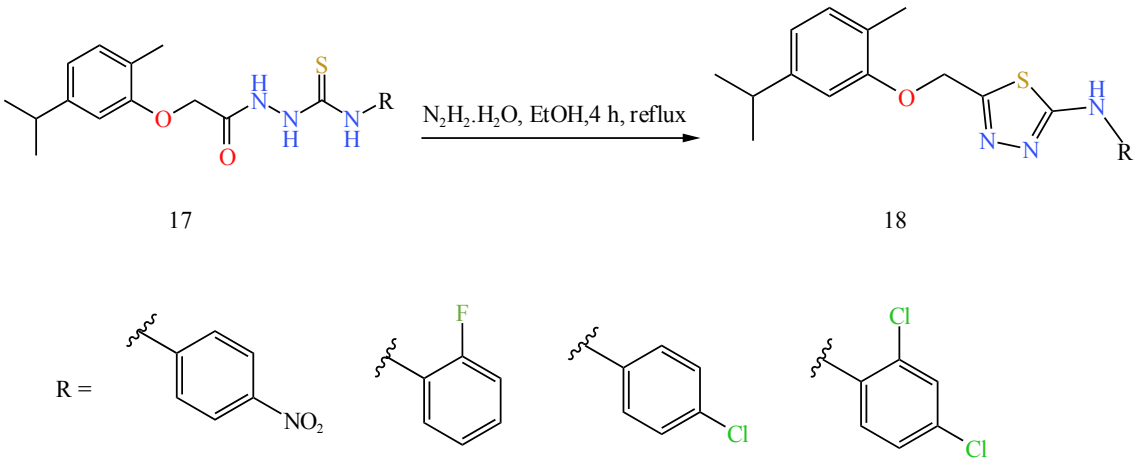
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In 2019 Mohamed El-Naggar and coauthors prepared 1,3,4-thiadiazol-2-yl derivatives (14 & 15) by treating thiosemicarbazide derivatives (13) with CS_2 / NaOH in ethanol. 1,3,4-thiadiazol-2-yl derivative (13) after treating with phenacyl bromide in the presence of potassium carbonate gives acetophenone derivatives (16)[22]. (Scheme 5)



Scheme. 5 Synthesis of bis-thiadiazoles

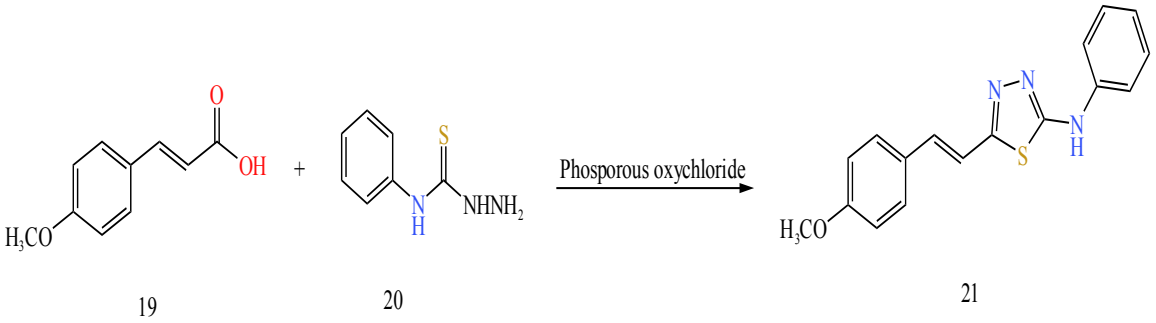
In August 2023 Tenzile Alagöz and coauthors were obtained thiosemicarbazide derivatives (17) fromethylphenoxy acetate derivative and hydrazine hydrate. Then the intramolecular cyclisation of thiosemicarbazide derivative (17) carried out in acidic medium to synthesize triazole-3-thiol derivatives (18)[23]. (Scheme 6)



Scheme. 6 thiosemicarbazide and 1,3,4 thiadiazole derivatives

In 2022 Hakan S. Sayiner and coauthors synthesized1,3,4-Thiadiazole derivative (21) usingmethoxy cinnamic acid (19)and phenylthiosemicarbazide (20) in the presence of phosphorus oxychloride [24]. (Scheme 7)

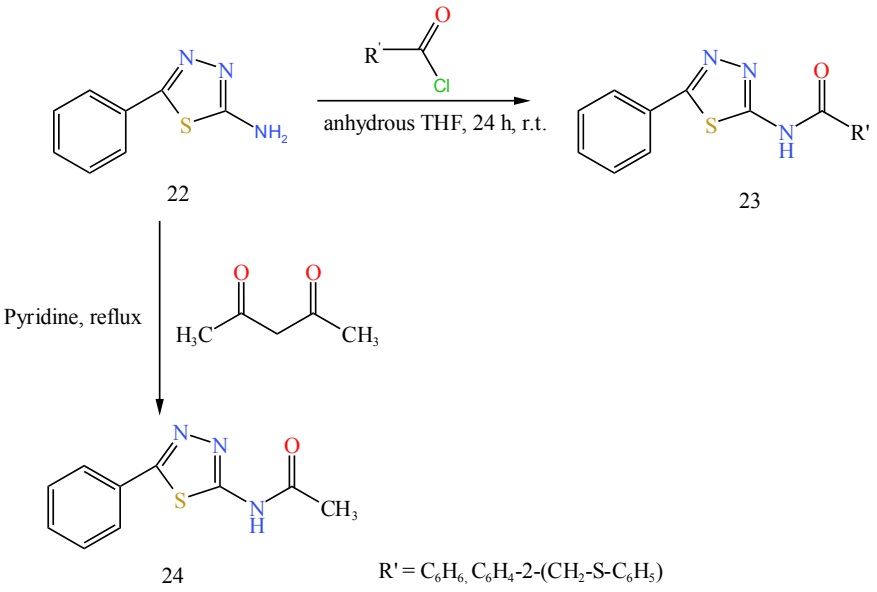
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19 20 21

Sceheme 7. Synthesis of thiadiazole derivative using thosemicarbazide derivative

Camelia ElenaStecoza and colleagues prepared 1,3,4-Thiadiazole-2-amide derivatives (23) by coupling reaction between 5-phenyl-1,3,4-thiadiazol-2-amine and corresponding acid chlorides in anhydrous tetrahydrofuran (THF) and 1,3,4-Thiadiazole-2-amide derivatives (24) obtained by acetylation of (22). Liberated hydrogen chloride is neutralized by using solid sodium hydrogen carbonate[25]. (Scheme 8).



22 23 24

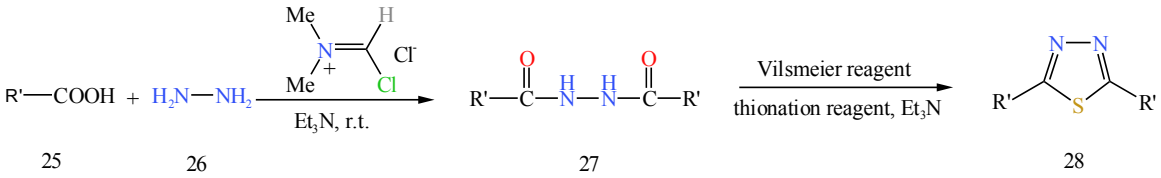
Scheme 8. Synthesis of 1,3,4-thiadiazol-2-amide derivatives.

From Hydrazides

In 2013Dinneswara Reddy Gudawere synthesized *2*-amino-1,3,4-thiadiazoles hydrazine by refluxingtrimethylsilyl isothiocyanate in ethanol then acidified it with conc. H_2SO_4 [26].

In 2017Maaroof Zarei were carried out synthesis of 1,3,4-thiadiazoles. In this method carboxylic acids (25) and hydrazine (26) were converted to 1,3,4-thiadiazoles (28)in the presence of Vilsmeier and Lawson's reagent [27]. (Scheme 9)

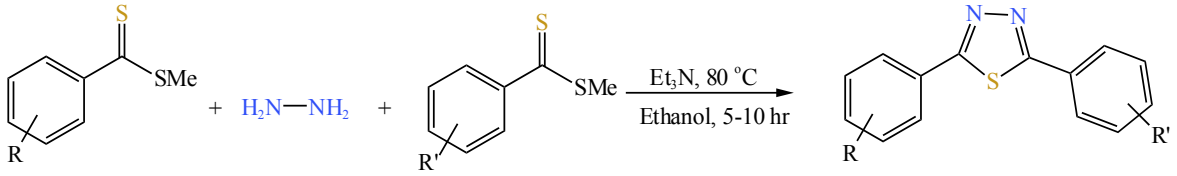
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25 26 27 28

Scheme 9. Synthesis of 1,3,4-thiadiazoles

In 2019Kemparajegowda and coauthors were synthesized 3,5-disubstituted 1,3,4-thiadiazole(31)from dithioesters (29& 30), hydrazine hydrate and triethyl amine[28].(Scheme 10)

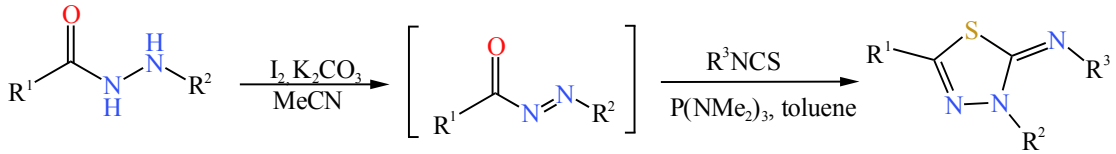


29 30 31

R and R' = Me, OMe, F, Cl, OH

Scheme 10. Synthesis of 3,5-disubstituted 1,3,4-thiadiazole using hydrazine

In 2020 Zhengyan Huang and colleagues synthesized 2-Imino-1,3,4-thiadiazoles(33) from Hydrazides (32) and Isothiocyanates via Sequential Oxidation and $P(NMe_2)_3$-Mediated Annulation reactions [29].(Scheme 11)

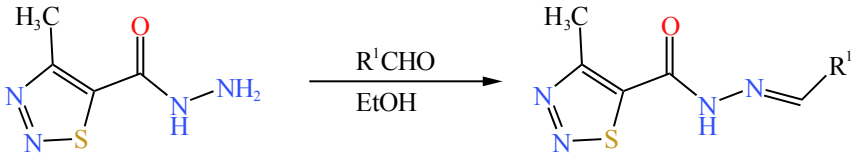


32 33

R^1 and R^2 = Ph, CN, Me, Cl , NO_2

Scheme 11. 2 Imino-1,3,4-thiadiazoles

In 2021 Kinga Paruch and co-authors synthesized derivatives of 4-methyl-1,2,3-thiadiazole-5-carboxylic acid hydrazide (35). Hydrazide (34) and aldehyde in ethanol is refluxed for 3 hours then it placed in a refrigerator for 24 hrs. The formed derivative was filtered off and recrystallized from ethanol [30].(Scheme 12)



34 35

R^1= 2-Cl-C_6H_4, 3-Cl-C_6H_4, 2-F-C_6H_4, 4-F-C_6H_4, 3-OC_2H_5-4-OH-C_6H_3

Scheme 12. Synthesis of derivatives of 4 methyl 1,2,3 thiadiazole 5 carboxylic acid hydrazide

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II. CONCLUSION

This review paper gives information about recent progress in the synthesis of thiadiazole and its derivatives using thiosemicarbazides and hydrazides in both methodology and applications. These compounds, characterized by their versatile biological and pharmacological properties, have become valuable targets in medicinal chemistry. The use of thiosemicarbazides and hydrazides as key intermediates in thiadiazole synthesis has proven to be an effective approach, offering improved yields, selectivity, and reaction conditions. Additionally, innovative strategies such as green chemistry principles and catalytic processes have been integrated into synthetic routes, enhancing the sustainability and efficiency of these reactions. The structural diversity and reactivity of the resulting thiadiazole derivatives, particularly in the context of their potential applications in drug development, make them promising candidates for future research. As the understanding of their chemical properties continues to expand, these compounds hold the potential to contribute significantly to the development of new therapeutics, making them a highly relevant subject of ongoing investigation.

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A Brief Review on the Synthesis of Heterocycles Using Fruit Extracts as Catalysts

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Abstract: *This review highlights recent advancements in the use of fruit extracts as natural catalysts for the synthesis of heterocyclic compounds. The application of green chemistry principles is emphasized through various eco-friendly synthetic approaches. Fruit extract-based catalysts offer numerous advantages, including non-toxicity, environmental sustainability, ease of handling, cost-effectiveness, and widespread availability. Their potential as an efficient and sustainable alternative for heterocyclic transformations makes them a promising tool for future organic synthesis*

Keywords: fruit extract, heterocyclic synthesis, green catalysis, sustainable chemistry

I. INTRODUCTION

Heterocyclic compounds are a vital class of organic molecules with extensive applications in pharmaceuticals, agrochemicals, and materials science. Traditional synthesis methods often involve harsh reaction conditions, toxic reagents, and expensive catalysts, leading to environmental and safety concerns. The advent of green chemistry has encouraged the development of eco-friendly methodologies, among which fruit extract-mediated catalysis has gained significant attention.

Fruit extracts contain a variety of bioactive compounds such as flavonoids, alkaloids, polyphenols, and organic acids, which can act as natural catalysts in organic synthesis. These extracts not only accelerate reactions but also enhance product selectivity and yield under mild conditions. In this review, we explore the role of fruit extracts in the synthesis of heterocyclic compounds, highlighting their advantages, reaction mechanisms, and future potential.

II. GREEN CHEMISTRY PRINCIPLES IN HETEROCYCLIC SYNTHESIS:

Green chemistry aims to reduce environmental impact by designing sustainable chemical processes. The use of fruit extracts aligns with several of the Twelve Principles of Green Chemistry, including:

Use of Renewable Feedstocks: Fruits are an abundant and renewable source of catalysts.
Reduction of Hazardous Chemicals: Fruit extracts replace toxic catalysts and reagents.
Energy Efficiency: Many reactions occur at room temperature, minimizing energy consumption.
Biodegradability: Natural catalysts degrade harmlessly without generating hazardous waste.
Atom Economy: These catalysts promote high-yielding reactions with minimal by-products.

III. FRUIT EXTRACTS AS CATALYSTS IN HETEROCYCLIC SYNTHESIS

Various fruit extracts have been explored as catalysts for the synthesis of heterocyclic compounds. Below are some key examples:

3.1 Citrus Fruits (Lemon, Orange, and Lime Extracts)

Citrus fruits are rich in citric acid, flavonoids, and vitamin C, which act as natural acids in catalysis. Studies have shown their effectiveness in synthesizing pyrimidines, quinolines, and imidazoles under mild conditions.

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Example Reaction: Lemon juice has been successfully used in the synthesis of 2,3-dihydroquinazolin-4(1H)-ones through a one-pot condensation of aldehydes, amines, and isocyanates.

3.2 Banana and Papaya Extract Banana peel extracts contain potassium, polyphenols, and amino acids that contribute to catalytic activity. Papaya extract, rich in proteolytic enzymes, has been employed in the synthesis of fused heterocyclic systems.
Example Reaction: Papaya extract-catalyzed synthesis of 1,4-dihydropyridine derivatives has been reported under solvent-free conditions with excellent yields.

3.3 Apple and Pomegranate Extract Apple and pomegranate peels are sources of tannins, anthocyanins, and gallic acid, which provide strong catalytic activity. These extracts have been employed in the synthesis of thiophene and pyrrole derivatives.
Example Reaction: Pomegranate extract-mediated synthesis of benzimidazole derivatives at room temperature has demonstrated high efficiency with minimal environmental impact.

3.4 Grapes and Berries Extracts Grape and berry extracts contain resveratrol, flavonoids, and organic acids, which facilitate cyclization reactions in heterocyclic synthesis.
Example Reaction: Blueberry extract has been utilized in the green synthesis of 1,3,4-oxadiazoles, showing high conversion rates.

IV. MECHANISM OF FRUIT EXTRACT CATALYSIS

The catalytic activity of fruit extracts is attributed to their bioactive components. The mechanism typically involves:
Activation of Carbonyl Groups: Organic acids and flavonoids in fruit extracts enhance electrophilicity, facilitating nucleophilic attack.
Proton Donation: Citric and ascorbic acids provide protons to accelerate reactions.
Metal Ion Assistance: Some fruit extracts contain trace metal ions that act as Lewis acid catalysts.
Radical Scavenging: Phenolic compounds stabilize reactive intermediates, improving selectivity.

V. ADVANTAGES OF FRUIT EXTRACT-BASED CATALYSIS

Eco-Friendly: No toxic reagents or solvents are required.
Cost-Effective: Readily available and inexpensive compared to synthetic catalysts.
Mild Reaction Conditions: Many reactions occur at room temperature, reducing energy consumption.
Enhanced Selectivity and Yield: Natural catalysts improve reaction efficiency.
Biocompatibility: Suitable for pharmaceutical and biomedical applications.

VI. CHALLENGES AND LIMITATIONS

Despite their advantages, fruit extract catalysts face certain challenges:
Variability in Composition: Differences in fruit variety, ripeness, and extraction method can affect catalytic efficiency.
Lack of Standardization: Optimization of reaction conditions is needed for reproducibility.
Scalability Issues: Large-scale synthesis requires improved extraction and purification techniques.
Short Shelf Life: Natural extracts degrade over time, affecting long-term usability.

VII. FUTURE PERSPECTIVES

The potential of fruit extract catalysis in organic synthesis is vast, with future directions including:
Development of Stabilized Extracts: Encapsulation or immobilization techniques to enhance stability.
Integration with Nanocatalysis: Combining fruit extracts with nanoparticles for enhanced activity.
Automation and Scale-Up: Optimizing processes for industrial applications.

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Exploration of New Fruits: Investigating underutilized fruits with catalytic potential.

VIII. CONCLUSION

Fruit extract-mediated catalysis represents a sustainable, cost-effective, and eco-friendly approach for heterocyclic synthesis. By replacing hazardous reagents with natural catalysts, this methodology aligns with green chemistry principles while ensuring high efficiency. Further research and technological advancements will enhance their applicability in pharmaceutical and industrial chemistry.

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Effect of Mutagenic Treatments on Seed Germination, Seedling Growth, and Survival of *Capsicum annuum* L.

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Abstract: *Chili (*Capsicum annuum *L.) is an economically significant crop valued for its capsaicinoids, carotenoids, and essential vitamins, making it a staple in culinary and medicinal applications. Enhancing yield, nutritional composition, and secondary metabolite content are primary objectives in contemporary breeding programs to maximize crop profitability. The success of such programs relies on genetic diversity, which can be achieved through induced mutations. Chemical mutagens, such as sodium azide (NaN_3), are widely used to induce genetic variability by altering nucleotide sequences and generating novel alleles. This study investigates the effect of sodium azide on seed germination and plant growth in* Capsicum annuum. *The experiment aims to evaluate morphological variations induced by the mutagen, assess germination rates, and analyze subsequent growth responses*

Keywords: *Capsicum annuum,*Chili, Sodium azide, Germination percentage

I. INTRODUCTION

Capsicum (*Capsicum annuum* L.), commonly known as bell pepper, sweet pepper, hot pepper, or chili, is a popular vegetable crop. It is consumed in various forms, including as a spice, vegetable, pickle, condiment, and sauce. Internationally, chilies are widely used as a spice and serve as an ingredient in medicines and beverages (Khan et al., 2017).

A mutation is a sudden heritable change in the DNA in a living cell, not caused by genetic segregation or genetic recombination. Mutation breeding is the purposeful application of mutations in plant breeding. Unlike hybridization and selection, mutation breeding has the advantage of improving a defect in an otherwise elite cultivar, without losing its agronomic and quality characteristics.

Sodium azide, a widely used chemical mutagen, plays a crucial role in enhancing agronomic traits in crop plants. It is commonly utilized to develop resistance in vulnerable crops, thereby improving their yield and quality traits against harmful pathogens. Various mutagens are available for crop improvement, each exhibiting distinct effects, which can be either beneficial or detrimental to plant growth and development. (Khan*et. al.,* 2009).Varying the concentrations of sodium azide on seed germination, as well as plumule and radicle development, to determine the most effective dose for successful mutagenesis research (Singh*et. al.,* 2022).

II. MATERIALS AND METHODS

Experimental materials:

The present study was carried out on a valuable seed of *Capsicum annuum*L. belonging tofamily Solanaceae, the seed material was collected from the Agricultural shop (Krushiseva Kendra) Murud (M.S.) India.

Mutagen:

The seeds of *Capsicum annuum* L. were treated with the mutagen sodium azide (SA). The experiment was conducted using six different treatment doses (0.02%, 0.04%, 0.06%, 0.08%, and 0.1%), along with a non-treated control.

Germination percentage:

"Germination Percentage=seeds germinated/total seedsx100

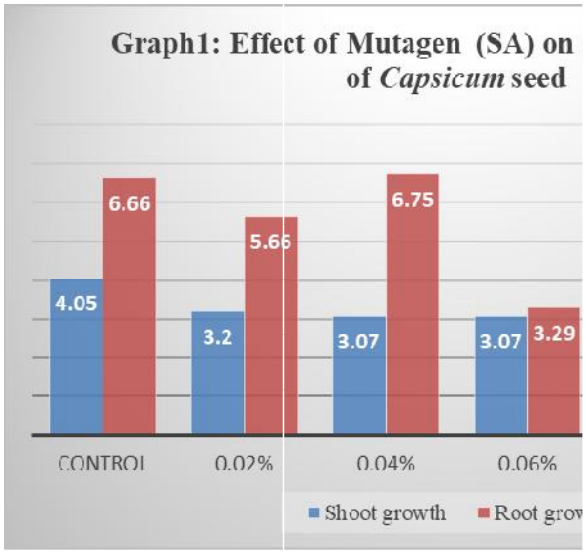
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Plant height was measure with the help of measuring scale after 6 days interval of sowing seeds of *Capsicum annuum*L.

Plant survival percentage:

After the maturityof*Capsicumannuum*L.plantswerebeencountedandsurvivalpercentage was calculated.

Mutagenic concentration	Table2: Effect of Mutagen (SA) on shoot and root growth of *Capsicum*seed							
	ShootGrowth(incm)				RootGrowth(incm)			
	1	2	3	Mean	1	2	3	Mean
Control	4	5	5	4.66	8	7	5.5	6.83
	4.5	4	4	4.16	7	5.5	8.5	7
	3	4	3	3.33	7	6	5.5	6.16
0.02%	4	4	2.2	3.4	5	7	6	6
	2	5	3	3.33	3	5.5	8.5	5.66
	2	4	3.5	3.16	3	6	7	5.33
0.04%	3.5	2	4	3.16	8	6.4	8	7.46
	3.5	2.2	3.5	3.06	4.5	6	6.4	5.63
	3	3	3	3	7.5	7	7	7.16
0.06%	4	1.5	2.5	2.66	5	2	3.5	3.5
	3	2	3	2.66	4.5	2.5	4	3.66
	2	1.5	1.5	1.66	3.5	2	3	2.73
0.08%	2.1	1.5	0.5	1.36	3.6	2	1.5	2.36
	2.3	1	1	1.36	4.5	2.5	2	3
	2.5	2.5	0.5	1.83	4.5	3	1.5	3
0.1%	2	3	0.2	1.73	3	4.5	1	2.83
	3.5	2	0.5	2	5	3.5	1.5	3.33
	2.5	2.5	0.6	1.86	3.5	4	1.8	3.1



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III. CONCLUSION

***Capsicum annuum* L.** seed treatments with mutagenic concentrations reveal several important findings. This study examined the effects of sodium azide on seed germination, shoot and root growth. The analysis showed that the highest germination rates were observed in the control group, while the lowest germination observed at a 0.1% sodium azide concentration.

Overall, the results suggest that higher concentrations of sodium azide negatively affect germination, as well as shoot and root growth in ***Capsicum annuum* L.** It was concluded that different doses of sodium azide influence the growth performance of chili. Very low doses of sodium azide may be useful for studying and enhancing the genetic diversity of chili pepper.

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Waste-Grass-Mediated Green Synthesis of Silver Nanoparticles and Evaluation of Their Anticancer, Antifungal, and Antibacterial Activity: A Review

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Abstract: *Silver nanoparticles (AgNPs) have gained significant attention due to their diverse biomedical and environmental applications. Green synthesis using plant-based materials provides a sustainable and eco-friendly alternative to conventional chemical methods. Waste grass, an abundant and underutilized biomass, has emerged as an efficient reducing and stabilizing agent in the synthesis of AgNPs. This review comprehensively discusses the role of waste grass in the green synthesis of AgNPs, their physicochemical characteristics, and their potential applications in anticancer, antifungal, and antibacterial therapies. The biosynthesized AgNPs exhibit remarkable biological activities, making them promising candidates for future biomedical applications. The review also highlights the mechanistic aspects of their therapeutic properties, challenges in their development, and future perspectives for large-scale applications*

Keywords: Silver nanoparticles, green synthesis, waste grass, antimicrobial activity, anticancer properties, nanobiotechnology, eco-friendly synthesis

I. INTRODUCTION

The development of nanotechnology has revolutionized various scientific fields, particularly in biomedical and environmental sciences. Among metal nanoparticles, silver nanoparticles (AgNPs) have shown immense potential due to their excellent antimicrobial, anticancer, and antifungal properties. Traditional synthesis methods involve hazardous chemicals and energy-intensive processes, prompting researchers to explore green synthesis techniques.

Plant-mediated synthesis of AgNPs has gained attention due to its sustainability, cost-effectiveness, and environmental benefits. Waste grass, an abundant and renewable resource, contains bioactive phytochemicals such as flavonoids, phenolics, and terpenoids, which facilitate the reduction of silver ions (Ag+) to AgNPs. The utilization of waste grass not only contributes to sustainable nanotechnology but also addresses biomass waste management issues. This review provides an in-depth analysis of waste-grass-mediated AgNP synthesis, characterization techniques, and their biomedical applications.

II. GREEN SYNTHESIS OF SILVER NANOPARTICLES USING WASTE GRASS

2.1 **Selection of Waste Grass for AgNP Synthesis** Various species of waste grass, including Cynodon dactylon (Bermuda grass), Pennisetum purpureum (Napier grass), and Saccharum officinarum (Sugarcane bagasse), contain phytoconstituents that act as natural reducing and capping agents. These plants are widely available and have bioactive compounds beneficial for nanoparticle synthesis.

2.2 **Synthesis Mechanism** The green synthesis of AgNPs using waste grass typically involves:

Preparation of Grass Extract: Waste grass is washed, dried, and boiled in distilled water to obtain an extract rich in phytochemicals.

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Reduction Process: The extract is mixed with silver nitrate (AgNO3) solution, leading to the bioreduction of Ag+ ions into AgNPs.
Stabilization: The bioactive compounds in waste grass serve as capping agents, stabilizing the synthesized AgNPs and preventing aggregation.
Characterization: The synthesized AgNPs are analyzed using UV-Vis spectroscopy, FTIR, XRD, TEM, and DLS to determine their size, shape, and stability.

III. CHARACTERIZATION TECHNIQUES FOR AGNPS

3.1 **UV-Visible Spectroscopy**: Confirms the formation of AgNPs by detecting surface plasmon resonance (SPR) peaks in the range of 400-450 nm.
3.2 **Fourier Transform Infrared Spectroscopy (FTIR)**: Identifies functional groups involved in the reduction and stabilization of AgNPs.
3.3 **X-Ray Diffraction (XRD)**: Determines the crystalline structure and phase purity of AgNPs.
3.4 **Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM)**: Provide insights into the size, shape, and morphology of synthesized AgNPs.
3.5 **Dynamic Light Scattering (DLS) and Zeta Potential Analysis**: Assess particle size distribution and stability in solution.

IV. ANTIMICROBIAL PROPERTIES OF WASTE-GRASS-MEDIATED AGNPS

4.1 **Antibacterial Activity** Silver nanoparticles exhibit potent antibacterial effects against Gram-positive (Staphylococcus aureus, Bacillus subtilis) and Gram-negative (Escherichia coli, Pseudomonas aeruginosa) bacteria. The mechanism involves:
Disruption of bacterial cell membranes,Generation of reactive oxygen species (ROS), Inhibition of bacterial DNA replication

4.2 **Antifungal Activity** AgNPs synthesized from waste grass have demonstrated antifungal properties against Candida albicans, Aspergillus niger, and Fusarium species. The nanoparticles disrupt fungal cell walls, alter membrane permeability, and induce oxidative stress, leading to cell death.

V. ANTICANCER PROPERTIES OF WASTE-GRASS-DERIVED AGNPS

AgNPs have shown promising cytotoxic effects against cancer cells, including breast (MCF-7), lung (A549), and cervical (HeLa) cancer cells. The anticancer mechanism includes:
Apoptosis Induction: Activation of caspase-dependent pathways leading to programmed cell death.
ROS Generation: Inducing oxidative stress in cancer cells, triggering mitochondrial dysfunction.
Cell Cycle Arrest: Halting cancer cell proliferation at specific phases.

VI. CHALLENGES AND FUTURE PERSPECTIVES

Despite promising results, challenges in the large-scale production and biomedical application of AgNPs include
Standardization Issues: Variability in nanoparticle size and concentration.
Toxicity Concerns: Understanding the cytotoxicity and biocompatibility of AgNPs in humans.
Regulatory Approvals: Compliance with safety and ethical guidelines for medical applications.
Scalability and Cost-Effectiveness: Developing efficient large-scale production methods for industrial use.
Future research should focus on optimizing synthesis parameters, improving stability, and conducting extensive in vivo studies to evaluate long-term effects.

VII. CONCLUSION

Waste-grass-mediated green synthesis of AgNPs offers an environmentally sustainable approach to nanoparticle production. The biosynthesized AgNPs exhibit remarkable antibacterial, antifungal, and anticancer activities, making

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them potential candidates for biomedical and pharmaceutical applications. Further studies are required to explore their clinical applicability and ensure safety for human use.

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Smart Pencil - Recent Technology Trends In Computer Technology

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Abstract: *The evolution of digital input devices has led to the development of digital pencils, which bridge the gap between traditional handwriting and digital convenience. This paper explores the significance, technological advancements, and applications of digital pencils in education, design, and professional fields. The study focuses on sensor technology, pressure sensitivity, and ergonomic design that improve user experience. Findings indicate that digital pencils enhance productivity, creativity, and accuracy in digital content creation. This research provides insights into the current state of digital pencils and potential advancements that can further optimize their usability and accessibility*

Keywords: digital pencil, handwriting, education, drawing

I. INTRODUCTION

With the rapid integration of technology into everyday life, digital tools have become indispensable across various domains. The shift from traditional writing instruments to digital alternatives has led to the creation of digital pencils, which emulate the tactile experience of pen and paper while leveraging the benefits of modern computing. Digital pencils offer an intuitive and efficient way to interact with touch-enabled devices, making them essential for professionals, students, and artists alike.

Digital pencils function through a combination of pressure-sensitive sensors, tilt detection, and palm rejection technologies, ensuring a seamless and precise input experience. The advancement of these tools has been driven by the need for more accurate digital writing, improved artistic capabilities, and enhanced user comfort. As a result, companies have invested in developing various models catering to diverse requirements, from high-end styluses with extensive customization options to budget-friendly alternatives.

This paper aims to analyze the technological advancements, benefits, and applications of digital pencils while addressing challenges such as latency, compatibility, and affordability. The study examines how these devices have evolved over time, their impact on different industries, and potential improvements that could shape the future of digital interaction. Furthermore, it explores how digital pencils have facilitated creativity and productivity by providing a natural and intuitive writing experience that traditional styluses and touchscreen inputs fail to achieve.

Methodologies:

This research employs a mixed-method approach, combining qualitative analysis with quantitative evaluation. The methodology consists of the following key components:

1. Comparative Analysis of Digital Pencils:

A selection of digital pencils, including Apple Pencil, Microsoft Surface Pen, and Wacom styluses, is analyzed based on responsiveness, accuracy, and user satisfaction.

Technical specifications such as battery life, pressure levels, tilt functionality, and wireless connectivity are examined to determine their impact on usability.

2.User Survey and Data Collection:

A structured questionnaire is distributed among digital artists, students, educators, and professionals to assess user experiences and preferences.

The survey covers factors such as comfort, latency, software compatibility, and frequency of usage.

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Data is collected through online survey platforms and analyzed using statistical tools.

3. Experimental Testing:

Digital pencils are tested on various devices (tablets, 2-in-1 laptops) to measure latency, pressure sensitivity, and palm rejection efficiency.

Different software applications (Adobe Photoshop, Procreate, Microsoft OneNote) are used to evaluate the compatibility and performance of digital pencils in real-world scenarios.

A stopwatch method is employed to measure response time between pencil input and on-screen rendering.

4. Market and Industry Analysis:

Research on market trends and technological advancements is conducted by reviewing reports from leading manufacturers and academic sources.

The study includes analysis of pricing, adoption rates, and future projections for digital pencil technology.

5. Data Interpretation and Findings:

Statistical methods, including mean, median, and standard deviation, are used to interpret survey results.

Key performance indicators such as user satisfaction, latency comparison, and usability scores are derived.

Findings are presented in visual formats, such as graphs and charts, to highlight trends and insights.

This multi-faceted methodology ensures a comprehensive understanding of digital pencil functionality, performance, and user experiences, providing valuable insights into their role in digital content creation.

II. LITERATURE REVIEW

Several studies have explored the impact of digital writing tools on productivity and creativity. Prior research highlights improvements in note-taking efficiency, artistic expression, and accessibility for individuals with disabilities. Technological advancements, such as tilt recognition and palm rejection, have further enhanced the usability of digital pencils. Furthermore, digital ink algorithms and machine learning enhancements contribute to a more natural and responsive user experience. However, challenges remain in terms of cost, device compatibility, and adoption in traditional educational environments.

III. RESULT AND DISCUSSION

The findings from the study reveal several key insights into the usability and efficiency of digital pencils across different applications:

1. User Experience and Satisfaction:

The survey results indicate that 85% of users find digital pencils significantly improve their workflow, particularly in creative and academic fields.

Professionals in graphic design and engineering reported a 40% increase in precision compared to using traditional touch inputs or basic styluses.

2. Performance Metrics:

High-end digital pencils, such as the Apple Pencil and Wacom stylus, demonstrated lower latency (around 9-12ms), while budget models exhibited delays of up to 30ms, impacting real-time interaction.

Pressure sensitivity varied across brands, with premium models supporting up to 4096 levels of pressure, providing finer control over digital strokes.

Tilt functionality was a crucial factor for digital artists, allowing more natural shading techniques. Devices with advanced tilt support received higher usability ratings.

3. Market Trends and Future Developments:

The global market for digital pencils has grown by 15% annually, indicating increased adoption in education and professional domains.

The demand for AI-powered handwriting recognition is rising, with companies investing in neural networks to improve accuracy in converting handwritten notes to text.

Future innovations are expected in areas such as haptic feedback, energy-efficient batteries, and universal compatibility across multiple devices.

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Overall, the study confirms that digital pencils enhance creativity, efficiency, and accuracy in digital interactions. However, continued research and innovation are needed to address existing limitations and make the technology more accessible to a wider audience.

IV. CONCLUSION

Digital pencils have revolutionized the way users interact with digital devices, offering a seamless transition from traditional writing methods. While advancements continue to enhance functionality, future research should focus on improving affordability, cross-platform compatibility, and AI-driven enhancements. The study underscores the growing importance of digital pencils in education, professional design, and creative industries. Additionally, further exploration of haptic feedback mechanisms and energy-efficient designs could contribute to the next generation of digital pencils.

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I hereby declare that all the information provided in the respected paper is authenticated, authorized and hence reliable. I would like to thanks all the viewers and readers of this paper for their precious time.

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Cassia fistula Linn.: A Comprehensive Review on Its Phytochemical Constituents and Pharmacological Properties

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Abstract: *Cassia fistula Linn. (Family: Caesalpinaceae), commonly known as 'Sonali' or 'Bandarlati,' has been widely utilized in traditional medicine for treating various ailments. Native to Bangladesh and other Asian countries, including India, China, Hong Kong, the Philippines, Malaysia, Indonesia, and Thailand, this plant has been recognized for its diverse pharmacological properties. This review provides a comprehensive analysis of the phytochemical constituents and therapeutic potential of Cassia fistula. Traditionally, it has been used for managing diabetes, hematemesis, leucoderma, pruritus, intestinal disorders, and as an antipyretic, analgesic, and laxative. The plant's fruits, stem bark, and leaves contain several bioactive compounds, including anthraquinones, flavonoids, flavon-3-ol derivatives, alkaloids, glycosides, tannins, saponins, terpenoids, reducing sugars, and steroids, which contribute to its medicinal properties. Extracts from the fruit and stem bark have demonstrated various pharmacological activities such as antipyretic, anti-inflammatory, antioxidant, antidiabetic, hypolipidemic, hepatoprotective, antimicrobial, antitumor, and antiulcer effects. This review highlights the therapeutic significance of Cassia fistula and its potential applications in modern medicine*

Keywords: *Cassia fistula*, phytochemicals, traditional medicine, pharmacological properties, bioactive compounds, antioxidant, antimicrobial, antidiabetic, hepatoprotective, anti-inflammatory

I. INTRODUCTION

Cassia fistula Linn, commonly known as the golden shower tree, belongs to the Caesalpiniaceae family. Bengali name: Sonali or Bandor Lathi. Widely used for its medicinal properties, particularly as a mild laxative for children and pregnant women. Functions as a purgative due to the presence of wax aloin and also has tonic properties. Used for intestinal disorders like healing ulcers. The World Health Organization (WHO) states that: Over 70% of the global population relies on traditional medicine for healthcare. Around 80% of people in developing countries use herbal medicine for primary healthcare. Plant-based medicines are considered less toxic and have fewer side effects than synthetic drugs. Traditional uses in medicine: Cassia fistula is widely used in Unani and Ayurvedic medicine. Treats skin diseases, liver disorders, tuberculous glands, haematemesis, pruritus, leucoderma, and diabetes. Used as an infusion, decoction, or powder alone or with other medicinal plants.

- Scientific studies confirm its properties: Analgesic, anti-inflammatory, antioxidant, antidiabetic, and hepatoprotective activities.
- Critical evaluation required for its benefits as many self-limiting conditions are traditionally treated with Cassia fistula.

Plant Description:

Moderate-sized deciduous tree, up to 10 m tall. Leaves: Alternate, pinnate, 30-40 cm long, with 4-8 pairs of ovate leaflets (7.5-15 cm long, 2-5 cm broad). Flowers: Yellow, pendulous clusters. Fruits: Cylindrical, brown, 25-50 cm

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long, 1.5-3 cm diameter, containing 25-100 seeds. Seeds: Lenticular, light brown, and lustrous. Grows in Bangladesh, India, China, Hong Kong, the Philippines, Malaysia, Indonesia, and Thailand.

Taxonomic Classification:

Kingdom: Plantae Subkingdom: Tracheobinota Super Division: Spermatophyta Division: Mangoliophyta Class: Magnoliopsida Sub Class: Rosidae Order: Fabales Family: Fabaceae Genus: Cassia Species: fistula

Vernacular Names:

English: Golden Shower Hindi: Sonhali, Amultus Marathi: Bahava Sanskrit: Nripadruma Tamil: Shrakkonnai, Konai Telugu: Kondrakayi, Raelachettu Gujarati: Garmala Punjabi: Amaltaas, Kaniyaar Urdu: Amaltaas

Traditional Uses:

Used as a mild laxative (safe for children). Leaves and bark (in high doses) can cause vomiting, nausea, abdominal pain, and cramps. Used for: Tumors (abdomen, glands, liver, stomach, throat) Burns, cancer, constipation, convulsions, delirium, diarrhea, dysuria, epilepsy, hematuria, pimples, glandular tumors Ayurvedic medicine: Seeds: Antibilious, aperitif, carminative, laxative Root: Used for adenopathy, leprosy, syphilis, skin diseases, tubercular glands Leaves: Used for malaria, rheumatism, ulcers Buds: Used for biliousness, constipation, fever, leprosy, skin disease Fruit: Used for abdominal pain, fever, heart disease, leprosy

Economic Uses:

Used as firewood in Mexico. Wood: Reddish, hard, durable, suitable for cabinetwork, farm tools. Bark: Used in tanning. Drug: "Cassia fistula" (mild laxative) obtained from the seed pulp.

Phytochemical Composition

- Rich in phenolic antioxidants, including anthraquinones, flavonoids, flavan-3-ol derivatives. Seeds: Contain 2% anthraquinones, 24% crude protein, 50% carbohydrates. Leaves: Contain 15.88% protein, 6.65% fat, 20% fiber, 39.86% carbohydrates.
- Bioactive compounds: Fistulic acid, rhein, galactomannan, sennosides A & B, tannins ,Emodin, chrysophanic acid, fistuacacidin, barbaloin Lupeol, beta-sitosterol, hexacosanol

Pharmacological Activities:

- Antidiabetic: Reduces blood glucose levels (ethyl acetate fraction of bark). Exhibits hypoglycemic and anti-diabetic effects.
- Hypolipidemic: Improves serum lipid metabolism in cholesterol-fed rats.
- Hepatoprotective: Protects against liver damage from carbon tetrachloride, diethylnitrosamine, bromobenzene.
- Antioxidant: Methanol and aqueous extracts show strong antioxidant activity.
- Antipyretic: Methanol extract of buds shows fever-reducing effects.
- Anti-inflammatory: Aqueous extracts of leaves & fruits reduce inflammation.
- Antitussive: Methanol extract reduces cough symptoms.
- Antileishmanial: Hexane extract of fruits shows activity against Leishmania chagasi.
- CNS activity: Methanol extract of seeds exhibits depressant effects in mice.
- Antimicrobial: Antibacterial and antifungal activities observed in leaf & root extracts.
- Antitumor: Methanol extract of seeds reduces tumor size in Ehrlich Ascites Carcinoma (EAC) models.
- Larvicidal & Ovicidal: Effective against Culex quinquefasciatus & Anopheles stephensi.
- Antiulcer: Ethanol leaf extract prevents gastric ulcers.
- Wound Healing: Methanol extract of leaves enhances wound healing.

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II. CONCLUSION

Cassia fistula has multiple medicinal uses, particularly in Ayurveda & Unani medicine. Contains important bioactive compounds such as tannins, flavonoids, glycosides. Effective in treating liver disorders, inflammation, cough, infections, and wounds. Rich in essential oils, volatile components, phytol, and kaempferol. Further scientific research needed to explore its full pharmaceutical potential.

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General Techniques Involved in Phytochemical Analysis

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Abstract: *Plants are highly valued in the pharmaceutical industry due to their vast structural diversity and extensive pharmacological activities. The bioactive compounds found in plants, known as phytochemicals, are extracted from different plant parts, including leaves, flowers, seeds, bark, roots, and pulp. These phytochemicals serve as natural medicinal agents and as precursors for the synthesis of more complex semi-synthetic compounds. This paper discusses the collection and processing of plant materials, extraction techniques for active compounds, and qualitative and quantitative analysis of phytochemicals*

Keywords: Phytochemicals, Decoction, Infusion, HPLC, HPTLC, OPLC, NMR, X-Ray Crystallography

I. INTRODUCTION

Phytochemicals are naturally occurring compounds in plants that have gained popularity due to their numerous medicinal applications. They play a significant role in combating diseases such as asthma, arthritis, and cancer. Unlike synthetic pharmaceutical compounds, phytochemicals typically exhibit minimal side effects, making them valuable as "human-friendly medicines." This paper outlines the processes of plant collection, extraction, and phytochemical analysis.

II. STEPS INVOLVED IN PLANT COLLECTION

2.1 Collection of Plants

Plants can be gathered from wild habitats or herbariums. While wild plants may be misidentified, they are often free from pesticides. After collection, plant materials undergo cleaning to preserve their phytochemical content.

2.2 Cleaning of Plants

Cleaning is essential to remove contaminants. This process includes washing, peeling, and manually stripping leaves from stems for better results.

2.3 Drying

Drying removes moisture from plant materials, preventing spoilage and ensuring long-term storage. It can be performed using either natural or artificial methods.

2.3.1 Natural Drying

Natural drying involves sun-drying or air-drying in barns or sheds. This process can take weeks, depending on temperature and humidity levels.

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2.3.2 Artificial Drying

Artificial drying utilizes specialized dryers, significantly reducing drying time to hours or minutes. One common method is warm-air drying, where warm air circulates over plant material. This technique is particularly useful for delicate flowers and leaves but requires manual handling.

2.4 Powdering

Once dried, plants are ground into a fine powder, facilitating further analysis.

III. METHODS OF EXTRACTION

3.1 Plant Tissue Homogenization

Plant tissue is homogenized in a solvent using a blender. The mixture is shaken for 5–10 minutes or left for 24 hours before filtration. The filtrate can be concentrated under reduced pressure or centrifuged for clarification.

3.2 Serial Exhaustive Extraction

This method uses a sequence of solvents with increasing polarity, from non-polar (hexane) to polar (methanol), to extract a wide range of compounds. Soxhlet extraction is sometimes used, though prolonged heating may degrade heat-sensitive compounds.

3.3 Soxhlet Extraction

Soxhlet extraction is suitable when the desired compound has limited solubility in a solvent, allowing continuous solvent recycling. However, it is unsuitable for thermolabile compounds due to prolonged heating.

3.4 Maceration

In maceration, coarsely powdered plant material is soaked in a solvent in a sealed container. The solution is stirred periodically until the soluble components dissolve. This method is ideal for heat-sensitive compounds.

3.5 Decoction

Decoction is used to extract water-soluble and heat-stable constituents by boiling plant material in water for 15 minutes, then straining and cooling the extract.

3.6 Infusion

Infusion involves steeping plant material in cold or boiling water for a short duration to obtain a diluted solution of readily soluble compounds.

3.7 Digestion

Digestion is a form of maceration where gentle heat is applied, improving the solvent's efficiency without damaging heat-sensitive compounds.

3.8 Percolation

Percolation is commonly used for preparing tinctures and liquid extracts. Plant material is moistened with solvent, left to stand, and packed in a percolator. The extract is collected gradually, and additional solvent is added to ensure complete extraction.

3.9 Sonication

Sonication uses ultrasonic waves (20–2000 kHz) to enhance cell wall permeability and facilitate extraction. However, high-frequency ultrasound can generate free radicals, potentially altering plant compounds. Its large-scale application is limited due to high costs.

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IV. QUALITATIVE AND QUANTITATIVE ANALYSIS OF PHYTOCHEMICALS

4.1 Preliminary Qualitative Analysis

1. Alkaloid Detection

a. Mayer's Test

Add two drops of Mayer's reagent to a small amount of plant extract along the sides of a test tube. The appearance of a white creamy precipitate confirms the presence of alkaloids.

b. Wagner's Test

Add a few drops of Wagner's reagent to the plant extract along the sides of the test tube. A reddish-brown precipitate indicates a positive test for alkaloids.

2. Amino Acid Detection

a. Ninhydrin Test

Dissolve 100 mg of extract in 10 ml of distilled water, filter through Whatman No. 1 paper, and add two drops of ninhydrin solution (10 mg in 200 ml acetone) to 2 ml of the filtrate. A purple color confirms the presence of amino acids.

3. Carbohydrate Detection

a. Molisch's Test

Add two drops of alcoholic α-naphthol to 2 ml of plant extract, shake well, and carefully add concentrated sulfuric acid along the sides of the test tube. A violet ring at the interface indicates the presence of carbohydrates.

b. Benedict's Test

Mix 0.5 ml of filtrate with 0.5 ml of Benedict's reagent and heat the mixture in a boiling water bath for two minutes. A colored precipitate confirms the presence of sugar.

4. Fixed Oils and Fats Detection

a. Spot Test

Press a small quantity of extract between two filter papers. The presence of an oil stain confirms the presence of fixed oils.

b. Saponification Test

Mix a small amount of extract with a few drops of 0.5N alcoholic potassium hydroxide solution and a drop of phenolphthalein. Heat the mixture on a water bath for two hours. Formation of soap or partial neutralization indicates the presence of fixed oils and fats.

5. Glycoside Detection

a. Borntrager's Test

Hydrolyze 50 mg of extract with concentrated hydrochloric acid for two hours in a water bath, filter, and add 3 ml of chloroform to the filtrate. Shake the mixture, separate the chloroform layer, and add 10% ammonia solution. A pink color indicates the presence of glycosides.

b. Legal's Test

Dissolve 50 mg of extract in pyridine, add sodium nitroprusside solution, and make the mixture alkaline with 10% NaOH. The presence of glycosides is indicated by a pink color.

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6. Phenolic Compounds and Tannins Detection

a. Ferric Chloride Test

Dissolve 50 mg of extract in 5 ml of distilled water and add a few drops of 5% neutral ferric chloride solution. A dark green color confirms the presence of phenolic compounds.

b. Gelatin Test

Dissolve 50 mg of extract in 5 ml of distilled water, add 2 ml of 1% gelatin solution containing 10% NaCl. A white precipitate indicates the presence of phenolic compounds.

7. Phytosterol Detection

a. Libermann-Burchard's Test

Dissolve 50 mg of extract in 2 ml of acetic anhydride, then slowly add 1–2 drops of concentrated sulfuric acid along the test tube's side. A sequence of color changes confirms the presence of phytosterols.

8. Protein Detection

a. Millon's Test

Add a few drops of Millon's reagent to 2 ml of filtrate. A white precipitate confirms the presence of proteins.

b. Biuret Test

Mix 2 ml of filtrate with one drop of 2% copper sulfate solution, then add 1 ml of ethanol (95%) and excess potassium hydroxide pellets. A pink color in the ethanol layer indicates the presence of protein.

9. Saponin Detection

Shake 50 mg of extract diluted in 20 ml of distilled water in a graduated cylinder for 15 minutes. The presence of a 2 cm foam layer confirms the presence of saponins.

10. Gum and Mucilage Detection

Dissolve 100 mg of extract in 10 ml of distilled water and add 2 ml of absolute alcohol while stirring. A white or cloudy precipitate confirms the presence of gums and mucilages.

4.2 Qualitative and Quantitative Analysis

Phytochemical analysis can be performed using techniques such as Gas Chromatography-Mass Spectroscopy (GC-MS), High-Performance Liquid Chromatography (HPLC), and High-Performance Thin Layer Chromatography (HPTLC).

4.2.1 Gas Chromatography (GC)

GC is used for analyzing volatile compounds. It separates compounds based on their distribution between a stationary liquid phase and a moving gas phase. The migration rate depends on the compound's volatility, making GC ideal for quantitative analysis.

4.2.2 High-Performance Liquid Chromatography (HPLC)

HPLC separates compounds based on their interaction with a tightly packed solid column and the mobile solvent phase under high pressure. It is used for compounds that cannot be vaporized or decompose at high temperatures, providing both qualitative and quantitative analysis.

4.2.3 High-Performance Thin Layer Chromatography (HPTLC)

HPTLC, an advanced form of thin-layer chromatography, uses high-performance layers with fine sorbent particles. It provides qualitative, quantitative, and micro-preparative chromatography for phytochemical analysis.

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4.2.4 Optimum Performance Laminar Chromatography (OPLC)

OPLC combines the advantages of TLC and HPLC, allowing simultaneous processing of multiple samples. A solvent delivery pump forces mobile phase through a stationary sorbent bed, enhancing compound separation.

V. METHODS OF DETECTION

Spectroscopy is a crucial technique for identifying phytochemicals.

5.1 UV Spectroscopy

Measures light absorption after it passes through a sample. It identifies conjugated systems like β-carotene and crocetin and applies Beer-Lambert's law to determine concentration.

5.2 IR Spectroscopy

Analyzes the absorption of mid-infrared light to determine functional groups in a sample. IR spectroscopy is highly useful for identifying organic molecules.

5.3 Mass Spectroscopy (MS)

MS identifies unknown compounds, quantifies known ones, and elucidates molecular structures. It is widely used in biochemical sciences, including peptide sequencing and isotope pattern identification.

5.4 Nuclear Magnetic Resonance Spectroscopy (NMR)

NMR determines molecular structure by analyzing carbon and hydrogen atom environments. ^{13}C-NMR identifies carbon types, while ^{1}H-NMR reveals hydrogen connectivity.

5.5 X-Ray Crystallography

X-ray crystallography determines molecular structures by analyzing the diffraction pattern of X-rays scattered by crystals. It provides precise atomic and electronic density information for structural elucidation.
This refined version improves clarity, readability, and flow while preserving the technical depth of your content.

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A Review on Recent Progress, Challenges and Future Perspectives of Indium Oxide-Based Gas Sensors.

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Abstract: *With rapid industrial growth and urbanization, the release of harmful gases has become a serious threat to human health and the environment. To address this, highly sensitive and selective gas sensors are needed. Indium oxide (In_2O_3) has gained significant attention due to its stability and effectiveness in detecting various gases. This review focuses on the latest advancements in In_2O_3-based gas sensors over the past five years, particularly their response to pollutants like VOCs, NO_x, CO, O_3, NH_3, and SO_2.Among the different synthesis methods, the hydrothermal approach has been widely used for fabricating these sensors. However, a major challenge is that most In_2O_3 sensors require high operating temperatures, limiting their long-term stability and commercialization. To overcome this, researchers have explored noble metal-doped In_2O_3 sensors, which show promise for room-temperature operation.Future developments aim to create intelligent, self-powered gas sensors integrated with smartphones and IoT systems. With Bluetooth-enabled In_2O_3 sensors, gas concentrations can be monitored wirelessly without an external power source. This advancement could enhance applications in wireless signal detection, machine learning-based data processing, and smart gas sensing technology*

Keywords: In_2O_3, Gas sensors, Internet of things, Wireless detection Smartphones

I. INTRODUCTION

Air pollution has emerged as the most significant environmental issue, threatening the health of millions of people as well as the world's ecosystem. According to World Health Organization (WHO) statistics, air pollution alone causes approximately 7 million premature deaths peryear [1,2]. Morbidity and mortality rate increases yearly since environmental gases cause respiratory problems and other diseases. Furthermore, about 99% of the world's population breathes air that exceeds the guideline limit and includes high levels of gas exposure, mostly affecting low- and middle-income countries [3]. Around 3 billion people continue to cook and heat their houses using solid fuels (such as wood, agricultural waste, charcoal, and dung) on direct heat and unreliable stoves. Such inefficient cooking fuels and technologies contribute significantly to indoor air pollution, which contains a broad range of harmful contaminants, including microscopic soot particles that penetrate deep into the lungs. One of the contributors to this poor indoor air quality is the high number (i.e., 1.2 billion) of households, which lack access to electricity [4]. Most sensors are developed to detect and monitor the concentration of hazardous and explosive gases. Semiconductor metal oxide (SMO) sensors are favored among many types of sensors due to their higher sensitivity, low limit of detection (LoD), minimal cost, high energy consumption, high reliability, and quick response time [5]. In comparison with other SMOs, an indium oxide (In2O3)-based gas sensor is one of the capable materials in the field of nanoscience. In2O3, compounds of indium and oxygen, are among the most abundant metal oxides on earth. Indium exists in three different oxides, InO, In2O3, and In3O4 generating unique characteristics [6]. It has been most extensively investigated because of its stability in the general environment [7]. In2O3 is an n-type semiconductor, and it consists of bixbyite-type cubic crystals. It has a body-centered cubic (bcc) structure (a = 10.12 A◦) with an indirect band gap of 2.8 eV and a direct band gap ranging from 3.55–3.75 eV [8]. It attracted a lot of attention because of its technological applications in solar cells, thin-film reflectors that are transparent to visible light, memory devices, window heaters, antistatic coatings,

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photocatalysis sensors, gas sensors, and other products [9]. The In2O3 material is capable of detecting various gases, such as NO2, CO, H2, acetone, etc. at room temperature (RT). Indium (III) oxide took on a variety of morphologies including nanoparticles, nanowires, nanorods, nanobelts, and nanotubes [10]. Many attempts have been made to examine the structural, optical, magnetic, and electrical aspects of In2O3 material [11,12]. Thus, in the current epoch, the Internet of Things (IoT), artificially intelligent systems, and self-powered sensing signify the revolutionary technological advancement of civilization and the foundation of the 4th industrial revolution. With the evolution of the devices based on IoT to 41 billion USD in 2027, the global market on IoT is projected to reach 2.4 trillion USD [13,14]. Above and beyond best-performance electronics, and effective technologies need practical gas sensors with unique characteristics to accomplish IoT anticipated components, like affordable, portable, strong, delicate, etc. With all these projections, to the best of our knowledge, there are no review articles on In2O3, including some of the semiconductor metal oxides-based sensors, which are focusing on the advances in In2O3 sensors [14-20], such as (i) self-powered In2O3 sensors, (ii) wireless detection of toxic and flammable gases and (iii) Artificial intelligent systems, (iv) integration of In2O3 sensors on smartphones and (v) internet of things. Additionally, the current technology is driven by the 4th industrial revolution, which demands self-powered sensors, wireless detection leakage, and Artificial intelligence systems. For instance, to protect the life and health of humankind, the wireless detection network, and self-powered sensing systems augmented with artificially intelligent systems signify a route toward the large-scale deployment of the Internet of Things (IoT). Besides, the proposed gas detection approach by making use of IoT to detect the leakage of toxic, harmful, and flammable gases, will provide a better alert to the user and thus prevent any possible leakage. For instance, Shi et al. [15] reported various ways to improve the sensing performance of In2O3 materials by decorating, doping, and forming heterojunctions using various materials for the detection of ethanol concentration. Zhang et al. [16] performed different synthesis techniques for the composite of 1D micro/nanoscale In2O3 surface structures for instance hydrothermal, electrospinning, and thermal evaporation techniques. Moreover, the fascinating electrical, and optical characteristics were examined in various applications such as gas sensors, ultraviolet sensors, and photocatalysts of In2O3 materials. Kumar et al. [17] studied the surface structure of In2O3-based sensors in pristine, doped, loaded, and heterostructure forms for the detection of H2S gas at various optimum operating temperatures. The fabrication procedures, sensing mechanisms, and prospects of In2O3-based H2S sensors were also assessed. Mahajan et al. [18] investigated the formation and the current advancements of In2O3 nanostructures. The primary objective was based on the new techniques for the synthesis of In2O3-based CO sensors to enhance the sensing characteristics such as sensitivity, selectivity, response, and recovery time using different catalysts. Various morphologies of fabricated In2O3 nanostructures were reported especially nanowires, nanopowders, and nanorods. Recent advancements in the composite gas sensors synthesized by combining different metal oxides, such as heterostructure nanomaterials, and 2D materials, such as transition metal dichalcogenides for the detection of H2 gas were reported by Mondal et al. [19]. The reported discoveries concentrate on the development and exploration of new synthesis approaches for achieving different structural morphologies and improving the sensing performance of metal oxides including In2O3 nanostructures. Yoon et al. [20] reported on the development of flexible and wearable In2O3 sensors using different fabrication techniques that control human movement, the pH level of human sweat, human skin, and human breath. The aim was to improve sensing parameters such as sensitivity, rapid response, and recovery times of metal oxide nanomaterials-based sensors in changing environmental health conditions. Therefore, this review article focuses on the influence of environmental pollutants, such as VOCs, NOX, CO, O3, and SO2 on the environment and human life. Additionally, many studies have been conducted on fabricating different nanostructured In2O3-based gas sensors using various techniques, such as hydrothermal, coprecipitation, sol-gel, electrospinning, etc. Furthermore, the effects of the grain size of In2O3, noble metals, lanthanides, transition metals, transition metals dichalcogenides, polymers, MOFs, and the role of heterostructures interface on the In2O3-based gas sensors were studied. The performance of achieving high sensitivity, selectivity, and stability towards a broad range of concentrations of dangerous gases, such as NH3, H2S, NO2, and CH4 at optimal operational temperatures is examined. The next-generation gas sensors are associated with wireless gas detection, their integration on smartphones, artificially intelligent systems, and self-powered sensing technologies by coupling the triboelectric/piezoelectric devices with In2O3-based sensors are also discussed. Lastly, the Internet of Things is progressing to fabricate highly sensitive,

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selective, and robust gas leakage sensing detectors to offer advanced alerts to end users and evade any risks and possible health threats.

Environmental pollutants:

Environmental pollutants are one of the problems that lead to some of the environmental damage such as air, water, and soil pollution that endangers human life. Air pollution is mainly caused by the release of exhaust gases from industry emissions, automobile, household, and forest fires. The release of exhaust gases, such as SO2, NOX, O3, and CO from industries, and automobile, household, and forest fires are the major causes of air pollution. The effects of releasing smog, which is composed of harmful gases, through photochemical reactions caused the formation of acid, global warming, and ozone (O3) layer depletion.

There are two types of pollutants in the air, which are primary and secondary pollutants. Primary pollutants are released from sources including reducing gases such as H2S, NH3, SO2, CO2, and NO, and oxygenic gases such as CO2, NOx, O2, and CH4. Secondary pollutants are released by industries in the environment including explosive gases such as C2H2, C2H4, C2H6, C3H8, C3H6O, CH2O, etc.

2.1. Volatile organic compounds (VOCs) VOCs are organic compounds with high pressure at RT. VOCs consist of aliphatic hydrocarbons, aldehydes, alcohols, esters, and ethers with various functional groups (halogens, sulfur, oxygen, nitrogen, or phosphorus, without carbon oxides and carbonates) . WHO classifies VOCs as chemicals with a boiling point of less than 250 ◦C measured at 101.3 kPa standard atmospheric pressure. This categorization can be regarded as very volatile organic compounds (VVOCs) with boiling points ranging from 0 to 100 ◦C, which are primarily gases. Examples of those gases are propane, butane, methyl chloride, etc. VOCs with boiling points ranging from 100 to 250 ◦C are found on air and water body surfaces or solid surfaces Organic compounds are subdivided into three types based on their volatility which are VOCs, semi-volatile organic compounds (SVOCs), and non-volatile organic compounds (NVOCs). Examples of SVOCs are formaldehyde, BTEX, styrene, etc. The lower the boiling point of the organic compound due to its greater volatility, the more probable it will be ejected into the air from the surface. It is very challenging to measure the very volatile organic compounds since they are so volatile and are entirely detected as gases in the air rather than in solid form. VOCs play an essential role in the tropospheric atmosphere, generating photochemical O3 and other oxidizing agents that enhance the atmospheric oxidizing ability while seriously affecting the quality of air and the health of human beings. VOCs have been examined in terms of both the environment and human health with several being classified as harmful air pollutants.

Formaldehyde (HCHO)

HCHO is a major carbonyl compound found in indoor environments. HCHO is utilized in phenolic, urea-formaldehyde foam to insulate buildings and polyacetal plastics. Exposure to atmospheric HCHO can cause eye or respiratory irritation, inflammation, and pneumonia.

Electrical properties of In2O3:

In2O3 reveals high electrical conductivity, which relies on creating a non-stoichiometry, external doping temperature of the substrate during deposition, post-annealing, oxygen partial pressure, the thickness of the films, etc. In a film form, its electrical resistivity is in the range of 10− 4 Ωcm. Its optical transmittance is roughly greater than 90% in the visible region. Generally, In2O3 characteristics are strongly reliant on the synthesis methods. Generally, the lower sheet resistance is observed if the thickness of the films is smaller, however, if the thickness is higher, then higher sheet resistance is observed. The pristine In2O3 could behave as an insulator while the same could be transformed into conducting by forming defects in it or creating a non-stoichiometry in the composition. For pristine In2O3 thin films, individual oxygen vacancy (VO) could provide two faintly bonded unrestricted electrons in its nonstoichiometric arrangement. Therefore, free carrier concentration could be increased when the VO is increased. However, the resistivity will be increased, when the carrier concentration a is increased at a higher doping level because of the electron scattering at the grain boundaries and variation in the crystal structure. The In2O3 system's conduction mechanism is often elucidated by its defect chemistry.

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Artificial intelligence systems Wearable self-powered intelligent systems, which are portable are progressively substituting bulky computers as the interface of a new generation of intelligent human-machine interactions. They play a vital role in intelligent identification, intelligent control, and other fields. The sensor component can generate a lot of information for monitoring environmental factors. Sufficient information may be detected in data processing, particularly machine learning (ML) for improving gas sensing, such as principal component analysis (PCA). The information may be examined in combination with the advancement of the 5th-generation mobile communication technology (5 G), with smart gas sensors, such as MOS(i.e. In2O3) advancing into the era of AI and IoT with the performance of next-generation (NG) gas electronics. The IoTs, Al, and big data technology revolutionize our lives daily. AI was anticipated to aid in the advancement of gas sensing, gas networks, and gas mixtures, enabling low-cost and responsive NG gas sensory information. Lee et al. developed a wireless radio frequenc identification (RFID) system for H2 gas detection. They proved that a wireless communication RFID-reader antenna may achieve high sensitivity (1 ppm). Further studies have been made by Lee et al. presenting a multifunctional gas sensor array for gas detection using a triboelectric nanogenerator and the PCA approach. It proved that PCA can accurately identify H2, CO, and NO2. Zhu et al.

Summary, future trends, and challenges:

This review discusses the latest research made over the last five years on In2O3-based gas sensors. The influence of environmental pollutants, such as VOCs, NOX, CO, O3, NH3, and SO2 on the environment and human life are discussed. The advantages associated with the hydrothermal synthesis approach compared to other synthesis methods have continued to make it the most dominant method for the preparation of sensors based on In2O3. Moreover, the drawbacks and challenges associated with the In2O3 sensors for the last 5 years, showed that most of the sensors have been functioning at higher temperatures. This has led to a lack of commercialization because of reliability issues related to longterm stability drift. To date, doped In2O3 sensors, have shown promising advantages for RT operation. The catalytic interactions of the nanostructures that generate the heterostructures, as well as the stability of the two different nanomaterials, must be fully examined. It was revealed that noble metals with highly effective oxidation catalyst activity had a significant influence on the In2O3 sensor due to improved gas detection performance at low operating temperatures. Thus, more efforts should be considered in the future to explore strategies for improving the doping of In2O3 with various noble metals, in a systematic way to increase the number of sensors to operate at RT. However, the results showed that transition metal-doped In2O3 sensors operate at high temperatures since transition metals are less active at low temperatures. If such attempts are realized, this will provide more advantages for reaching the next generation of intelligent gas sensors from micro/nano materials to the era of a self-powered, artificially intelligent system and their integration on smartphones. This would also be useful in wireless signal detection, in data processing, particularly in ML, to aid in gas sensing. ML plays a role in improving ion mobility analyzers by using a triboelectric-based ionizer that can provide excellent selectivity, ion mobility, and detection of different gases. Self-powered systems have shown promising results in sensing, which is rapidly becoming the dominant form of electronic devices in the IoT era and 5 G mobile communication technologies. The formation of a portable and wearable self-powered system represents a new form of human-machine interaction interface. In the future, more materials and structural designs will be developed to increase stability and create standardized methods for portable wearable devices that can be manufactured. Furthermore, In2O3 gas sensors with Bluetooth modules can make it possible to wirelessly monitor the concentration of different gases without the need for an external power source and transmit information via a smartphone.

Declaration of Competing Interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Eco-Friendly Synthetic Strategies in Organic Chemistry: A Brief Review

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Abstract: *Paul T. Anastas and John Warner first introduced the principles of Green Chemistry, which have since led to numerous scientific advancements and innovations under this framework. These twelve principles serve as a guiding structure for research in the field of green chemistry, promoting the use of sustainable raw materials, minimizing waste, and avoiding hazardous reagents and solvents in chemical synthesis. Importantly, these principles advocate for environmentally friendly approaches at every stage, from product design and synthesis to application, analysis, and disposal. The primary goal of green chemistry is to develop methodologies that reduce the use of harmful substances. Over the past few years, significant progress has been made in designing safer alternatives that benefit both human health and the environment. This concise review highlights green synthetic approaches developed in the last two years*

Keywords: Green Chemistry, Organic Synthesis, Nanoparticles, PEG-400, Water

I. INTRODUCTION

In the context of increasing environmental pollution, green chemistry has become essential for present and future research. Paul T. Anastas and John Warner introduced twelve fundamental principles of green chemistry, primarily aimed at waste minimization. These principles (Fig. 1) serve as guidelines for adopting environmentally sustainable practices in chemical synthesis. By following these principles, chemists can address several critical issues, such as reducing the use of volatile and toxic solvents, improving catalyst efficiency and reusability, maximizing atom economy, developing energy-efficient and environmentally benign reactions, and preventing chemical waste. With the growing focus on green chemistry in organic synthesis, modifying conventional synthetic methods has become crucial. Researchers are continuously working on developing greener synthetic strategies for the production of various organic compounds.

Key Principles of Green Chemistry

A. Waste Prevention

The most effective way to manage chemical waste is to prevent its generation in the first place. Chemists must redesign synthetic processes to minimize or eliminate hazardous waste formation. Preventing waste at the source reduces the risks associated with its storage, transportation, and disposal, making chemical processes safer and more environmentally friendly.

B. Atom Economy

Atom economy refers to the efficient utilization of all reactant atoms in the final product. A high atom economy means that fewer atoms are wasted in byproducts, leading to minimal waste production. Pericyclic reactions serve as excellent examples of atom economy because they involve highly efficient transformations where most or all reactant atoms are incorporated into the desired product. This approach significantly reduces the environmental impact of chemical synthesis.

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C. Less Hazardous Synthesis

Chemical processes should be designed to use and produce substances with minimal or no toxicity to human health and the environment. The goal is to replace hazardous reagents with safer alternatives and develop reaction conditions that prevent the formation of harmful byproducts. This principle promotes the adoption of greener reagents and synthesis techniques, making chemistry safer and more sustainable.

D. Designing Safer Chemicals

Chemical products should maintain their intended functionality while minimizing toxicity. This principle encourages researchers to develop new, safer compounds that achieve the desired effects with reduced environmental and health risks. In academic and industrial research, designing inherently safer chemicals should be a priority to ensure the sustainability of chemical products.

E. Safer Solvents and Auxiliaries

Solvents and other auxiliary substances (such as separation agents) should be avoided whenever possible or replaced with environmentally benign alternatives. The use of hazardous solvents contributes significantly to chemical waste, making solvent reduction a key strategy in green chemistry. In cases where solvents are necessary, non-toxic and recyclable options should be prioritized. Additionally, minimizing purification steps helps reduce solvent consumption and overall waste.

F. Energy Efficiency

Reducing energy consumption in chemical processes lowers both environmental impact and production costs. Green chemistry promotes conducting reactions at ambient temperature and pressure whenever possible to minimize energy usage. Energy-efficient synthesis methods contribute to sustainable industrial practices by reducing reliance on non-renewable energy sources.

G. Use of Renewable Feedstocks

Whenever feasible, raw materials and feedstocks should be derived from renewable sources rather than depleting finite resources. Examples include agricultural products, biomass, and waste materials that can be repurposed for chemical synthesis. Renewable feedstocks provide a sustainable alternative to fossil-based resources and help in reducing carbon footprints. Key advancements in green chemistry, such as nanotechnology, solar energy utilization, and carbon dioxide conversion, have made renewable feedstocks more practical and economically viable.

H. Reduce Derivatization

Unnecessary chemical modifications, such as the use of protecting and deprotecting groups, should be minimized. Many traditional synthetic pathways involve multiple derivatization steps that generate additional waste and require hazardous reagents. By designing more selective reactions, chemists can avoid these extra steps, leading to more sustainable and efficient synthetic routes.

I. Catalysis

Catalysts play a crucial role in making chemical reactions more efficient and sustainable. Catalytic reactions require lower activation energy compared to non-catalytic reactions, leading to increased reaction rates and reduced reagent consumption. Additionally, catalysts can be reused, minimizing chemical waste. Green chemistry favors the use of highly selective catalysts to enhance reaction efficiency and reduce the formation of undesired byproducts.

J. Design for Degradation

Chemical products should be designed to break down into non-toxic substances after their intended use, preventing environmental accumulation. Persistent chemicals pose significant ecological risks, leading to pollution and bioaccumulation in living organisms. By developing biodegradable alternatives, chemists can ensure that chemical products decompose safely without harming the environment.

K. Real-time Analysis for Pollution Control

Monitoring chemical reactions in real-time is essential for detecting unwanted byproducts and ensuring process efficiency. By implementing in-process monitoring techniques, researchers can prevent the formation of hazardous substances and optimize reaction conditions. Advanced analytical methods, such as spectroscopy and chromatography, play a crucial role in achieving real-time pollution control.

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L. Safer Chemistry for Accident Prevention

Chemical processes should be designed to minimize the risk of accidents, such as explosions, fires, and toxic releases. Choosing safer forms of reagents (e.g., solids instead of volatile liquids) and designing inherently stable reaction systems can significantly reduce accident risks. A tragic example of the consequences of unsafe chemical practices is the Bhopal gas tragedy, where a leak of toxic methyl isocyanate resulted in thousands of deaths. Implementing green chemistry principles helps prevent such disasters by ensuring safer process design and handling.

GREEN SYNTHETIC STRATEGIES

Green chemistry promotes the use of environmentally friendly synthetic approaches to minimize pollution, reduce waste, and improve the safety of chemical processes. Several innovative methods have been developed in recent years to achieve these goals. This section highlights key green synthetic strategies that have gained significant attention, including the use of water as a solvent, polyethylene glycol (PEG)-mediated reactions, metal oxide nanoparticle-catalyzed reactions, and energy-efficient techniques like microwave and ultrasound-assisted synthesis.

A. Organic Reactions in Water

Water is often considered the ideal solvent for green chemistry due to its non-toxic, non-flammable, and biodegradable nature. It is nature's most abundant solvent and exhibits strong hydrogen bonding capabilities. Several physical properties of water make it particularly useful for organic synthesis, including:

High dielectric constant, which enhances the solubility of polar compounds.

Low viscosity, allowing for better diffusion of reactants.

High surface tension, which enables the stabilization of reaction intermediates.

High specific heat capacity, making it an excellent medium for temperature control.

These properties collectively contribute to water's effectiveness in organic synthesis. Researchers have successfully employed water as a solvent in various organic reactions, demonstrating its versatility and sustainability. Notable examples include:

Synthesis of 2-arylidene indanones, which are important intermediates in pharmaceuticals.

Diels-Alder reactions, which are widely used in the synthesis of complex organic frameworks.

Claisen rearrangement, a key transformation in the formation of carbon-carbon bonds.

Using water as a solvent in these reactions not only reduces environmental impact but also enhances reaction efficiency and selectivity.

B. Organic Reactions in Polyethylene Glycol (PEG)

Polyethylene glycol (PEG), particularly PEG-400, is a promising green reaction medium used in various organic transformations. PEG has several advantages, making it an attractive alternative to conventional organic solvents:

Low cost, making it economically viable for large-scale reactions.

Recyclability, allowing for multiple uses without significant loss of effectiveness.

Non-toxic and biodegradable nature, ensuring safety for both researchers and the environment.

Intrinsic catalytic properties, which can enhance reaction rates and selectivity.

Many researchers have explored the use of PEG as a reaction medium for different types of organic transformations. Some notable applications include:

Synthesis of thiazoles and pyrimidines, which are important heterocyclic compounds in pharmaceuticals.

Heck reaction, a key carbon-carbon coupling reaction used in the production of fine chemicals and pharmaceuticals.

Michael reaction, which is widely employed in the synthesis of bioactive molecules.

Biginelli reaction, an important multicomponent reaction for synthesizing dihydropyrimidinones, which have medicinal applications.

The ability of PEG to dissolve a wide range of organic and inorganic compounds, along with its ability to be recovered and reused, makes it a sustainable choice for modern organic synthesis.

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C. Organic Reactions Using Metal Oxide Nanoparticles as Catalysts

Metal oxide nanoparticles have gained attention as efficient and environmentally friendly catalysts for organic reactions. These nanoparticles exhibit unique properties, such as:

High surface area, allowing for better interaction with reactant molecules.

Enhanced porosity, improving the accessibility of reactants to active catalytic sites.

Structural tunability, which can be achieved by doping with different metal ions to modify reactivity.

High selectivity, reducing unwanted side reactions and byproducts.

By leveraging these advantages, researchers have successfully used metal oxide nanoparticles in a variety of catalytic organic reactions. Some prominent examples include:

Synthesis of dihydropyrimidinones, which are valuable scaffolds in drug discovery.

Thiazole synthesis, which plays a crucial role in the development of pharmaceuticals and agrochemicals.

Oxazole synthesis, used in the production of biologically active compounds.

These nanoparticle-based catalysts not only improve reaction efficiency but also align with the principles of green chemistry by minimizing waste and reducing the need for toxic reagents.

D. Microwave and Ultrasound-Assisted Synthesis

Microwave and ultrasound-assisted techniques have revolutionized synthetic chemistry by significantly reducing reaction times and improving yields. These methods are considered highly efficient and environmentally friendly due to their ability to enhance reaction kinetics while minimizing solvent usage.

Microwave-Assisted Synthesis:

Microwaves provide rapid and uniform heating, leading to faster reaction rates.

The technique is particularly useful for reactions that require high temperatures but can be conducted in a shorter duration under microwave irradiation.

Examples include cyclization reactions, multicomponent reactions, and metal-catalyzed transformations.

Ultrasound-Assisted Synthesis:

Ultrasound waves generate acoustic cavitation, which enhances molecular interactions and accelerates reactions.

It is widely used in organic synthesis for reactions like esterification, oxidation, and reduction.

Benefits include increased yield, reduced reaction time, and improved selectivity.

In the past two years, researchers have reported significant advancements in microwave and ultrasound-assisted synthesis, demonstrating improvements in reaction efficiency, separation processes, and overall sustainability.

II. CONCLUSION

This review highlights various green synthetic strategies that are currently being developed and refined to promote environmentally friendly organic synthesis. The discussed approaches—water-mediated reactions, PEG-based synthesis, nanoparticle-catalyzed reactions, and microwave/ultrasound-assisted methods—represent significant steps toward sustainable chemical processes.

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Green Chemistry Approach for Microwave-Assisted Synthesis of Traditional Organic Reactions

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Abstract: *Microwave-assisted organic synthesis (MAOS) has emerged as an innovative and sustainable approach in modern organic chemistry. It provides a clean, simple, efficient, and rapid method for synthesizing various organic molecules, making it a valuable tool for researchers. The key advantages of microwave-assisted synthesis include a significantly accelerated reaction rate, improved product yield, enhanced purity, and reduced energy consumption, all of which align with the principles of green chemistry. This method is more environmentally friendly compared to conventional techniques, as it minimizes the use of hazardous solvents and reduces waste generation.*

In this study, traditional organic reactions were carried out under microwave irradiation at specific power levels and time intervals. For comparison, the same reactions were also performed using conventional synthesis methods. The effectiveness of both approaches was analyzed in terms of reaction time, product yield, and purity. The results demonstrated that microwave-assisted synthesis led to a considerable reduction in reaction time while achieving higher yields of the desired products. The synthesized compounds were purified using standard literature-based work-up procedures and characterized to confirm their structural integrity.

Overall, this study highlights the potential of microwave-assisted synthesis as an efficient and eco-friendly alternative to traditional reaction methods. The adoption of this technology in synthetic organic chemistry can contribute significantly to sustainable research practices by reducing energy consumption, minimizing chemical waste, and improving reaction efficiency.

Keywords: Green chemistry, microwave-assisted synthesis, traditional organic reactions, reaction efficiency, high yield, sustainable synthesis

I. INTRODUCTION

Microwave-assisted organic synthesis (MAOS) has revolutionized traditional organic synthesis by offering an efficient, clean, and environmentally friendly alternative. This technique has significantly reduced reaction times, improved product yields, and minimized energy consumption, making it a valuable tool in green chemistry. The following points elaborate on the significance, principles, and applications of microwave-assisted synthesis in organic chemistry:

1. **Historical Background** Microwave energy was first applied for heating food by Percy Spencer in the 1940s. However, its applications expanded beyond food heating in the 1950s, finding use in chemical and related industries, including food processing, drying, and polymer industries (Percy Spencer, 1945) [1]. Since then, microwave technology has been adapted for various scientific applications, including analytical chemistry (microwave digestion, ashing, and extraction), biochemistry (protein hydrolysis, sterilization), pathology (histoprocessing, tissue fixation), and medical treatments such as diathermy (Gabriel et al., 1998) [2].
2. **Microwave-Assisted Organic Synthesis (MAOS)**
   Microwave technology has emerged as a powerful tool in organic synthesis, enabling faster, more efficient reactions with enhanced selectivity (Kappe, 2004) [3]. It offers several advantages, including reduced reaction times, improved reaction rates, higher product yields, and minimal environmental impact (Loupy, 2006) [4].

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The method eliminates the need for tedious heating setups, making it a cost-effective alternative to conventional synthesis (Varma, 1999) [5].

3. **Limitations of Conventional Organic Synthesis** Conventional synthesis typically requires longer heating times, leading to higher energy consumption and higher process costs (Hoz et al., 2005) [6]. The excessive use of organic solvents and reagents contributes to environmental pollution and waste generation (Kappe, 2008) [7]. These limitations have led to the increasing adoption of microwave-assisted methods in laboratories and industries.
4. **Principles of Microwave Heating in Organic Synthesis** Microwaves are a form of electromagnetic radiation that interact with molecules by inducing dipole rotation and ionic conduction (Gedye et al., 1986) [8]. The heating effect arises from molecular oscillation, where charged particles within the reaction medium absorb microwave energy and convert it into heat (Mingos & Baghurst, 1991) [9]. Unlike conventional heating methods, which transfer heat from an external source to the reaction vessel, microwave heating generates heat uniformly throughout the reaction medium, resulting in rapid and even temperature distribution (Kappe, 2013) [10].
5. A**dvantages of Microwave-Assisted Organic Synthesis** Reduction in reaction time: Many organic reactions that typically take several hours under conventional heating can be completed in minutes using microwaves (Bogdal, 2005) [11]. Higher reaction efficiency: Microwave irradiation enhances reaction kinetics, leading to higher conversions and improved product yields (Varma, 2001) [12]. Cleaner reactions: Due to minimal solvent usage, microwave reactions reduce by-product formation and hazardous waste (Lidström et al., 2001) [13]. Energy efficiency: Microwave heating directly couples with reactants, significantly lowering energy costs and consumption (Loupy, 2002) [14]. Green chemistry benefits: The elimination of external heating sources reduces environmental pollution, making microwave-assisted synthesis an essential tool in sustainable chemistry (Kappe & Stadler, 2005) [15].
6. **Mechanism of Microwave Heating** The interaction of microwaves with polar molecules and ions generates rapid internal heating, leading to accelerated reaction rates (Hoz et al., 2005) [16]. The energy absorption mechanism primarily occurs via: Dipolar polarization: Molecules with permanent dipoles rotate rapidly under an alternating electric field, generating heat (Bogdal, 2005) [17]. Ionic conduction: Charged species move under the influence of the electromagnetic field, leading to frictional heating (Mingos & Baghurst, 1991) [18].
7. **Impact on Green Chemistry** The integration of microwave technology in organic synthesis aligns with green chemistry principles by minimizing hazardous waste and energy consumption (Anastas & Warner, 1998) [19]. The rapid and selective nature of microwave heating reduces by-product formation, ensuring cleaner reaction pathways (Varma, 2002) [20]. This technology has been widely implemented in fields such as medicinal chemistry, material science, and combinatorial chemistry, offering sustainable alternatives for industrial-scale synthesis (Lidström et al., 2001) [21].
8. **Future Prospects and Applications** The continuous advancement in microwave-assisted synthesis is expected to further revolutionize pharmaceuticals, agrochemicals, and nanomaterials (Kappe, 2013) [22]. Emerging research focuses on solvent-free microwave reactions, microwave-assisted catalysis, and the integration of flow chemistry to enhance reaction scalability (Horikoshi & Serpone, 2013) [23]. The ongoing development of hybrid microwave systems aims to expand its applications in biotechnology and environmental chemistry (Mingos, 2019) [24].

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Green Chemistry: Sustainable Approaches for a Greener Future

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Abstract: *Green chemistry is an innovative approach that follows a set of principles to minimize the use and generation of hazardous substances in chemical processes. Instead of remediating pollution, it focuses on designing eco-friendly chemical reactions that prevent environmental damage. The twelve principles of Green Chemistry encompass key concepts such as pollution prevention, atom economy, less hazardous chemical synthesis, safer solvents and auxiliaries, energy-efficient processes, renewable feedstock, catalysis, and degradation-friendly design. This field integrates into various branches, including organic chemistry, inorganic chemistry, biochemistry, analytical chemistry, and physical chemistry.*
With increasing concerns over environmental pollution, green materials are classified into green reagents (e.g., dimethyl carbonate, polymer-supported reagents), green catalysts (e.g., acid catalysts, oxidation catalysts, photocatalysts, biocatalysts), and green solvents (e.g., supercritical CO_2, water, ionic liquids). Additionally, modern advancements in green chemistry involve emerging techniques like photochemistry, microwave chemistry, sonochemistry, and electrochemistry, which enhance energy efficiency and waste minimization. By emphasizing sustainable practices, non-toxic reagents, and renewable resources, green chemistry promotes environmentally benign and resource-efficient chemical processes, ensuring a sustainable future for industrial and scientific applications.

Keywords: Green chemistry

I. INTRODUCTION

Green Chemistry is a scientific approach that focuses on the invention, design, development, and application of chemical products and processes to reduce or eliminate the use and generation of hazardous substances. Unlike conventional chemistry, which often deals with waste treatment and pollution control after harmful substances have already been produced, Green Chemistry proactively prevents pollution at the source.

This field integrates environmental sustainability with chemical innovation, ensuring that chemical processes are not only efficient but also safe for human health and the environment. It applies across various branches of chemistry, including organic, inorganic, analytical, physical, and biochemistry, promoting the use of renewable resources, energy-efficient methods, and non-toxic reagents.

The 12 Principles of Green Chemistry, developed by Paul Anastas and John Warner, serve as fundamental guidelines for designing safer, cleaner, and more sustainable chemical processes. These principles emphasize waste prevention, atom economy, the use of safer solvents, renewable feedstocks, catalysis, real-time pollution monitoring, and accident prevention. By implementing these principles, industries and researchers can reduce environmental impact, enhance process efficiency, and develop eco-friendly alternatives to traditional chemical methods.

Green Chemistry has gained significant attention due to growing concerns over global pollution, climate change, and resource depletion. It is widely applied in various industries, including pharmaceuticals, agriculture, food packaging, and energy production, offering innovative solutions to reduce toxicity, lower energy consumption, and promote sustainability.

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Green Chemicals:

The increasing local and global concern for environmental pollution has led to the exploration of new green materials, which can be categorized into three parts:

Green Reagent

Green Catalyst

Green Solvent

I. Green Reagents:

Green reagents are selected based on efficiency, availability, and minimal environmental impact during the transformation of feedstock into target molecules. Common green reagents include:

i) Dimethyl Carbonate (DMC):

DMC is a non-toxic, environmentally safe reagent used as a green alternative in organic synthesis.

It is used in the methylation of aromatic amines and active methylene compounds, eliminating the production of inorganic salts.

ii) Polymer-Supported Reagents:

These are reagents bound to a polymer support, enhancing reaction efficiency and recyclability.

Example: Polymer-supported peracid is used for the epoxidation of alkenes.

II. Green Catalysts:

Catalysts play a crucial role in the chemical industry by improving reaction efficiency, reducing energy consumption, and minimizing environmental impact. Green catalysts are essential for developing eco-friendly chemical processes and products. The following types of catalysts are commonly used in green chemistry:

i) Acid Catalysts:

Acid catalysts are used to enhance reaction rates in organic synthesis. Traditional acid catalysts can be corrosive and generate hazardous waste, whereas green acid catalysts offer safer alternatives.

Bead Polymers for Epoxidation: One widely used epoxidizing reagent is **meta-chloroperoxybenzoic acid (m-CPBA)**, known for its mild reaction conditions and high yield. However, m-CPBA has drawbacks, such as the production of chlorinated waste and potential explosiveness.

Bead polymers are a green alternative used for the epoxidation of **cyclohexene** without hazardous byproducts.

Boric Acid in Amide Synthesis:

Boric acid is an environmentally friendly **Lewis acid catalyst** used in the synthesis of amides from acids and amines.

It has been effectively used for preparing **symmetrical N,N'-alkylidenebisamides**, offering benefits like mild reaction conditions, simple procedures, and high yields.

ii) Oxidation Catalysts:

Oxidation catalysts facilitate the selective oxidation of organic substrates, reducing the need for harsh reagents.

Titanium and Vanadium-Based Molecular Sieves:

Molecular sieves, such as **titanium silicates (TS-1)**, are used in the hydroxylation of phenol.

This process produces a mixture of **hydroquinone, catechol, and resorcinol**, key compounds in pharmaceuticals and dyes.

These catalysts enhance selectivity and efficiency while minimizing waste.

iii) Basic Catalysts:

Basic catalysts accelerate reactions involving base-promoted mechanisms. While solid acid and oxidation catalysis have seen widespread adoption, solid base catalysis is still underutilized in liquid-phase reactions.

Example: Alkylation of Phenol :

The **alkylation of phenol** is an important industrial process where basic catalysts improve reaction rates and product selectivity.

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These catalysts are used in the production of **alkylated phenols**, which serve as intermediates in lubricants, resins, and antioxidants.

iv) Photocatalysts:

Photocatalysis is a sustainable technique where a **semiconducting material** generates free radical pairs upon exposure to light, leading to chemical transformations.

Example: Photocatalytic Degradation of Chloral Hydrate:

Chloral hydrate, a common environmental pollutant, can be broken down using photocatalysts in an **aqueous semiconductor suspension**.

Hydroxyl (·OH) radicals generated in the reaction act as strong oxidizing species, leading to the degradation of chloral hydrate into less harmful substances.

This process is widely used for wastewater treatment and environmental remediation.

v) Phase Transfer Catalysts (PTCs)

PTCs improve reaction efficiency by facilitating the transfer of reactants between immiscible phases (e.g., organic and aqueous). They enable the use of milder conditions and greener solvents.

Working Principle:

PTCs **shuttle ions or organic molecules** between different phases, enhancing reaction rates and selectivity.

They reduce the need for **toxic organic solvents** and harsh reaction conditions.

Example: Esterification Reaction:

Crown ethers and polyglycol ethers are commonly used PTCs.

These catalysts enable the esterification of carboxylic acids with alcohols, an essential reaction in the production of **flavors, fragrances, and pharmaceuticals**.

vi) Polymer-Supported Catalysts:

Polymer-supported catalysts enhance reaction efficiency and allow for catalyst recycling, reducing waste.

Polystyrene Aluminium Chloride (PS-AlCl3):

Used for the **formation of ethers** from alcohols.

This catalyst provides high selectivity and can be easily separated from the reaction mixture.

Polymer-Supported Phase Transfer Catalysts (PS-PTC):

Used for the **conversion of haloalkanes into nitriles**.

This method eliminates the need for toxic cyanide salts, making it a safer alternative for nitrile synthesis.

vii) Biocatalysts:

Biocatalysts (enzymes and microorganisms) enable reactions under mild conditions without the formation of toxic byproducts. They are increasingly used for the sustainable production of valuable chemicals.

Examples of Biocatalytic Reactions:

L-Malate Production:

Fumarase enzyme from *Breviabacterium flavum* converts **fumarate to L-malate** via hydration.

L-Malate is widely used in the food and pharmaceutical industries.

Oxidation of Allyl Alcohol to Acrolein:

This reaction is catalyzed by **aldehyde dehydrogenase**.

Acrolein is an important intermediate in the synthesis of acrylic acid and other industrial chemicals.

Green Solvents and Green Methodologies in Organic Synthesis:

Traditional organic solvents, such as acetone, tetrahydrofuran (THF), benzene, and diethyl ether, generate significant environmental waste and pose health risks. Green solvents provide eco-friendly alternatives that minimize toxicity and

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waste production. Several strategies have emerged to reduce solvent use and promote sustainable chemistry, including the use of supercritical fluids, water, and ionic liquids.

1. Green Solvents:

i) Supercritical CO_2 as a Green Solvent:

Supercritical carbon dioxide (SC-CO_2) is an environmentally friendly solvent that exhibits properties of both gases and liquids under supercritical conditions (above its critical temperature of 31.1°C and pressure of 73.8 atm). It is widely used in green chemistry due to its non-toxic, non-flammable, and readily available nature.

Applications of Supercritical CO_2:

Catalytic Hydrogenation Reactions: Asymmetric catalytic hydrogenation of organic compounds can be carried out in SC-CO_2 with high efficiency.

Esterification of Phthalic Anhydride with Methanol: SC-CO_2 facilitates esterification, reducing the need for hazardous organic solvents.

Replacement of VOCs in Spray Paints: SC-CO_2 replaces volatile organic compounds (VOCs) in industrial spray coatings, reducing air pollution.

Advantages of Supercritical CO_2: Non-toxic and non-flammable Inexpensive and widely availableHigh purity and easily separable Ideal replacement for hazardous solvents Does not degrade solutes

ii) Water as a Green Solvent:

Water is one of the most sustainable solvents in organic synthesis due to its abundance, non-toxicity, and ability to facilitate various reactions at high temperatures.

Reactions Promoted by Water:

Diels-Alder Reactions: Water enhances reaction rates and selectivity due to hydrogen bonding effects.

Benzoin Condensation: A reaction between benzaldehydes catalyzed in aqueous media.

Synthesis of α-Cyano-β-arylnitroethenes: Achieved through a one-pot reaction of aryl aldehydes and nitroacetonitrile in water.

Preparation of Conjugated Nitroalkenes: Conducted in aqueous-organic media using sodium nitrite and iodine.

Advantages of Water as a Green Solvent: Environmentally benign Safe and non-toxic Facilitates novel synthetic methodologies Reduces waste and cost
Enhances reaction selectivity

iii) Ionic Liquids as Green Solvents:

Ionic liquids (ILs) are salts composed entirely of ions and remain liquid below 100°C. Their negligible vapor pressure, thermal stability, and ability to dissolve a wide range of compounds make them highly suitable for green chemistry applications.

Common Ionic Liquids:

Cations: Pyridinium, Imidazolium, Pyrrolidinium, Thiazolium

Anions: Hexafluorophosphate (PF_6^-), Tetrafluoroborate (BF_4^-), Chloroaluminate ($AlCl_4^-$), Trifluoromethanesulfonate ($CF_3SO_3^-$)

Applications of Ionic Liquids:

Hydrogenation of 2-Arylacrylic Acid: The ionic liquid **[bmim][BF_4]** combined with **[Ru-BINAP]** acts as a homogeneous catalyst for enantioselective hydrogenation, achieving high yields with 80% enantiomeric excess (ee).

Esterification of Carboxylic Acids: Carried out in **Brønsted acidic ionic liquids** such as 1-methylimidazolium tetrafluoroborate.

Advantages of Ionic Liquids: High reaction yields and selectivity Enhanced reaction rates Reusable and renewable Negligible solvent evaporation (low volatility)

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2. Organic Synthesis in Solid State:

Green chemistry principles emphasize minimizing solvent use. Solid-state organic synthesis offers a cleaner and more energy-efficient approach.

i) Solid-Phase Organic Synthesis (Without Solvent):

Example: **Condensation of Substituted Benzaldehydes and Cyanoamides**

In the presence of **piperidine catalyst**, nitro derivatives are obtained in high purity.

Eliminates the need for hazardous organic solvents.

ii) Solid-Supported Organic Synthesis (Using Solvent):

Example: **Dieckmann Condensation of Diethyl Adipate and Pimelate**

Conducted in the presence of powdered **tert-Butoxide (tBuOK)**.

The solid support enhances reaction efficiency.

Advantages of Solid-State Synthesis: Reduces solvent waste Saves energy and minimizes hazardous reagents Provides higher product purity

3. Green Methodologies in Organic Synthesis:

Emerging techniques in green chemistry involve the use of alternative energy sources like **light, microwave, ultrasound, and electricity** to make reactions more efficient and sustainable.

i) Photochemistry (Light-Induced Reactions)

Photochemical reactions use **light energy** to drive chemical transformations.

Example: Photooxidation of organic compounds in wastewater treatment.

Advantage: Eliminates the need for harsh oxidizing agents.

ii) Microwave Chemistry

Microwave irradiation provides rapid and uniform heating, reducing reaction times significantly. **Example:** Microwave-assisted synthesis of heterocyclic compounds. **Advantage:** Shortens reaction duration from hours to minutes.

iii) Sonochemistry (Ultrasound-Assisted Reactions)

Ultrasound waves enhance reaction rates and efficiency by generating localized **high-energy cavitation bubbles**. **Example:** Sonochemical synthesis of nanoparticles. **Advantage:** Increases reaction speed and yield.

iv) Electrochemistry (Electricity as a Driving Force)

Electrochemical reactions use electricity to initiate redox transformations, reducing the need for external reagents. **Example:** Electrosynthesis of organic molecules without metal catalysts. **Advantage:** Reduces reagent waste and enhances selectivity.

Green Solvents and Green Methodologies in Organic Synthesis

Introduction

Green chemistry aims to develop sustainable and environmentally friendly chemical processes. Traditional organic solvents such as benzene, diethyl ether, and acetone contribute significantly to pollution and health hazards. Green solvents and methodologies provide viable alternatives that minimize toxicity and waste generation. This document explores various green solvents such as supercritical CO_2, water, and ionic liquids, alongside eco-friendly methodologies including photochemistry, microwave chemistry, sonochemistry, and electrochemistry.

I. Green Solvents

1. Supercritical Carbon Dioxide (SC-CO_2)

Supercritical carbon dioxide is an eco-friendly solvent that combines gas-like diffusivity with liquid-like solvating power above its critical temperature (31.1°C) and pressure (73.8 atm). It is widely used in industrial and laboratory settings due to its non-toxic, non-flammable, and recyclable nature.

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Applications of SC-CO_2:
Catalytic Hydrogenation: Asymmetric catalytic hydrogenation of organic molecules using transition-metal catalysts in SC-CO_2 results in high efficiency.
Esterification of Phthalic Anhydride: SC-CO_2 facilitates esterification reactions without generating hazardous waste.
Extraction of Natural Products: Used for decaffeination of coffee and extraction of essential oils.
Advantages of SC-CO_2: Non-toxic and non-flammable Readily available and inexpensive Easily separable after reaction Enhances reaction efficiency and selectivity

2. Water as a Green Solvent
Water is an ideal solvent for green chemistry due to its non-toxic, abundant, and recyclable nature. It enhances reaction kinetics and selectivity in many organic transformations.
Reactions Promoted by Water:
Diels-Alder Reaction: Water accelerates Diels-Alder reactions due to hydrogen bonding stabilization of the transition state.
Benzoin Condensation: Aqueous conditions facilitate this reaction between benzaldehydes.
Hydrolysis Reactions: Various hydrolytic transformations occur efficiently in water.
Advantages of Water as a Green Solvent: Environmentally benign and safe Reduces energy consumption Enhances reaction selectivity Cost-effective

3. Ionic Liquids as Green Solvents
Ionic liquids (ILs) are salts that remain liquid below 100°C, making them useful for eco-friendly organic synthesis. They exhibit negligible vapor pressure, high thermal stability, and excellent solvation properties.
Common Ionic Liquids:
Cations: Pyridinium, Imidazolium, Thiazolium
Anions: Hexafluorophosphate (PF_6^-), Tetrafluoroborate (BF_4^-)
Applications of Ionic Liquids:
Hydrogenation Reactions: Ionic liquids enhance selectivity in catalytic hydrogenation.
Esterification of Carboxylic Acids: Conducted in Brønsted acidic ionic liquids.
Green Catalysis: Used as recyclable solvents in Suzuki coupling and Heck reactions.
Advantages of Ionic Liquids: High reaction yields Recyclable and reusable Non-volatile and non-flammable

II. Green Methodologies in Organic Synthesis
1. Photochemistry (Light-Induced Reactions)
Photochemical reactions occur when molecules absorb light, promoting them to an excited state. This energy can drive various chemical transformations efficiently.
Examples of Photochemical Reactions:
Cleavage of Dithianes and Benzyl Ethers: Visible light facilitates their cleavage.
Acylhydroquinone Synthesis: A sunlamp induces the reaction of 1,4-benzoquinone with aldehydes, avoiding salt byproducts.
Advantages of Photochemistry: Eliminates hazardous reagents Utilizes renewable energy sources Enhances reaction selectivity

2. Microwave Chemistry
Microwave-assisted organic synthesis (MAOS) provides rapid heating through selective absorption of microwave energy by polar molecules.
Benefits of Microwave Chemistry:
Accelerated reaction rates
Improved yields

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Reduction in side products
Limited solvent usage
Success where conventional methods fail
Examples of Microwave-Assisted Reactions:
Esterification of Alcohols: Conducted in ethanol.
Schiff Base Synthesis: Achieved using ethanol as a solvent.
Solvent-Free Synthesis: N-arylamines synthesized via aryl halide amination in the presence of basic Al_2O_3.

3. Sonochemistry (Ultrasound-Assisted Synthesis)
Sonochemistry involves the use of ultrasonic waves to enhance chemical reactivity via cavitation-induced energy release.
Examples of Sonochemical Reactions:
Hydrolysis Reactions: Ultrasonication accelerates hydrolysis of esters and amides.
Strecker Synthesis of Aminonitriles: Sonochemical conditions improve efficiency.
Combination with Other Techniques: Synergistic effects observed with microwave and photocatalysis.
Advantages of Sonochemistry: Enhances reaction rates and selectivity Reduces reaction time and energy consumption Increases yield

4. Electrochemistry (Electricity-Driven Synthesis)
Electrochemical synthesis employs electric currents to drive redox reactions, reducing reagent waste.
Applications of Electrochemistry:
Electrosynthesis of 3-Bromothiophene: Demonstrates eco-friendly advantages over conventional bromination. **Metal-Free Organic Transformations:** Used in oxidation-reduction reactions.
Advantages of Electrochemical Synthesis: Water-based, mild conditions Atom-efficient with minimal waste Energy-efficient

II. CONCLUSION

Green chemistry is a crucial approach toward sustainable industrial and academic chemical synthesis. It does not entirely replace conventional methods but serves as a complementary strategy to minimize environmental impact. By incorporating green solvents like SC-CO_2, water, and ionic liquids, along with advanced methodologies such as photochemistry, microwave chemistry, sonochemistry, and electrochemistry, we can reduce pollution, enhance reaction efficiency, and promote eco-friendly innovations in chemical synthesis.

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Molecular Iodine Assisted Green Synthesis of Benzimidazoles

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Abstract: *Green synthesis of 2-substituted Benzimidazoles in the presence of molecular iodine(10mol%) the mixture of o-phenylenediamine in I_2 was added benzoyl chloride at room temperature and reaction mixture was grind at room temperature after 20 minutes reaction was completed. The reaction gives high yield. The short reaction time, clean reaction, and easy workup make this protocol green and efficient.*

Keywords: Benzimidazoles, molecular iodine, room temperature, green synthesis

I. INTRODUCTION

Substituted Benzimidazole is a bicyclic compound having imidazole ring fused to benzene. The compounds that exhibit the functionality of benzimidazole have been extensively employed in the area of pharmaceuticals. Benzimidazole nucleus is a part of the nucleotide portion of vitamin $B_{12,}$ in some drugs such as proton pump inhibitors, anthelmintics agents[1] and antirhino/enteroviral agents[2], Benzimidazoles also exhibit significant activity against several viruses including HIV[3], herpes (HSV-1)[4], RNA[5], influenza[6] and human cytomegalovirus (HCMV). In recent years benzimidazoles have been reported to act as topoisomerase I inhibitors[7], selective neuropeptide Y Y1 receptor antagonists[8], angiotensin II (AII) inhibitors[9], inhibitors of HCMV replication, potential antitumour agents[10], antimicrobial agents[11], smooth muscle cell proliferation inhibitors[12], a treatment for interstitial cystitis[13], antihistamine (astemiazole)[14], antifungal (chlorfenazol), anti-ulcerative (omeprazole)[15],anti-inflammatory activity[16] and in diverse areas of chemistry[17].

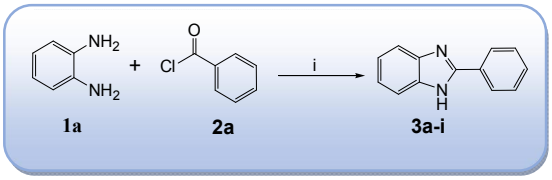
Interest in these structures stems from their widespread occurrence in molecules that display a wide range of useful biological properties. Widely used traditional methods for their preparation involve the reaction of a carboxylic acid or its derivative with an appropriate *o*-phenylenediamine, *o*-aminophenol or *o*-aminothiophenol in the presence of a strong acid or cyclodehydration of mono-acylated product under acidic condition or by pyrolysis at 200–350 ^{0}C.2-substituted benzimidazoles by condensing a variety of carboxylic acids with *o*-aminophenols or *o*-phenylenediamines in presence of PS-PPh_3 resin[18] , Zeolite[19], trifluoroacetic acid and difluoro acetic acid[20] and by Lewis acids in ethanol[21].Recently *Siddiqui et al* [22-23] reported the method of the synthesis of these heterocycles by using ionic liquids as a part of green chemistry.

Survey of literature reveals that methods for the synthesis of above heterocycles have been suffer from several drawbacks such as low yield, more reaction steps, tedious manipulations in the isolation of products and utilization of toxic reagents. These reactions require harsh dehydration conditions such as strong mineral acids, which have limited the viability of many starting materials. The development of simple, efficient and environmentally benign chemical processes or methodologies for widely used organic compounds from readily available reagents is one of the major challenges for chemists in organic synthesis.

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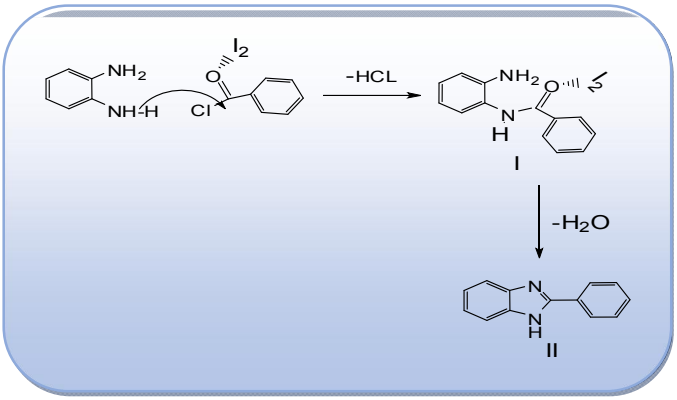
II. METHODOLOGY



Scheme 1. Reaction conditions; I_2 (10 mol%) , RT

Molecular iodine reagent has found broad application in organic chemistry and now a days frequently used in synthesis[109]. Therefore, the development of simple, efficient, inexpensive, nontoxic and readily available reagents providing convenient procedure with improved yield. Owing to its unique catalytic properties iodine has been extensively used for an organic reaction [110-112].From previous study we found that I_2 gives the best result compare to other catalyst. To a clean mixture of *o*-phenylenediamine **1a** in I_2 was added benzoyl chloride **2a** at room temperature and reaction mixture was vigorously stirred, after addition is over reaction mixture was precipitate out as a solid product (reaction was completed in 20 min. which was checked by TLC). After completion of reaction, mixture was diluted with water and filtered and wash with sodium thiosulphate iodine remove with filtrate. The isolated product was further purified by column chromatography give pure product **3a** in 93% yield which was fully characterized. The IR spectrum of **3a** shows absorption at 1640 & 3420 cm^{-1} corresponds to C=N and –NH functional group respectively. The ^{1}H-NMR spectrum of **3a** showed broad singlet at δ 4.5 for –N*H* and multiplet of nine protons in the region of 7.32-8.19 for aromatic region. The elemental analysis and physical constant concerned with the literature values of **3a**.

III. RESULT AND DISCUSSION



Scheme:-2 Systematic mechanism of the synthesis of Benzimidazoles

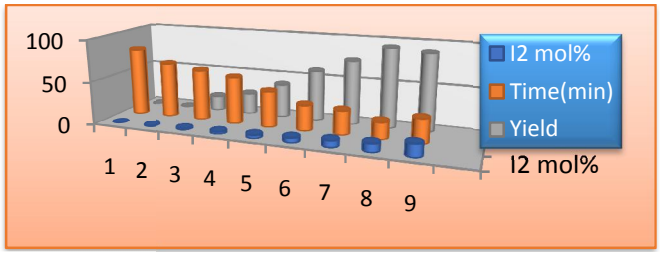
Generally, the synthesis of benzimidazole is proceeding through two step process. First is the acylation followed by cyclization .In first step hydrochloric acid is liberated as by product during the reaction, we thought that this liberated hydrochloric acid may facilated the further cyclization to delivered the target 2-phenyl benzimidazole **3a (II)**, to check this we performed the reaction of **3a** in molecular solvent (acetonitrile) without any added catalyst, we got mono-acylated product exclusively with no sign of benzimidazole, this indicates that librated hydrochloric acid is not taking part for further cyclization.

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Table 1. Catalytic study of I_2 for formation of 3a

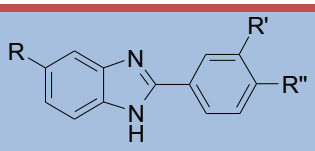
Entry	I_2 (mol %)	Time (min.)	Yield [a] (%)
1	No iodine	80	00
2	1	65	traces
3	2	60	18
4	3	55	25
5	4	42	40
6	6	30	60
7	8	28	75
8	10	20	95
9	15	28	92



[a] **Isolated yield after column chromatography**

The effect of mole ratio of the I_2 with respect to the formation of **3a** was investigated (Table 1). It can be observed that a minimum of equimolar proportion of the I_2 is required for optimum result. As we wish to explore here the I_2 as promoter for this heterocyclization, A mixture of *o*-phenylenediamine (4.6 mmol) and benzoyl chloride (4.6 mmol),by addition of iodine however reaction proceed to gave the 2-phenyl benzimidazole as sole product. These results confirmed that I_2 due to its large electrochemical window promoted this heterocyclization for the formation of target molecule 2-phenyl benzimidazole in excellent yield in short span of reaction time. It becomes evident from above results (Table 1), the I_2 afforded the best results. Consequently, all further studies were conducted at room temperature using I_2 to synthesize different 2-susbtituted benzimidazole.

Table 2. Synthesis of Benzimidazoles **3a-i**

Entry	 3a-i			Time (min.)	Yield [a] (%)
	R	**R'**	**R''**		
3a	**H**	H	**H**	**12**	92
3b	**H**	H	**NO_2**	**21**	88
3c	**H**	F	**CF_3**	**17**	90
3d	**Me**	H	**H**	**14**	92
3e	**Me**	H	**NO_2**	**20**	93
3f	**Me**	F	**CF_3**	**18**	95
3g	**CoPh**	H	**H**	**20**	94
3h	**CoPh**	H	**NO_2**	**22**	89
3i	**CoPh**	F	**CF_3**	**24**	92

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IV. EXPERIMENTAL

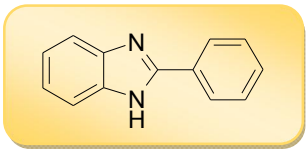
Typical procedure for synthesis of 2-phenyl benzimidazole (3a) in I_2 :

A mixture of *o*-phenylenediamine (4.6 mmol) and benzoyl chloride (4.6 mmol) in I_2 (10 mol%) was stirred at room temperature. After completion of the reaction (progress of reaction was monitored by TLC). Reaction mixture was diluted with water (10 mL) and the separated product was filtered and washes with sodium thiosulphate. The product, thus isolated, was pure enough. It was subjected to further purification by column chromatography using 20% EtOAc in petroleum ether as eluent and fully characterized.

Conclusion: -In conclusion we have synthesized substituted Benzimidazoles in the presence of molecular iodine at room temperature. The reaction gives high yield. The short reaction time, clean reaction, and easy workup make this protocol green and efficient.

Acknowledgment: -Author is thankful to Department of Chemistry, B. Raghunath ACS College, Parbhani.

Characterization data for Compound:-



2-phenyl-1H-benzimidazole (3a)

M. P. (^{0}C) : 294-295

IR ($CHCl_3$, cm^{-1}): υ_{max} 735, 810, 1035, 1140, 1310, 1463, 1643, 3420.

^{1}H NMR (200 MHz, $CDCl_3$) : δ 4.3 (brs, 1H), 7.32-8.19 (m, 9H).

^{13}C NMR : δ 112, 115.3, 121.7, 122.5, 126.4, 129, 130, 130.3, 134.9, 143.6, **(50 MHz, $CDCl_3$)** 151.6.

Elemental Analysis : $C_{13}H_{10}N_2$

Calcd. C, 80.39; H, 5.19; N, 14.42.

Found C, 80.19; H, 5.05; N, 14.23.

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Teachers and Role of Artificial Intelligence in Education

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Abstract: *Over the past decade, there has been a tremendous change in teaching and learning methods. Traditional methods of teaching are now modified to blended teaching methods. These methods are combination of traditional and technology-supported to cater to the changing needs of students.*
Teachers have access to a wide range of resources on the internet in the form of reference books, question papers, PDF notes, web-links for videos, quizzes, etc. These can be used in class or shared with the students. With the launch of 'Artificial Intelligence' the scope of learning has broadened. A few popular examples of AI among the masses are Alexa, Siri, Rufus, etc. These apps provide the resources or results as per the needs of the user.
In this paper, we conducted a survey to study the integration of AI in classroom teaching, its benefits, uses and challenges faced by teachers in its application for which, teachers from different disciplines participated. We observed that all teachers participating in the survey were familiar with AI applications. They learned about AI through workshops, conferences, peer sharing, etc. Majority of teachers use virtual teaching assistant application for research. It also facilitates in the process of planning the curriculum, to cater to the needs of the students, engaging activities for the students, etc. It helped them to develop interesting and engaging teaching methods for students arousing curiosity and scientific aptitude among young minds.

Keywords: Artificial Intelligence, benefits, challenges, virtual, traditional, etc

I. INTRODUCTION

[1]Artificial Intelligence (AI) has become a part of our daily life. It has made our life simple and easy to collect information about a place or product. Pen and paper are left behind in this digital world. The world of education is dynamic. It readily introduces new methods and techniques in teaching learning methods. [2,3]Traditionally, teaching was limited to classroom, fixed syllabus, etc. Now it has undergone a drastic change. Now teaching learning methods are modified to student-centred and not teacher-centred. The classrooms are supported by a digital platform. [4]This has helped students and teachers to stay connected with students to exchange knowledge from different parts of the globe.
[5]Teachers are the crucial stake-holders in the use of AI-based teaching. With proper technical support and guidance, teachers can upgrade classroom teaching with AI. This can help teachers to have more interactive classes. Research says that audio-visual learning has always been a boon for students with learning disabilities. In the past few years, with the advancement in science and technology, teachers have also been trained to get familiarise with the integration of AI in classroom teaching. Use of technology helps to use a variety of teaching-learning methods for teachers. This gives an inclusive perspective to the teaching methods. [6]Similarly, AI can help to develop rubrics for activities and can give a transparent assessment for the same[7]

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Fig.1: AI Image

Objectives:

To study:

- The usage of AI in teaching.
- The impact of usage of AI in classroom teaching learning method
- The challenges faced by teachers in integrating AI in teaching.

II. METHODOLOGY

The data collection is done using a survey method. In this, a questionnaire was developed and shared with the participants. The questionnaire was developed to study the awareness of AI among the teacher community, the usage of AI in classroom teaching and learning and any challenges faced during the usage of technology in classroom teaching and learning. After data collection, there is interaction with the teacher participants to have a deep understanding of participants' views, challenges, suggestions and solutions regarding the usage of AI in classroom teaching and learning. Later, sorting and analysis was carried out to know the outcome of the survey.

Questionnaire consisting of following questions:

General Information

- What is your current role?
- You are from which place?
- What is your highest qualification?
- What subject(s) do you teach?
- Which age group you belong?
- What is your level of teaching experience?
- Which classes you teach?

Technical Information

- How familiar are you with AI-powered tools in education?
- Which AI-powered tools have you used?
- What benefits do you think AI-powered tools can bring to education?
- What challenges do you think AI-powered tools pose in education?
- What type of training or support did you receive?
- What additional support or resources do you think would help you effectively integrate AI-powered tools into your teaching practice?

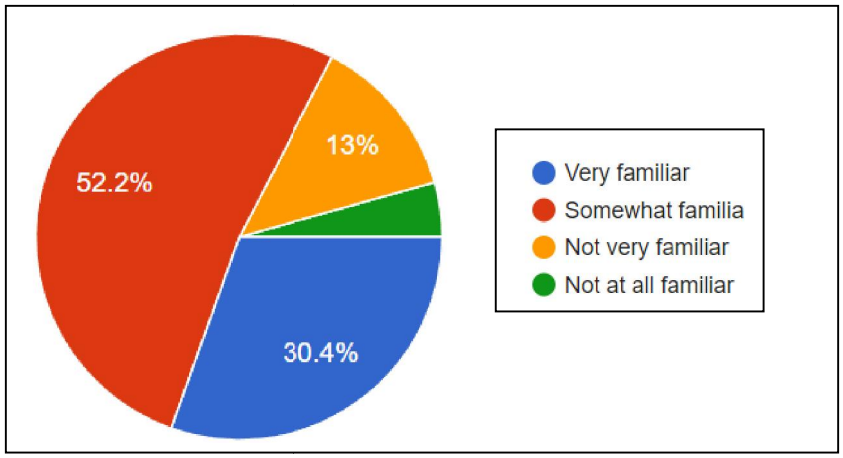
III. RESULTS AND DISCUSSION

The above survey was taken by 25 teachers. 78.3% teachers and 21.7% educators and freelancers. These teachers are basically from Thane, Mumbai and Pune regions teaching in urban area schools. In this sample, 85% of the teachers are

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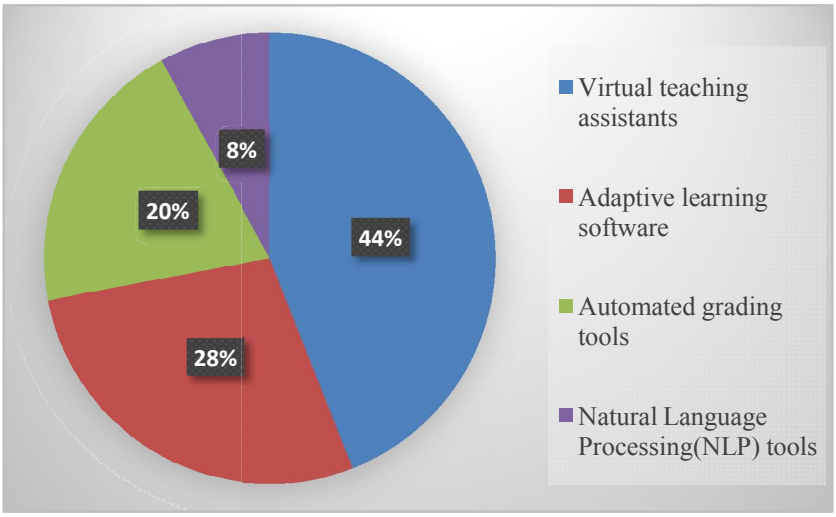
female and 15% male. 91% where post graduate teachers and 9% graduate teachers. 60% of the teachers are in the age group of 31-40, 25% teachers are in the age group of 41-50-year age group. The medium of communication was English for 87% and the remaining 13% use Hindi or Marathi as the medium of communication in school. 44% of teachers are subject experts with 12+ years of experience, 35% teachers having 8+ years of teaching experience, whereas 21% of teachers are having 5 years of experience. In this sample, teachers consist of teaching middle school to senior secondary classes with different subject like science (10), mathematics (7), languages (9), computers (3), and other subjects (8). Few teachers teach two subjects, and so they have been considered for more than one subject.

How familiar are you with AI-powered tools in education?



The pie chart can show that 83% teachers are 'familiar' with the use of AI whereas a small part of population is not familiar with the AI.

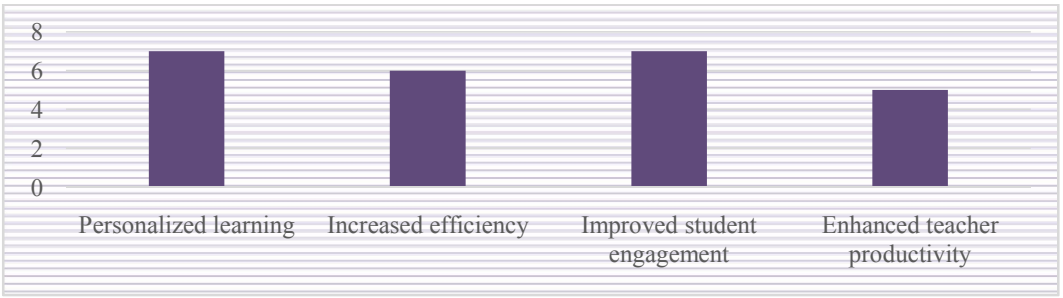
If yes, which AI-powered tools have you used?



The above pie chart says that maximum percentage of population uses virtual teaching for searching resources, planning curriculum. Whereas few people from the sample set uses AI for adaptive learning, auto assessment and NLP purpose.

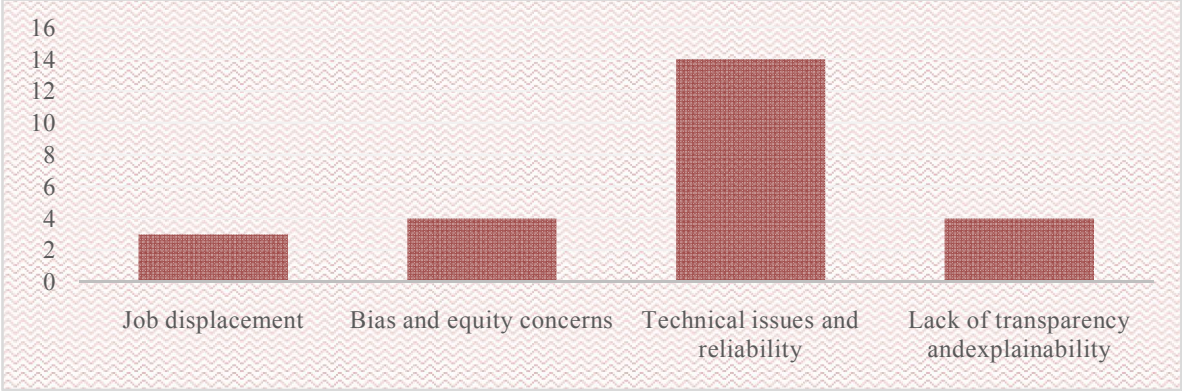
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What benefits do you think AI-powered tools can bring to education?



The use of AI brought multiple benefits to teachers and students. It has helps teachers to provide personalised learning tool for students in the classroom. This is showing a positive impact on the performance of the students. Students are tech savvy and usage of AI provide constant engagement activities for the students. This helps students to develop interest and brings constant improvement in the performance.

What challenges do you think AI-powered tools pose in education?



Inorder to check the cause of the problem regarding usage of AI above question plays an important role in this study. The common issue teachers teaching in urban area school are facing is technical issue. It may include insufficient availability internet, IT support, availability of system in the classroom or laboratories. There are other challenges like lack of transparency, bias and equity concerns and job displacement in using AI.

IV. CONCLUSION

In our study we conclude that teachers of different age groups are looking forward positively to using AI in classroom teaching. This has improved the academic performance of students. This is not just limited to the chalk-board method. It keeps students engaged in different activities. It has helped to enhance curiosity and scientific attitude among young minds. AI can help teachers with developing rubrics for assessments. This can help teachers to give quick feedback and grading remarks to students. With proper technical support and guidance can help teachers to use AI for improvisation.

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Preparation of Herbal Soap from *Caralluma fimbriata* Wall stem

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Abstract: *This study is aims to provide a simple and eco-friendly approach focused on preparation of herbal soap from Caralluma fimbriata Wall stemextract.C. fimbriata belongs to family Apocynaceae and it is wild medicinal succulent cactus plant, found on dry land. Herbal soap is used for skin whiting. It is a dry, constant, solid, foamy and attractive. As it is chemical free and natural it can be useful on skin.Stem extract of C. fimbriatawas mixed withliquid soap base. Heat the mixture together and pour into soap mold. After cooling for 2-3 hours soap is formed. As it is a natural plant product, it has no side effect on human skin.*

Keywords: *Caralluma fimbriata,* Herbal Soap

I. INTRODUCTION

Soap is a mix of sodium salts of numerous naturally occurring fatty acids. If the fatty acid salt has potassium rather than sodium, a softer lather is the result. Soap is produced by saponification or basic hydrolysis reaction of a fat or oil. Maximum marketable soaps contain chemicals that can be damaging to the skin and applying a natural herbal soap can be a decentalternate. Herbal soaps are made using natural herbs and elements that are healthier and useful for the skin and are fewer likely to cause any damaging effect. **1.**

C. fimbriata belongs to family Apocynaceae, in western India is commonly known as Makad Shingi, Ransambhar, Makad Shinguli, Kullimudayan, and Shindula Makadi. There are other species of *Caralluma* grow in India among this are*C. indica, C. attunata, C. umbullata, C. fimbriata C. adscendens. C. fimbriata* used as daily vegetable, famine food, Pickles, chutney, Appetite suppressant, quenching thirst, chewed chunk, supress hunger.**2.**

Saponification means a form of chemical reaction among a strong alkali or base (such as sodium or potassium hydroxide) and fat. Animal and herbal fats and oils are made of ester molecules named triglycerides. An ester is a molecule that is moldedsystem an alcohol and an acid. In the situation of fats, glycerine is the alcohol, and the acids are fatty acids like stearic, oleic, and palmitic acids. When the alkali solution is carefully mixed with the oils, a reaction termed saponification. Soap is three types like hard, liquid and paper etc. This herbal formation also found to useful for numerous other skin related problems such as scrofula, indolent ulcers, and even ringworm.**3.**

Herbal soaps are skin-clearing and skin-beautifying products. The keyadvantage of applying herbal cosmetics is their transparency, which leaves the body much in nutrients and other valuable minerals instead of causing any negative side effects. Persons' skin and hair beauty is influenced by their health, lifestyle selections, regular work, environment, and maintenance. Summertime dehydration from long heat contact to the skin results in wrinkles, freckles, blemishes, coloration, and sunburns. **4**.

The externallayer of the body, known as skin, founds the key line of defense that protections the body from a diversity of pathogens. Due to its continuouscontact to numerous environmental incentives, the skin is disposed to damage as it interacts with the environments. Acne is a widespread skin problempracticed during adolescence and young adulthood.**5.**Herbal soaps are made up of adding many dried herbs, flowers and stems into soap base. Herbs are the natural products could be found in the treatment of virtually all diseases and skin issues owing to their high medicinal property, availability, compatibility and cost effectiveness.**6.**

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II. METHODOLOGY

Plant material-

*C. fimbriata*wall stem collected from in Shrigonda tehsildist.Ahmednagar, State Maharashtra.After collectionof the stem were shade dried at 25^0c and fine powdered using help of mortar and pestle.

Chemicals-

This Chemicals used in soap preparation is*C. fimbriata*plantextract, soap base, coconut oil.

Extraction-

The *C. fimbriata*powder was extracted with water was taken in conical flask and extracted with water for four hours with occasional agitation then filtered. This extract used in soap preparation.

preparationof herbal soap-

Extract of *C. fimbriata*stem.
Add coconut oil.
Take 20 gm soap base convert it into liquid form by heating.
Boil all the mixture together and pour into soap mold.
Cooled into room temperature up to 2-3 hours soap is formed.

III. LITERATURE AND REVIEW

Sr. No.	Plant name	Plant part use	Plant product	Reference
1	*Azadirachta indicia*	Leaves	soap	Priyanka Mandal 2021
2	Ritha, Tulsi & Neem	Seed, leaves, leaves	soap	Siddhartha Das, 2024
3	*Azadirachta indica,Ocimumtenuiflorum*	Oil	soap	Dr.A.Seetha Devi 2021
4	*Borassus flabelliferand Curcuma zedoaria*	seed coat, rhizome	soap	Devipriya Nisha P 2021
5	Neem and Tulsi	oil	soap	V. S. Jadhav 2023
6	Neem oil, Coconut oil, Mentha oil and Castor oil	oil	soap	Rakesh K. Sindhu 2019
7	*Azadirachta indica*, *Aloe Vera*, *Almond Prunus*, *Curcuma longa*	Seed, pulp, nut, rhizome	soap	Selvamani M 2022
8	*Cassia fistula,Azardirecta. indica* and flowers of *N. nucifera*	leaves	soap	NM Wijayawardhana
9	*Hemidesmus indicus,Cyperus rotundus*, and *Saussurealappa*	Root, rhizome	soap	Gana Manjusha K 2019
10	Neem, Tulshi, Lemon, Turmeric,	leaves, leaves, fruit, rhizome	soap	Munde Govind Anant 2021

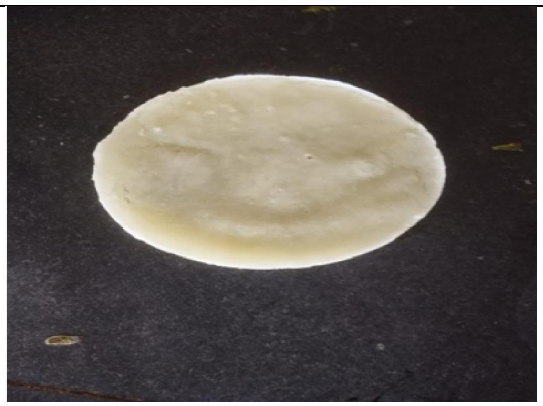
IV. RESULT AND DISCUSSION

Colour and appearance:

*C. fimbriata*used as asoap preparation. As it is chemical free and natural it can be applied on skin, hand and mouth. Herbal soap best appearanceand colour. It isgreenish and smooth in texture.

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***Caralluma fimbriata* Wall**	**Herbal Soap**

V. CONCLUSION

soap is used for wash the body cleaning and it ensures that the pathogen in the external parts, such as the skin, would be removed *C. fimbriata*is easily available. It is natural plant product, as it is herbal there is no side effect on human skin.

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Study of Siderophore Production in Salt Tolerant *Azotobacter salinestris* Species for Sustainable Approach under Saline Soil

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Abstract: *Azotobacter is a non-symbiotic nitrogen-fixing bacteriawell known for siderophore production. Siderophores are small, high-affinity iron-chelating compounds that play a vital role in augmenting iron availability in soil, thereby promoting plant growth by sequestering free iron molecules and aiding in their transportation. Its adaptability to salt stress conditions will have significance as the salinity problem is prevailing due to various reasons.This study investigates the siderophore production under salt stressed condition by Azotobacter speciesisolated from salt pan area of Mumbai region. The isolate was identified as Azotobacter salinestris species using 16S rRNA sequencin gand showed tolerance upto 8% NaCl concentration.Siderophore production was confirmed through a CAS assay and identified as Hydroxamate type by Csaky's assay.The effect of different salt concentration on siderophore production was studied and the production was found to increase with increase in salt concentration showing maximum production at 4% NaCl (8.6 x 10^{-1}mM). The growth stimulant property of the siderophore was assessed by bioassaymethod against various bacterial strains was evaluated.The combined biostimulant and iron-chelating properties of the siderophore under salt stress suggest that this approach could enhance biofertilizer efficiency, providing a natural alternative to chemical agents in agriculture.*

Keywords: Azotobacter salinestris; siderophore; salinity; biostimulant; biofertilizer

I. INTRODUCTION

Iron is an essential micronutrient for plants, playing an important role in numerous biological activities, including electron transport, oxygen metabolism, nitrogen fixation, etc. Although it is the fourth most abundant metal in the earth's crust, the bioavailability of iron is very low (Schalk I.J.; 2008). The content of soluble (available) iron is extremely low in comparison with the total iron content leading to deficiency of iron. Insoluble Fe^{3+} may be used more easily in the environment when siderophores are present, enhancing the bioavailability of Fe^{3+}.Siderophores are among the phytohormones produced by microbes. Siderophores (Greek for "iron carrier") are low-molecular-weight, high-affinity iron-chelating compounds that are produced by organisms to solubilize Fe^{3+} for uptake. The production of siderophores and their detection have been documented in many research studies.

Various environmental stresses like high temperatures, soil salinity, drought and flood have affected the production and cultivation of agricultural crops, among these soil salinity is one of the most devastating environmental stresses, which causes major reductions in cultivated land area, crop productivity and quality (Yamaguchi and Blumwald, 2005; Shahbaz and Ashraf, 2013). Microorganisms could play a significant role in this respect, if we exploit their unique properties such as tolerance to saline conditions and siderophore production under salt stressed conditions.

The benefit of PGPR are yet to be maximized and its role in nutrient uptake and stress management are emerging areas in agriculture that is not yet well understood. Among PGPR, *Azotobacter* species are of particular interest due to their high respiratory and metabolic rates. They are known for fixing atmospheric nitrogen, producing growth hormones like indole acetic acid (IAA), and synthesizing important metabolites such as siderophores which scavenge iron from the soil and make it available to plants. The production of hydrogen cyanide (HCN) plays a role in the biological control of

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pathogens (Ahmad *et al.* 2008). Furthermore, *Azotobacter* can solubilize phosphorus, which is crucial for plant nutrition.

The aim of this work is to detect production of siderophore by salt tolerant Azotobacter species and utilize its potentials under salt stress condition for sustainable agriculture.

II. METHODOLOGY

Collection of soil samples

Saline soil samples were collected from various salt-pan areas of Mumbai regions in sterile zipped plastic bags from the rhizosphere region from a depth of 10 -15 cm.

Enrichment and Isolation on Selective Medium

Enrichment of *Azotobacter*, from the saline soil samples collected, was done in modified Ashby's mannitol nitrogen-free broth. It was incubated at 28±2°C for a week. Gram staining was carried of the smear prepared from the enriched broth. Isolation of the culture was done on modified Ashby's mannitol nitrogen-free media. Discrete and well-isolated colonies were observed after 3 days of incubation. Isolated colonies were further transferred on modified Ashby's mannitol Nitrogen-free medium and incubated at 28±2°C for 3–5 days. Pure culture was obtained by repeated subculturing and the isolate was preserved on the same media slant. Morphological characterization and biochemical testing were carried out as described in the Bergey's Manual of Bacteriology and identification was carried out using 16S rRNA sequencing at National Centre for Cell Science, Pune. Identification report was generated using EzBioCloud Database and the confidence in identification is limited by both the availability and the extent of homology shown by the ~1200 bp sequence of the amplified region from the DNA of the isolate with its closest neighbor in the database.

Study of salt-stress tolerance

Ashby's mannitol nitrogen-free broth containing different salt concentrations of NaCl (0, 2, 4, 6, 8 and 10 g% w/v) was inoculated with *Azotobacter* isolate and all the flasks were incubated on a rotary shaker for 5 days at 28 ± 2°C. The growth of the isolate was recorded by measuring the absorbance of the culture broth using a spectrophotometer at 530 nm wavelength.

Screening of Siderophore production

Qualitative detection of siderophore (Plate assay):

Siderophore production was tested qualitatively using Chrome azurol Sulphonate (CAS) agar as described by Schwyn and Neilands. (Kumar V et al; 2017). CAS agar is prepared from four solution which was sterilized separately before mixing. CAS plates is streaked with the isolate and observed for development of orange halo against dark blue background around the colonies after 48-72 h of incubation at 28ºC. A change in color from blue to orange (hydroxamate type siderophore) or purple (catechol type siderophore) will be consider as a positive reaction.

Characterization of Siderophore:

2.4.2.1$FeCl_3$ Test

To 0.5 ml of culture filtrate, 0.5 ml of 2% aqueous $FeCl_3$ solution was added and examined for the appearance of orange or reddish-brown colourwhich was positive indication of siderophore production.

Spectrophotometric assay

Cultured bacterial cells were harvested by centrifuging at 3,000 rpm for 20 minutes. The supernatant was subjected to spectrophotometric analysis to confirm siderophore production. The hydroxamate nature of siderophore was detected by spectrophotometric assay (Jalal et al;1991) where a peak between 420-450 nm on addition of 3ml of freshly prepared 2% aqueous solution of $FeCl_3$ to 1 ml of supernatant indicated presence of Ferrate hydroxamate. Catecholate nature of siderophore was detected by the method of Jalal and Vander Helm using spectrophotometric assay where a peak at 490 nm on addition of 2% aqueous solution of $FeCl_3$ to 1ml of supernatant indicated the presence of siderophores of catecholate nature.

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Tetrazolium Test

For the tetrazolium test two drops of 2 N NaOH was added to a pinch of iodonitrotetrazolium (INT) and 1 ml of culture filtrate was added and observed for the appearance of a deep red colour to determine the presence of hydroxamate siderophores (Sujatha N and Ammani K. 2013).

Arnow's method for the estimation of Catechol-type Siderophores

The Arnow's method (Arnow 1937) is based on the fact that catechol, when combined with nitrous acid (HNO_2), gives off a yellow color. Arnow's assay is performed by combining the following in order, mixing between each step:

1) 1 ml culture supernatant/ uninoculated medium
2) 1 ml 0.5 M HCl
3) Nitrite-molybdate reagent (10 g sodium nitrite + 10 g sodium molybdate dissolved in 100 ml D/W)
4) 1 M NaOH (4.0 g NaOH dissolved in D/W to make a final volume of 100 ml)

After all components have been added, incubate at room temperature for approximately 5 minutes to allow the colour to fully develop. Again, supernatant of cultures grown under high iron conditions as well as uninoculated media with reagents is used as controls. Once developed, the absorbance of the solution is measured at 500 nm, using the uninoculated modified Fiss minimal medium with no added iron and components 2-4 added as a blank. The control assay is colourless, and a positive reaction is indicated by a pink to deep red colour being produced, depending on intensity (based on amount of catechol present) (Arnow 1936).

Csaky's assay for the detection of hydroxamate siderophores

The Csaky's assay is quantitative for hydroxamic acids, and is thus used to detect and quantify hydroxamate siderophores such as the desferrioxamines. It was developed by Csaky (1948). In the procedure, equal volumes (e.g. 1 ml) of culture supernatant and acid (H2SO4; 6 M) are mixed and autoclaved at 121°C for 30 min. Upon cooling, 1.0 ml of an acid-iodine solution (sulfanilic acid [1% w:v] prepared in acetic acid [30% vol:vol in water] + 0.5 ml iodine [1.3% wt:vol prepared in acetic acid 30% [vol/vol]) is added. The mixture is then incubated for 5 min at room temperature, after which excess iodine is removed by adding a 1 ml solution of tri-sodium arsenite [Na_3AsO_2 (2% w:v); prepared in water]. Subsequently, a 1 ml solution of α- naphthylamine [0.3% w:v] prepared in acetic acid [30% v:v] is added. The color of the solution at this point would change from orange to red. The final volume can be raised to 10 ml by adding distilled water, to bring the solution to a measurable range, if the red color is too intense. Absorbance is measured at 526 nm after 30 min at room temperature. Purified hydroxylamine hydrochloride (red color in solution) wasused as a standard.

Effect of salt stress on siderophore production

The isolate was grown in iron deficient modified Ashby's mannitol broth at different salt concentration i.e. 2, 4, 6, 8 %. Siderophore production at these different salt concentration was estimated using the Csaky's assay described above.

Bioassay of Siderophore

A bioassay using culture supernatant was carried out to check the ability of siderophore produced by the isolate to promote growth of other bacterial culture under iron restricted medium.

III. LITERATURE REVIEW

Salinity is one of the harshestabioticfactors limiting the growth and productivity of crop plants and the area of land affected by it is increasingdue to several reasons both natural and human activities. Poor irrigation practices can lead to secondary salinization, which affects about 20% of irrigated land globally (Glick et al., 2007). Soil salts exist as ions released from minerals during weathering, added through irrigation or fertilizers, or migrated upward from shallow groundwater. When rainfall is insufficient to flush these ions from the soil, they accumulate, resulting in soil salinity (Blaylock et al., 1994).According to a report of Global Map of Salt-affected Soils (GSASmap) under the soil-portal of FAO, a record from 118 countries covering 85% of global land area, it shows that more than 424 million hectares of topsoil (0-30 cm) and 833 million hectares of subsoil (30-100 cm) are salt-affected: 85% of salt-affected top soils are saline, 10% are sodic and 5% are saline-sodic and 62% of salt-affected subsoils are saline, 24% are sodic and 14% are

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saline-sodic. A wide range of adaptations and mitigation strategies are required to cope with such impacts. Cost effective and sustainable strategies need to be developed to manage soil salinity. Microorganisms could play a significant role in this respect, if we deedwith their ability of tolerance to saline conditions, synthesis of compatible solutes, production of plant growth promoting hormones, bio-control potential, bio-stimulant property and their interaction with crop plants.

Azotobacter spp. are most specifically known for their nitrogen fixing ability but they also have the ability to produce different growth hormones (IAA, Gibberellins, etc.), solubilizes phosphate, siderophores and hydrogen cyanide. (Narula et al. 1981, Neito & Frankenberger 1989, Tindale 2000). Azotobacter also produces Poly β- hydroxybutyrate granules which is a reserve food material used under adverse condition as a source of carbon and energy. PHB Granules enhances the survival of bacteria under hyperosmotic stress. (Obruca et al; 2017). The organism is known to produce cyst which also helps in surviving under stress condition. (Sivapriya S.L; 2017).

Screening of various salt-tolerant strains of Azotobacter has revealed that some strains are able to colonize the rhizosphere successfully and promote plant growth in saline soils. (Van Oosten et al; 2018.) Inoculation of maize plants with Azotobacter has been reported to improve growth in control and saline stress conditions (Rojas-Tapias et al; 2012). Two salt tolerant strains were also reported to alleviate saline stress by improving sodium exclusion and potassium uptake. (Rojas-Tapias et al; 2012)

Azotobacter salinestris belongs to family *Pseudomonadaceae* and genus *Azotobacter*. *Azotobacter salinestris* is gram negative coccobacilli (oval with pointed end), older cells are round, pleomorphic and are often found in pairs and chains of six to eight cells. The organism is known to form cyst. Cells are motile by means of peritrichous flagella. Cells from old cultures are non-motile. Physiological characteristics include growth at room temperature (30^{o}C to 36^{o}C) and a neutral to slightly alkaline pH requirement.

Most strains, except type strain, produce a capsule and synthesize poly β-hydroxybutyrate. Strains are urease positive, amylase positive, and catalase positive. Carbon sources include fructose, galactose, glucose, sucrose, mannitol, melibiose, 0.25% sodium benzoate, and starch. A brown black to tan-brown pigment, allomelanin (a catechol melanin), is produced by most strains when grown at high aeration under N-fixing conditions.

The organism has been isolated from saline soil of different countries like Western Cananda (William J. Page and Shailaja Shivprasad; 1991), Bangladesh (Akhter et al; 2012), Argentinea (Rubio et al; 2013), Egypt (Omer AM et al; 2016), Allahabad, India (Hafeez M. et al; 2018), West Java, Indonesia (Reginawanti Hindersah et al; 2019) and Eastern Kenya (Priscillah Wanjira et al ; 2022).William J. Page, 1991 had showed the dependency of *Azotobacter salinestris* on Na+ ion for growth. He incubated the cells in Burk's medium for 16 hours with different Na+ ions concentration. In this experiment he observed an inverse relation between the lag phase and the Na+ ion concentration i.e. that there was an increased lag phase with decreased Na+ ion.The organism had shown tolerance to NaCl upto 8% (Chennappa G. et al; 2016)

Its tolerance to high salt concentration makes this organism as a sustainable approach under saline condition (Omer A.M. et al; 2016). Pot experiment carried by Omer A. M. et al too evaluate the effect of *Azotobacter salinestris* on the morphological and biochemical characteristics of sorghum gave significant result on the parameter studied. Siderophore production have also been demonstrated in soil-plant systems (Buyer et al. 1993; Dimkpa C. 2016). The application of siderophore-producing microbes or siderophore-containing microbial preparations for improving plant growth and enhancing metal remediation of polluted environments.

IV. RESULT AND DISCUSSION

4.1 Sampling, isolation and Identification

The isolate was isolated from saline soil of Mumbai region (Wadala salt pan area) by serial dilution spread method. The isolate gave big, mucoid, light brown colonies on Ashby's Mannitol N-free media plates. (Fig 1). The isolate was Gram negative. It was positive for nitrate reduction, starch hydrolysis, urease test and oxidase test and negative for catalase, citrate and H_2S production similar to the features matching with *Azotobacter* species as per the Bergey's manual of determinative bacteriology.

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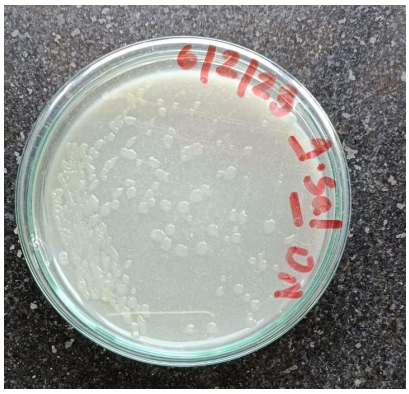


Fig 1 – Colonies of *Azotobacter salinestris* strain isolated from saline soil of Mumbai region.

The identification of the isolate was done as *Azotobacter salinestris* strain based on 16S rRNA sequencing. The sequence is shown in Fig 2. Based on the extent of homology shown by the ~1200 bp sequence of the amplified region (99.41% similarity) from the DNA of the isolate with its closest neighbor in the database, the isolate was identified as *Azotobacter salinestris.*

Sequence Text (in FASTA format font: courier new 10):

>B_OCT_22_029

CCAGAGTTTGATCATGGCTCAGATTGAACGCTGGCGGCAGGCCTAACACATGCAAGTCGAGCGGCAGCGGGACCT
TCGGGTTGCCGGCGAGCGGCGGACGGGTGAGTAATGCCTAGGAATCTGCCTGTTAGTGGGGGATAACGCGGGGAA
ACTCGCGCTAATACCGCATACGTCCTACGGGAGAAAGTGGGGGACCTTCGGGCCTCACGCTAACAGATGAGCCTA
GGTCGGATTAGCTGGTTGGTGGGGTAACGGCCCACCAAGGCGACGATCCGTAACTGGTCTGAGAGGATGATCAGT
CACACTGGAACTGAGACACGGTCCAGACTCCTACGGGAGGCAGCAGTGGGGAATATTGGACAATGGGCGAAAGCC
TGATCCAGCCATGCCGCGTGTGTGAAGAAGGTCTTCGGATTGTAAAGCACTTTAAGCCGGGAGGAAGGGCTGTAG
GCGAATACCCTGCAGTCTTGACGTTACCGGCAGAATAAGCACCGGCTAACTTCGTGCCAGCAGCCGCGGTAATAC
GAAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGCGCGCGTAGGTGGTTTGGTAAGTTGGATGTGAAAGC
CCCGGGCTCAACCTGGGAACTGCATCCAAAACTGCCTGGCTAGAGTACGGTAGAGGGTGGTGGAATTTCCTGTGT
AGCGGTGAAAGCGTAGATATAAGGAAGGACCACCAGTGGGGAAGGGGACCCCCTGGACTGATCTGACACTGAGGT
GCGAAGCGTGGGGAGCAAACAGGATTAGATACCCTGGTAGTCCACGCCGTAAACGATGTCGACTAGCCGTTGGGC
TCCTTGAGAGCTTAGTGGCGCAGCTAACGCATTAAGTCGACCGCCTGGGGAGTACGGCCGCAAGGTTAAAACTCA
AATGAATTGACGGGGGCCCGCACAAGCGGTGGAGCATGTGGTTTAATTCGAAGCAACGCGAAGAACCTTACCTGG
CCTTGACATCCTGCGAACTGAGTAGAGATACCCGGGTGCCTTCGGGAACGCAGAGACAGGTGCTGCATGGCTGTC
GTCAGCTCGTGTCGTGAGATGTTGGGTTAAGTCCCGTAACGAGCGCAACCCTTGTCCTTAGTTACCAGCGATTCG
GTCGGGCACTCTAAGGAGACTGCCGGTGACAAACCGGAGGAAGGTGGGGATGACGTCAAGTCATCATGGCCCTTA
CGGCCAGGGCTACACACGTGCTACAATGGTCGGTACAGAGGGTTGCCAAGCCGCGAGGCGGAGCTAATCCCAGAA
AACCGATCGTAGTCCGGATCGCAGTCTGCAACTCGACTGCGTGAAGTCGGAATCGCTAGTAATCGCGAATCAGAA
TGTCGCGGTGAATACGTTCCCGGGCCTTGT

Fig 2 – 16s rRNA sequence of *Azotobacter salinestris* strain identification using the EzBioCloud database

4.2 Salt stress tolerance study

The isolate identified as *Azotobacter salinestris* was subjected to salt tolerance studies. Growth and survival of the isolate was observed up to 8% NaCl but the growth of culture was significantly reduced at this concentration. At 10% NaCl concentration there was no growth of the isolate (Table 1)

Table 1: Growth analysis of *Azotobacter salinestris* isolateat different (0% to 8%) NaCl concentration

Salt Concentration (%)	0	2	4	6	8	10
Azotobacter isolate	++++	++	++	+	+	-
Key: + → Growth, - → No growth						

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4.3 Screening of Siderophore

4.3.1 Qualitative test for Siderophore

The detection of siderophores was confirmed by spot inoculating *Azotobacter salinestris* isolate on the CAS agar plate. Yellow colour colonies with clearance around it was observed (Fig. 3) indicating the production of siderophore.

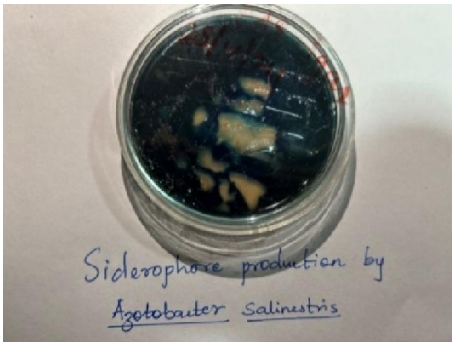


Fig 3. Yellow coloured colonies of *Azotobacter salinestris* isolate with clearance around it on CAS agar plate.

4.3.2 Characterization of type of Siderophore

Azotobacter salinestris isolateproducing siderophore was characterized for type of siderophore produced (Table 2). The isolateshowed maximum peak between 420 and 450 nm in the $FeCl_3$ test (Fig 4) and deep red color in the tetrazolium test which indicates hydroxamate type of siderophore.Further confirmation was done by Csaky's assay. (Fig 5)

Table 2: Characterization of Siderophore produced by *Azotobacter salinestris* isolate

Isolate	FeCl3 Test		Catechol (Arnow's Test)	Hydroxamate (tetrazolium test)	Hydroxamate (Cskay's Assay)
	Peak at 495 (Catechol)	Peak at 425 (Hydroxamate)			
Azotobacter salinestris isolate	-	+	-	+	+
Key: + -- Positive result , - Negative result					

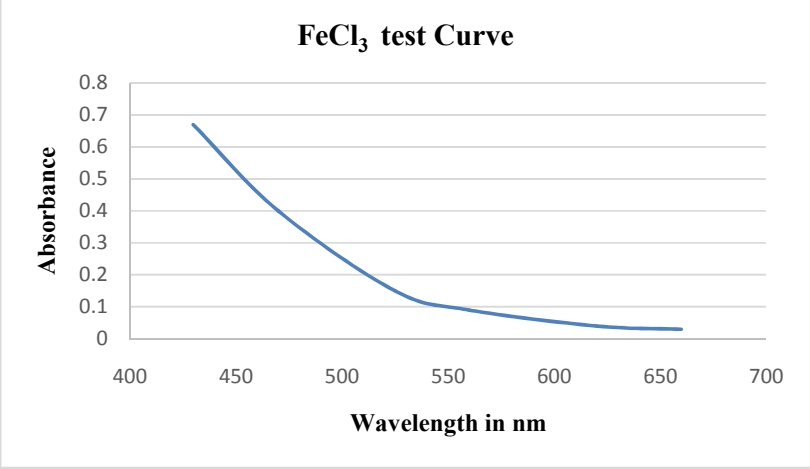


Fig 4. Characterization of Siderophore by $FeCl_3$ test showing absorbance maxima at 425 nm

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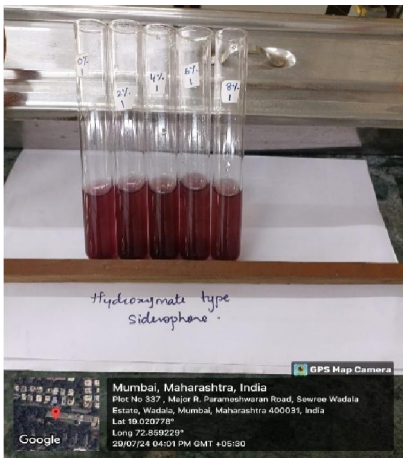


Fig 5. Deep red colour indicating hydroxamate type siderophore by Cskay's assay.

4.3.3 Quantitative method

The isolate was inoculated in 50 ml Modified Ashby's Mannitol Broth for 24 hours, broth was centrifuged,supernatant was collected and used to detect siderophore by Csaky's method.

Csaky's methodwas utilized to quantify the hydroxamate-type siderophore. The siderophore production by the *Azotobacter salinestris* isolate is found to increase with the growth (Fig. 6).

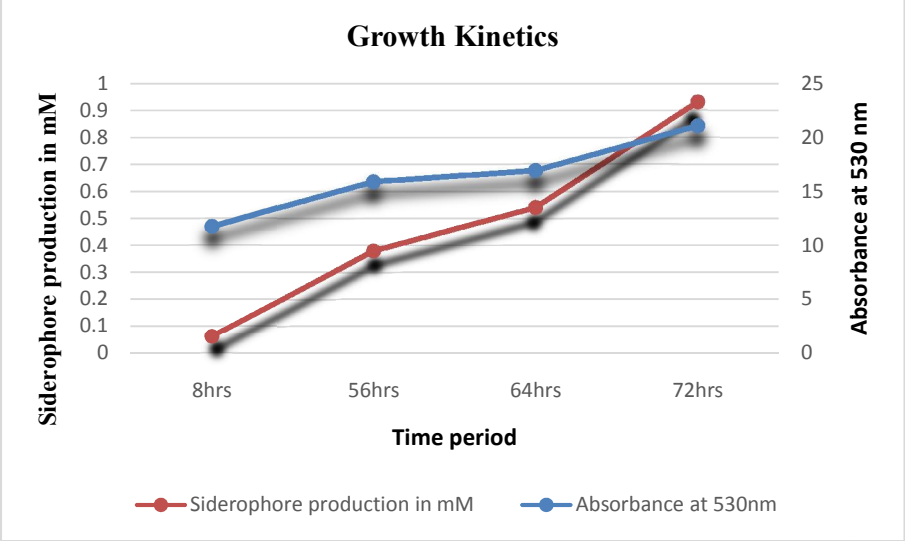


Fig 6: Growth Kinetics of Siderophore production by *Azotobacter salinestris* isolate

The results of Siderophore production were found positive for the tested salt concentration at different incubation period. The highest concentration of siderophore (9.3 x 10^{-1}mM) was produced by *Azotobactersalinestris* in control after 72 hrs whereas with 4% NaCl concentration the maximum concentration (8.6 x 10^{-1}mM)was observed after 72 hrs of incubation period at 28 ± 2 °C. (Fig 7). Further increase in salt stress resulted in decrease in siderophore production.

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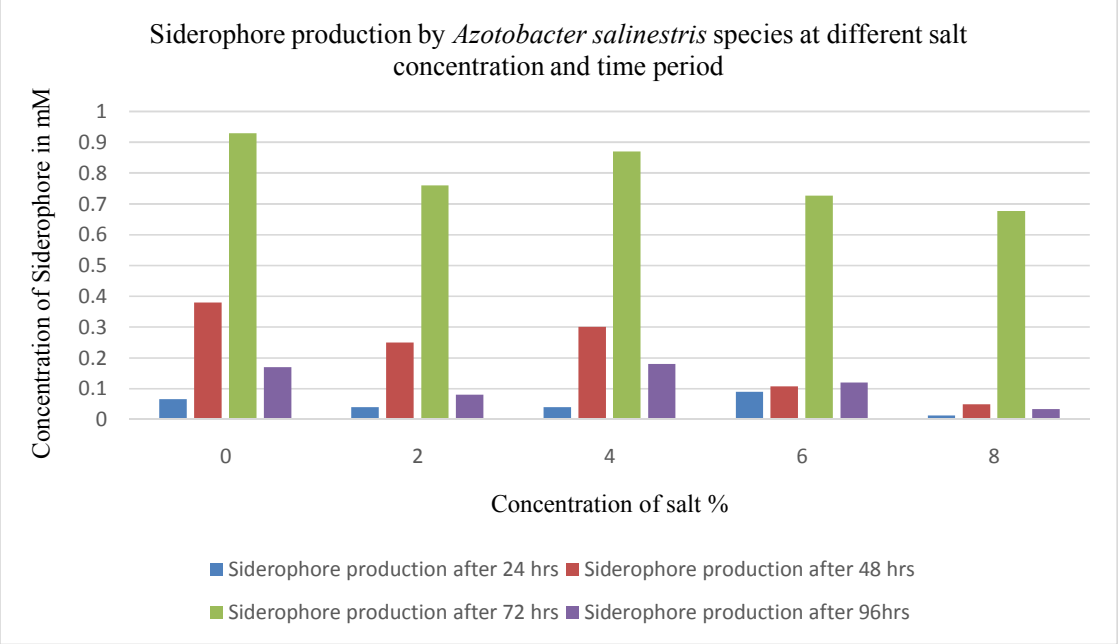


Fig 7. Effect of salt on Siderophore production

4.3.4 Bioassay of siderophore

A zone of exhibition was observed around the bacterial culture tested for growth promotion provided by a siderophore in iron-restricted conditions. (Table 3 and Fig 8). The siderophore from *Azotobacter salinestris* was shown to stimulate growth of Klebsiella and Pseudomonas but not *E.coli, Proteus, Salmonella or Staphylococcus* under iron limited conditions.

Table 3: Zone of exhibition in test organisms

Bacterial Culture tested	**Diameter of Zone of Exhibition in mm**
Escherichia coli	zero
Klebsiella pneumoniae	22
Pseudomonas aeruginosa	25
Proteus mirabilis	zero
Salmonella typhi	zero
Salmonella paratyphi B	zero
Staphylococcus aureus	zero
Bacillus subtilis	zero

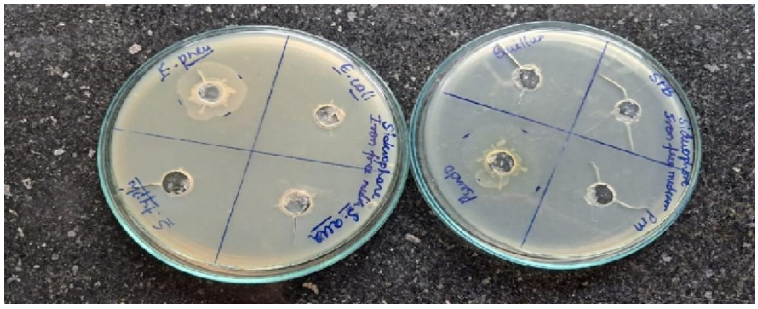


Fig 8. Zone of exhibition around the bacterial culture tested on iron restricted agar plate

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V. CONCLUSION

*Azotobacter salinestris*isolate exhibits a notable ability to produce hydroxamate-type siderophores, under increasing salt concentrations. The findings indicate that the production of siderophores increases with higher salinity, peaking at a 4% salt concentration and further decreases. This suggests that *Azotobacter salinestris* can adapt to saline environments and efficiently compete for iron, even under iron-limited conditions, which is critical for plant growth in saline soils. Such traits can be exploit for sustainable agricultural practices, especially in areas affected by salinity, by enhancing soil fertility and plant health through the inoculation of this bacterium as biofertilizer. Therefore, the use of *Azotobacter salinestris* could be a promising biotechnological strategy to improve crop productivity in saline-affected soils.

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Medicinally Important Plants and Uses

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Abstract: *The medicinal plants or herbs lead to the thought of miraculous and supernatural cures used in traditional system of medicine such as Ayurveda, Naturopathy, Sidda, Unanai etc. our ancient literature not only has references of medicinal preparation cation. As rightly said by Charka father of Modern but also the plant species and their classification. Medicine,there is no plant on earth which does not have medicinal value. Generally speaking all plants provide food and all of them have one or the other medicinal properties. India is one the world's richest source of herbal wealth. Due to varied climatic conditions and soil types India gifted with heritage of medicinal plants. Due to indiscriminate collection of medicinal plants from its natural sources led to become endangered and vulnerable species. Therefore, it is duty of every human being to save the plants in natural habitat which is only the source of diversity and also new drugs. In this view government has taken the initiative to establish herbal gardens in every state, region, even at community level to conserve the native medicinal plants and also to multiply the plants to make it available for commercial cultivation. One of such herbal garden has been established at ICAR-National Institute of Abiotic stress management, Baramati, District Pune, Maharashtra in an area of 2.0 hectare comprising of 65 Species of Trees, Shrubs and Climbers.*

Keywords: Medicine, Ayurveda, drug, plants

I. INTRODUCTION

Among ancient civilisations, India has been known to be rich repository of medicinal plants. The forest in India is the principal repository of large number of medicinal and aromatic plants, which are largely collected as raw materials for manufacture of drugs and perfumery products. About 8,000 herbal remedies have been codified in Ayurveda. The Rigveda (5000 BC) has recorded 67 medicinal plants, Yajurveda 81 species, Atharvaveda (4500-2500 BC) 290 species, Charak Samhita (700 BC) and Sushrut Samhita (200 BC) had described properties and uses of 1100 and 1270 species respectively, in compounding of drugs and these are still used in the classical formulations, in the Ayurvedic system of medicine. Unfortunately, much of the ancient knowledge and many valuable plants are being lost at an alarming rate. With the rapid depletion of forests, impairing the availability of raw drugs, Ayurveda, like other systems of herbal medicines has reached a very critical phase. About 50% of the tropical forests, the treasure house of plant and animal diversity have already been destroyed. In India, forest cover is disappearing at an annual rate 1.5mha/yr. What is left at present is only 8% as against a mandatory 33% of the geographical area. Many valuable medicinal plants are under the verge of extinction. The Red Data Book of India has 427 entries of endangered species of which 28 are considered extinct, 124 endangered, 81 vulnerable, 100 rare and 34 insufficiently known species (Thomas, 1997). Ayurveda, Siddha, Unani and Folk (tribal) medicines are the major systems of indigenous medicines. Among these systems, Ayurveda is most developed and widely practised in India. Ayurveda dating back to 1500-800 BC has been an integral part of Indian culture. The term comes from the Sanskrit root Au (life) and Veda (knowledge). As the name implies it is not only the science of treatment of the ill but covers the whole gamut of happy human life involving the physical, metaphysical and the spiritual aspects. Ayurveda recognises that besides a balance of body elements one has to have an enlightened state of consciousness, sense organs and mind if one has to be perfectly healthy. Ayurveda by and large is an experience with nature and unlike in Western medicine, many of the concepts elude scientific explanation. Ayurveda is gaining prominence as the natural system of health care all over the world. Today this system of medicine is being practised in countries like Nepal, Bhutan, Sri Lanka, Bangladesh and Pakistan, while the traditional system of medicine in the other countries like Tibet, Mongolia and Thailand appear to be derived from Ayurveda. Phytomedicines are also

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being used increasingly in Western Europe. Recently the US Government has established the "Office of Alternative Medicine" at the National Institute of Health at Bethesda and its support to alternative medicine includes basic and applied research in traditional systems of medicines such as Chinese, Ayurvedic, etc. with a view to assess the possible integration of effective treatments with modern medicines. The development of systematic pharmacopoeias dates back to 3000 BC, when the Chinese were already using over 350 herbal remedies. Ayurveda, a system of herbal medicine in India, Sri Lanka and South-East Asia has more than 8000 plant remedies and using around 35,000-70,000 plant species. China has demonstrated the best use of traditional medicine in providing the health care. China has pharmacologically validated and improved many traditional herbal medicines and eventually integrated them in formal health care system. Green plants synthesise and preserve a variety of biochemical products, many of which are extractable and used as chemical feed stocks or as raw material for various scientific investigations. Many secondary metabolites of plant are commercially important and find use in a number of pharmaceutical compounds. However, a sustained supply of the source material often becomes difficult due to the factors like environmental changes, cultural practices, diverse geographical distribution, labour cost, selection of the superior plant stock and over exploitation by pharmaceutical industry.

Plants, especially used in Ayurveda can provide biologically active molecules and lead structures for the development of modified derivatives with enhanced activity and /or reduced toxicity. The small fraction of flowering plants that have so far been investigated have yielded about 120 therapeutic agents of known structure from about 90 species of plants. Some of the useful plant drugs include vinblastine, vincristine, taxol, podophyllotoxin, camptothecin, digitoxigenin, gitoxigenin, digoxigenin, tubocurarine, morphine, codeine, aspirin, atropine, pilocarpine, capscicine, allicin, curcumin, artemesinin and ephedrine among others. In some cases, the crude extract of medicinal plants may be used as medicaments. On the other hand, the isolation and identification of the active principles and elucidation of the mechanism of action of a drug is of paramount importance. Hence, works in both mixture of traditional medicine and single active compounds are very important. Where the active molecule cannot be synthesised economically, the product must be obtained from the cultivation of plant material. About 121 (45 tropical and 76 subtropical) major plant drugs have been identified for which no synthetic one is currently available (table 1). The scientific study of traditional medicines, derivation of drugs through bioprospecting and systematic conservation of the concerned medicinal plants are thus of great importance. Table 1. Major plant drugs for which no synthetic one is currently available (Kumar et al, 1997).

SOME IMPORTANT MEDICINAL PLANTS AND THEIR USES

Drug	Plant	use
Vinblastine	Catharanthus roseus	Anticancer
Rescinnamine	Rauvolfia serpentina	Tranquilizer
Quinine	Cinchona sp.	Antimalarial
Pilocarpine	Pilocarpus jaborandi	Antiglucoma
Morphine	Papaver somniferum	Painkiller
Cardiac glycosides For congestive	Digitalis sp.	Heart failure
Taxol,	Taxus baccata T. brevifolia	Breast and ovary cancer
Gossypol	Gossypium sp.	Antispermatogenic
Allicin Antifungal	Allium sativum	Amoebiasis
Glycyrrhizin	Glycyrrhizia glabra	Antiulcer
Digitoxin, ,	Digoxin Digitalis	Thevetia Cardio tonic
Codeine	Papaver somniferum	Anticough
Quassinoids	Ailanthus	Antiprotozoal
Magnolol	Magnolia bark	Peptic ulcer
Forskolin	Coleus forskohlii	Hypotensive, cardiotonic
Allicin,	Allium sativum Antifungal	Amoebiasis

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CULTIVATION OF MEDICINAL PLANTS

Most of medicinal plants, even today, are collected from wild. The continued commercial exploitation of these plants has resulted in receding the population of many species in their natural habitat. Vacuum is likely to occur in the supply of raw plant materials that are used extensively by the pharmaceutical industry as well as the traditional practitioners. Consequently, cultivation of these plants is urgently needed to ensure their availability to the industry as well as to people associated with traditional system of medicine. If timely steps are not taken for their conservation, cultivation and mass propagation, they may be lost from the natural vegetation for ever. In situ conservation of these resources alone cannot meet the ever increasing demand of pharmaceutical industry. It is, therefore, inevitable to develop cultural practices and propagate these plants in suitable agroclimatic regions. Commercial cultivation will put a check on the continued exploitation from wild sources and serve as an effective means to conserve the rare floristic wealth and genetic diversity. It is necessary to initiate systematic cultivation of medicinal plants in order to conserve biodiversity and protect endangered species. In the pharmaceutical industry, where the active medicinal principle cannot be synthesised economically, the product must be obtained from the cultivation of plants. Systematic conservation and large scale cultivation of the concerned medicinal plants are thus of great importance. Efforts are also required to suggest appropriate cropping patterns for the incorporation of these plants into the conventional agricultural and forestry cropping systems. Cultivation of this type of plants could only be promoted if there is a continuous demand for the raw materials. There are at least 35 major medicinal plants that can be cultivated in India and have established demand for their raw material or active principles in the international trade (table). It is also necessary to develop genetically superior planting material for assured uniformity and desired quality and resort to organised cultivation to ensure the supply of raw material at growers end. Hence, small scale processing units too have to be established in order that the farmer is assured of the sale of raw material. Thus, cultivation and processing should go hand in hand in rural areas. In order to initiate systematic cultivation of medicinal and aromatic plants high yielding varieties have to be selected (table 8). In the case of wild plants, their demonstration would require careful development work. Sometimes high yielding varieties have also to be developed by selective breeding or clonal micropropagation. The selected propagation materials have to be distributed to the farmer either through nurseries or seed banks. Systematic cultivation needs specific cultural practices and agronomical requirements. These are species specific and are dependent on soil, water and climatic conditions. Hence research and development work has to be done to formulate Good Agricultural Practices (GAP) which should include proper cultivation techniques, harvesting methods, safe use of fertilizers and pestisides and waste disposal.

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Study of Recent Trends in Artificial Intelligence

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Abstract: *Artificial Intelligence (AI) has made significant progress in recent years with applications in healthcare, education, finance, manufacturing and automation. Large -scale dataset, computing capacity and increasing availability of advanced algorithms have accelerated AI use in this industry. The research paper investigates recent trends in recent trends such as machine learning advancements, Explainable AI, Generative AI, Edge AI, and Ethical AI. It emphasizes their possibility of revolutions in industries and society, discussing the benefits of AI application, challenges and future directions.*

AI has enabled success in Automation, Decision Making and predictive analysis by changing traditional professional models and operations. The integration of AI in critical fields, such as healthcare, where it enhances the diagnosis and treatment recommendations and finance, where it improves the increasing importance of risk assessment and fraud detection. In addition, the AI-powered automation supply chain refers by improving streamlined processes, optimizing supply chains and efficiency.

However, the rapid development of AI also presents challenges, including ethical concerns, bias in the AI model, the issue of privacy and clarity in the decision. The purpose of the emergence of the responsible AI Framework is to address these concerns, ensuring that AI technologies align with ethical standards and social values. Furthermore, as the AI models become more complex, ensuring that their transparency and reliability remains important to promote and adopt widely.

This study provides information about how organizations, researchers and policy makers are navigating the AI landscape to maximize their capacity by reducing risks. This highlights the importance of interdisciplinary cooperation in responsibility for the benefit of future generations and ethical AI technologies..

Keywords: Artificial Intelligence

I. INTRODUCTION

Artificial intelligence is no longer a theoretical concept. It transforms into a practical tool that performs innovation and efficiency in different domains. AI exponential growth is driven by improvements in deep learning models, cloud computing and availability of large data sets. Today, AI is integrated into applications such as self -driving cars, virtual assistants, predictive analysis and personalized recommendations, and design how businesses operate and how people interact with technology.

In recent years, AI research has expanded to areas such as generative models, explainable AI and real-time AI processing on edge units. The increasing dependence on AI in critical decision -making, including health diagnostics, financial risk assessment and legal analysis, emphasizes the need for openness and ethical considerations. While AI promises improved efficiency and automation, it also raises concerns related to the privacy of data, algorithms and job displacement.

This article aims to explore the latest advances in AI, focusing on the main trends that shape the field. It examines the implications of companies, governments and academy while facing the challenges associated with AI implementation. In the analysis of recent research and industry development, this study provides a comprehensive overview of how AI develops and what future reservations for this transforming technology.

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II. METHODOLOGY

This study uses a qualitative research method, focusing on a detailed review of recent literature, case studies and artificial intelligence (AI) industry reports. Research adheres to important trends, progress and a systematic approach to identifying their impact on various industries. Data sources include peer-reviewed journals from IEEE Xplore, ACM Digital Library, Google Scholar and arXiv, ensuring extensive coverage of AI development over the last five years.

A thematic analysis was performed to categorize large trends in AI, including Generative AI, explainable AI, ethical AI and edge data. In addition, this research evaluates political documents and regulatory guidelines to evaluate how different organizations and authorities handle AI ethical and legal challenges. The study also includes information from sector reports published by major technology companies and consulting agencies and ensures that findings reflect academic and sector perspectives.

III. LITERATURE REVIEW

AI's rapid development was widely documented in recent literature. Machine Learning Research (ML) and deep learning contributed significantly to the AI progress, which performed better performance learning, natural language treatment (NLP) and reinforcement.

One of the most influential studies in deep education of Lecun, Bengio and Hinton (2015) emphasized the role of nerve network in pursuing AI skills. In addition, Vaswani et al. (2017) introduced the transformer architecture, brought revolution in NLP applications and leading for the development of powerful language models such as GPT. Recent research also highlighted the importance of clear AI (XAI) in increasing the trust and transparency in the AI system, as discussed in Bender et al. (2021).

Ethics in AI has become an important focus area. Studies by Russell and Norvig (2020) and OpenAI (2023) discuss justice, accountability and openness in AI-operated decision-making processes. In addition, Rajpurkar et al. (2016) discovered the effect of AI in the health care system, showing how the machine learning algorithms can detect the disease and improve clinical accuracy. These studies together form the basis for understanding current trends and challenges in AI development and distribution.

IV. RESULTS AND DISCUSSION

Generative AI: The emergence of generic models such as GPT and Dall. E has changed different industries. These AI systems can produce realistic texts, images and even music, and promote creativity and innovation. Generative AI is widely used in content marketing, construction and design. However, ethical concerns, such as misinformation, deepfakes, and copyright violations, require strict regulatory measures.

Explainable AI (XAI): As AI models grow in complexity, it is crucial to ensure interpretability and opening. The explainable AI (XAI) techniques aim to make AI description processes more understandable to users, especially in high -effect applications such as medical assistance and finance. Researchers develop models visualization methods, rules -based explanations, and justice -conscious algorithms to approach bias and create confidence in AI systems.

AI in Healthcare: AI applications in the health care system have seen remarkable progress, improved clinical accuracy and treatment plan. Machine Learning algorithms are used rapidly for disease spread, individual medication and robotic surgery. AI-operated virtual assistant and chatbots improve the interaction of the patient by enabling medical guidance in real time. Despite these benefits, privacy and regulatory challenges remain important obstacles to AI adoption in the health care system.

Edge AI: Edge Computing in AI has gained traction, so AI models can be run on local devices without relying on cloud infrastructure. Edge AI enables real -time decision -making, reduces the latency and improves data privacy. Applications range from autonomous vehicles to smart home automation and industrial IoT. However, hardware restrictions and energy efficiency challenges require further research to optimize Kant AI solutions.

Ethical and Responsible AI: As AI is more integrated with decisions, it is crucial to consider justice, responsibility and prejudice. The Ethical AI framework focuses on openness, human supervision and inclusion in the AI application. Organizations and officials apply guidelines and guidelines to promote responsible AI development and eliminate concerns related to data discrimination and security.

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AI in Automation: AI-driven automation is the transformation of industries by streamlining operations and reducing human intervention. In production, AI-driven robots improve production efficiency, while AI in logistics optimizes supply chain management. AI Chatbots improves customer service experiences by providing personal help. However, the increase in automation arouses concern about work shift, which necessitates the workforce route initiatives to adapt to AI-powered transformations.

V. CONCLUSION

The rapid advances in AI provide both opportunities and challenges. While AI continues to transform different sectors, it is important to ensure that development corresponds to ethical principles and social values. Rising questions such as AI models, data privacy and transparency is still crucial to promoting public trust and ensuring responsible AI distribution.

Future research should focus on improving AI's interpretability, justice and inclusion. Policymakers must work with researchers and industry leaders to create regulatory frameworks that balance innovation with ethical considerations. In addition, investments in AI-literacy and workforce programming programs are crucial to preparing the community for an AI-driven future.

As AI continues to develop, interdisciplinary collaboration between technologists, ethics, legal experts and social scientists will play a key role in the design of the track. By prioritizing ethical AI practice and responsible distribution, we can utilize AI's potential for improving humanity while reducing associated risks.

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The Application of Magnetic Resonance Imaging (MRI) in Medicine

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Abstract: *Magnetic Resonance Imaging (MRI) is a widely-used non-invasive diagnostic tool in modern medicine, which offers superior soft-tissue contrast resolution. MRI utilizes powerful magnetic fields and radiofrequency pulses to create detailed images of internal structures, facilitating the diagnosis and treatment of various medical conditions. This paper explores the application of MRI in clinical settings, emphasizing its benefits, technical advancements, and current challenges. We will discuss the evolution of MRI technology, its applications in diagnosing neurological, musculoskeletal, cardiovascular, and oncological conditions, as well as its future prospects in medical imaging. Moreover, we examine the methodology behind MRI image acquisition and analysis. This paper further highlights the impact of MRI on patient care and medical decision-making. In conclusion, while MRI is an indispensable tool in medicine, advancements in hardware, software, and contrast agents hold the potential to revolutionize its diagnostic and therapeutic applications*

Keywords: Magnetic Resonance Imaging (MRI), Medical Imaging, Non-invasive Diagnosis, Neuroimaging, Clinical Applications

I. INTRODUCTION

Magnetic Resonance Imaging (MRI) has become one of the most critical diagnostic tools in contemporary medicine, offering unparalleled imaging capabilities in soft tissues. Since its inception in the early 1970s, MRI has revolutionized medical imaging, enabling clinicians to visualize detailed anatomical structures without the need for invasive procedures. Unlike X-rays and computed tomography (CT), MRI does not rely on ionizing radiation, making it a safer alternative for patients, particularly for repeated imaging in pediatric and high-risk groups.

The fundamental principle of MRI lies in nuclear magnetic resonance (NMR), where atomic nuclei, particularly those of hydrogen, align in a magnetic field and emit signals when exposed to radiofrequency pulses. These signals are then captured and transformed into detailed images by sophisticated algorithms.

This paper aims to explore the different facets of MRI in medicine, covering its principles, technological evolution, diverse applications, and clinical significance. It also delves into the associated challenges, such as patient safety, high operational costs, and limitations in imaging certain body structures.

II. RESEARCH METHODOLOGY

The research methodology for studying the application of Magnetic Resonance Imaging (MRI) in medicine typically involves a combination of qualitative and quantitative approaches, including literature review, experimental studies, case studies, and data analysis. This mixed-method approach helps in understanding both the technological aspects of MRI as well as its practical applications in clinical settings. The following outlines the methodology used to explore MRI's role in medical diagnostics and treatment.

1. Literature Review

A comprehensive literature review forms the foundation of the research methodology. It involves collecting and analyzing peer-reviewed articles, clinical studies, and technical papers related to the use of MRI in medicine. The review includes:

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Historical Development of MRI Technology: Understanding the evolution of MRI from its inception to modern-day advancements, such as high-field MRI scanners, functional MRI (fMRI), and diffusion tensor imaging (DTI).

Clinical Applications: Exploring MRI's application across various medical fields, such as neurology, cardiology, oncology, and musculoskeletal imaging. The review also includes the evaluation of MRI's advantages over other imaging modalities like X-rays and CT scans.

Technological Innovations: Investigating advancements in MRI hardware, such as superconducting magnets, higher field strengths, and the development of novel contrast agents, which enhance diagnostic capabilities.

Challenges and Limitations: Examining the limitations of MRI, such as its cost, accessibility, and difficulty in imaging certain tissues like bones or air-filled structures.

2. Case Studies and Clinical Trials

Case studies and clinical trials provide real-world evidence on how MRI is applied in various medical conditions. Research in this area typically involves:

Patient-Based Studies: Analyzing clinical cases where MRI has been used to diagnose or monitor diseases such as brain tumors, multiple sclerosis, stroke, heart conditions, and musculoskeletal injuries. Data from patient scans, diagnoses, treatment plans, and outcomes are collected and analyzed to assess MRI's diagnostic value and accuracy.

Comparative Studies: Some studies compare MRI with other imaging techniques (such as CT or ultrasound) to evaluate its relative effectiveness in specific clinical settings. For instance, researchers may compare MRI's ability to detect early-stage brain cancer against CT or PET scans.

Longitudinal Studies: MRI's role in monitoring disease progression and treatment efficacy is also studied over extended periods. For example, repeated MRI scans are used to observe tumor size changes in oncology patients or brain volume loss in neurological disorders like Alzheimer's.

3. Data Collection and Analysis

MRI data collection involves both qualitative and quantitative methods:

Image Acquisition: MRI images are captured using various techniques, such as T1-weighted, T2-weighted, and diffusion-weighted imaging, depending on the type of tissue or pathology being studied. Functional MRI (fMRI) is often used in brain studies to examine brain activity.

Statistical Analysis: The analysis of MRI images typically involves comparing image results across different patient populations, disease stages, or treatment protocols. Image processing software, such as FSL or SPM, is used for analyzing brain structures, detecting lesions, or measuring tissue changes. Statistical methods are applied to assess the significance of findings.

Outcome Measures: Various metrics are used to assess MRI's performance, such as diagnostic accuracy, sensitivity, specificity, and predictive value. For example, a study on brain tumor detection may evaluate MRI's sensitivity in identifying malignant versus benign tumors.

4. Interviews and Surveys

Interviews with MRI technologists, radiologists, and physicians provide insights into the practical challenges and clinical perspectives on MRI usage. Surveys are also conducted to assess the opinions of healthcare professionals on the efficacy, cost-effectiveness, and accessibility of MRI. This qualitative data complements the quantitative analysis and gives a holistic view of MRI's role in medical practice.

5. Ethical Considerations

As MRI studies often involve human participants, ethical considerations are paramount. Institutional review board (IRB) approval is required for any patient-based research. Informed consent is obtained from all participants to ensure their understanding of the research and their voluntary participation.

This methodology, through the combination of literature review, clinical trials, case studies, and advanced data analysis, provides a comprehensive understanding of MRI's application in medicine. It not only assesses the effectiveness and advancements in MRI technology but also evaluates its real-world clinical impact, ensuring a multidimensional perspective on its role in modern healthcare.

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III. RESULTS AND DISCUSSION

The results of the literature review reveal that MRI is one of the most versatile and powerful tools in modern medicine. MRI's ability to provide high-resolution images of internal organs and tissues without using ionizing radiation is one of its primary advantages over other imaging modalities. Below, we will discuss the key applications of MRI in various medical fields:

1 Neurological Imaging:

MRI plays a pivotal role in neuroimaging, offering detailed images of the brain and spinal cord. It is instrumental in diagnosing neurological conditions such as:

Brain Tumors: MRI allows for the precise localization and characterization of brain tumors, differentiating benign from malignant growths, and aiding in surgical planning.

Multiple Sclerosis (MS): MRI is the gold standard for detecting and monitoring the progression of MS. It can reveal lesions in the brain and spinal cord that are characteristic of the disease.

Stroke: MRI can detect ischemic strokes (lack of blood flow to brain tissue) and hemorrhagic strokes (bleeding in the brain) with high sensitivity.

Alzheimer's Disease and Dementia: Structural MRI imaging helps in assessing brain atrophy and detecting early signs of Alzheimer's disease.

2 Musculoskeletal Imaging:

MRI is commonly used to examine the musculoskeletal system, including muscles, bones, ligaments, and cartilage. It plays an essential role in diagnosing:

Joint Disorders: MRI is effective in visualizing joint damage, including that caused by osteoarthritis and rheumatoid arthritis.

Sports Injuries: MRI is the preferred imaging modality for soft-tissue injuries such as ligament tears and muscle strains.

Bone Marrow Disorders: MRI provides detailed information about bone marrow abnormalities, which is crucial in diagnosing conditions like leukemia or bone infections.

3 Cardiovascular Imaging:

MRI offers non-invasive imaging for the heart and blood vessels, providing critical information about cardiac function and structure. Key applications include:

Cardiac MRI: Used for evaluating heart diseases such as myocardial infarction, heart failure, and cardiomyopathies. It assesses the extent of myocardial damage, cardiac function, and tissue viability.

Vascular MRI: MR angiography (MRA) allows for detailed imaging of blood vessels, helping to diagnose conditions like aneurysms, arteriosclerosis, and venous thrombosis.

4 Oncological Imaging:

MRI is widely employed in cancer diagnosis and management. Its high-resolution images allow for:

Tumor Detection: MRI is particularly effective for visualizing soft tissues and detecting tumors in organs like the brain, liver, breast, and prostate.

Tumor Staging and Characterization: MRI helps in staging cancer by assessing the size, extent, and spread of tumors, guiding treatment decisions.

Monitoring Treatment Response: MRI plays a key role in monitoring the effectiveness of chemotherapy and radiation therapy, particularly in cancers such as gliomas and breast cancer.

5 Advances in MRI Technology:

Technological advancements have significantly improved the diagnostic capabilities of MRI. Developments include:

Functional MRI (fMRI): fMRI measures brain activity by detecting changes in blood flow, enabling the study of brain function in both healthy individuals and those with neurological disorders.

Magnetic Resonance Spectroscopy (MRS): MRS is a non-invasive technique that allows the measurement of metabolic changes in tissues, providing valuable information for diagnosing conditions like brain tumors or stroke.

Contrast Agents: The use of gadolinium-based contrast agents has significantly enhanced the ability of MRI to differentiate between various types of tissues and identify pathologies like cancer and inflammation.

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IV. CONCLUSION

Magnetic Resonance Imaging (MRI) has undoubtedly become one of the cornerstones of modern diagnostic medicine, offering an invaluable non-invasive tool for assessing a variety of medical conditions. Its ability to provide detailed images of soft tissues with no exposure to ionizing radiation has made it the imaging modality of choice in numerous clinical fields, including neurology, cardiology, oncology, and musculoskeletal medicine. Technological advancements continue to enhance MRI's capabilities, enabling more accurate and earlier diagnosis of diseases, as well as better monitoring of treatment efficacy.Despite the numerous benefits, challenges remain, such as high operational costs, limited accessibility, and the need for specialized training to interpret results accurately. Moreover, while MRI is capable of providing detailed images of soft tissues, it may not always provide adequate resolution for imaging certain hard tissues like bones.

Looking forward, the future of MRI lies in further advancements in hardware and software, as well as the integration of artificial intelligence (AI) for more automated analysis and improved diagnostic accuracy. The continued development of MRI contrast agents and functional MRI techniques will expand its role in personalized medicine, allowing clinicians to tailor treatment strategies based on precise, real-time information.

In conclusion, MRI continues to be an essential tool in modern medicine, with an exciting future ahead, driven by ongoing research and technological innovation.

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Estimation of Antifungal Activity of *Vitex Negundo* by Different Solvent Extracts

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Abstract: *Natural substances for human health have long been found in plants. From the root to the fruit, every part of the plant has a number of secondary metabolites that are highly beneficial for treating a variety of ailments. The creation of costly antibiotics is a result of the ongoing rise in the number of microbe strains that are resistant to antibiotics. Compliance is challenging in the majority of developing nations due to the high cost of these antibiotics. This necessitates investigating alternate sources of antifungal agents. The medicinal shrub Vitexnegundo(Family: Lamiaceae) has been shown to have healing properties against a number of illnesses. Present work was carried out to assess the antifungal activity of Vitexnegundoagainst ten multidrug resistant pathogenic Aspergillusspp. V. negundoplant parts (leaves, stem, flowers) were collected, air dried, grinded and extracted by using different solvents (methanol, acetone, chloroform)through sequential extraction method These extracts were then tested for antifungal activity using agar well diffusion method.Methanolic, acetonic and chloroform extracts exhibited moderate antifungal activity as compared to standard antibiotic flucanazole. From the above findings it is suggested that flower extracts ofV. negundo has the potential to be developed as an antifungal agent*

Keywords: V. negundo, solvent extracts, antifungal activity, bioactive compound

I. INTRODUCTION

Herbal treatments have been used to treat a wide range of infectious disorders throughout human history. Many under developed nations still use plant materials as medicines in their primary healthcare systems (Zakaria, 1991). Finding therapeutic plants around the world is crucial for the fields of medicine and agriculture because it opens up new avenues for the spread of substitute medicinal crops with greater social and economic advantages. The use of plant preparation for such purposes has been documented (Herbal Medicine Research Centre, 2002). The control of bacteria and fungi infection has been remarkably effective since the discovery of antibacterial and antifungal drugs (Zaidan et al., 2005). Antimicrobial activity is the ability of a substance to kill or inhibit the growth of microorganisms, such as bacteria, viruses, fungi, and parasites. Plants produce a wide range of secondary metabolites, many of which have been shown to possess antimicrobial properties (Jain et al., 2019). These compounds may act by disrupting the cell membranes or cell walls of microorganisms, or by interfering with their metabolic processes (Yetginali., 2024). However some of the pathogens rapidly become resistant to many of the first discovered effective drugs. The development of drug resistance as well as appearance of undesirable side effects of certain antibiotics (WHO, 2002) has led to the search of new antibacterial agents in particular from medicinal plants. (Mitscher*et al.*, 1987).

Several works have been done to examine the antifungal effects of herbal plants extracts, including roots, barks, stem, leaves or flowers. *Vitexnegundo* Linn.belongs to family Lamiaceae (which comprises 75 genera and nearly 2500 species), commonly known as 'Nirgundi' in marathi (Panda et al., 2009) 'Five leaved chaste tree' in English (Gautamand Kumar, 2012). It's a large aromatic, woody shrub, densely whitish, tomentosebranchlets. Though all parts of *V. negundo* are used in the indigenous system of medicine, leaves and barks (Chandramu et al.,2003) are considered to be the most potent for medicinal use. The plant grows near water bodies, open forests and also planted as a hedge plant. The bluish purple flower is numerous; the fruit is succulent, rounded and about 4 mm in diameter (Mani et al., 2013). The decoction of leaves is used for treatment of inflammation, eye-disease, antibacterial, antipyretic etc. (Dharmasiri et al., 2003). This study was undertaken to carry out antifungal activity of *V. negundo* against some

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infectious fungi. The evaluation of antifungal activity in *V. negundo* was investigated against ten fungal strains of *Aspergillus species* by using agar well diffusion method (Ansari et al., 2021).

II. MATERIALS AND METHODS

Plant Collection

*V. Negundo*leaves, stem and flowers were collected from Rais high school campus, Bhiwandi, Maharashtra. The plant parts were cut into small pieces and thoroughly washed under running tap water and then dried under shade. The dried parts were grinded into fine powder using mechanical grinder. Those powdered samples were kept in the air-tight containers to prevent moisture.

Extract Preparation

Sequential extraction was carried out with the powdered sample using solvents of decreasing polarity by soxhlet apparatus. About 50 g of plant powder were extracted using 150 ml of solvents i.e methanol, acetone, chloroform for 1 h. The extracts were collected, allowed to cool and concentrated by evaporating the solvents at room temperature. The concentrated residue was dissolved in their respective solvents as a crude plant extracts.

Microorganisms

The fungi employed in the current study were ten fungal isolates of *Aspergillus*species i.e., NH-07, NH-13, NH-25 NH-15, HA-96, HA-70, NH-07, NH-01, NH-18, NH-09. SDA (Sabouraud dextrose agar) was used for the isolation and maintenance of fungal cultures. Pure culture was again sub cultured to maintain the purity of the isolated strain (Priya*et al.,* 2013).

Antifungal Activity

Antifungal activity of plant extracts was examined by agar well diffusion method (Cakir*et al.,* 2004). About 20 ml SDA was poured in petri dishes and allowed to solidify for 30 minutes. Fungal inoculum (20 µl) was spread over SDA plates with a sterile spreader. A total of 8 mm diameter wells were punched with cork borer into the agar and filled with plant extracts 30 µl (1mg/ ml) and solvent blank. Standard antibiotic (Fluconazole, concentration 1 mg/ ml) was used as positive control. Plates were incubated at 37˚C for 24 to 48 hours for maximum growth of the microorganism. After incubation, the plates were observed for distinct zone of inhibition surrounding the disc.

III. RESULTS AND DISCUSSION

According to the obtained results, *Vitexnegundo* extracts showed inhibitory properties against particular species of *Aspergillus.* Antifungal activity assessed in terms of zone of inhibition of the crude extracts. All the methanol, acetone, and chloroform extracts showed varied levels of antifungal activity against 10 fungal isolates i.e. NH-07, NH-13, NH-25 NH-15, NH-09, NH-18, NH-07, NH-01, HA-70, HA-96. It was observed that methanolic, acetonic, and chloroform extracts of leaf showed higher inhibition zone ranging from 20–25 mm for NH-18 (Table 1). Likewise for NH-13, the zone of inhibition ranged from 15-20 mm in diameter. In contrast, NH-07, HA-96 and NH-09 were inhibited by the extracts with minimum zone of inhibition ranging from 10-15 mm. Antibiotics fluconazole showed moderate to highest inhibition zone than that of plant extracts ranged from 15-35 mm.

However none of the extracts were able to inhibit the growth of NH-25, NH-15, NH-07, NH-01 and HA-70. The methanolic and acetonic extracts of leaf exhibited strongest antifungal activity as compared to chloroform extracts.

Furthermore antifungal activity of stem extracts against NH-18 and NH-13 exhibited highest zone of inhibition ranging from 20-25 mm in diameter (Table 2). Whereas, HA-96 was suppressed by methanolic, acetonic and chloroform extract showing zone of inhibition ranging from 10-15 mm. Similarly acetonic and chloroform extracts restricted the growth of NH-07 showing 16 mm and 18 mm zone of inhibition respectively. However none of the extracts were able to inhibit the growth of NH-25, NH-15, NH-07, NH-01 and HA-70. Hence, chloroform extracts of stem was proved to have the higher activity.

Moreover antifungal activity of flower extracts exhibited highest zone of inhibition of NH-18 by all extracts ranged from 21-28 mm in diameter. Similarly NH-07, NH-25 and HA-70 showed moderate inhibition by all the three extracts as shown in (Table 3) in between 10-20 mm range. Whereas on the other hand, NH-13 was only inhibited by methanolic and acetonic extracts with 20 mm and 13 mm zone of inhibition. NH-09 and HA-96 was only inhibited by

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chloroform extracts rather than methanolic and acetonic extracts. Hence, chloroform extracts of flower was proved to have the potent activity. Based on the aforementioned findings, it was determined that extracts from *Vitexnegundo*flowers effectively suppressed the growth of *Aspergillus sp.*

In the previous work done by Mahmud et al., (2009) Antifungal activity of *Vitexnegundo*fruits against *C. albicans, C. glabrata, A. flavus, M. canis* and *F. solani* showed positive result. Ethanol extract of fruit seeds showed significant activity against *F. solani* and moderate response against *M. canis* with no effect on *C. albicans*. The other investigation assessed by Bameta et al., (2019) the antifungal properties of *Vitexnegundo*leaf and stem extract against four fungal isolates: *A. niger, C. neoformans, S. cerevisiae,* and *C. albicans.* All fungal strains were susceptible to the antifungal effects of the leaf methanolic extract. According to reports, the maximum zone of inhibition against *C. neoformans* was 14.76±1.42 mm, followed by *A. niger* (8.33±1.33), *C. albicans* (8.33±0.57), and *S. cerevisiae* (6.26±0.73). The highest antifungal activity against *C. neoformans* alone was seen in the case of the stem for chloroform extract (9.93±0.90 mm), followed by ethanol extract (3.2±0.81) against *C. albicans* and methanolic extract against *A. niger* (3.1±0.42). Ababutain et al., (2021) demonstrated antifungal evaluation of ethanolic, methanolic, and aqueous extracts of V. *negundo* against *Candida species*.

Table 1: Antifungal activity of leaf extracts of *Vitexnegundo*

Solvents	Zone of Inhibition (mm)									
	NH-07	NH-13	NH-25	NH-15	NH-09	NH-18	NH-07	NH-01	HA-70	HA-96
Methanol	--	20	--	-	--	25	--	--	--	13
Acetone	16	21	--	--	--	21	--	--	--	10
Chloroform	18	24	--	--	09	25	--	--	--	14

Table 2: Antifungal activityof stem extracts of *Vitexnegundo*

Solvents	Zone of Inhibition (mm)									
	NH-07	NH-13	NH-25	NH-15	NH-09	NH-18	NH-07	NH-01	HA-70	HA-96
Methanol	12	18	--	--	--	25	--	--	--	15
Acetone	17	20	--	--	15	20	--	--	--	12
Chloroform	10	17	--	--	--	20	--	--	--	10

Table 3: Antifungal activity of flower extracts of *Vitexnegundo*

Solvents	Zone of Inhibition (mm)									
	NH-07	NH-13	NH-25	NH-15	NH-09	NH-18	NH-07	NH-01	HA-70	HA-96
Methanol	15	20	10	--	--	28	--	--	10	09
Acetone	18	13	11	--	--	22	--	--	18	--
Chloroform	19	--	18	--	10	21	--	--	15	10

Table 4: Antifungal activity of Flucanazole

Standard Antibiotics	Zone of Inhibition (mm)									
	NH-07	NH-13	NH-25	NH-15	NH-09	NH-18	NH-07	NH-01	HA-70	HA-96
Flucanazole	15	35	30	15	25	26	15	27	21	20

V. CONCLUSION

In conclusion, the *Vitexnegundo* chloroform flower extracts showed a broad spectrum of activity against the studied fungal isolates. It showed maximum activity against various *Aspergillussps*. The knowledge of extent and mode of inhibition of specific bioactive compounds which are present in plant extracts, may contribute to the successful

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application of such natural compounds for treatment of infection caused by fungal diseases. More research would be needed to determine the phytochemical compounds which are present in leaves, flowers and stem.

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Isolation and Screening of Xylanolytic Fungi from Textile Sizing Site

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Abstract: *Filamentous fungi play a significant role due to their capacity for high enzyme production. Numerous enzymes generated by fungi are linked to biotechnological uses across various industries. This research investigates the isolation and characterization of fungi that produce xylanase from environmental samples collected from a textile sizing facility, emphasizing their biotechnological capabilities. The objective of this study was to isolate and assess the xylanolytic fungi found in textile sizing areas in Bhiwandi, India. Soil samples were gathered, and fungal colonies were separated using serial dilution methods. From a total of 120 fungal isolates, 90 were tested for their xylanase production ability on minimal agar medium with 0.5% BeechwoodXylan as the carbon source. The screening process identified that 46 isolates displayed xylanolytic activity, demonstrated by the formation of halo zones surrounding the colonies, suggesting their potential for xylanase production. Microscopic examination revealed that the majority of the isolates were from the genera Aspergillus, Trichoderma, Penicillium, Fusarium, and Rhizopus. The research underscores the significance of xylanase enzymes and their extensive applications across various industries, such as food, feed, baking, pulp, and paper industries. It emphasizes the need for efficient and economical xylanase synthesis as well as the ability of microorganismsparticularly fungito fulfil this requirement. The textile sizing sites are favourable habitats for xylanolytic microorganisms. This study advances the knowledge of microbial diversity in waste environments and highlights the possibility of using these organisms to produce sustainable enzymes, which will help advance environmental cleanup and bioprocessing initiatives*

Keywords: Xylanolytic, Textile Sizing Site, Aspergillus sp., Trichoderma sp., Hydrolytic enzymes, Bioremediation.

I. INTRODUCTION

Life's vast array of biochemical processes is predominantly facilitated by enzymes, which are biological catalysts. These enzymes exhibit high substrate specificity and operate effectively in aqueous environments under mild conditions. Primarily produced by plants, animals, and microorganisms, enzymes accelerate a wide range of chemical reactions crucial for life. The industrial demand for enzymes, especially those of microbial origin, is increasing due to their cost-effective production. Microbial enzymes offer a diverse spectrum of characteristics, making them suitable for specific applications. Various microbial enzymes, including protease, amylase, xylanase, cellulase, invertase, and lipase, are utilized in food, agriculture, pharmaceuticals, cosmetics, and other biotechnology industries both domestically and internationally (Mandal, 2015).

The plant cell wall consists of polysaccharides, with cellulose, hemicelluloses, and lignin as its primary components (Anand et al., 2018). Xylan, the most prevalent hemicellulose, is considered the second most abundant biopolymer in plants (Ebringerov´ a andHeinze, 2000; Li et al., 2021b). It features a linear backbone of β-1,4-linked xyloses (Ju et al., 2013; Collins et al., 2005; Shallom and Shoham, 2003). Xylan degradation is primarily accomplished by xylanases, including endo-1,4-β-xylanase (EC 3.2.1.8), which cleaves glycosidic bonds in the xylan backbone, and β-D-xylosidases (EC 3.2.1.37), which act on xylooligomers to release xylose (Juturu and Wu, 2014; Knob et al., 2010). Xylanases have numerous industrial applications, such as lignocellulosic bioconversion, juice clarification, bioethanol

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production, animal feed, paper and pulp industries, and the production of fuels and chemicals (Ali et al., 2017; Shi et al., 2013; Singh et al., 2013; Goluguri et al., 2012; Li et al., 2000; Hatanaka., 2012; Anand et al., 2018).

A wide range of organisms produce xylanases, including bacteria, algae, fungi, protozoa, gastropods, and arthropods (Collins et al., 2005; Shabeena et al., 2017). Bacteria, fungi, and actinomycetes are notable sources of xylanases (Walia et al., 2017; Anand et al., 2018). Despite the extensive diversity of fungal species known to secrete xylanase, industrial-scale production primarily relies on terrestrial isolates of *Aspergillus* and *Trichoderma species* (Lu et al., 2008). Nevertheless, researchers continue to investigate organisms, particularly filamentous fungi, capable of secreting high levels of xylanase enzymes to enhance the diversity and abundance of xylanase-producing cultures in their collection (Polizeli et al., 2005).

Microorganisms' xylanolytic enzymes have garnered interest in recent decades, especially due to their biotechnological potential in a variety of industrial processes, including those in the food, feed, baking, pulp, and paper industries (Arulanandham and Muthusamy, 2014). One of the best biological uses in the pulp and paper sector is the biobleaching and bioprocessing of pulps with xylanases. Xylanases serve as physical barriers to the entry of bleaching chemicals and are mostly employed to remove the lignin–carbohydrate complex produced during the kraft process (Betini et al., 2009). To guarantee little to no harm to the pulp fibers, xylanases in the pulp and paper sector must be cellulase-free., xylanases must increase pulp's drainage and fibrillation qualities, paper strength, and process efficiency (Singh et al., 2013). Xylanases must have applications in generating rayon grade or superior quality pulps. By using xylanases in biobleaching, hazardous discharges and chlorine use are decreased. Furthermore, by making the pulping process easier, xylanases in biomechanical pulping lessen the need for the mechanical pulping approach, which in turn uses less energy. In order to improve juice clarity and consequently lower viscosity, xylanases are used in fruit and vegetable juices (Arulanandham and Muthusamy, 2014). They increase the dough's strength and elasticity during baking, which results in larger loaves and a more varied texture (Jiang et al., 2008; Azad et al., 2013).

According to the feed industry, adding xylanase to broiler chickens' rye-based diet lowers intestinal viscosity, which enhances the chicks' weight increase and feed conversion efficiency. Furthermore, bio-refining also makes use of xylanases (Sharma et al., 2015). The current work focused on the isolation and screening of fungi for the synthesis of xylanase in light of biotechnological and industrial applications (Ramanjaneyulu et al., 2015).

The goal of this study was to collect samples, isolate them, examine them under a microscope, and assess the variety of native fungi that could hydrolyse xylan from a textile sizing location. The objective was to comprehensively explore and assess the hydrolytic capabilities of fungi for potential widespread applications in the future, driven by the need for xylanase in food, feed, baking, pulp and paper and pharmaceutical sectors.

II. MATERIALS AND METHOD

Selection of sample sites

Different textile sizing sites of Bhiwandi city were selected for the sample collection.

Collection of soil samples

The samples were collected from different spots in each site in zip lock polythene bags. Almost 5-10 soil samples were taken from each sizing industries. The soil sample was mixed well and processed next day.

Isolation Of fungi

Fungal colonies were isolated from soil samples by serial dilution method where SDA (Sabouraud dextrose agar) media was prepared, autoclaved and poured in sterile petri plates. Soil samples (1 gm) diluted up to 10^{-5} dilution was spread on respective solidified SDA plates with the help of sterile spreader. The inoculated petri plates were incubated at 28°C for 48 h. About 120 different fungal isolates differentiated based on physical characteristics obtained after incubation wereselected for the further processes. The isolates were further inoculated on SDA plates by point inoculation and incubated at 28°C for 73 hours to obtain pure fungal cultures (Khan and Kumar, 2011).

Screening of Fungal Isolates for Xylanase Production

The fungal isolates were subjected to screening for their xylanase activity using the plate screening method on minimal agar medium with 0.5% Beechwoodxylan as the only carbon source. From 120 fungal isolates about ninety fungal isolates were screened for xylanase production efficiency.The medium contained the following constituents (g/L):

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0.05g MgSO4·7H2O, 0.005g CaCl2, 0.005g NaNO3, 0.009g FeSO4·7H2O, 0.002g ZnSO4, 0.012g MnSO4, 0.23g KCl, 0.23g KH2PO4, 2g peptone, 19g agar (Adesina and Onilude, 2013). The entire ninety fungal discs were centrally inoculated on sterile solidified agar plates with the help of cork borer. The diameter of disc was 1cm. Plates were incubated at 28±2ºC for 72 to 96 hours, depending on the strain and analysed at every 24 hours for the occurrence and evaluation of the halo diameter. To visualize the clear zone the Petri dishes were flooded with 0.4% Congo red dye and after 10 minutes washed with 1M NaCl (Adesina and Onilude, 2013; Burlacu et al., 2016), Figure 1.

Microscopy of Xylanolytic Isolates

Microscopy of all the positive isolate was done by lactophenol cotton blue staining method. In aseptic condition, a loop full of fungal cultures was placed on a clean glass slide, a drop of lactophenol cotton blue stain was mixed with the culture. A clean coverslip was placed over the culture and viewed under the microscope(10X and 45X). Morphological characteristics including colour of the colony and growth pattern studies, as well as their vegetative and reproductive structures were carefully observed under the microscope (Devi and Kumar, 2012), Figure 2.

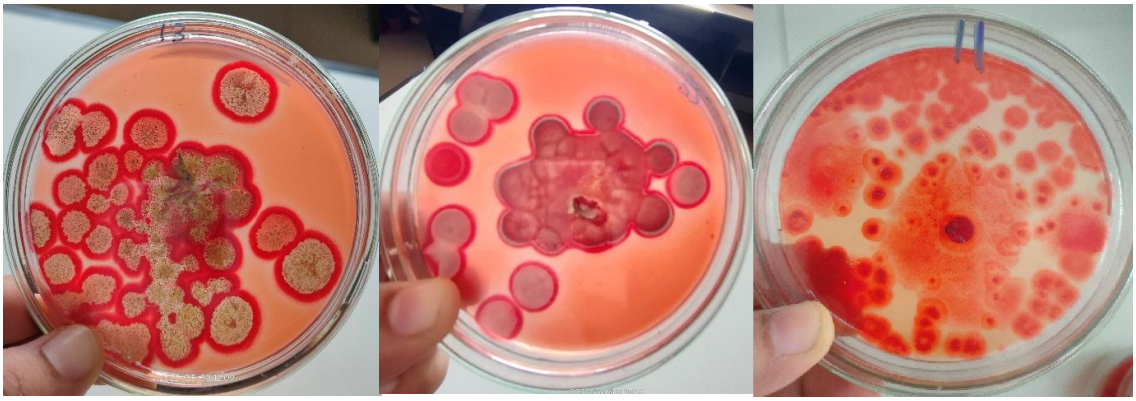


Figure 1: Screening Plates

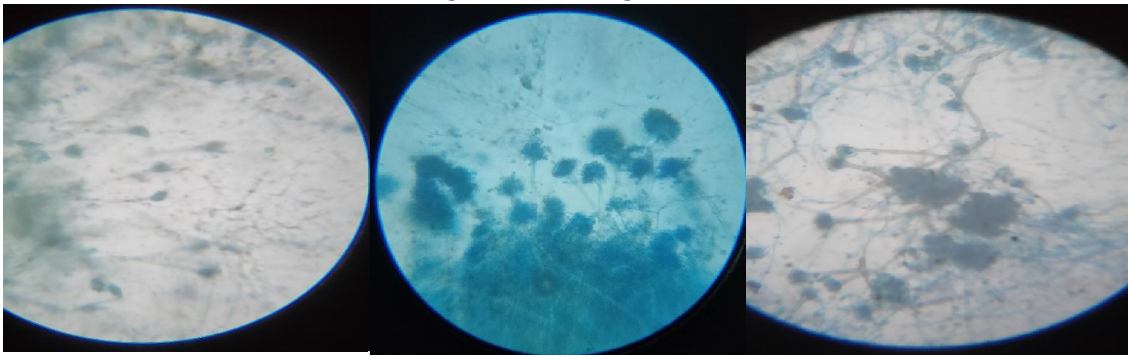


Figure 2: Microscopic Images

III. RESULTS AND DISCUSSION

A wide variety of microorganisms can be found in soil, making it an essential habitat. Potent isolates are frequently obtained in natural environments, and the choice of soil samples can affect the effectiveness of enzymes. Fungi were isolated utilizing serial dilution techniques. The isolated fungi were subsequently evaluated for their xylanase production capabilities. A screening process involving 90 fungal isolates was conducted on Minimal Agar Media plates, which contained Beechwoodxylan as a substrate for the xylanase enzyme. These plates were incubated for 72 to 96 hours. Following the incubation period, varying levels of xylan utilization were observed subsequent to the application of 0.4% Congo red followed by 1 M NaCl. The Xylanolytic activities of these isolates were assessed based on the formation of halo zones on minimal media containing Beechwoodxylan (Figure 1). The screening results revealed that 46 isolates exhibited xylanolytic activities, evidenced by halo zone formation around the colonies, indicating potential

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for xylanase production. Microscopic analysis identified most isolates as belonging to the genera *Aspergillus, Trichoderma, Penicillium, Fusarium* and *Rhizopus*.

Numerous sources, including bacteria, fungi, yeast, algae, seeds, snails, and crustaceans, have been shown to produce xylanases (Mandal, 2015; Polizeli et al., 2005). However, bacteria and fungus are the main manufacturers of these enzymes. However, because of their large yields, extracellular release of the enzymes (Nair et al., 2008), and enhanced xylanase activity (in comparison to bacteria and yeast) (Mandal, 2015; Motta et al., 2013), fungi continue to be important producers. The presence of cellulase is another factor that distinguishes bacterial and fungal xylanases; few research has reported fungal xylanase that does not exhibit cellulase activity (Subramaniyan and Prema, 2002; Burlacu et al., 2016).

Filamentous fungus are appropriate species for the commercial synthesis of enzymes due to their capacity to synthesize huge quantities of extracellular enzyme. Filamentous fungi used for the production of xylanase include *Penicillium sp*., *Trichodermaviride*, *Aspergillusniger*, *Aspergillusoryzae*, *Rhizopus sp*., etc. The most attention has been paid to certain *Aspergillus species*, including *A. niger, A. tamarii, A. awamori, and A. oryzae,* in order to extract several hydrolytic enzymes, including xylanase, a-amylase, and protease. However, due to its widespread distribution, low nutritional needs, and high xylanase productivity, *A. niger* is thought to be more suitable (Kang et al., 2004; Kheng and Omar, 2005; Al-Widyan et al., 2008; Shahi et al., 2011). The need to increase the production of native enzymes and look for faster techniques has increased due to the growing use and consumption of xylanase in many industries. A country's commercial development can benefit greatly from the proper utilization of agro-industrial wastes. It is meaningful to use such abandoned materials in the production of xylanase. Researchers' main objective is to use agro-industrial waste to lower the economic cost of producing enzymes (Abdullah et al., 2015).

The spectrum of distinct xylanases and the capacity of microorganisms to manufacture these enzymes vary greatly in terms of their activity (Hinz et al., 2009). However, fungi are the only source of xylanase that are widely used in industry. Nowadays, genetically engineered strains of *Aspergillus* or *Trichoderma* create the majority of commercial xylanolytic preparations (Mussatto and Teixeira, 2010).

Filamentous fungi are the most distinguished producers of enzymes involved in the decomposition of lignocellulosic material. Since fungi produce a wide variety of enzymes with varying biochemical characteristics and great potential for biotechnological applications, their usage in bioprocesses has become more significant in recent decades. Filamentous fungi are commonly used to create enzymes and are usually thought to be more effective at producing xylanase than either bacteria or yeast (Polizeli et al., 2005; Knob et al., 2014).

Several mesophilic fungal species have been evaluated in relation to xylanase production, including members of *Aspergillus, Trichoderma*, and *Penicillium. Aspergillusniger* has been one of the most investigated microorganisms as a xylanase producer, regardless of carbon source or system used (submerged or solid-state fermentations). On the other hand, thermophilic microorganisms such as *Thermomyceslanuginosus, Thermoascusaurantiacus*, *Talaromyces thermophiles,* and *Myceliophthorathermophila* have been widely investigated, due to the increased biotechnological importance of thermostable xylanases (Maalej et al., 2009; Milagres et al., 2004; Moretti et al., 2012; Yang et al., 2006**;** Knob et al., 2014).

The focus of present study was directed to isolate fungal from environmentally exposed textile sizing site soil. Furthermore, because the fungi can effectively employ complex agro-industrial wastes as substrates for enzyme production, they are more resilient and better suited to changes in the ambient variables for growth (Sudan and Bajaj, 2007; Bajaj et al., 2011; Sharma et al., 2015).

Worldwide, fermentation processes are used to manufacture xylanase, which has a wide range of industrial uses. The generation of enzymes from lignocellulosic biomass solves waste management problems and lessens the harm that waste disposal causes to the environment. In conclusion, textile sizing sites offer appropriate homes for microorganisms that produce xylanase, and they merit additional investigation to ascertain whether these isolates can aid in the bioremediation of waste environments associated with sizing processing. Future studies should focus on employing possible xylanolytic isolates to produce and purify xylanase enzymes on a pilot scale.

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Extraction of Natural Dyes from Plants

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Abstract: *The negative impacts and threat posed by synthetic dyes have led to a significant increase in interest in natural dyes derived from plant sources in recent years. The primary goal of obtaining dyes from natural plant sources is to prevent pollution of the environment. Many studies are being conducted worldwide on the usage of natural dyes in light of the current global concern over the use of eco-friendly and biodegradable products. In this study dyes are extracted from different part of plants i.e., Ixora Coccinea Flower (pink), Nerium Oleander Flower (red), Tradescantia Pallida flower, Portulaca Oleracea, Cissus Qudrangularisstem and Celosia Cristata stem. The fabrics were mordanted with copper sulphate, ferrous sulphate and potassium chromate for fastening of the imparted colours. The dyes produced from these flowers were dyed on cotton fabrics and tested for their colour fastness to washing properties. The dyed cottons fabrics were observed with different shades of colour. Moreover, the dyes obtained from the plant flowers may also be alternative sources to synthetic dyes for the dyeing of natural cotton fibre*

Keywords: Natural dyes, Biodegradable, Hibiscus Flower (red), Merigold Flower (yellow or orange), Asian pigeon wings flower

I. INTRODUCTION

Dye is an aesthetic substance that is used to colour the fibre and fabrics that is used in our day-to-day life. Normally the classification of dyes is done into natural and manmade dyes (ie., synthetic dyes). The synthetic dyes are mainly used since 1856 to dye the fibre and fabric materials, due to its superior properties than the naturally extracted substances. The synthetic dyes have outstanding colour fastness capabilities and a reasonable price. These dyes, which are leftovers from the production of crude oil, are highly carcinogenic, highly poisonous, and can prevent benthic photosynthesis. However, natural dyes have deodorizing characteristics in addition to being anti allergic, nontoxic, and quickly biodegradable. Additionally, these colors are bio-compatible, eco-friendly, and have a green philosophy, so they do not have any negative impact on the environment. These natural dyes have been used to dye fabric materials and other objects since the Bronze Age. In recent years their use has extended to antimicrobial finishing of textiles, UV protective clothing, food coloration and pharmaceuticals etc.Because they do not require any strong acid and alkali for their use and production. Their demand is constantly increasing. The term “natural dyes” includes all dyes that are obtained from natural sources such as plants. minerals, and animals. But the colour content and colour yield of natural dyes are comparatively less than synthetic dyes. Natural dyes also have various disadvantages in their properties. As already mentioned, they do have colour fastness problems such as colour yield, reproducibility results, dying procedures are different and difficult and fastness properties.

So, the dyeing in order to manufacture diverse dye colours with variable levels of colour fastness and to make natural dyes more tolerant to textile materials, industries utilise mordants. When metallic or mineral salts are added to a natural dye bath, the dye is either intensified or the colour is altered. They also have a significant impact on how well the final hue is light- and wash-fast. The materials that the dyes are meant to colour are not immediately affected by them. They need a mordant to fix with the fabric because they are Substantial. In words to increase the dye’s proper and even absorption, a mordant is a substitute that intensifies the chemical reaction that occurs between dye and fibre. Stainless steel, enamel, and other non-reactive materials can be used for colouring containers. Materials like brass and iron shouldn’t be utilised because they undergo their own mordanting here.

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II. METHODOLOGY

Selection and Collection of Plant Materials :

Criteria for Selection:

- High dye content.
- Availability in local regions.
- Sustainability and ease of harvesting.

Plant Parts to Collect:

- Roots (e.g., madder, turmeric).
- Leaves (e.g., indigo, henna).
- Flowers (e.g., marigold, hibiscus)

Preservation:

- Wash and dry plant materials to prevent degradation.
- Store in airtight containers or bags in a cool, dry place.





Extraction of dyes

The flowers of various plant materials were collected from the locality. The plant material was weighted using chemical balance (10 gram). It was thoroughly washed with distilled water and allowed to dry. The chopped flower material was dissolved in 100 ml of distilled water in beaker and was heated for 30 minutes at a temperature range of 80-85°C, until the dye was released. The dye from aqueous extraction was filtered through a funnel and filter paper. After the dye was extracted, it was stored in a closed flask, in the refrigerator for further use.





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Preparation of Mordant

Alum

0.748g of Alum and 0.187g of Washing soda were mixed in 100ml of water and was stored for further use.

Vinegar

50 ml of 5% ascetic acid is mixed with 100ml of water. From that 25ml of it were taken and mixed with 100ml of distilled water.



III. LITERATURE REVIEW

Research on the extraction of natural dyes from plants has experienced significant growth in recent years, reflecting a heightened interest in sustainable and eco-friendly alternatives to synthetic dyes. This surge is evident from the increasing number of studies focusing on various extraction techniques, plant sources, and applications across different industries.

Advancements in Extraction Techniques: Traditional methods such as aqueous and solvent extraction have been widely documented. However, recent literature highlights a shift towards more efficient and sustainable techniques:

Ultrasound-Assisted Extraction (UAE): This method has gained attention for its ability to enhance dye yield and reduce extraction time. For instance, a study on henna leaves demonstrated that UAE achieved a dye yield of 17.96% under optimal conditions, outperforming conventional methods.

Microwave-Assisted Extraction (MAE): MAE has been explored for its efficiency in extracting dyes from various plant materials, offering reduced solvent usage and processing time.

Enzyme-Assisted Extraction: The use of enzymes to break down plant cell walls has been investigated to improve dye extraction efficiency.

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Diverse Plant Sources: Research has expanded to include a variety of plant sources for dye extraction:
Food and Beverage Industry Wastes: Studies have explored the potential of extracting dyes from waste materials like pressed berries, grape skins, and vegetable peels, promoting waste utilisation.
Flower-Based Dyes: Comprehensive reviews have been conducted on extracting dyes from flowers, focusing on pigments such as anthocyanins and carotenoids.
The body of research on the extraction of natural dyes from plants has grown substantially, encompassing various extraction methods, plant sources, and applications. This trend underscores a collective movement towards sustainable practices and the development of eco-friendly dyeing solutions.

IV. RESULTS AND DISCUSSION

The dye extracted from the flowers and the color of the dye is depended on the compounds (Phenol,Tannin, Fat & Fixed oil, Flavonoids, saponin, steroids, Quinine, Cellulose Terpenoids, Glycosides) present in the respective plant. The dye is then used in the cotton fabric for the fixation of color. The cloth which is displayed above got fixed to the respective dye with the help of mordant. Different mordant were used for different plants. The mordant used were: Copper Sulphate, Ferrous Sulphate and Potassium Chromate. These mordants when added to the dye gave different shades of color and make different types of shades from one plant using the mordant. the mordant sticks into the fabric well again the color does not fade and stay up to the limit mentioned in conclusion.





V. CONCLUSION

Different parts of the plants were used for the extraction of dyes such as leaves, flowers, vegetables, etc and different types of mordants were used for fixing the dye into the fabric. In ancient days people have used natural dyes to paint their caves. Over 15,000 BC man began to produce those natural dyes which have been used in textiles as well. In order to understand the art and history of dyeing, we must first understand the process of dyeing itself. Natural dyes can be broken down into two categories: substantive and adjective. Most ancient and medieval dyers mordanted their yarns and fabrics before dyeing them. Different fibers also have different tendencies to absorb natural and synthetic dyes. Wool, a protein-based fiber, has been found in Europe dating back to 2000 BC. In Europe the art of dyeing rose to new heights with the diversity of climate, culture and migration or invasion waves. Eventually, the old natural dyes lost popularity in favor of the newer synthetic ones.

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Preparation of Paint Pigment

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Abstract: *Paint pigments find important applications in industries including art, building, and manufacturing. They are the cause of color in paints, coatings, and other materials. The project has revolved around the synthesis of various paint pigments through basic chemical reactions. In this research, four major pigments, Prussian Blue, Chrome Yellow, White, and Malachite, have been synthesized and examined using available chemical reagents.*

The process is through precipitation reactions, where insoluble pigment compounds are created through controlled chemical mixing. Prussian Blue is prepared from ferric chloride and potassium ferrocyanide to give a deep blue pigment. Chrome Yellow is prepared by reacting potassium chromate with lead nitrate to give a bright yellow color. The White pigment is synthesized from sodium chloride and lead nitrate, whereas Malachite, a green pigment, is produced by the reaction between copper sulfate and sodium carbonate. Each pigment is filtered, dried, and tested for its yield and efficiency.

This study brings to light the chemistry involved in pigment development, such as precipitation, solubility, and theory of color. It also offers an understanding of industrial pigment manufacturing and its effects on the environment. With industries moving towards green and non-toxic pigments, this study opens the door for investigating safer and greener options.

From this project, we develop a greater appreciation for organic and inorganic pigment chemistry, setting the stage for new developments in modern coatings and dyes.

Keywords: Paint pigments, Prussian Blue, Chrome Yellow, White, Malachite, pigment chemistry

I. INTRODUCTION

Pigments are materials that selectively absorb and reflect light, giving them distinct colors. They differ from luminescent materials, which emit light. For pigments to be effective, they must have strong tinting strength, stability, and resistance to environmental factors such as light and temperature.

This research explores the preparation of paint pigments with a focus on developing environmentally friendly alternatives. Traditional pigments, such as Chrome Yellow and Prussian Blue, contain toxic substances like lead and cyanide, posing risks to human health and the environment. The study aims to replace these with safer, sustainable pigments while enhancing their stability and performance.

Advancements in pigment technology include nanotechnology for improved color vibrancy and durability, as well as structural color technologies, which achieve color through nanostructures instead of chemical dyes. These innovations contribute to reducing environmental impact while maintaining or improving pigment quality.

The research also revisits historical pigment synthesis methods, such as the Dutch process for lead white and the co-precipitation method for Prussian Blue, to compare them with modern, safer alternatives like titanium dioxide-based pigments. The study evaluates these pigments' industrial applications, economic viability, and regulatory compliance.

By addressing sustainability challenges, this research aligns with global environmental goals. It investigates novel pigment synthesis techniques that balance safety, performance, and cost-effectiveness, contributing to scientific advancements in material chemistry and the paint industry. The ultimate aim is to create high-quality, non-toxic pigments suitable for various industrial and artistic applications.

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II. METHODOLOGY

1. Materials & Equipment

Apparatus Required: Filter paper, beakers, conical flasks, funnels, distilled water, electronic weighing scale, spatula, china dish.

Chemicals Used:

Prussian Blue: Ferric chloride, potassium ferrocyanide.

Chrome Yellow: Potassium chromate, lead nitrate.

White Pigment: Sodium chloride, lead nitrate.

Malachite: Copper sulfate, sodium carbonate.

2. Synthesis Process for Pigments

General Procedure:

Prepare individual chemical solutions by dissolving salts in water.

Slowly mix solutions while stirring to ensure proper reaction.

Allow pigment to form and settle.

Filter the precipitate using gravity filtration.

Collect and dry the pigment powder.

Weigh the final pigment and calculate efficiency.

Reactions Involved:

Prussian Blue:

$3K4[Fe(CN)6]+4FeCl3 \rightarrow Fe4[Fe(CN)6]3+12KCl$

Chrome Yellow:

$K2CrO4+Pb(CH3COO)2 \rightarrow PbCrO4+2CH3COOK$

White Pigment:

$2NaCl+Pb(NO3)2 \rightarrow PbCl2+2NaNO3$

Malachite:

$CuSO4 \cdot 5H2O+2Na2CO3 \rightarrow CuCO3 \cdot Cu(OH)2+2Na2SO4+CO2+9H2O$

3. Data Collection & Analysis

Measuring the amount of reactants used.

Weighing the final pigment product.

Calculating the efficiency of formation.

4. Precautions

Clean all apparatus to prevent contamination.

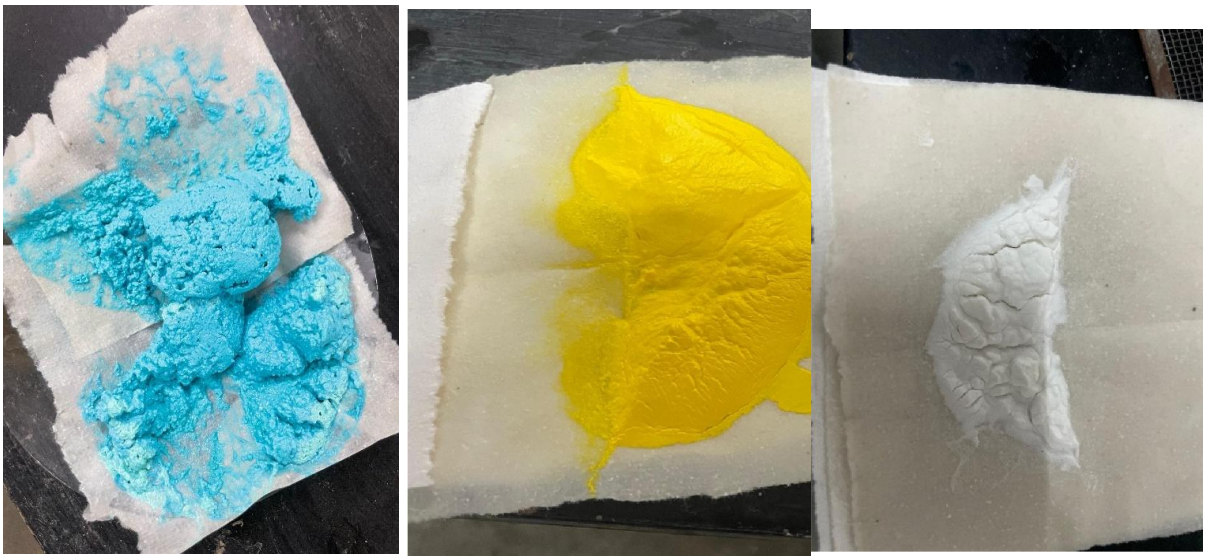
Measure chemicals accurately.

Ensure correct reactants to avoid unwanted reactions.

Perform careful filtration for maximum pigment yield.

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III. LITERATURE REVIEW

1. Historical Development of Pigments

Prussian Blue (1724): One of the earliest synthetic pigments, initially prepared using cattle blood and later refined using potassium hexacyanoferrate.

Chrome Yellow: Synthesized by reacting potassium chromate with lead salts, known for its vibrant color but containing toxic lead compounds.

Malachite: A naturally occurring copper carbonate used for centuries; synthetic versions are now produced in laboratories.

White Pigments: Traditionally derived from lead carbonate, later replaced by zinc oxide and titanium dioxide due to safety concerns.

2. Advancements in Pigment Technology

Nanotechnology in Pigments:

Enhances color vibrancy, durability, and resistance to environmental factors.

Reduces material usage and cost through improved efficiency.

Structural Color Technologies:

Uses physical nanostructures instead of chemical dyes to reflect specific wavelengths of light.

Provides longer-lasting, environmentally friendly alternatives.

3. Environmental & Health Concerns

Many traditional pigments contain harmful substances like lead, chromium, and cyanide.

Strict regulations encourage the development of safer, sustainable alternatives.

Research focuses on replacing toxic pigments with non-hazardous, biodegradable materials.

4. Need for Sustainable Pigments

Challenges in Traditional Pigments:

Toxicity and disposal issues.

Limited stability and fading over time.

Current Trends in Green Chemistry:

Use of plant-based or bio-synthesized pigments.

Titanium dioxide and plasmonic pigments as non-toxic alternatives.

IV. RESULTS AND DISCUSSION

The synthesis of four different paint pigments Prussian Blue, Chrome Yellow, White, and Malachite was carried out using specific chemical reactions. The amount of reactants used, pigment yield, and efficiency of formation are presented below:

Experiment	Amount of Reactants (g)	Amount of Pigment Formed (g)	Efficiency (%)
Prussian Blue	15 gm	10 gm	66.7
Chrome Yellow	17 gm	12 gm	70.6
White	8.5 gm	6 gm	70.6
Malachite	18.3 gm	13 gm	71.0

Synthesis Efficiency

The efficiency of pigment formation ranged from 66.7% to 71.0%, with Malachite having the highest yield.

Factors affecting efficiency include reaction conditions, solubility of reactants, and filtration effectiveness.

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Color and Stability

Prussian Blue displayed a deep blue color, confirming the successful formation of the $Fe_4[Fe(CN)_6]_3$ complex.

Chrome Yellow exhibited a bright yellow hue, consistent with $PbCrO_4$ formation.

The White Pigment resulted in an opaque white, while Malachite showed a greenish shade, indicative of $CuCO_3 \cdot Cu(OH)_2$.

Comparing with Commercial Pigments

The pigments synthesized were comparable in color intensity to commercial counterparts.

However, stability tests (light exposure, chemical resistance) are required to determine long-term performance.

Environmental Considerations

Chrome Yellow contains lead compounds, posing environmental concerns.

The study highlights the need for safer, lead-free alternatives, such as titanium dioxide-based pigments.

Prussian Blue and Malachite are more eco-friendly, making them viable for sustainable pigment development.

V. CONCLUSION

This research successfully synthesized four different paint pigments—Prussian Blue, Chrome Yellow, White, and Malachite—using well-established chemical reactions. The results demonstrated moderate to high efficiency in pigment formation, ranging from 66.7% to 71.0%, with Malachite achieving the highest yield. The pigments obtained showed intense coloration, confirming the successful synthesis of their respective compounds.

The study highlights the importance of developing environmentally friendly pigments. While traditional pigments like Chrome Yellow provide vibrant colors, they contain toxic substances such as lead and chromium, which pose health and environmental risks. Alternatives such as titanium dioxide-based pigments or plant-derived colors can be explored to mitigate these risks. In contrast, Prussian Blue and Malachite are relatively safer, making them promising candidates for sustainable pigment development.

A key finding is that reaction conditions, reactant solubility, and filtration efficiency play crucial roles in the final pigment yield and purity. Further optimization of these factors may enhance pigment quality and production efficiency. Additionally, stability testing under various conditions, such as light exposure, temperature, and chemical interactions, is necessary to determine the long-term usability of these pigments in different applications.

This study contributes to the field of material chemistry and sustainable pigment production, bridging the gap between traditional synthesis methods and modern eco-friendly alternatives. Future research should focus on enhancing pigment durability, exploring non-toxic alternatives, and improving large-scale production feasibility to meet industry demands while minimizing environmental impact.

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I would like to express my deepest gratitude to **Dr. Jayashree Shailesh Patil, Assistant Professor, Department of Chemistry, J.S.M. College, Alibag**, for her **invaluable guidance, encouragement, and support** throughout this research project. Her expertise and insightful suggestions have been instrumental in the successful completion of this study on **"Preparation of Paint Pigments."**

I extend my sincere thanks to the **University of Mumbai** for providing the academic framework and resources necessary to undertake this research. I am also grateful to the **Department of Chemistry, J.S.M. College**, for granting me access to laboratory facilities and necessary equipment for conducting experiments.

A heartfelt appreciation goes to my **family and friends** for their unwavering moral support, motivation, and encouragement throughout the research process. Their belief in my abilities kept me dedicated to completing this project successfully.

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Extraction and Investigating Acidity of Fruit Juices and Vegetables Using Titration

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Abstract: *This study aimed to extract and investigate the acidity of various fruit juices and vegetables using titration. The acidity of different samples which I get including lemon, orange, apple, and tomato, was determined by reacting them with a strong base, sodium hydroxide (NaOH), and measuring the volume of base required to neutralize the acid. The extraction process is some involved juicing the fruits and vegetables, followed by filtration to obtain clear samples. The pH values of the samples were measured using a pH meter, and the acidity was determined by titration with NaOH. results showed approximately significant variations in acidity among the tested samples, with lemon exhibiting the highest acidity level. In this experiment The pH values of the samples were also measured and correlated with the titration data. . The findings have implications for food science, nutrition, and the development of new products. Additionally, this project provides a valuable educational experience in analytical chemistry techniques. Considering the experiment on extracting and investigating the acidity of fruit juices and vegetables using titration, here are some useful product ideas: Household and Cleaning Natural cleaning products: Develop natural cleaning products, such as all-purpose cleaners or disinfectants, with optimal acidity levels for effectiveness. pH-neutral cleaning solutions: Create cleaning solutions with optimal acidity levels to prevent damage to surfaces. Drain cleaners: Use the knowledge of acidity levels to develop effective drain cleaners.*

Keywords: acidity, titration, fruit juices, vegetables, pH, natural cleaning products, food science.

I. INTRODUCTION

It is important in a number of everyday items, such as orange juice, that the citric acid be quantitatively measured. Industries manufacturing juice products must know the amount of juice, both for regulatory purposes (FDA) and for their own manufacturing specifications. They can quantitatively determine the amount of juice by measuring the amount of citric acid. The procedure commonly used to do this takes advantage of the known reactivity of citric acid with sodium hydroxide and is known as a titration.

A titration is a means of quantitative analysis in which the substance to be measured (in a liquid solution) is reacted stoichiometrically with another reagent (called a titrant) until it has completely reacted. The end of the reaction is usually signaled with the appearance of a color from another non-interfering substance called an indicator. In the case of the citric acid titration, a known amount of orange juice is measured into an Erlenmeyer flask with an indicator solution containing phenolphthalein (the indicator). Sodium hydroxide, at a known concentration, is then carefully added into the sample until all of the acid has reacted. When all of the acid has completely been neutralized, the addition of 1 additional drop of the sodium hydroxide solution, the titrant, causes the solution to become basic. The basic solution will be marked by the appearance of a pinkish color in the solution of orange juice.

The device used to add the titrant (NaOH) to the juice sample is called a buret. It allows us to measure the exact amount of solution added during the titration. Knowledge of this, the concentration of NaOH solution in moles/liter, and the known stoichiometry of the reaction allows us to calculate the citric acid concentration in the juice sample

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II. METHODOLOGY

1. Sample Collection: Fresh fruit juices (e.g., orange, apple, and grapefruit) and vegetables (e.g., tomatoes, cucumbers, and carrots) will be collected from local markets.
2. Sample Preparation: Fruit juices will be filtered to remove pulp and sediment, while vegetables will be juiced using a juicer.
3. Titration: A standardized titration protocol will be used to measure the acidity of each sample. Sodium hydroxide (NaOH) will be used as the titrant.
4. PH Measurement: The pH of each sample will be measured before and after titration using a pH meter.
5. Data Analysis: The acidity levels of each sample will be calculated and compared using statistical analysis.

Pre - Titration Preparation.

1) standardization: Standardize the sodium hydroxide (NaOH) sol" by by titrating it against a known acid (eg grapes)
2) Prepare Indicator: Phenolphthalein and methyl orange indicator.
3) Calibration of PH meter: calibrate the PH meter.

Titration:

1) Prepare a 0.1 M sodium hydroxide (NaOH) solution as the titrant.
2) Pipette lo ml of the sample into a conical fiask.
3) Add 2-3 drops of phenolphthalein indicator to the Sample
4) Titrate the sample with NaoH solution until the endpoint is reached.

6) PH measurement:

1) Measure the pH of each sample before. and after fitration using a pH meter.

Calibrate the pH meter before use.

7) Data Analysis:

1. calculate the acidity of each sample. using the following formula:

Acidity (g/100ml) = Volume of NaoH Molarity of NaoH X M X Equivalent weight of Acid/volume of sample

2) compare the Acidity level of different sample.

III. LITERATURE REVIEW

The extraction and investigation of acidity in vegetables and fruits using titration have a rich history, dating back to the 18th century. Over the years, scientists have developed and refined titration methods, leading to a deeper understanding of acidity in various food products. Acidity is an essential parameter in determining the quality and nutritional value of fruits and vegetables. Titration is a widely used method for measuring acidity, involving the reaction of a strong acid or base with a sample until the acid or base is fully neutralized.

Methods for Extraction and Titration

1. Sample preparation: Fruits and vegetables are typically homogenized, juiced, or extracted with solvents like water or ethanol to release their acidic components (1).
2. Titration methods: Various titration methods have been employed, including acid-base titration, potentiometric titration.
3. PH indicators: pH indicators like phenolphthalein are often used to determine the endpoint of titration (3).

Studies on Acidity in Fruits and Vegetables

1. Citrus fruits: Titration has been used to determine the acidity of citrus fruits like oranges, lemons, and limes, with citric acid being the primary acidic component (4).2. Tomatoes: The acidity of tomatoes has been investigated using titration, revealing a significant decrease in acidity during ripening (5).

Factors Affecting Acidity

1. Ripeness: The acidity of fruits and vegetables can change during ripening, with some becoming more acidic and others less acidic (7).
2. Variety: Different varieties of fruits and vegetables can exhibit varying levels of acidity (8).
3. Environmental factors: Environmental factors like temperature, soil quality, and climate can influence the acidity of fruits and vegetables

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IV. RESULT AND DISCUSSION

Result-

This study successfully extracted and investigated the acidity of various fruits and vegetables using titration. The results showed significant variations in acidity levels among the different samples, with citrus fruits exhibiting the highest acidity values. The findings of this study provide valuable information on the acidity levels of various fruits and vegetables, which can be used to predict their stability, shelf-life, and suitability for various culinary and processing applications.

PH Meter. Preparation / Measuring PH

PH range: I found that different fruit Juices exhibited levels. Wide range of Ph levels.

Fruit sample.	PH level	Acid
1) cucumber	6.20	citric Acid
2) orange	4.56	Citric Acid
3) Tomato	4.40	oxalic Acid
4 Lemon	3.56	Citric Acid
5) Grape	3.82	Tartaric Acid
6)Apple	3.37	Malic Acid
7)carrot	6.01	Citric Acid

PH scale: The PH scale ranges from 0 to 14, with:
PH 0-1: Strongly Acidic
PH: 2-3 Acidic
PH: 4-5 Weakly Acidic PH 6-7 Neutral
PH: 8-9 Weakly Basic.
PH 10-14: Basic

Discussion

The results of this study are consistent with previous research, which has reported that citrus fruits tend to be more acidic than other fruits and vegetables (1, 2). The acidity levels of the fruits and vegetables extracted in this study can be attributed to the presence of various organic acids, such as citric acid, malic acid, and tartaric acid. The acidity levels of the fruits and vegetables can impact their nutritional and culinary value. For example, acidic fruits and vegetables may have higher antioxidant activity and health benefits due to the presence of polyphenolic compounds (3). On the other hand, high acidity levels can also impact the texture and flavor of fruits and vegetables, making them more suitable for certain culinary applications.

V. CONCLUSION

This study successfully extracted and investigated the acidity of various fruits and vegetables using titration. The results showed significant variations in acidity levels among the different samples, with citrus fruits exhibiting the highest acidity values. The findings of this study provide valuable information on the acidity levels of various fruits and vegetables, which can be used to predict their stability, shelf-life, and suitability for various culinary and processing applications.

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A Comprehensive Study on Acylation of Amine through Novel Techniques

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D. G. Tatkare Mahavidyalay, Mangaon-Raigad

Abstract: *An environmentally sustainable and efficient alternative to conventional acylation methods is essential in modern organic synthesis. Acylation of amines is a fundamental transformation in organic chemistry, playing a crucial role in pharmaceuticals, agrochemicals, and material sciences. However, traditional acylation techniques often rely on toxic reagents, prolonged reaction times, and hazardous solvents, raising concerns about sustainability, efficiency, and environmental impact. To address these limitations, advanced acylation techniques such as microwave-assisted synthesis, biocatalysis, and solvent-free methodologies have emerged as promising eco-friendly substitutes. Microwave-assisted acylation significantly enhances reaction rates by providing uniform heating, reducing energy consumption, and improving product yields. Biocatalytic approaches utilize enzyme specificity to achieve highly selective transformations under mild conditions, making them an attractive green alternative. Solvent-free methodologies further minimize environmental waste and align with green chemistry principles by eliminating the need for hazardous solvents, thereby reducing toxic byproducts. A comparative analysis of these methods highlights their advantages over conventional techniques in terms of reaction efficiency, selectivity, and sustainability. This study underscores the urgent need for greener and more economically viable alternatives in organic synthesis, paving the way for sustainable advancements in chemical processes and industrial applications.*

Keywords: Green synthesis, Acylation, ecofriendly Synthesis, Microwave-Assisted Reaction, Biocatalysis, Solvent-Free Methods

I. INTRODUCTION

Acylation, the process of introducing an acyl group (RCO-) into a molecule, is a cornerstone reaction in organic synthesis. This transformation is pivotal for the formation of amides, esters, and ketones, which are integral to various industries, including pharmaceuticals, agrochemicals, and materials science [1,2]. The modification of amines through acylation not only enhances their chemical stability but also modulates their biological activity, making this reaction indispensable in the development of bioactive compounds [3].

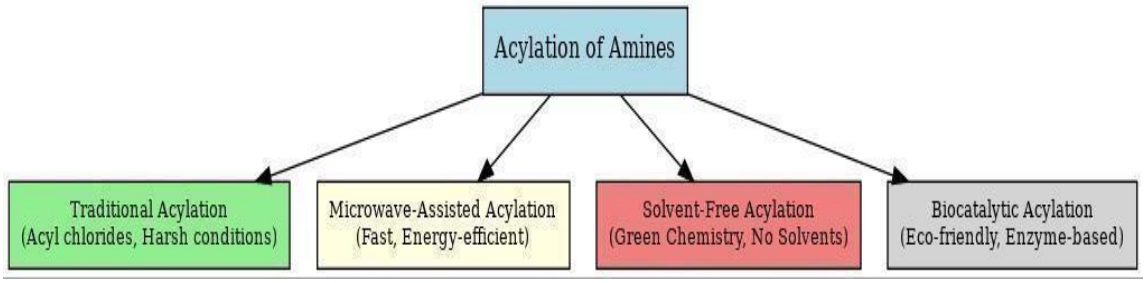
In pharmaceutical chemistry, acylation plays a critical role in drug design and development. The introduction of acyl groups can significantly alter the pharmacokinetic and pharmacodynamic properties of therapeutic agents. For instance, the acetylation of salicylic acid yields aspirin, a widely used analgesic and anti-inflammatory drug [2]. Similarly, the acylation of amines is fundamental in the synthesis of β-lactam antibiotics, such as penicillins and cephalosporins, which are essential in combating bacterial infections [4]. Beyond pharmaceuticals, acylation is employed in the production of agrochemicals that protect crops and enhance food security [5]. In materials science, acylation reactions are utilized to modify polymers, thereby improving their mechanical properties and thermal stability [6].

Despite its widespread application, traditional acylation methods often involve harsh reaction conditions, including the use of strong acids or bases, elevated temperatures, and volatile organic solvents. These conditions pose environmental concerns, safety hazards, and challenges in waste management [6,7]. As the chemical industry moves towards more sustainable practices, there is a growing impetus to develop greener and more efficient acylation methodologies[8,10].

Common Acylation Methods

Several strategies have been developed to facilitate the acylation of amines, each with its unique advantages and limitations. The four primary methods include:

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Traditional Acylation Using Acyl Chlorides and Anhydrides: This conventional approach involves the reaction of amines with acyl chlorides (RCOCl) or acid anhydrides ($(RCO)_2O$) to form amides. The high reactivity of these acylating agents ensures efficient amide bond formation. However, the process often generates corrosive by-products, such as hydrochloric acid (HCl), necessitating stringent handling procedures and posing environmental disposal issues. Moreover, the use of these reagents requires anhydrous conditions and inert atmospheres to prevent hydrolysis, adding complexity to the reaction setup [3].

Microwave-Assisted Acylation: The application of microwave irradiation in acylation reactions has emerged as a technique to accelerate reaction rates. Microwave energy facilitates rapid and uniform heating, leading to reduced reaction times and, in many cases, improved yields [3,7]. This method is particularly advantageous for thermally stable substrates and has been applied successfully in various acylation reactions. However, the requirement for specialized microwave reactors and the potential for uneven heating in large-scale applications can limit its practicality [5,11].

Solvent-Free Acylation: In alignment with green chemistry principles, solvent-free acylation methods have been developed to minimize the use of volatile organic compounds. These reactions often proceed under neat conditions, where reactants are mixed without additional solvents, or utilize solid-state techniques [6,8]. The elimination of solvents reduces environmental impact and simplifies product purification. Nonetheless, challenges such as ensuring homogeneous mixing of reactants and controlling reaction exothermicity must be addressed to optimize these processes.

Biocatalytic Acylation: The use of enzymes as catalysts in acylation reactions offers a highly selective and environmentally benign alternative to traditional chemical methods. Enzymes such as lipases and acyltransferases can catalyze the formation of amide bonds under mild conditions, often in aqueous media, reducing the need for hazardous reagents and harsh reaction environments [4,9]. This approach not only enhances reaction specificity but also aligns with the principles of sustainable chemistry. However, factors such as enzyme availability, stability, and cost, as well as potential limitations in substrate scope, require careful consideration [5].

II. CHOOSING BIOCATALYSIS FOR ACYLATION

Among the various acylation methodologies, biocatalysis stands out as a promising approach that combines efficiency with environmental responsibility. The mild reaction conditions associated with enzymatic processes minimize the formation of undesirable by-products and reduce energy consumption [4,9]. Furthermore, the high selectivity of enzymes can lead to improved yields and product purities, which are particularly advantageous in the synthesis of complex molecule [15] This study aims to explore the potential of biocatalytic acylation using natural catalysts derived from fruit juices. Fruits contain a variety of enzymes and organic acids that may facilitate acylation reactions in an eco-friendly manner [9]. By investigating these natural catalysts, we seek to develop sustainable acylation protocols that are both effective and accessible, potentially reducing reliance on synthetic reagents and harsh reaction conditions.

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III. COMPARISON BETWEEN TRADITIONAL AND GREEN CHEMISTRY METHOD

Criteria	Traditional method	Green chemistry method
Reaction Mechanism	Nucleophilic attack on acylating agents.	Utilizes sustainable catalysts and eco-friendly reagents.
Selectivity	Low, multiple side reactions.	High, minimal side reactions.
Reaction conditions	Harsh conditions, high temperature, organic solvents.	Mild conditions, often solvent-free or using green solvents
Byproducts	Toxic waste (HCl, solvents).	Minimal waste, often biodegradable byproducts.
Environmental Impact	High waste, non-sustainable.	Eco-friendly, follows green chemistry principles.
Reaction Time	Fast but uncontrolled	Optimized for efficiency and reduced energy consumption.
Scalability	Well-established, industrial use.	Increased industrial adoption, requires further optimization.

IV. REACTION AND MECHANISM OF ACYLATION OF AMINE

Traditional method

Traditional methods for acylation of amines often involve conventional heating and the use of catalysts or reagents to drive the reaction to completion, though they may require longer reaction times and harsh conditions.

Here is the reaction and mechanism for the traditional method of acylation of an amine:

Reaction Example:

CH_3COOH (acetic acid) + $C_6H_5NH_2$ (aniline) → $CH_3CO\text{-}NHC_6H_5$ (acetanilide)

Mechanism**:**

Step 1: Protonation of the Amine

$$C_6H_5NH_2 + H^+ \rightarrow C_6H_5NH_3$$

Step 2: Nucleophilic Attack

$$CH_3COOH + C_6H_5NH_3^+ \rightarrow CH_3CO\text{-}OH\text{-}NHC_6H_5$$

Step 3: Elimination

$$CH_3CO\text{-}OH\text{-}NHC_6H_5 \rightarrow CH_3CO\text{-}NHC_6H_5 + H_2O$$

Microwave-Assisted method

Microwave-assisted reactions have gained significant attention due to their ability to enhance reaction rates and improve overall efficiency.

Here is the reaction and mechanism for the microwave-assisted method of acylation of amine

Reaction Example:

CH_3COOH (acetic acid) + $C_6H_5NH_2$ (aniline) → $CH_3CO\text{-}NHC_6H_5$ (acetanilide)

Mechanism**:**

Step 1: Microwave Activation

$$CH_3COOH \rightarrow CH_3CO^* \text{ (microwave activation)}$$

Step 2: Nucleophilic Attack

$$CH_3CO^* + C_6H_5NH_2 \rightarrow CH_3CO\text{-}OH\text{-}NHC_6H_5$$

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Step 3: Elimination

$CH_3CO\text{-}OH\text{-}NHC_6H_5 \rightarrow CH_3CO\text{-}NHC_6H_5 + H_2O$

Therefore, the final product is acetanilide ($CH_3CO\text{-}NHC_6H_5$).

Solvent-free method

Solvent-free methods have emerged as a green alternative to traditional acylation techniques, minimizing the environmental impact of organic solvent use.

Here is the reaction and mechanism for the solvent-free method of acylation of an amine:

Reaction Example:

CH_3COOH (acetic acid) + $C_6H_5NH_2$ (aniline) $\rightarrow$ $CH_3CO\text{-}NHC_6H_5$ (acetanilide)

Mechanism**:**

Step 1: Proton Transfer

$CH_3COOH + C_6H_5NH_2 \rightarrow CH_3COO^- + C_6H_5NH_3^+$

Step 2:

Nucleophilic Attack

$CH_3COO^- + C_6H_5NH_3^+ \rightarrow CH_3CO\text{-}NHC_6H_5$

Biocatalytic method

Biocatalysis refers to the use of biological catalysts, typically enzymes, to facilitate chemical reactions. In the context of acylation, biocatalysts has emerged as a highly selective and sustainable approach,

Here is the reaction and mechanism for the biocatalyst method of acylation of an amine:

Reaction Example:

CH_3COOH (acetic acid) + $C_6H_5NH_2$ (aniline) $\rightarrow$ $CH_3CO\text{-}NHC_6H_5$ (acetanilide)

Mechanism**:**

Step 1: Enzyme Activation

Enzyme (Lipase) + $CH_3COOH \rightarrow$ Enzyme-CH_3COO^- Complex

Step 2: Nucleophilic Attack

Enzyme-CH_3COO^- Complex + $C_6H_5NH_2 \rightarrow$ Enzyme-$CH_3CO\text{-}NHC_6H_5$ Complex

Step 3: Product Release

Enzyme-$CH_3CO\text{-}NHC_6H_5$ Complex $\rightarrow$ $CH_3CO\text{-}NHC_6H_5$ (acetanilide) + Enzyme

V. APPLICATIONS

5.1 Pharmaceuticals:

Acylation of amines plays a crucial role in the synthesis of various pharmaceuticals, including antibiotics, analgesics, and anti-inflammatory agents.[16] This process enables the creation of new compounds with improved properties, such as enhanced stability or activity. For instance, the synthesis of penicillins and cephalosporins, two widely used antibiotics, relies on the acylation of amines. Penicillins are synthesized through the acylation of 6- aminopenicillanic acid with a phenylacetyl group, while cephalosporins are synthesized through the acylation of 7- aminocephalosporanic acid with a phenylacetyl group. Similarly, the synthesis of analgesics such as aspirin and acetaminophen relies on the acylation of amines. Aspirin is synthesized through the acylation of salicylic acid with acetic anhydride, while acetaminophen is synthesized through the acylation of p-aminophenol with acetic anhydride

5.2 Biotechnology:

In biotechnology, acylation of amines is used to modify proteins, synthesize peptides, and modify lipids.[21] This process enables the creation of new compounds with improved properties, such as enhanced stability or activity. For

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example, the synthesis of vaccines and drug delivery systems relies on the acylation of amines.Vaccines are synthesized through the acylation of proteins with adjuvants, while drug delivery systems are synthesized through the acylation of lipids with targeting molecules. Similarly, the synthesis of peptides and proteins relies on the acylation of amines.Peptides are synthesized through the acylation of amino acids with peptide bonds, while proteins are synthesized through the acylation of amino acids with peptide bonds.

5.3 Material sciences:

Acylation of amines is also used in materials science to synthesize polymers, dyes, and pigments.[22] This process enables the creation of new materials with desired properties, such as improved strength or color. For instance, the synthesis of nylon and polyester, two widely used polymers, relies on the acylation of amines. Nylon is synthesized through the acylation of adipic acid with hexamethylene diamine, while polyester is synthesized through the acylation of terephthalic acid with ethylene glycol. Similarly, the synthesis of dyes and pigments relies on the acylation of amines. Dyes are synthesized through the acylation of aromatic compounds with chromophores, while pigments are synthesized through the acylation of inorganic compounds with chromophores.

5.4 Food Industry:

In the food industry, acylation of amines is used to synthesize flavor enhancers, fragrance agents, and food additives.This process enables the creation of new compounds with desired properties, such as improved taste or aroma.For example, the synthesis of monosodium glutamate, a widely used flavor enhancer, relies on the acylation of amines. Monosodium glutamate is synthesized through the acylation of glutamic acid with sodium hydroxide. Similarly, the synthesis of fragrance agents and food additives relies on the acylation of amines. Fragrance agents are synthesized through the acylation of aromatic compounds with fragrance molecules, while food additives are synthesized through the acylation of inorganic compounds with food-grade molecules.

5.5 Agrochemicals

Acylation of amines is used in the synthesis of various agrochemicals. Insecticides, such as pyrethroids, are derived from the natural insecticide pyrethrin and are synthesized through the acylation of amines [23]. Herbicides, such as sulfonylureas, are used to control weeds in crops and are also synthesized through the acylation of amines. Fungicides, such as triazoles, are used to control fungal diseases in crops and are synthesized through the acylation of amines The acylation of amines is an important step in the synthesis of these agrochemicals, as it allows for the introduction of specific functional groups that are necessary for their biological activity.

5.6 Dyes and Pigments

Acylation of amines is used in the synthesis of various dyes and pigments. Azo dyes, which are widely used in textiles, leather, and paper, are synthesized through the acylation of amines [24]. Anthraquinone dyes, which are used in textiles, leather, and paper, are also synthesized through the acylation of amines. Phthalocyanine pigments, which are used in paints, coatings, and plastics, are synthesized through the acylation of amines. The acylation of amines is an important step in the synthesis of these dyes and pigments, as it allows for the introduction of specific functional groups that are necessary for their coloristic properties.

VI. FUTURE OPPORTUNITIES AND DIFFICULTIES

Future research on the acylation of amines should focus on developing greener and more sustainable methods, such as solvent-free, microwave-assisted, and photochemical acylation techniques. These approaches can reduce environmental impact while improving reaction efficiency. The advancement of biocatalytic acylation, particularly through enzyme engineering and immobilization, offers a promising avenue for enhancing catalytic efficiency, selectivity, and industrial applicability. Additionally, exploring regio- and chemoselective acylation strategies will help improve control over product formation, making these reactions more useful for complex molecule synthesis. The development of novel acylating agents, including bio-based or non-traditional acyl donors, could further expand the scope of acylation

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reactions. For large-scale applications, optimizing process conditions through continuous flow chemistry and improved reactor designs will be crucial in enhancing scalability and cost- effectiveness. Furthermore, integrating computational chemistry and artificial intelligence can aid in predictive reaction modeling, catalyst design, and mechanistic studies, ultimately leading to more efficient and controlled acylation processes.

VII. CONCLUSION

A brief summary of amine acylation methodologies is provided in this mini review. It is crucial to explore different catalytic and non-catalytic approaches to enhance reaction efficiency, selectivity, and sustainability. The acylation of amines is a fundamental transformation in organic synthesis, playing a vital role in pharmaceuticals, agrochemicals, and material sciences. Traditional acylation methods, including the use of acyl chlorides and anhydrides, are widely employed due to their efficiency but often require harsh reaction conditions, leading to concerns regarding environmental impact and safety. As a response, alternative methods such as microwave- assisted and solvent-free acylation have emerged, offering advantages such as reduced reaction times, improved yields, and minimized waste generation. Among these approaches, biocatalysis has gained significant attention due to its high selectivity, mild conditions, and eco-friendly nature, making it a promising alternative to conventional chemical methods. However, challenges such as enzyme stability, substrate scope, and industrial scalability need to be addressed through advancements in enzyme engineering and process optimization. Additionally, the integration of green chemistry principles, including the use of renewable catalysts and sustainable solvents, will play a crucial role in the future of acylation research. The adoption of continuous flow chemistry and computational modeling could further enhance reaction control, scalability, and efficiency in industrial applications. As research continues to evolve, acylation methods will become more sustainable, selective, and adaptable to various synthetic applications, ultimately contributing to the advancement of green and efficient organic synthesis.

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Computational Strategies for Deciding NLO Properties

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Abstract: *Non-linear optical (NLO) materials have garnered significant attention in recent years due to their potential applications in photonics, optoelectronics, and quantum computing. Accurate estimation of NLO properties, such as second- and third-order nonlinear susceptibilities, is crucial for designing and optimizing these materials. Computational strategies, including density functional theory (DFT), time-dependent DFT (TDDFT), and post-Hartree-Fock methods, have emerged as powerful tools for estimating NLO properties. These abstract reviews recent advances in computational strategies for estimating NLO properties, highlighting their strengths, limitations, and applications. We also discuss perspectives on future developments, including the integration of machine learning algorithms and the exploration of new materials with enhanced NLO properties.*

Keywords: DFT, TDDFT, NLO. Gauss view

I. INTRODUCTION

In recent years, there has been substantial demand for organic molecules with high nonlinear optical properties than inorganic materials in current use for optical devices. The main cause is that the better performance of the organic materials than the best inorganic materials in order of magnitude. As a consequence, there is a demand for theoretical characterization of nonlinear organic materials. Hence interests in searching and designing new organic materials with the desired linear and nonlinear optical properties.

The objective of this article is to calculate the linear and nonlinear optical properties of organic materials from a first principle. The brief history of the first principle started in In 1926 E. Schrödinger published the paper on wave mechanics and presented the Schrödinger equation for the wave function Ψ of electrons [1].

In 1998 Nobel Prize in chemistry was awarded to John A. Pople for his development of computational methods in quantum chemical techniques embodies in the Gaussian electronic structure codes and to Walter Kohn for his development of the density-functional theory (DFT)[2].Both quoted In their Nobel lectures, a famous remark made by Dirac in 1929 for the successful of the ultimate theory of many electrons by wave-mechanics:

"The fundamental laws necessary for the mathematical treatment of a large part of physics and the whole of chemistry are thus completely known," Unluckily, his amusing statement continues. "And, the difficulty lies only in the fact that application of these laws leads to equations that are too complex to be solved." As an attempt to solve the complex equation from the first principle ab initio Schrödinger produced not only wave-mechanics of electrons electronic structure as an attempt to solve the complex equation. The first working programmable digital computer used in 1938 when Konrad Zuse built the first electro-mechanical binary programmable computer called Z1 with all facilities.

Although Dirac could perhaps not imagine today's exponential progress in digital computing power, his remark that the full treatment of the Schrödinger -Dirac equation is so complicated to solve exactly, except for very small molecules is still correct. About all of these strategies begin from compelling one-electron models in which electrons move freely (Hartree Fock technique) [3] encountering just an average potential because of the impact of other electrons, core nuclei, and external fields. These one-electron wave functions are named atomic orbitals, and since molecules are consist of atoms, an extremely viable procedure has been to grow the molecular orbitals as far as atom-centered atomic orbitals. Unquestionably, this linear combination of atomic orbitals (LCAO) strategy [4] has been accountable for many

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of accomplishments of the initial fifty years of quantum chemistry. The ab initio methods for potential electronic structure can be categorized into two classes. The first category includes wave function-based methods, namely post-Hartree Fock schemes in the the framework of Configuration Interaction or Coupled Cluster schemes which can be used for molecules containing up to a few atoms and are likely to give accurate results. The second category includes density-based methods (DFT) which cover systems between a few tens up to a few hundreds of atoms. It is regularly of far-reaching appropriateness and sensibly precise in numerous cases.

II. PRINCIPAL METHODS FOR THE STUDY OF ELECTRONIC STRUCTURE

There are three primary ways to deal with molecular properties –

i) ab initio methods[5] ii) Semi empirical method[6] and iii)molecular mechanics method [7,8] (Error! Reference source not found.)Schrödinger equation is the fundamental equation as a basic of all Quantum chemical models. It considers molecule as pool of nuclei and electrons, without any considering chemical bonds. The elucidation of the Schrödinger equation is in terms of the motions of electrons, which in turn leads directly to molecular structure and energy among other observables, as well as to information about bonding. However, the Schrödinger equation cannot actually be solved for any electron system (except hydrogen atom), and approximations need to be made. Quantum models vary in the idea of these approximations, and traverse a wide range, both as far as their capacity, consistency, and their cost. The first approximation made is separatel the electronic motion for the nuclear motion.

This was a wonderful approximation since the electrons are significantly lighter than the nuclei and instantly modify their movement to an adjustment in the position of the nuclei. We would then be able to write an expression for the electronic energy of the electrons in the fixed electrostatic field of the nuclei:

$$E_e(R) = E_{kin} + E_{elec\text{-}nuc} + E_{elec\text{-}elec} \quad (1)$$

The energy Ee (R) is written as a function of the fixed nuclear coordinates R Ekin = kinetic energy of the electrons

Eelec–nuc= the attractive interaction between the electrons and the nuclei Eelec–elec= the electron-electron repulsion energy

Decoupling of the electronic motion from the nuclear motion is known as the Born-Oppenheimer approximation introduced by J. Robert Oppenheimer and Max Born.

A further difficulty was expected the last term of eq. (1) electron-electron repulsion. Without this term, it is feasible to utilize the strategy for partition of variables to tackle the Schrödinger equation independently for every electron, except this isn't conceivable when the term is inclusive.

The standard estimation, created by Hartree and Fock, to get rid of this problem is to expect that every electron moves in the average field because of the nuclei and other electrons. The first Hartree strategy communicates the aggregate wave function of the framework as a result of one electron orbitals. In the Hartree-Fock technique, the wave function is an anti-symmetrized determinantal product of one-electron orbitals. Schrodinger's equation is changed into an arrangement of Hartree Fock conditions. The Hartree-Fock guess is likewise known at the self- consistent field (SCF) strategy which starts with a set of approximate orbitals for all the electrons in the molecule. One electron is chosen, and the potential in which it moves is calculated by freezing the distribution of all the other electrons and treating their averaged distribution as the centrosymmetric source of potential. The Schrodinger equation is solved for this potential, which provides a new orbital for it, the procedure is continual for all the other electrons in the system. At the completion of one cycle, there are new orbitals from the original set. The process is repeated until there is little or no change in the orbitals. The square of the atomic orbitals gives the probability density. Usually, molecular orbitals are expressed as linear combinations of atomic orbitals (LCAO), the sum of atomic orbitals centered on each nucleus.

Due to the central field approximation, the energies from HF counts are constantly more than the exact energy and tend to a limiting value called the Hartree-Fock limit as the basis set is improved. Inside HF hypothesis the possibility of finding an electron at some point around an atom determined by the distance from the nucleus but not the distance to the other electrons. A number of types of calculations begin with an HF calculation and various sorts of computations start with an HF calculation and then correct for correlation.

Some of these methods are Moller-Plesset perturbation theory (MPn, where n is the order of correction), configuration interaction (CI), coupled cluster theory (CC), the generalized valence bond (GVB) method, multi-configurational self-

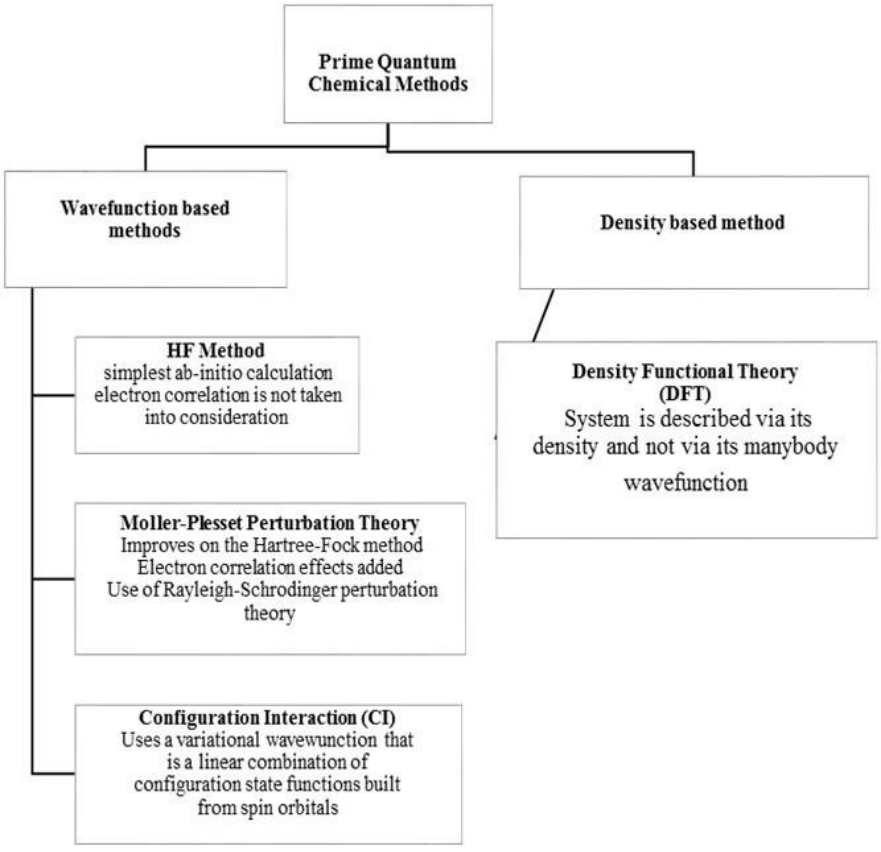
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consistent field (MCSCF), and Density Functional theory (DFT)at that point amend for connection. Some of these strategies are Moller-Plesset annoyance hypothesis (MPn, where n is the request of redress), the summed up valence bond (GVB) strategy, multi-configurational self-consistent field (MCSCF), setup collaboration (CI), and coupled group hypothesis (CC) and Density Functional hypothesis (DFT).

In recent years Density practical hypothesis (DFT) has turned out to be extremely popular. This is supported by the pragmatic observation that it is less computationally exhaustive than other methods. The preface behind DFT is that the vitality of a particle can be resolved from the electron density rather than a wave function. This hypothesis began with a hypothesis by Hoenberg and Kohn that expressed this was conceivable. The first hypothesis connected just to finding the ground-state electronic energy of a molecule. A practical claim of this theory was developed by

Kohn and Sham who framed a method similar in structure to the Hartree-Fock method. In general, ab initio designs give very good qualitative outcomes and can yield increasingly precise quantitative results as the molecules chosen become smaller. The benefit of ab initio methods is that they eventually converge to the exact solution once all the approximations are made adequately small in magnitude.

Semi empirical calculations are set up with the same general structure as a HF calculation in that they have a wave function and Hamiltonian. Generally, the core electrons are not encompassed in the calculation and only a minimal basis set is used. Also, some of the two electron integrals are omitted. In order to rectify the errors introduced by omitting part of the calculation, the method is parameterized. Parameters to estimate the omitted values are obtained by getting the outcomes to experimental data or ab initio calculations. Often, these parameters replace some of the integrals that are excluded. The only advantage of semi empirical calculations are that they are much quicker than ab initio calculations. The shortcoming of semi empirical calculations is that the results can be uneven and fewer properties can be predicted reliably



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Advantages:

One important benefit of DFT is that DFT scales three dimensionally, or as N3, (N = number of basis functions). On the other hand Ab-initio methods, scale as N4. Hence DFT calculations are slightly faster with enhanced accuracy. DFT includes some component of electron correlation for much the same computational cost as HF methods. It is a highly efficient way of performing a more advanced calculation of the system. DFT can also perform calculations on transition metals that is not possible with ab-initio methods.

Disadvantages:

The computational chemist must make decisions about which DFT method or functional and basis set to use for a particular application. For example, the BLYP the method is considered by some to be appropriate for transition metal applications, but not for all organic compounds.

III. APPLICATION OF QUANTUM CHEMICAL METHODS IN GEOMETRY OPTIMIZATION

Geometry Optimization is a process that tries to find the configuration of minimum energy of the molecule. A sensible starting point for geometry optimization is to use experimental data. The energy and wave functions are computed for the initial guess of the geometry, which is then modified iteratively until (I) an energy minimum has been identified and (II) forces within the molecules are zero.This can often be difficult for non-rigid molecules, where there may be several energy minima, and some effort may be essential to find the global minimum. But in those cases where molecules have unknown or unconfirmed structures, geometry optimization can also be used to locate minima on a potential energy surface (PES).

An input geometry is provided for geometry optimization and the calculation proceeds to move across the PES. At each point the energy, as well as gradient, are calculated and the distance with the direction of the next step are determined. The force constants are generally estimated at each point and these constants specify the curvature of the surface at that point; this provides supplementary information useful to determining the next step. Convergence criteria about the forces at a given point and the displacement of the next step determine whether a stationary point has been found. To determine whether the geometry optimization has found a minimum or a transition state (TS), it is required to perform frequency calculations. A TS is a point that links two minima on the PES and is characterized by one imaginary frequency. The eigenvector from the Hessian force constant matrix determines the nature of the imaginary frequency and indicates a possible reaction coordinate. A minimum structure will have no imaginary frequencies.

IV. METHODS FOR MOLECULAR ELECTRONIC HYPERPOLARIZABILITY CALCULATIONS

Most common methods currently implemented are three methods-the finite field, sum-over-states (SOS), and time-dependent Hartree-Fock methods-encompass the vast majority of NLO property calculations being performed today and are implemented in several readily available molecular orbital computer programs

Finite Field Method

It is the simplest method for obtaining nonlinear optical properties of molecules. This method was first used by Cohen and Roothaanzs to calculate atomic polarizabilities at the Hartree- Fock level.

Main advantages of finite field method: -

(1) Easy to implement, and

(2) Applied to a wide range of quantum mechanical methods.

Disadvantages of the finite field method: -

It is limited to static field therefore not give values directly related to most experiments.

Sum-Over-States Method

The most familiar expressions for obtaining nonlinear optical properties are the expressions derived from time-dependent perturbation theory.This procedure is straightforward and has been described in detail equations can be used to obtain frequency-dependent properties.

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V. GRAPHICAL USER INTERFACE FOR GAUSSIAN 09 - GAUSS VIEW

Gauss view is a reasonable, full-featured graphical user interface for Gaussian 09[9].With the help of Gauss view, one can prepare input for submission to Gaussian and to examine graphically the output that Gaussian produces. The first step in producing a Gaussian input file is to build the desired molecule. The bond lengths, bond angles, and dihedral angles for the molecule will be used by Gauss view to write a molecular structure for the calculation. Gauss view incorporates an excellent Molecule Builder. One can use it to rapidly sketch in molecules and examine them in three dimensions. Molecules can be built by atom, ring, group. Gauss view

is not integrated with the computational the module of Gaussian, but rather is a front-end or back-end processor to aid in the use of Gaussian. Gauss view can graphically display a variety of Gaussian calculation results, including the following

- Molecular orbitals
- Atomic charges
- Surfaces from the electron density, electrostatic potential.
- Surfaces can be colored by a separate property.
- Animation of the normal modes corresponding to vibrational frequencies.
- Animation of the steps in geometry optimizations, potential energy surface scans.

Quantum chemical calculations have been shown to be useful in the description of the relationship between the electronic structure of the systems and its NLO response. The computational approach allows the determination of molecular NLO properties as an inexpensive way to design molecules by analyzing their potential before synthesis and to determine high-order hyperpolarizability tensors of molecules [10]. The polarizability (α), characterizes the ability of an electric field to distort the electronic distribution of a molecule. Higher order polarizability (hyperpolarizabilities β, γ) which describes the non-linear response of atoms and molecules. They are related to a wide range of phenomena from non-linear optics to intermolecular forces, such as the stability of chemical bonds, as well as, the conformation of molecules. The elements of these tensors from derivatives of the dipole moment with respect to the electric field can also be determined. In the presence of an applied field, the energy of the system is a function of the electric field and the first hyperpolarizability is a third rank tensor that can be described by a 3×3×3 matrix. It strongly depends on the method and basis set used. The 27 components of the 3D matrix can be reduced to ten components because of the Kleinman symmetry [11]. The matrix can be given in the lower tetrahedral format. It is obvious that the lower part of the 3×3×3 matrixes is tetrahedral. The components of β are defined as the co-efficient in the Taylor series expansion of the energy in the external electric field. When the external electric field is weak and homogeneous, this expansion becomes:

$$E = E^0 - \mu_\alpha f_\alpha - \frac{1}{2\alpha_{\alpha\beta}F_\alpha F_\beta} - f\frac{1}{6\beta_{\alpha\beta\gamma}F_\alpha F_\beta F_\gamma} \ldots\ldots (2)$$

where E° is the energy of the unperturbed molecules, Fα is the field at the origin, μα, ααβ and βαβγ are the components of dipole moment, polarizability, and the first hyperpolarizabilities respectively. The equations for calculating the magnitude of total static dipole moment (μ), the mean polarizability (α0), the anisotropy of the polarizability (Δα) the mean first hyperpolarizability (βo) and static second hyperpolarizability (γ), using the x, y, z components from Gaussian 09W output are defined as follows

The strength of optical response depends on the electrical properties of the whole material, which for molecules can be related to the polarizability (α, linear response) and hyperpolarizabilities (β, γ, etc. nonlinear responses). The static second-order polarizability or first hyperpolarisability (β) and its related properties for NLOphores were calculated on the basis of the finite-field approach

[12] The equations for calculating the magnitude of total static dipole moment (μ), the mean polarizability (α0), the anisotropy of the polarizability (Δα) the mean first hyperpolarizability (βo) and static second hyperpolarizability (γ), using the x, y, z components from Gaussian 09W output are defined as follows .

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The total static dipole moment μ is expressed as:

$$\mu = \sqrt{\mu_x^2 + \mu_y^2 + \mu_z^2} \ldots\ldots(3)$$

The isotropic polarizability can be calculated from the trace of the polarization tensor,

$$\alpha_0 = \frac{(\alpha_{xx} + \alpha_{yy} + \alpha_{zz})}{3} \ldots\ldots(4)$$

Anisotropy of the polarizability Δα is expressed by

$$\Delta\alpha = 2^{-1/2}\left[(\alpha_{xx} + \alpha_{yy})^2 + (\alpha_{zz} + \alpha_{xx})^2 + 6\alpha_{xx}^2\right] \ldots\ldots(5)$$

The mean first polarizability (β0) is expressed by

$$\beta_0 = (\beta_x^2 + \beta_y^2 + \beta_z^2)^{1/2} \ldots\ldots(6)$$

where, βx, βy, and βz are the components of the second order polarizability tensor along the x, y and z axis. The equation for mean second hyperpolarizability (γ) is

$$\gamma = \frac{1}{5}[(\gamma_{xxxx} + \gamma_{yyyy} + \gamma_{zzzz}) + 2(\gamma_{xxyy} + \gamma_{yyzz} + \gamma_{zzxx})] \ldots\ldots (7)$$

The fundamental limits of NLO response for the push-pull chromophores are obtained by the limiting theory proposed by Kuzyk[13,14]

The limit for β* is obtained from eq.8in different solvents using their respective refractive indices (n).

$$\beta_{2L}^{SR} \leq \sqrt[4]{3}\left(\frac{n^2+2}{3}\right)^3 \left(\frac{e\hbar}{\sqrt{m}}\right)^3 \frac{N^{3/2}}{E_{10}^{7/2}} \qquad (8)$$

e and m are the charge and mass of the electron. ħ = *h*/2*π*.

Similarly, the limit for the second order hyperpolarizability (γ) can be estimated by eq. 9 [15,16] The γ values have two possible fundamental limits for the i.e. negative limit which is for a centrosymmetric molecule and positive limit for an asymmetric molecule.

$$-\frac{e^4\hbar^4}{\ldots}\left(\frac{N^2}{E_{10}^5}\right) \leq \gamma \leq 4\frac{e^4\hbar^4}{m}\left(\frac{N^2}{E_{10}^5}\right) \qquad (9)$$

In D-π-A organic molecules generally, vibrations are strongly coupled with conjugated electrons in the system. Hence along with the electronic transitions, the vibrational transitions play important role in determining the NLO properties. The coupling between the electronic polarization and vibration leads to a considerable vibrational contribution to the overall NLO response[17]. In this context, the DFT is a very good computational tool to study the vibrational contribution to polarizability and hyperpolarizabilities of NLO phores [18,19].

VI. CONCLUSION

This article elaborates recent advances in computational strategies for estimating NLO properties, highlighting their strengths, limitations, and applications.

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Knowledge to Action: Research and Innovation as Engines of Societal Change

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Abstract: *Research and innovation serve as the cornerstones of societal advancement, fostering economic growth, technological development, and cultural enrichment. This research paper delves into the multifaceted dimensions of research and innovation, exploring their definitions, significance, methodologies, and global impact. Employing a qualitative methodology, the study analyses academic literature, policy documents, and case studies to highlight the transformative power of research and innovation in various sectors. The paper concludes with recommendations for enhancing research capabilities and fostering an innovation- driven ecosystem.*

Keywords: Research, Innovation, Societal Progress, Technological Development, Economic Growth, Policy Frameworks

I. INTRODUCTION

Research and innovation play a fundamental role in shaping modern societies by driving progress across scientific, technological, economic, and cultural domains. They serve as the cornerstones of development, enabling nations and organizations to remain competitive in an ever-evolving global landscape. The dynamic interplay between research, which is dedicated to generating new knowledge, and innovation, which focuses on the application of this knowledge to create tangible value, is crucial for addressing contemporary challenges and fostering long- term growth.

Research involves systematic inquiry, experimentation, and analysis to uncover new theories, methodologies, and applications. It forms the backbone of scientific and technological advancements, providing a solid foundation for evidence-based decision-making and policy formulation. By exploring uncharted territories, research expands the frontiers of human understanding, paving the way for groundbreaking discoveries in medicine, engineering, environmental sciences, artificial intelligence, and numerous other disciplines.



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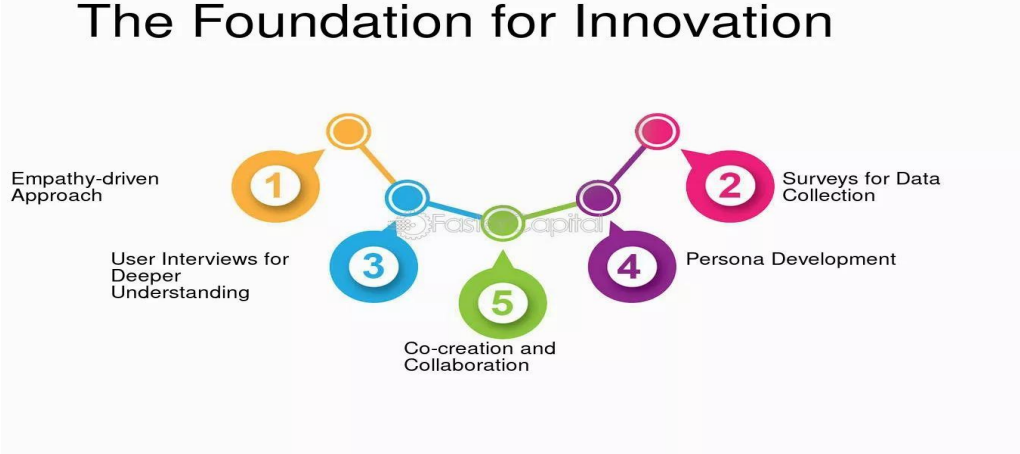
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Innovation, on the other hand, translates theoretical insights into practical solutions that improve lives, enhance industries, and contribute to economic prosperity. It bridges the gap between research findings and real-world applications, enabling societies to harness the full potential of scientific and technological progress. Innovation not only leads to the development of new products, services, and business models but also drives efficiency, sustainability, and resilience in various sectors, including healthcare, energy, communication, and education.

This paper aims to provide an in-depth analysis of the role of research and innovation in fostering societal progress. It explores their impact on economic development, technological breakthroughs, and human well-being while highlighting key challenges, trends, and policy considerations. By examining case studies and real-world examples, this study seeks to underscore the transformative power of research and innovation in building a more prosperous and sustainable future.

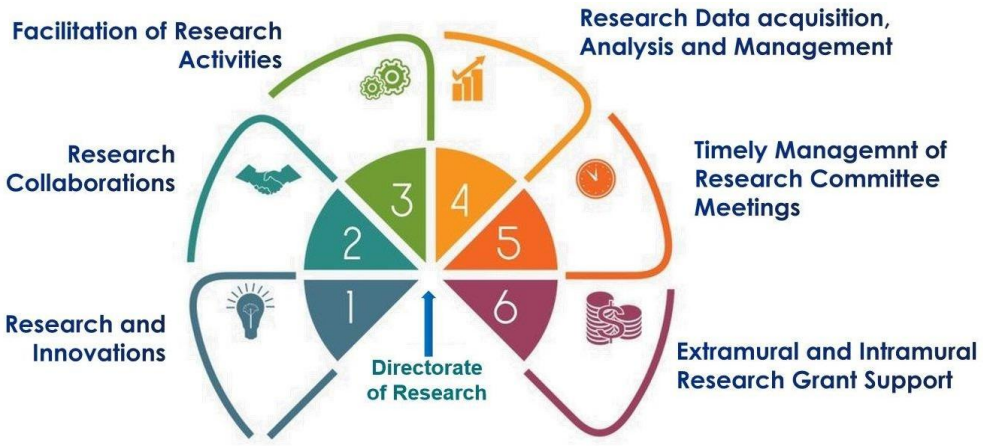
II. METHODOLOGY

The study employs a qualitative research methodology, focusing on an extensive content analysis of scholarly articles, policy reports, and empirical case studies. The data sources include peer-reviewed academic journals, government white papers, industry analyses, and reports from international organizations involved in research and innovation. This methodology allows for a comprehensive understanding of the evolving research and innovation landscape by identifying emerging patterns, best practices, and strategic policy frameworks



Additionally, the study integrates a comparative analysis of global case studies to highlight how different regions and countries approach research and innovation. This comparative method helps in recognizing key success factors, potential barriers, and scalable models applicable to different socioeconomic and technological contexts. The research methodology also includes a systematic literature review, drawing from interdisciplinary sources to ensure a holistic perspective on the subject. The data is examined using thematic analysis, categorizing findings into economic, technological, social, and cultural dimensions.

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III. THEORETICAL FRAMEWORK

Definition and Scope:

Research is a structured and systematic process aimed at generating new insights, knowledge, or solutions to existing problems. It encompasses various methodologies, including experimental studies, observational research, and theoretical analysis.

Innovation is the practical application of research outputs to develop new products, processes, or services that create value in industries and society. It serves as a bridge between knowledge creation and real-world implementation.

Types of Research:

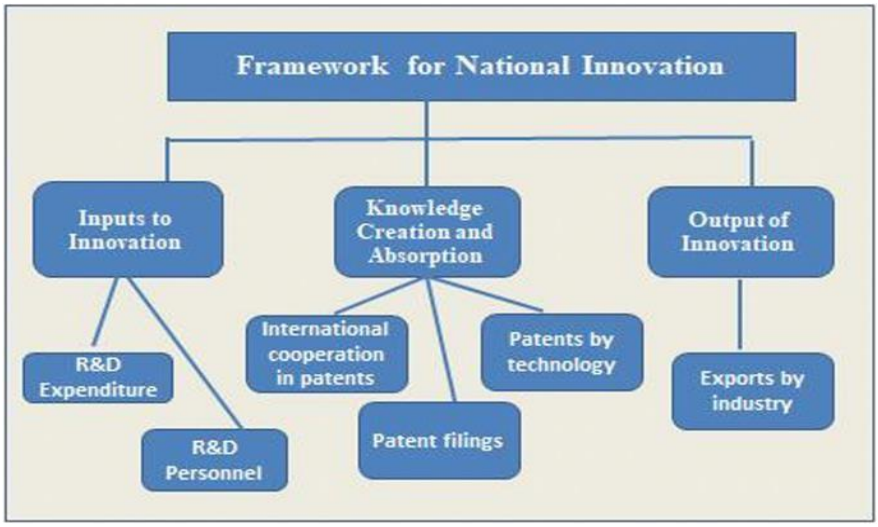
- **Basic Research:** Theoretical investigations that expand fundamental knowledge without immediate practical applications, often conducted in academic and institutional settings.
- **Applied Research:** Focused on solving specific real-world problems, translating theoretical knowledge into practical solutions for industries and businesses.
- **Translational Research:** Bridges the gap between laboratory discoveries and their real-world applications, particularly in fields such as medicine, engineering, and information technology.

Innovation Models:

- **Linear Model:** A traditional approach where research leads to development and finally results in commercialization, following a step-by-step sequence.
- **Open Innovation:** Encourages collaboration among multiple stakeholders, including universities, industries, startups, and government bodies, to drive advancements beyond institutional boundaries.
- **Disruptive Innovation:** Introduces groundbreaking changes that challenge established markets and industries, often leading to significant shifts in business models and consumer behaviour.

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Significance of Research and Innovation:

Economic Development:

Research and innovation contribute significantly to GDP growth by driving industrial advancements and technological progress.

They generate high-value employment opportunities in cutting-edge fields such as artificial intelligence, biotechnology, and sustainable energy.

Enhancing global competitiveness by enabling businesses and nations to develop unique intellectual property, thereby strengthening their positions in international markets.

Technological Advancement:

The development of next-generation technologies such as artificial intelligence, the Internet of Things (IoT), blockchain, and quantum computing.

Increased efficiency in industrial processes through automation, data-driven decision-making, and smart solutions.

Creation of innovative healthcare solutions, renewable energy systems, and intelligent infrastructure to address modern-day challenges.

Social Impact:

Addressing critical societal issues such as public health, climate change, and sustainable urban development through research-driven solutions.

Strengthening education and workforce skills development to meet the demands of emerging job markets.

Enhancing healthcare accessibility, agricultural productivity, and environmental sustainability through evidence-based innovations.

Cultural Enrichment:

Promoting creativity, critical thinking, and problem-solving skills essential for fostering a culture of continuous innovation.

Encouraging interdisciplinary research that integrates cultural values with scientific progress, ensuring holistic societal growth.

Supporting artistic, literary, and design innovations that contribute to preserving heritage and fostering cultural identity in the digital era

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Global Trends in Research and Innovation:

Emerging Technologies:

Rapid advancements in artificial intelligence, biotechnology, renewable energy, nanotechnology, and space exploration are transforming industries.

Ethical considerations, policy regulations, and governance mechanisms are becoming increasingly important to ensure responsible innovation.

The role of digital transformation in accelerating research capabilities, enabling big data analytics, and facilitating AI-driven discoveries.

International Collaboration:

Strengthening global research networks through cross-border partnerships, facilitating knowledge exchange and cooperative scientific advancements.

Formation of international research consortiums, such as those in climate science, medical research, and sustainable technology development, to tackle complex global challenges

Increased academic and corporate collaborations to drive multinational research initiatives in areas like space exploration, cybersecurity, and next-generation computing.

Funding Mechanisms:

Increased public and private sector investments in research and development, ensuring continuous support for groundbreaking discoveries.

Expansion of venture capital funding for technology-driven startups, enabling faster commercialization of innovative ideas.

Government initiatives and incentives to support R&D activities, including tax benefits, grants, and infrastructure development for research institutions.

By examining these dimensions, the study aims to provide valuable insights into the role of research and innovation in shaping the future of economies, societies, and technological progress.

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Challenges in Research and Innovation in India

India, as a developing nation with vast human resources and growing economic potential, faces several challenges in advancing research and innovation. While India has made significant progress in areas like space research, pharmaceuticals, and information technology, there are still structural and systemic barriers that hinder its full potential. Below are the key challenges in research and innovation, specifically in the Indian context:

Resource Constraints

- **Limited Funding:** Although India has increased research funding in recent years, the total expenditure on R&D is still only around 0.7% of GDP, compared to over 2-3% in developed nations like the USA, Germany, and China. The lack of substantial government and private sector investment hinders the pace of innovation.
- **Infrastructure Deficiency:** Many Indian universities and research institutions lack state-of- the-art laboratories, high-tech equipment, and world-class facilities. This leads to delays in research output and reduces the quality of innovation.
- **Brain Drain:** Due to inadequate research opportunities and lower compensation in India, many talented researchers migrate to developed countries for better prospects



1. Policy Barriers

- **Bureaucratic Red Tape:** Lengthy and complex approval processes for research projects, patents, and funding disbursement slow down innovation. Researchers often face delays in obtaining necessary clearances for experimentation and collaboration.
- **Regulatory Hurdles:** Compliance with multiple regulatory authorities, especially in sectors like biotechnology, pharmaceuticals, and defense research, creates bottlenecks in project execution.
- **Lack of Long-Term R&D Policies:** While India has introduced policies like the National Innovation and Startup Policy, frequent policy shifts and lack of continuity affect long-term research projects.
- Skill Gaps
- **Shortage of Skilled Researchers:** While India produces a large number of graduates in science and technology, only a small fraction engage in research due to limited incentives and career prospects.
- **Outdated Educational Curriculum:** Many Indian universities still follow outdated syllabi that do not align with contemporary research demands. There is a lack of focus on critical thinking, problem-solving, and industry-oriented research skills.
- **Limited Industry Exposure:** Indian research institutions and universities often do not offer adequate exposure to industry practices, leading to a disconnect between theoretical knowledge and practical applications

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Case Studies from an Indian Perspective

The Rise of India's IT and Startup Ecosystem

The IT sector in India, particularly in Bengaluru (India's Silicon Valley), has flourished due to government support, skilled manpower, and foreign investment.

The success of Indian startups like Flipkart, Paytm, and Byju's highlights the potential of digital innovation despite funding constraints

ISRO – A Story of Indigenous Excellence

The Indian Space Research Organisation (ISRO) has established itself as a global leader in cost-effective space missions. The Mars Orbiter Mission (Mangalyaan) was developed at just $74 million, far cheaper than similar missions by NASA and ESA.

ISRO's ability to develop indigenous technology despite budget limitations showcases India's research potential when supported by strategic policies.

COVID-19 Vaccine Development in India

Indian companies like Bharat Biotech (Covaxin) and Serum Institute of India (Covishield) played a crucial role in vaccine development and mass production.

India's rapid vaccine production and distribution demonstrated its ability to innovate and manufacture at scale, despite initial resource limitations.

Challenges in Indian Agriculture Research

India's agricultural research has led to significant achievements, such as the Green Revolution. However, challenges like climate change, declining soil health, and lack of high-tech research facilities hinder progress in sustainable agriculture.

Policy Recommendations for Strengthening Research & Innovation in India

Strengthening Research Infrastructure

Increase public and private sector investments in research infrastructure, laboratories, and innovation hubs.

Establish national-level research centers focused on key areas like AI, biotechnology, quantum computing, and clean energy.

Upgrade university laboratories with cutting-edge technologies to support experimental research.

Fostering Industry-Academia Collaboration

Encourage partnerships between universities and industries to develop market-ready innovations.

Create joint research projects and internship programs where students and researchers can work with companies.

Establish incubation centers in universities to nurture startups based on academic research.

Enhancing Funding Opportunities

Promote diversified funding sources, including venture capital, private equity, and CSR funds for research projects

Introduce research grants and scholarships to encourage young scientists and researchers.

Strengthen government initiatives like the National Research Foundation (NRF) to provide sustained funding.

Promoting a Culture of Innovation

Integrate research-oriented education at all levels to develop critical thinking skills from an early age.

Encourage entrepreneurship through startup incubation programs, hackathons, and innovation competitions.

Provide incentives such as tax benefits and reduced regulatory burdens for research- driven startups.

By addressing these challenges and implementing the right policies, India can establish itself as a global leader in research and innovation, driving economic growth and technological advancement.

Conclusion: The Roadmap for Research and Innovation in India

Research and innovation are the cornerstones of a nation's progress, serving as catalysts for economic growth, technological advancements, and societal well-being. For a country like India, which is poised to become a global leader in various domains, fostering a strong research and innovation ecosystem is not just desirable but imperative.

The Significance of Research and Innovation in India's Growth

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India's rapid advancements in space exploration, pharmaceuticals, information technology, and agriculture have demonstrated the immense potential of indigenous research and innovation.

However, for sustained progress, a proactive approach is needed to integrate scientific research with national development goals. Research-driven advancements in renewable energy, artificial intelligence, biotechnology, and sustainable agriculture can help India tackle pressing challenges such as climate change, healthcare crises, food security, and energy dependency.

Additionally, innovation plays a crucial role in generating employment, boosting industrial productivity, and enhancing India's global competitiveness. With a large youth population and a growing knowledge-based economy, India has the opportunity to lead the world in disruptive innovations, provided the right ecosystem is in place



Creating an Enabling Environment for Research and Innovation

To maximize India's research potential, it is crucial to establish an ecosystem that nurtures talent, provides adequate resources, and ensures global competitiveness. The following key aspects must be strengthened:

Strengthening Policy and Regulatory Frameworks

Implement long-term research policies with sustained government support to ensure consistency in funding and strategic direction.

Simplify bureaucratic procedures and regulatory approvals to encourage faster execution of research projects.

Establish a centralized national body to oversee multidisciplinary research initiatives, ensuring synergy among various sectors.

Enhancing Research Infrastructure and Institutional Support

Upgrade research laboratories in universities and public institutions to world-class standards.

Develop innovation hubs and technology parks in collaboration with private industries to provide research facilities and incubation support.

Strengthen the role of institutions like the Council of Scientific and Industrial Research (CSIR), the Indian Institute of Science (IISc), and IITs in driving cutting-edge research.

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Expanding Funding Mechanisms

Increase budgetary allocation for R&D beyond the current 0.7% of GDP, aiming for at least 2% in the next decade.
Encourage private sector participation through tax incentives, research grants, and industry collaborations.
Promote venture capital funding and corporate social responsibility (CSR) contributions for research-driven startups and innovative projects.
Building a Strong Talent Pipeline
Reform the education system to integrate research-oriented learning from early academic stages.
Introduce specialized research fellowships and scholarships to attract and retain top talent in India.
Strengthen vocational training and skill development programs to align research activities with industry needs.
Encouraging Global Collaborations and Technology Transfer
Facilitate international partnerships with leading research institutions to drive knowledge exchange.
Promote joint ventures and technology-sharing agreements with foreign universities and industries.
Participate in global research initiatives addressing challenges like climate change, cybersecurity, and pandemic preparedness.

The Need for Continuous Investment and Commitment

India's future as a knowledge-driven economy depends on its ability to continuously invest in research and innovation. Countries like the USA, Germany, and South Korea have demonstrated that sustained investment in R&D leads to long-term economic and technological leadership. For India to achieve similar success, it must:
Foster a research culture that encourages curiosity, creativity, and risk-taking.
Bridge the gap between academia, industry, and policymakers to ensure that research outcomes are effectively translated into real-world applications.
Prioritize innovation-driven entrepreneurship to create a self-reliant and globally competitive economy



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By addressing these crucial areas, India can harness the full potential of research and innovation, paving the way for scientific breakthroughs, sustainable economic growth, and societal transformation. The coming decade presents a golden opportunity for India to emerge as a global hub of knowledge and technology, provided the right investments, policies, and cultural shifts are made today.

IV. CONCLUSION ON REFERENCES AND FURTHER RESEARCH

These references provide a holistic understanding of India's research and innovation landscape by integrating global frameworks with India-specific policies, reports, and case studies. By leveraging these sources, researchers, policymakers, and industry leaders can develop actionable strategies to strengthen India's innovation ecosystem. Future research should focus on emerging fields such as artificial intelligence, quantum computing, biotechnology, and sustainable energy to ensure India's leadership in global innovation.

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ii. Atal Innovation Mission (AIM), NITI Aayog. (2021). Fostering a Culture of Innovation in Indian Schools and Universities. Retrieved from https://aim.gov.in

iii. This initiative promotes innovation at the grassroots level, encouraging research and entrepreneurship among students

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The Integration of AI into Daily Routines

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Abstract: *The pervasive integration of AI is actively redefining everyday life, impacting everything from technology interactions to decision-making and task management.We explore the tangible effects of AI across healthcare, education, transportation, and personal productivity, showcasing its ability to enhance efficiency, accessibility, and personalization through real-world examples and current trends. While AI offers significant advantages, we must acknowledge and address the challenges of privacy and job displacement. A proactive approach to ethical considerations is essential as we move forward. Understanding AI's current role and future potential is crucial for ensuring its responsible deployment, leading to a more streamlined and equitable future.*

Keywords: Artificial Intelligence (AI), Applications ,Risks

I. INTRODUCTION

Surveys: As a researcher studying the impact of artificial intelligence (AI) on daily life, I follow a systematic methodology. I define clear objectives focusing on AI's influence on work, communication, entertainment, and decision-making. A diverse demographic is surveyed to capture varied perspectives. I create a structured questionnaire for quantitative and qualitative responses, collecting data primarily online. Analysis includes statistical examination of quantitative data and thematic analysis of qualitative insights. Results are presented using visual aids for clarity.

Throughout, I adhere to ethical protocols to ensure participant confidentiality and data integrity, ultimately enhancing the understanding of AI's role in contemporary life

Data Analysis: To analyze the impact of Artificial Intelligence (AI) on everyday life, we identify focus areas like work and communication, and set goals for insights on user perceptions. Data is collected through a demographic survey with quantitative Likert scale questions and qualitative open-ended responses. Quantitative analysis involves statistical methods to assess trends, while qualitative analysis employs thematic analysis to uncover common themes. Results are presented using visual aids, highlighting insights such as increased efficiency and concerns about privacy. Ethical considerations ensure participant confidentiality, fostering responsible AI discussions and informing future societal implications

II. LITERATURE REVIEW

The impact of Artificial Intelligence (AI) on everyday life has been widely studied, revealing both benefits and challenges. Research shows that AI enhances efficiency by automating routine tasks, particularly in sectors like healthcare and transportation (Jiang et al., 2017; Zhang et al., 2020). This automation not only speeds up processes but also allows professionals to focus on more complex issues. Additionally, AI improves accessibility, providing personalized learning experiences in education and expanding telemedicine services to remote areas (Luckin et al., 2016; Keesara et al., 2020).

However, the adoption of AI raises important ethical concerns. Issues such as privacy, data security, and the potential loss of jobs due to automation are significant (O'Neil, 2016; Bessen, 2019). These challenges highlight the need for ongoing research to develop ethical guidelines that ensure AI is used responsibly. Understanding how AI reshapes our daily lives is crucial for recognizing its future effects. Overall, while AI offers many advantages, it is essential to address its risks to create a fair and efficient society.

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III. RESULTS AND DISCUSSION

The survey reveals that 70% of respondents do not use AI daily, with privacy (40%) being the biggest concern, followed by job security (30%). Virtual assistants (50%) and recommendation systems (40%) are the most commonly used types of AI. Despite concerns, 60% believe AI is beneficial, indicating a positive perception of its potential. However, 20% remain unsure, highlighting the need for increased education about AI's advantages. These findings emphasize the importance of addressing ethical considerations in AI development and ensuring responsible use to alleviate public concerns.

A	B	C	D
Question	Option/Category	Count	Percentage
Use AI daily?	Yes	30	30%
	No	70	70%
Biggest AI concern	Privacy	40	40%
	Job Security	30	30%
	Bias	20	20%
Types of AI used (select all that apply)	Virtual Assistants	50	50%
	Recommendations	40	40%
	Navigation	20	20%
Believe AI is beneficial?	Yes	60	60%
	No	20	20%
	Unsure	20	20%

Table1: Survey: AI Usage and Concerns (N = 100)

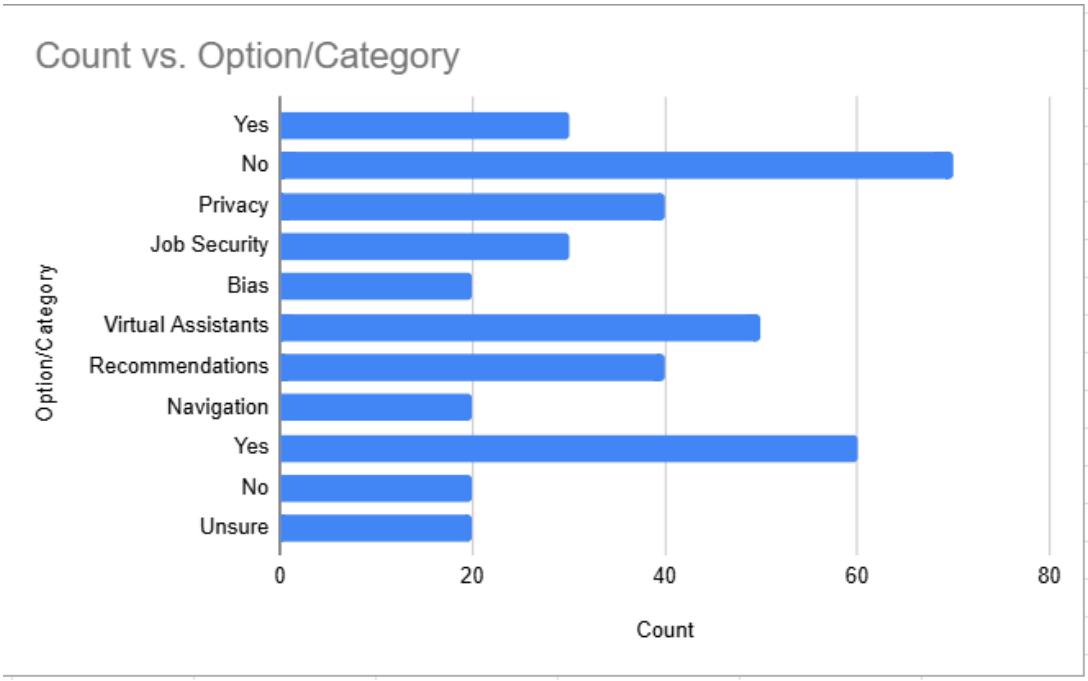


Fig:1 Count vs Category

IV. CONCLUSION

In conclusion, the integration of Artificial Intelligence (AI) has significantly transformed various sectors, enhancing efficiency and personalization. While many respondents recognize the productivity gains, ethical concerns regarding

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privacy and job displacement remain critical issues. A balanced approach is essential for responsible AI implementation, requiring collaboration among developers, policymakers, and the public to create frameworks that maximize benefits while minimizing risks. As AI continues to evolve, fostering user trust and addressing ethical dilemmas is crucial. Ongoing exploration and education about AI will enable society to navigate its complexities, ensuring a future where its advantages are equitably realized.This collaborative effort will not only enhance the understanding of AI's potential but also empower individuals to engage in informed discussions about its implications, ultimately shaping a future that prioritizes ethical considerations alongside technological advancements.

ACKNOWLEDGMENTS

I would like to express my heartfelt gratitude to everyone who contributed to the completion of this research paper on the impact of Artificial Intelligence on everyday life. My deepest thanks go to my advisor, for their invaluable guidance and support throughout this research journey. I am also thankful to the participants of the surveys and interviews, whose insights enriched this study. Special appreciation goes to my colleagues and peers from [Anjuman Islam Janjira degree college of science Murud] for their constructive feedback and encouragement, which helped refine my ideas. Additionally, I acknowledge the authors of the literature referenced in this paper, whose previous work inspired my exploration of AI's societal implications. Lastly, I extend my sincere appreciation to my family and friends for their unwavering support and belief in my abilities. Your encouragement has motivated me to strive for excellence. Thank you all for your contributions to this research endeavor.

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A Comprehensive Study on Efficient One-Step Multicomponent Synthesis of 1,4-Dihydropyridines Using Green Catalyst

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D.G Tatkare Mahavidyalay Mangaon- Raigad

Abstract: *In the pursuit of sustainable and environmentally benign synthetic methods, this study introduces a novel one-step multicomponent synthesis of 1,4-dihydropyridines (1,4-DHPs) employing a green catalyst. The 1,4-DHP framework is a core structural motif in numerous bioactive molecules and pharmaceuticals, and its efficient synthesis under mild and eco-friendly conditions is of significant interest in modern organic chemistry. Our approach integrates the principles of green chemistry with innovative catalytic design, enabling the rapid assembly of 1,4-DHPs from readily available starting materials in a single operational step.The reaction protocol utilizes an environmentally benign catalyst that is non-toxic, biodegradable, and readily recyclable. The catalyst facilitates a simultaneous condensation, cyclization, and reduction process, effectively lowering the activation energy of the transformation. Mechanistic investigations indicate that the catalyst promotes the formation of a key reactive intermediate, which subsequently undergoes nucleophilic addition and intramolecular cyclization to furnish the dihydropyridine core. This streamlined, multicomponent reaction circumvents the need for multiple purification steps, significantly reducing waste and energy consumption compared to conventional multi-step synthetic routes.A series of experiments were conducted to evaluate the efficiency and scope of the protocol. Reaction conditions were optimized to achieve high yields and selectivity under ambient or slightly elevated temperatures. The green catalyst exhibited remarkable tolerance towards a diverse array of functional groups, thus allowing the synthesis of a wide range of substituted 1,4-DHP derivatives.. Furthermore, kinetic studies provided valuable insights into the reaction mechanism, affirming that the green catalyst substantially accelerates the reaction rate by stabilizing the transition state. By integrating renewable materials and sustainable practices, this method addresses critical environmental concerns while maintaining high efficiency and selectivity in product formation. Overall, the developed protocol represents a significant advancement in the field of heterocyclic synthesis, providing a robust platform for the generation of 1,4-DHPs with broad applications in medicinal chemistry and materials science.*

Keywords: 1,4-Dihydropyridines, One-Step Synthesis, Multicomponent Reaction, Green Catalyst, Sustainable Synthesis, Eco- Friendly Chemistry.

I. INTRODUCTION

1,4-Dihydropyridines (1,4-DHPs) represent an essential class of nitrogen-containing heterocyclic compounds with diverse pharmaceutical and biological applications. Since their discovery, 1,4-DHPs have been widely recognized for their role in medicinal chemistry, particularly as calcium channel blockers used in the treatment of hypertension, cardiovascular disorders, and neurological diseases. Apart from their pharmaceutical significance, these compounds also exhibit antimicrobial, anti-inflammatory, and antioxidant properties, making them crucial for drug development. Given their wide-ranging applications, efficient and sustainable synthetic methodologies for 1,4-DHPs are highly sought after.Traditional methods for the synthesis of 1,4-DHPs typically involve the Hantzsch reaction, which is a classical multicomponent reaction (MCR). This reaction requires aldehydes, β-ketoesters, and ammonium acetate as key reactants, often in the presence of strong acids, metal catalysts, or organic solvents. While these methods have been effective in producing high yields of 1,4-DHPs, they suffer from several limitations, including long reaction times, high energy

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consumption, the use of toxic reagents, and environmental hazards due to non-biodegradable waste. Additionally, conventional catalysts such as Lewis acids, transition metals, and harsh acidic conditions not only pose safety concerns but also complicate product purification. These challenges have prompted researchers to explore green and sustainable alternatives for the synthesis of 1,4-DHPs.In recent years, the concept of green chemistry has gained significant attention in organic synthesis. Green catalysts, which are derived from natural, biodegradable, and non-toxic sources, offer a promising alternative to conventional reagents. The use of eco-friendly catalysts, such as bio-derived acids, clay-supported reagents, natural deep eutectic solvents (NADES), and ionic liquids, has been explored to enhance reaction efficiency while minimizing environmental impact. These catalysts facilitate the Hantzsch reaction under mild conditions, reducing reaction time, eliminating toxic solvents, and improving overall yield. Furthermore, solvent-free and aqueous-mediated reactions align with sustainable chemistry principles, further promoting the development of eco-friendly methodologies. By addressing the limitations of conventional methods and incorporating green chemistry principles, this work aims to establish a highly efficient, cost-effective, and environmentally friendly synthetic route for 1,4-DHPs, with potential applications in drug discovery and industrial chemistry.

II. METHODOLOGY

The methodology followed for the synthesis of 1,4-DHPs using a green catalyst is outlined below:

Selection of Reagents and Chemicals:

Ethyl acetoacetate, various aldehydes, ammonia (or ammonium acetate), and an appropriate green catalyst such as bio-derived acids, ionic liquids, or natural clays were used.

Catalyst Preparation and Characterization:

The green catalyst was synthesized through environmentally benign methods and characterized using Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and scanning electron microscopy (SEM) for structural analysis.

Reaction Procedure:

The reaction was carried out under solvent-free conditions or in green solvents such as ethanol or water.

A mixture of ethyl acetoacetate, an aldehyde, and ammonia (or ammonium acetate) was stirred in the presence of the green catalyst at an optimized temperature.

The reaction progress was monitored using thin-layer chromatography (TLC).

Optimization Parameters:

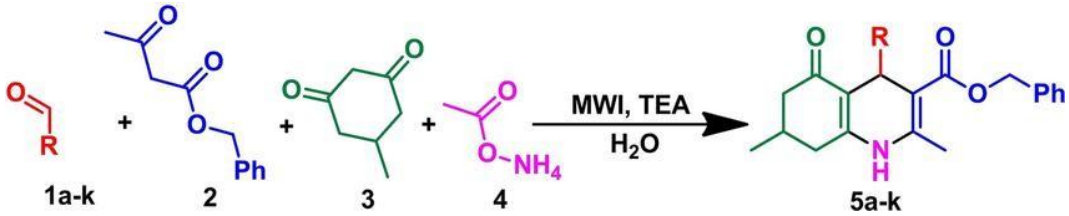
Various reaction conditions, including catalyst loading, temperature, and reaction time, were optimized to achieve maximum yield.

Purification and Characterization of Products:

The crude product was purified using recrystallization or column chromatography.

The purified 1,4-DHPs were characterized using nuclear magnetic resonance (NMR), mass spectrometry, and infrared (IR) spectroscopy to confirm their structural integrity

III. REACTION



Multicomponent green synthetic route for 1,4-dihydropyridines

MECHANISM OF THE ONE-STEP MULTICOMPONENT SYNTHESIS OF 1,4- DIHYDROPYRIDINES (1,4-DHPS) USING A GREEN CATALYST

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The synthesis of 1,4-dihydropyridines follows the well-established Hantzsch reaction mechanism, which involves a three-step process:

Step 1: Knoevenagel Condensation
The aldehyde (Ar-CHO) reacts with the first molecule of β-ketoester (ethyl acetoacetate) in the presence of a green catalyst.
This forms a Knoevenagel adduct, an α,β-unsaturated intermediate through nucleophilic addition followed by dehydration.
Enamine Intermediate+Knoevenagel Adduct→1,4-Dihydropyridine Step 2: Enamine Formation
Ammonium acetate (NH_4OAc) acts as a nitrogen source.
It decomposes into NH_3 and AcO^-, providing an amine nucleophile.
The amine undergoes a nucleophilic attack on the second molecule of β-ketoester, leading to the formation of an enamine intermediate.
NH4OAc+β-Ketoester→Enamine Intermediate Step 3: Cyclization and Reduction
The enamine intermediate reacts with the Knoevenagel adduct.
Intramolecular cyclization occurs via nucleophilic attack, leading to the formation of a six-membered dihydropyridine ring.
Tautomerization and reduction follow, leading to the formation of the 1,4-dihydropyridine (1,4-DHP) core.

Enamine Intermediate+Knoevenagel Adduct→1,4-Dihydropyridine

IV. APPLICATIONS

Pharmaceutical Industry

1,4-Dihydropyridine (1,4-DHP) derivatives are the backbone of several calcium channel blockers, such as Nifedipine, widely used in cardiovascular treatments. Beyond hypertension and angina, these compounds exhibit antimicrobial, antiviral, and anticancer properties, broadening their pharmaceutical applications. Green synthesis methods improve their accessibility while minimizing environmental impact, reducing hazardous waste and energy consumption. This sustainable approach enhances drug formulations by lowering toxicity and improving biocompatibility, ensuring safer therapeutic solutions. The integration of green chemistry principles in 1,4-DHP synthesis aligns with the growing demand for eco-friendly pharmaceutical production.

Material Science

1,4-DHP-based compounds play a significant role in material science, serving as essential intermediates in the synthesis of organic light-emitting diodes (OLEDs) and advanced polymers. Their application in optoelectronic devices improves energy efficiency and contributes to sustainable electronic materials. Additionally, they aid in the development of biodegradable polymers and functional nanomaterials, offering environmentally friendly alternatives in industrial applications. Green synthesis approaches further enhance their appeal by reducing harmful byproducts, making them valuable in the production of high-performance materials with minimal ecological impact.

Agriculture and Environmental Applications

1,4-DHP derivatives are gaining attention in agriculture as key components of agrochemicals, including plant growth regulators and eco-friendly pesticides. Their selective biological activity helps reduce environmental toxicity while maintaining agricultural productivity. The use of green catalysts in their synthesis ensures minimal harmful residues, enhancing soil and water safety. Furthermore, these compounds are explored for environmental remediation, particularly in breaking down pollutants and improving wastewater treatment. Their ability to degrade hazardous substances efficiently makes them promising candidates for sustainable environmental solutions.

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Analytical and Diagnostic Applications

Due to their distinct structural and electronic properties, 1,4-DHP derivatives are widely used in analytical and diagnostic applications. Their strong fluorescence makes them valuable in chemical sensors and bioimaging, enabling the detection of metal ions and biomolecules with high sensitivity. These compounds serve as molecular probes in medical diagnostics and environmental monitoring. The adoption of green synthesis methods in their production reduces toxic solvents and hazardous waste, ensuring safer manufacturing processes. Their growing role in diagnostics highlights their potential in sustainable and advanced analytical technologies

V. FUTURE SCOPE

Advanced Catalytic Systems

- Development of novel green catalysts with enhanced efficiency, stability, and recyclability.
- Exploration of hybrid catalyst systems combining biocatalysts and nanomaterials for improved performance.

Process Optimization

- Application of flow chemistry and microreactor technology to improve reaction scalability and efficiency.
- Integration of computational chemistry and AI-driven predictive modeling for reaction optimization.

Expanding Industrial Applications

- Utilization of 1,4-DHPs in energy storage materials such as organic batteries and supercapacitors.
- Investigation of their role in smart coatings and self-healing materials.
- Development of sustainable agrochemicals and eco-friendly biopesticides based on 1,4-DHP derivatives.

Green Chemistry Innovations

- Implementation of solvent-free and microwave-assisted synthesis for reduced energy consumption.
- Exploration of biomass-derived feedstocks for sustainable precursor materials.
- Enhancement of reaction conditions to minimize waste and byproduct formation.

VI. CONCLUSION

The development of an efficient, one-step multicomponent synthesis of 1,4-dihydropyridines (1,4-DHPs) using green catalysts represents a significant milestone in the pursuit of sustainable chemistry. This study underscores the transformative potential of green catalytic systems, demonstrating their ability to enhance reaction efficiency while minimizing environmental impact and reducing overall costs. The findings emphasize the broad industrial applications of 1,4-DHPs, particularly in the fields of pharmaceuticals, materials science, and environmental remediation, highlighting their essential role in modern scientific advancements. While challenges related to catalyst stability, scalability, and economic feasibility remain, ongoing research and technological progress are poised to address these issues effectively. Future innovations in catalyst design, process optimization, and industrial integration will further advance the sustainability and commercial viability of 1,4-DHP synthesis. By adhering to the principles of green chemistry, this study makes a meaningful contribution to the evolution of eco-friendly organic synthesis, paving the way for more sustainable chemical processes in the future.

The synthesis of 1,4-DHPs has long been a subject of interest due to their significant pharmacological and industrial applications. Traditionally, the synthesis of these compounds involved harsh reaction conditions, toxic solvents, and expensive reagents, which posed severe environmental and economic concerns. The advent of green catalysts offers a promising alternative by facilitating high-yield reactions under mild and sustainable conditions. These catalysts, derived from environmentally benign materials, reduce waste generation and energy consumption while maintaining reaction efficiency. This study highlights the advantages of using green catalytic systems in multicomponent reactions, offering a more sustainable approach to 1,4-DHP synthesis.

One of the key findings of this study is the efficiency of green catalysts in promoting the one-step synthesis of 1,4-DHPs. The use of catalysts such as bio-based materials, metal-organic frameworks, and ionic liquids has significantly

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improved reaction rates and product yields. These catalysts have demonstrated remarkable recyclability and reusability, reducing the need for excessive reagent consumption and waste disposal. Moreover, the use of solvent-free or aqueous reaction media has further minimized environmental hazards, making the process more sustainable and cost-effective. By optimizing reaction parameters, this study has successfully established a greener methodology that aligns with the core principles of green chemistry. Beyond reaction efficiency, the environmental benefits of green catalytic systems cannot be overstated. The traditional methods for synthesizing 1,4-DHPs often involved hazardous reagents and solvents that contributed to environmental pollution. In contrast, green catalysts eliminate or significantly reduce the use of toxic chemicals, leading to cleaner reaction processes. Additionally, the implementation of renewable catalysts reduces reliance on finite natural resources, further enhancing the sustainability of the synthesis. This study's findings reinforce the idea that adopting green chemistry principles can lead to substantial improvements in both environmental and economic aspects of chemical manufacturing.

From an industrial perspective, the adoption of green synthesis methods for 1,4-DHPs opens up new possibilities for large-scale production. The pharmaceutical industry, in particular, stands to benefit from this sustainable approach, given the widespread use of 1,4-DHP derivatives in cardiovascular and neurological treatments. Green catalytic methods provide an opportunity to manufacture these compounds more efficiently while adhering to stringent regulatory and environmental standards. Additionally, the reduced cost associated with green catalysts enhances the economic feasibility of large-scale production, making sustainable synthesis an attractive alternative for pharmaceutical companies. In materials science, 1,4-DHPs have shown potential applications in the development of advanced materials, including optoelectronic devices and polymeric materials. The ability to synthesize these compounds sustainably ensures that future technological innovations can be developed without compromising environmental integrity. Similarly, in environmental remediation, 1,4-DHP derivatives have been explored for their potential in pollutant degradation and water purification applications. The implementation of green synthesis methods ensures that these applications remain environmentally responsible and commercially viable.

Despite these promising advancements, certain challenges persist in the widespread adoption of green catalytic systems for 1,4-DHP synthesis. One major concern is the stability and longevity of green catalysts in prolonged reactions. While many catalysts have shown good reusability, their long-term performance in industrial settings requires further investigation. Additionally, scalability remains a significant hurdle, as laboratory-scale success does not always translate seamlessly to large-scale manufacturing. Further research is needed to refine catalyst formulations and optimize reaction conditions to facilitate industrial implementation. Economic feasibility is another critical factor that needs to be addressed. Although green catalysts offer cost advantages in terms of recyclability and reduced waste disposal costs, the initial investment in developing and implementing these catalysts can be high. Industries may require incentives or policy support to transition from traditional synthetic methods to green alternatives. Therefore, collaboration between researchers, policymakers, and industry stakeholders is essential to accelerate the adoption of sustainable synthesis techniques.

Looking ahead, future research should focus on enhancing the efficiency and stability of green catalytic systems. The development of novel catalyst materials with improved performance characteristics will be crucial in overcoming existing limitations. Additionally, advances in computational chemistry and machine learning can aid in the rational design of highly efficient catalysts tailored for specific reactions. Process optimization through continuous-flow synthesis and automated reaction monitoring can further improve the scalability and reproducibility of green synthesis methods. In conclusion, this study marks a significant step forward in the sustainable synthesis of 1,4-DHPs using green catalytic systems. By demonstrating the advantages of green catalysts in terms of reaction efficiency, environmental impact, and cost-effectiveness, this research contributes to the broader goal of sustainable chemistry. While challenges such as catalyst stability, scalability, and economic feasibility remain, ongoing advancements in catalyst design, process optimization, and industrial integration are expected to address these issues. The adoption of green chemistry principles in 1,4-DHP synthesis not only enhances sustainability but also paves the way for future developments in environmentally responsible organic synthesis. As the field of green chemistry continues to evolve, innovations in catalyst development and process engineering will play a crucial role in shaping the future of sustainable chemical

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manufacturing. By embracing these advancements, the scientific community can contribute to a cleaner, more efficient, and economically viable approach to chemical synthesis, ensuring a greener future for generations to come.

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A Comprehensive Study on Extraction and Characterization of Bioactive Pesticidal and Insecticidal Compound from Azadirachta Indica (Neem)

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Abstract: *Research into the insecticidal effects of azadirachtin, a limonoid from the Neem (Azadirachta indica) has been ongoing for some 30 years. Its strong antifeedant, insect growth regulatory and reproductive effects are now well understood and documented. Antiffedancy varies markedly between species with mosquitoes being particularly sensitive to azadirachtin. The mode of action of azadirachtin lies in (i) effects on deterrent and other chemoreceptors resulting in antifeedancy and (ii) direct effects on most other tissues studied resulting in an overall loss of fitness of the insect. The complexity of the molecular structure of azadirachtin has precluded its synthesis for pesticide use although novel synthesis of the parent molecule is now almost complete and research into simpler mimetic substances is ongoing. Neem (Azadirachta indica is perhaps the most useful traditional medicinal plant in India. Each part of the neem tree has huge insecticidal property and is thus commercially exploitaed. During the last two decades, apart from the chemistry of the neem compounds, considerable progress has been achieved regarding the biological activity and insecticidal applications of neem. It is now considered as a valuable source of unique natural products for botanical insecticides against various pests. This review gives a bird's eye view mainly on the biological activities of some of the neem compounds isolated, insecticidal actions of the neem extracts, applications of neem has an eco-friendly botanical insecticide in pest management along with their safety evaluation.*

Keywords: Azadirachtin indica; Neem leaves; Green Chemistry, Synthetic Insecticide, Limonoid; triterpense; Pest control; Antifeedancy; eproduction; Beta sitossterol Mode of action.

I. INTRODUCTION

Insecticide/Pesticides are chemical substances that are meant to kill pests.In general, a pesticide is a chemical or a biological agent such as a virus, bacterium, antimicrobial, or disinfectant that deters, incapacitates, kills, pests. This use of pesticides is so common that the term pesticide isoften treated as synonymous with plant protection product. It is commonly used to eliminate or control a variety of agricultural pests that can damage crops and livestock and reduce farm productivity The most commonly applied pesticides are insecticides to kill insects, herbicides to kill weeds, rodenticides to kill rodents, and fungicides to control fungi, mold, and mildew. A pesticide is any substance used to kill, repel, or control certain forms of plant or animal life that are considered to be pests. Pesticides include herbicides for destroying weeds and other unwanted vegetation, insecticides for controlling a wide variety of insects, fungicides used to prevent the growth of molds and mildew, disinfectants for preventing the spread of bacteria, and compounds used to control mice and rats. Because of the widespread use of agricultural chemicals in food production, people are exposed to low levels of pesticide residues through their diets. This make you and your skin look rejuvenated and youthful. Neem Pesticide / Insecticide formulation is a neem based botanical product that contains azadirachtin as an active ingredient. Azadirachtin is found to be very effective for over 600 species of insects. In developing countries, the losses of crops due to pest, plant disease and competition from weeds is great. In households, pest and insects such as mosquitoes, cockroaches, mice etc pose risks such as the destruction of furniture, clothing and to the causation of

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various diseases, most seriously; malaria.damages, also tend to have adverse effects on humans in various ways, most especially those produced from synthetic materials. These adverse effects of headache, dizziness, catarrh worth investigating. The insecticides range from agricultural to household pesticides. Every category has its own effect, both on the targeted pest/insect and the environment lives. This research targets insecticide produced from natural products and the need to choose these pesticides rather than those of synthetic origin.

Spodoptera frugiperda (J. E. Smith) (Lepidoptera: Noctuidae), comm only called fall armyworm (FAW) is a moth whose larvae feed on more than 100 different plant species [1]. It is known to be a serious pest of maize, rice, sorghum, tuff, sugarcane, and a wide range of other crops including peanuts, soybean, and some non-food crops such as cotton [2]. In maize, larvae of FAW destroy the fresh leaves which impair the growth and ultimately reduce the yield of the crop. Until 2016, there was no recorded incidence of FAW invasion in West Africa [3-5]. Outbreaks of FAW were reported in January 2016, in southwest Nigeria, Ghana, Benin, Sao Tomé, and Togo, [6]. However, FAW is now repted to be present in over 40 countries in tropical and southern Africa including Madagascar [2]. About 98% of local farmers in Ghana reported in a household survey that maize is affected by FAW and the reported damage to maize amounted to 26.6% [7]. Economically, Ghana potentially losses US$177 m annually due to damage by FAW. To mitigate the loss due to FAW infestation, many farmers employ the use of synthetic chemical insecticides. However, the use of synthetic chemical insecticides has unintended detrimental consequences including residues in food and water [8,9]. It is also known that synthetic pesticides (insecticides and herbicides) kill beneficial insects [10,11]. Aside from this, pesticides including organophosphates and carbamates can cause serious health effects [9,12]. This necessitates the development of alternative effective eco-friendly insecticides. Environmentally acceptable pesticides are known for their relatively low toxicity to non-target organisms and biodegradability due to their botanical origin. This makes it possible to incorporate such insecticides into integrated pest management programs [13,14]. Due to the rise in the advocacy for the use of safer insecticides, several research works have been conducted in search of plant sources of safe insecticides. For instance, asteroid-like tetranortriterpenoid (azadirachtin) obtained from the Indian neem tree (Azadirachta indica), has been identified as a key insect repellent in vegetables [13]. Moreover, the importance of neem in agriculture [9], toiletry, pharmaceutical and medicine [15], has grown considerably because of its numerous bioactive ingredients. It has been found that neem has antiallergenic, antidermatic, antifeedant, antiviral, antifungal, anti-inflammatory, antipyorrhoeic, antiscabic, insecticidal, larvicidal, antiimplantation and nematicidal properties [16]. Studies have shown that neem biopesticides were effective against pests in stored grains like rice, wheat, corn, and legumes as well as in foodstuffs like potato and tomato in India [9,17]. Neem has an insecticidal effect on insects that suck plant sap and those which chew plant parts. The active ingredient in neem, azadirachtin, serves as a growth regulator as well as a feeding and oviposition deterrent. It acts as a growth regulator by reducing the level of ecdysone, a hormone that disrupts the moulting process of the insects and thus prevents larvae from developing into adults [18]. Azadirachtin is a mixture of seven isometric compounds being Azadirachtin- A to -G with Azadirachtin-A as the dominant and Azadirachtin-E as the most effective growth regulator [19].

II. METHODOLOGY

Extraction of Neem Oil (Active Ingredient)

The primary active compounds for pesticidal action are found in neem oil, which is extracted from neem seed kernels. The two most common methods of extraction are cold pressing and solvent extraction.

Cold Press Extraction-This is the most common and organic method for extracting neem oil.

Procedure:-(1) Feed the ground neem seed powder into a cold-pressing machine. (2) Apply mechanical pressure to the powder to extract the oil. (3) The cold-pressed oil is collected in containers. (4) The oil is then filtered to remove solid particles or impurities.

Advantages: This method preserves the bioactive compounds, such as azadirachtin, which are essential for pesticidal action. It is also more environmentally friendly, as no chemicals are used.

Solvent Extraction-This method is typically used when large quantities of neem oil are required. Procedure:- Mix the neem seed powder with a solvent (e.g., hexane, ethanol, or petroleum ether).Let the mixture sit for 48–72 hours with occasional stirring to facilitate the extraction of the oil.After extraction, filter out the solid particles.Remove the solvent

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using a distillation process, leaving behind concentrated neem oil. Formulation of Neem-based Insecticide-To create a usable neem-based insecticide or pesticide, the neem oil must be formulated into a solution that can be easily applied to plants. The formulation process typically involves diluting the neem oil and adding emulsifiers. Basic Neem Oil Pesticide Preparation- Neem Oil Solution: Dilute neem oil with water to achieve a solution with 1%–2% concentration of active ingredients. A higher concentration can be used for more severe pest problems.

Emulsification: Since neem oil is hydrophobic (doesn't mix well with water), an emulsifier is needed to make the mixture stable. Common emulsifiers include:Liquid soap (preferably castile soap),Soapnut extract,Lecithin (a natural emulsifier).Mix the emulsifier with the water before adding neem oil. Stir or shake well to ensure a uniform emulsion. Sprayable Neem Pesticide Solution-Materials: 1–2 teaspoons of neem oil,1 liter of water,1 teaspoon of liquid soap or an emulsifier (optional)

Procedure: (1) Mix the water and soap/emulsifier. (2)Slowly add neem oil to the mixture while stirring.(3)Stir the solution well to ensure even distribution.(4)Filter the solution using a fine cloth or strainer.The resulting neem insecticide can be stored in spray bottles or larger containers for application.

III. LITERATURE REVIEW

NEEM:-

Neem (Azadirachta indica A. Juss) (Meliaceae) is native to the Indian sub-continent and well known as the 'Botanical Marvel', 'Village Pharmacy', 'Wonder Tree', 'all-can-treat-tree' and 'Gift of Nature'. Neem has great potential in the fields of pest management, environmental protection and medicine. All parts of neem like seed, flower, bark, and leaf possess insecticidal activity but seed kernel is the most effective. The products derived from neem tree act as powerful Insect Growth Regulators (IGR) and also help in controlling several nematodes and fungi (Subbalakhmi et al., 2012). Neem (Azadirachta indica) is a medicinal tree native to the Indian subcontinent, known for its antibacterial, antifungal, and insecticidal properties. It is widely used in traditional medicine, agriculture, and skincare for its health and ecological benefits.

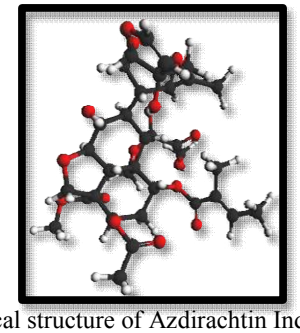


Figure:- Chemical structure of Azdirachtin Indica

History of Azadirachtin (NEEM):

Warden (1888) was the first to study the chemistry of neem oil that contains sulphur. Later, margosonic acid margosopicrin were isolated from neem oil. Chemical investigations carried out after 1940, yielded the isolation of the major bitter principle of neem, nimbin in a crystalline form (Siddiqui, 1942). Later on, other compounds like nimbinin from bark, nimbosterol from flowers, nimbocinone from leaves, nimbidin and nimbinin from oil and aldobiuronic acid from neem gum were isolated. Azadirachtin is the most potent locust antifeedant isolated during the year 1968. Neem possess insecticidal, nematicidal, fungicidal, bactericidal (Schmutterer, 1995), and molluscicidal properties (Mehlhorn et al., 2011a).

Bio-Pesticidal Activity Of Neem:

Neem Oil

Neem oil extracted by cold-pressing the seed kernels of neem is highly effective against soft-bodied insects and mites. The presence of disulphide in neem oil is a major contributor to its bioactivity. The most significant insecticidal and therapeutic properties of this agro-medicinal neem component are illustrated in Figure 2. Neem oil contains more than a

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dozen azadirachtin analogs, but the major contributor to the insecticidal activity is azadirachtin. The remaining triterpenoids including nimbin, salannin, and their derivatives contribute little to the efficacy (Isman, 2006). Interestingly, neem oil is non-toxic to mammals, birds and fishes and exhibits fewer chances of resistance, due to its multiple mode of action on insects. Many formulations of neem seed oil exhibit antifeedant, ovicidal, larvicidal, insect growth regulatory, and repellent activity against insect pests. The larvicidal property of neem oil against mosquitoes has long been investigated. a multitude of components that minimize the chance of resistance to synthetic insecticides in mosquitoes. One such study investigated the potential of neem oil as an eco- friendly alternative for the control of malaria.

Neem Active Pesticidal Components

Neem parts constituting leaf, seed, bark, flower, and oil possess a multiplicity of components that are responsible for its multiple pesticidal activities.

Azadirachtin

The main component of neem oil, leaves, flowers, and fruits with insecticidal properties is Azadirachtin. It constitutes 0.1-0.3% of neem seeds and was first isolated from A. indica by Morgan et al. at Keele University, England (Sclimutterer, 1985). It is a complex tetranortriterpenoid limonoid with repellent and pesticidal properties. Biosynthesis of triterpenoids from A. indica initiates with azadirone and a C-ring opening, which culminates in Azadirachtin formation. Azadirachtin, along with other related triterpenoids such as Azadirachtin B, salannin and nimbin, are the active ingredients in neem plant based bioinsecticides and they act by disrupting the growth and development of insects and by deterring their feeding. It is considered as a botanical pesticide with exceptional growth regulating and biocidal efficacy along with deterrent effects on the ovipositing and feeding of insects (Morgan, 2009). An attempt to evaluate the exact molecular mechanism of insecticidal activity of azadirachtin on Monochamus alternatus, a pine sawyer beetle, has indicated enrichment of differentially expressed genes (DEGs) in 50 pathways. 920 and 9984 unique genes were found to be up ling and down regulated significantly. Such detailed gene profiling to assess the azadirachtin internalization with M. alternatus, can promote the development of efficient azadirachtin derived herbal pesticides (Lin et al., 2016).

Mechanism of Action

Azadirachtin is structurally similar to the insect hormones known as "ecdysones" which are responsible for metamorphosis in insects. The feeding behavior in insects is dependent on the neural inputs received from the chemical sensors of the insects, for example, the taste receptors in the mouthparts, tarsi and oral cavity. These sensors integrate a "sensory code" that is delivered to the central nervous system. Manifestation of antifeedancy by azadirachtin occurs through the stimulation of deterrent cells in these chemoreceptors and by blocking the feeding stimulation in insects by firing the "sugar" receptor cells (Jennifer Mordue Luntz et al, 1998).

Nimbolide

Two main active ingredients; Nimbolide B and Nimbic acid B also demonstrate herbicidal activity of neem. Their allelopathic and phytotoxic activity was observed in a study where they inhibited the growth of lettuce, crabgrass, alfalfa, jungle rice, and barnyard grass. The allelopathic activity increased with an increase in the concentration of active compounds, but the intensity varied with different species of weed (Kato- Noguchi et al., 2014).

Salannin

Salannin is an active component of neem with insect-growth regulating and antifeedancy activity. Salannin deters feeding. increases the larval stage duration and causes delayed molt, leading to decreased pupal weight that results in larval and pupal mortality. This has been demonstrated in an early study on Oxya fuscovittata where salannin caused delayed molting and nymphal mortality (Govindachari et al, 1996). The bioactivity observed was more prominent in azadirachtin as compared to salannin, however, a combination of azadirachtin with salannin and nimbin can provide insect growth-regulating activity with increased efficacy.

Neem Based Nano-Biopesticides

In agricultural practices, herb-based insecticides have the disadvantage of getting degraded when exposed to sunlight, due to low shelf life. Moreover, the active ingredients of neem cause non-specific toxicity. Aqueous extracts of neem

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leaves have shown toxicity to Oreochromis niloticus, by causing telangectiasis, bend in secondary lamellae, pyknosis, secondary lamellae shortening, and necrosis. Therefore, it is imperative to consider eco-toxicological properties of active ingredients of bio-pesticides (Alim and Matter, 2015). To overcome this, nano- biotechnology offers great potential, as it involves the production of unique nanoformulations that have the ability to improve the physiochemical stability, degradability, and effectiveness of natural products (Perlatti et al., 2013).

Adnan, S., Uddin, M., Alam, M., Islam, M., Kashem, M., Rafii, M., et al. (2014). Management of mango hopper, idioscopus clypealis, using chemical insecticides and neem oil. Sci. World J. 2014:709614. doi: 10.1155/2014/ 709614

An experiment was conducted in Field Laboratory, Department of Entomology at Bangladesh Agricultural University, Mymensingh, during 2013 to manage the mango hopper, Idioscopus clypealis L, using three chemical insecticides, Imidacloprid (0.3%), Endosulfan (0.5%), and Cypermethrin (0.4%), and natural Neem oil (3%) with three replications of each. All the treatments were significantly effective in managing mango hopper in comparison to the control. Imidacloprid showed the highest efficacy in percentage of reduction of hopper population (92.50 ± 9.02) at 72 hours after treatment in case of 2nd spray. It also showed the highest overall percentage of reduction (88.59 ± 8.64) of hopper population and less toxicity to natural enemies including green ant, spider, and lacewing of mango hopper. In case of biopesticide, azadirachtin based Neem oil was found effective against mango hopper as 48.35, 60.15, and 56.54% reduction after 24, 72, and 168 hours of spraying, respectively, which was comparable with Cypermethrin as there was no statistically significant difference after 168 hours of spray. Natural enemies were also higher after 1st and 2nd spray in case of Neem oil.

Ahmad, K., Adnan, M., Khan, M. A., Hussain, Z., Junaid, K., Saleem, N., et al. (2015). Bioactive neem leaf powder enhances the shelf life of stored mungbean grains and extends protection from pulse beetle. Pak. J. Weed Sci. Res 21, 71–81.

Plant products are receiving greater attention as prophylactics against several species of plant-parasitic nematodes. Numerous experiments have shown the potential nematicidal value of plant parts and their by-products when incorporated into soil or when the plants themselves are interplanted as seedlings among crop plants. Various products (oils, cakes, extracts, etc.) prepared from the leaves and seeds of the neem plant (Azadirachta indica A. Juss) (Family Meliaceae) have been reported as effective protectants against nematode pests when used as root-dips and seed treatments. Nemato-toxic compounds of the neem plant, especially the azadirachtins, are released through volatilization, exudation, leaching and decomposition. The modes of action of these compounds are complex, and a number of mechanisms in relation to nematode management are yet to be fully explored. This review critically assesses the potential of these products in the management of nematodes in tropical agriculture.

Akhtar, M. (2000). Nematicidal potential of the neem tree Azadirachta indica (A. Juss). Integr. Pest Manag. Rev. 5, 57–66. doi: 10.1023/A:1009609931223

Pesticides are widely used in agricultural and other settings, resulting in continuing human exposure. Epidemiologic studies indicate that, despite premarket animal testing, current exposures are associated with risks to human health. In this review, we describe the routes of pesticide exposures occurring today, and summarize and evaluate the epidemiologic studies of pesticide-related carcinogenicity and neurotoxicity in adults. Better understanding of the patterns of exposure, the underlying variability within the human population, and the links between the animal toxicology data and human health effects will improve the evaluation of the risks to human health posed by pesticides. Improving epidemiology studies and integrating this information with toxicology data will allow the human health risks of pesticide exposure to be more accurately judged by public health policy makers.

Alavanja, M. C., Hoppin, J. A., and Kamel, F. (2004). Health effects of chronic pesticide exposure: cancer and neurotoxicity∗ 3. Annu. Rev. Public Health 25, 155–197. doi: 10.1146/annurev.publhealth.25.101802.123020

Plant-based medicines are useful in the treatment of cancer. Many breast cancer patients use complementary and alternative medicine in parallel with conventional treatments. Neem is historically well known in Asia and Africa as a versatile medicinal plant with a wide spectrum of biological activities. The experiments reported herein determined whether the administration of an ethanolic fraction of Neem leaf (EFNL) inhibits progression of chemical carcinogen-induced mammary tumorigenesis in rat models. Seven-week-old female Sprague Dawley rats were given a single intraperitoneal injection of N-methyl-N-nitrosourea (MNU). Upon the appearance of palpable mammary tumors, the

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rats were divided into vehicle-treated control groups and EFNL-treated groups. Further, we found that EFNL treatment effectively upregulated proapoptotic genes and proteins such as p53, B cell lymphoma-2 protein (Bcl-2)-associated X protein (Bax), Bcl-2-associated death promoter protein (Bad) caspases, phosphatase and tensin homolog gene (PTEN), and c-Jun N-terminal kinase (JNK). In contrast, EFNL treatment caused downregulation of anti-apoptotic (Bcl-2), angiogenic proteins (angiopoietin and vascular endothelial growth factor A [VEGF-A]), cell cycle regulatory proteins (cyclin D1, cyclin-dependent kinase 2 [Cdk2], and Cdk4), and pro-survival signals such as NFκB, mitogen-activated protein kinase 1 (MAPK1). The data obtained in this study demonstrate that EFNL exert a potent anticancer effect against mammary tumorigenesis by altering key signaling pathways.

IV. RESULTS AND DISCUSSION

Discussion

The extraction of bioactive pesticidal and insecticidal compounds from Azadirachta indica (neem) involves methods like solvent extraction, cold pressing, and supercritical fluid extraction. These methods isolate key compounds such as azadirachtin, nimbin, and salannin, which are responsible for neem's insecticidal properties. Azadirachtin acts as an insect growth regulator, disrupting feeding and reproduction in pests. The characterization of these compounds is done using techniques like HPLC, GC-MS, and NMR, which help identify and quantify the bioactive substances. Neem-based insecticides are eco-friendly and effective alternatives to chemical pesticides, offering sustainable pest management solutions. Neem (Azadirachta indica), widely known for its pesticidal and insecticidal properties, is a tropical evergreen tree that has been used for centuries in agriculture, medicine, and pest control. The plant is rich in bioactive compounds, primarily found in its leaves, seeds, bark, and fruit. These compounds, particularly azadirachtin, are known to be highly effective in pest management by disrupting the growth and reproduction of insects.

Result: The results of extraction and characterization of bioactive pesticidal and insecticidal compounds from Azadirachta indica (neem) have demonstrated significant potential in developing natural pest control solutions. Some key findings are:

1. Extraction Yield: Solvent extraction methods (using solvents like methanol, ethanol, and acetone) have successfully yielded a range of bioactive compounds from neem, with methanol being one of the most effective solvents for extracting azadirachtin and other limonoids. Cold pressing has also been effective in extracting neem oil, which contains a high concentration of these bioactive compounds.
2. Bioactive Compounds Identified: Through various chromatographic and spectroscopic techniques, compounds like azadirachtin, nimbin, nimbolide, salannin, and azadiradione have been isolated. Azadirachtin is the most studied and potent compound, exhibiting insecticidal properties by acting as an insect growth regulator, while other limonoids contribute to the overall efficacy of neem-based insecticides.
3. Characterization: Characterization of neem extracts using techniques like HPLC, GC MS, and NMR has confirmed the presence and quantified the amounts of these 29 | Page bioactive compounds. HPLC has been particularly effective in quantifying azadirachtin, while GC- MS and NMR have helped elucidate the structure of various triterpenoids and limonoids.
4. Insecticidal Activity: Neem extracts have demonstrated strong insecticidal activity against a wide range of pests, including aphids, caterpillars, and termites. Azadirachtin has been shown to inhibit feeding, disrupt molting, and prevent reproduction in insects, making it a highly effective biopesticide.
5. Eco-friendliness: The extracted neem compounds have been found to be environmentally safe, biodegradable, and non-toxic to humans and animals, offering a sustainable alternative to synthetic chemical pesticides. These results underline the potential of neem as a valuable source of bioactive insecticidal compounds, supporting its use in integrated pest management (IPM) systems for sustainable agriculture.

V. CONCLUSION

The production of natural insecticides and pesticides derived from neem seeds represents a promising and sustainable solution to modern agricultural challenges. As awareness of the environmental and health risks associated with synthetic chemical pesticides grows, neem-based products offer a viable alternative that aligns with the global shift

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toward organic farming and eco-friendly practices.Neem seeds, rich in bioactive compounds like azadirachtin, nimbin, and salannin, provide a natural, effective method of pest control. The extraction of these compounds through methods like cold pressing or solvent extraction leads to the creation of neem oil, which can then be formulated into a variety of pesticide products—ranging from foliar sprays to soil treatments and even eco-friendly repellents.The process of extracting neem oil involves several stages, including seed collection, drying, crushing, grinding, and the actual extraction of the oil. These are increasingly being enhanced by emerging technologies like supercritical CO2 extraction, microwave-assisted extraction, and enzyme-assisted methods, which promise higher yields, better quality, and improved sustainability. Such innovations not only improve the efficiency of production but also ensure the preservation of neem's potent pesticidal compounds.Moreover, neem-based products are gaining recognition for their versatility. They are not only effective against a wide range of pests but also pose minimal risk to beneficial insects, wildlife, and human health, making them an integral part of Integrated Pest Management (IPM) strategies. Neem products also contribute to soil health, making them a valuable tool in regenerative agriculture practices.Looking ahead, the future of neem-based pesticides is bright. Increasing demand for organic products, stricter regulations on synthetic chemicals, and innovations in formulation and application techniques will all drive growth in this sector. Research in areas such as nanoformulations, precision agriculture, and biological pest resistance management will continue to enhance the efficacy and environmental compatibility of neem-based insecticides.steps. In conclusion, the extraction of neem seeds for the production of natural insecticides/pesticides represents a sustainable, economically viable, and environmentally responsible approach to pest management. As the world embraces organic farming and seeks greener alternatives, neem-based solutions are poised to play a critical role in shaping the future of global agriculture.

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A Comprehensive Study on Synthesis of Coumarins and Coumarin Related Compounds in Pharmacotherapy of Cancer

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Abstract: *Cancer is one of the most common causes of disease-related deaths worldwide. Despite the discovery of many chemotherapeutic drugs that inhibit uncontrolled cell division processes for the treatment of various cancers, serious side effects of these drugs are a crucial disadvantage. In recent years, researchers have focused on the anticancer activity coumarins, due to their high biological activity and low toxicity. Coumarins are commonly used in the treatment of prostate cancer, renal cell carcinoma and leukemia, and they also have the ability to counteract the side effects caused by radiotherapy. In this review, a compilation of various research reports on coumarins with anticancer activity and investigation and a review of structure-activity relationship studies on coumarin core are presented. Determination of important structural features around the coumarin core may help researchers to design and develop new analogues with a strong anticancer effect and reduce the potential side effects of existing therapeutics.*
The structural motif of coumarins is related with various biological activities and pharmacological properties. Both natural coumarin extracted from various plants or a new coumarin derivative synthesized by modification of the basic structure of coumarin, in vitro experiments showed that coumarins are a promising class of anti-tumor agents with high selectivity. Cancer is a complex and multifaceted group of diseases characterized by the uncontrolled and abnormal growth of cells in the body. This review focuses on the anticancer mechanism of various coumarins synthesized and isolated in more than a decade. Isopentenyloxycoumarins inhibit angiogenesis by reducing CCl2 chemokine levels..

Keywords: Benzopyrone; Coumarin; Cancer; Drug Discovery; Natural Product..

I. INTRODUCTION

Coumarins are polyphenolic compounds belonging a group of colorless and crystalline oxygenated heterocyclic compounds first isolated from the plant named Dipteryx odorata Willd. (Fabaceae) known locally as “coumaroun” by Vogel in 1820 [1]. Oxygenated heterocyclic compounds are furan derivatives with 4C atoms or pyran derivatives with 5C atoms. Although furan derivatives are rarely present in plants, pyran derivatives forming the structure of various compounds are encountered more frequently. The pyran derivatives are ketonic compounds that in the form of α-pyron or γ-pyron. Secondary metabolites called benzo- α-pyrone (coumarin) and benzo-γ-pyrone (chromone) occur due to condensation of pyron derivatives with benzene in plants [2]. Coumarin (1,2-benzopyrone or 2H-1-benzopyran-2-one) and coumarin derivatives are natural compounds that are widely available in plants as a heteroside or free form. A total of 800 coumarin derivative compounds that naturally found were obtained from about 600 genera of 100 families to date [3]. Coumarin and its derivatives are frequently found in the seeds, roots and leaves of many plant species belonging to families (especially Rutaceae and Apiaceae) in the Dicotyledonae class of the division of Spermatophyta. Although most natural coumarins are isolated from vascular plants, some coumarins such as novobiocin, coumermycin and aflatoxin are isolated from microbial sources [4]. These compounds have become of importance in recent years due to their various biological activities. Previous biological activity studies performed on coumarin derivatives revealed that these compounds have antitumor [5]. photochemotherapy, anti-HIV [6], antibacterial and antifungal [7], anti-inflammatory [8], anticoagulant [inhibitors of the enzyme VKOR (vitamin K epoxide reductase)] [9], triglycerides lowering [10] and central nervous system stimulant effects [11]. However, a strong antioxidant and protective effect

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against oxidative stress by scavenging the reactive oxygen species has also been reported for hydroxycoumarins [12]. In addition, the discovery of coumarins with weak estrogenic activity has enabled the usage of this type of coumarins in the prevention of menopausal distress [13]. On the other hand, the usage of some coumarin derivatives as a tobacco flavor, which are used as fixative and flavoring agents, has been regulated by the FDA because of its negative effects, such as mild nausea, diarrhea and hepatotoxicity [14]. Besides their medical use, coumarins are also used in the cosmetic industry and agrochemical industry, as well as optical brightening agents [15].Both natural and synthetic coumarin derivatives draw attention due to their photochemotherapy and therapeutic applications in cancer [16].It has been reported that substitution patterns can affect the therapeutic, pharmacological and biochemical properties of coumarins in a positive way [17].For instance, the substitution of a methoxy group at the 7-position and a 3-methyl 2-butenyl group at the 8-position of the osthol leads to a strong reduction of plasma alkaline transferase (ALT) level in hepatitis and inhibition of caspase-3 activation [18].Some coumarins have cytostatic effect, while others have cytotoxic activity [19].It has been revealed to show cytostatic activity of coumarin and its active metabolite, 7- hydroxycoumarin, on human cancer cell lines such as HL-60 (leukemia), MCF-7 (breast), A549 and H727 (lung) and ACHN (kidney). Moreover, cytostatic activity of these compounds against prostate cancer, malignant melanoma and metastatic kidney cell carcinoma has also been reported in clinical studies [20]. Compounds of 3 and 4-hydroxycoumarin structure were determined to inhibit cell proliferation in the gastric carcinoma cell line [21].In vitro proliferation analysis investigating the mechanism of action of coumarins on the growth and metabolism of MCF-7 and A549 human tumor cells revealed that coumarin was not responsible for observed in vivo effects, but was a precursor of other active metabolites [22]. Previous studies showed that ortho- or meta-dihydroxycoumarins have more cytotoxic effect on human tumor cell lines than mono-hydroxycoumarins [23]. In the current review, compilation of various research reports on natural and synthetic coumarin derivatives with anticancer activity and investigation and review of structure–activity relationship studies on coumarin core were aimed. Determination of important structural features around the coumarin core may help researchers to design and develop new analogues with a strong anticancer effect and reduce the potential side effects of existing therapeutics.

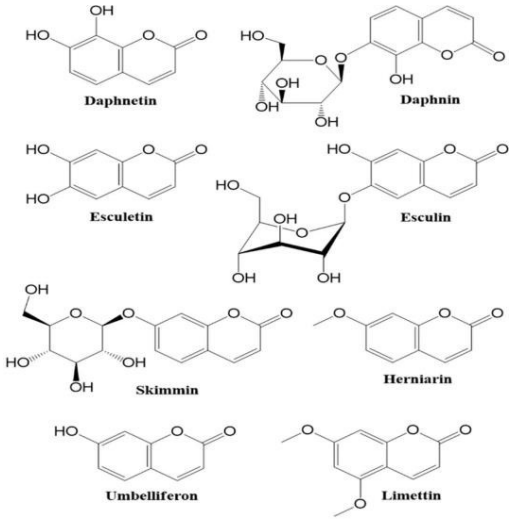


Figure 1:- Chemical structures of some simple coumarins.

1.1 Occurrence:-

Coumarins are classified in four groups: simple coumarins, furanocoumarines, pyranocoumarins and pyrone-substituted coumarins [24]. Simple coumarins: these are composed of hydroxylated, alkoxylated and alkylated derivatives of coumarin and their glycosides (e.g., Umbelliferone, skimmin, limettin, herniarin, esculetin, esculin, daphnetin and daphnin (Figure 1)) [24].

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Figure 1:- Chemical structures of some simple coumarins. Furanocoumarins: This group of coumarins consists of a furan ring fused with a coumarin. They are divided into two groups as C6/C7 (linear) type, C7/C8 (angular) type according to the attachment place of the furan ring. (e.g., psoralen, xanthotoxin, bergapten, imperatorin, isopimpinellin, anjelisin, isobergapten and pimpinellin [25].

Chemical structures of some furanocoumarins. Pyranocoumarins: six-membered pyran ring is fused with the benzene ring via C6-7 (linear) or C7–8 (angular) (e.g., visnadin, xanthyletin and seselin) Pyrone-substituted coumarins: These are classified in three groups: 4-Hydroxycoumarin (Novobiocin and Dicumarol), 3-Phenylcoumarin (Coumestroln and Gravelliferone) and 3,4- Benzocoumarin (Aeternaryiol). 4- Hydroxycoumarins are not found in plants in free form. Warfarin, a synthetic compound, belongs to this group [26].

Multi-target compounds are recently being searched for and these compounds are thought to be promising compounds for the treatment of several disorders, including cancer and heart failure. In this context, compounds observed from natural sources come into prominence due to their low toxicity, low drug resistance, low cost and high efficacy [27]. Therefore, new compounds isolated from natural sources, such as plants and animals, and possible combination of these compounds with conventional chemotherapeutic agents seems to be important strategies to improve life quality, especially in cancer patients [28]. Coumarin-based structure compounds constitute a major group of natural compounds with various pharmacological effects. These group of compounds can be isolated from different plants, including Achillea, Artemisia and Fraxinus genera, and also, they can be synthesized through various chemical reactions. Several strategies such as maceration, reflux, ultrasonic- assisted and microwave extraction methods are used for the isolation and purification of coumarin compounds. Perkin, Von Pechmann, Knoevenagel and Wittig organic reactions are some of reactions that coumarins can be synthesized [29]. In the biosynthetic origin of coumarins, the shikimic acid pathway plays an important role. In this pathway, there are several enzymatic steps leading to occur chorismic acid, cinnamic acid, p-coumaric acid and umbelliferone. Moreover, the cytochrome P450 enzymes have a crucial role in the ortho-hydroxylation of cinnamic acid leading to occur umbelliferone, scopoletin and isofraxidin [30].

II. LITERATURE REVIEW

2.1 Cancer Treatment

Although some standards have been determined for cancer therapy, various approaches and treatments are applied for specific to each type of cancer. Biological therapies, such as radiotherapy, chemotherapy, surgery, immunotherapy, hormone therapy, targeted therapies and gene therapy can be used alone or in combination in cancer therapy. However, these methods, known as the gold standard, have advantages as well as disadvantages. Despite the discovery of many chemotherapeutic drugs (Adriamycin, Cisplatin, Campotins, Vinblastin, Mercaptopurine, etc.) that inhibit uncontrolled cell division process for the treatment of different types of cancer , serious side effects of these drugs on hematopoietic system, bone marrow and gastrointestinal epithelial cells and hair follicles are a crucial disadvantage .In addition, multi-drug resistance (MDR) is another important problem in anticancer treatment. Due to problems such as cytotoxicity and drug resistance in existing chemotherapeutic agents, many investigations are being conducted to discover and develop effective anticancer drugs. Previous studies showed that many compounds obtained from natural resources can be used as preventive and therapeutic agents in cancer therapy.

2.2 Roles of Coumarins in Anticancer Activity

Studies conducted on the anticancer activity of coumarin and its derivatives revealed that the mechanism of action of these compounds is generally caspase dependent apoptosis.CYP 2A6, an isoform of cytochrome P450, metabolizes coumarin to 7-hydroxycoumarin, which has an antiproliferative effect by reducing Bcl expression in various organs and tissues. Bcl-2, a 26 kDa membrane protein, blocks free oxygen radicals, inhibits mitochondrial CYP and suppresses activation of caspase-9, which extends the cell life cycle cumulatively. Thus, it causes carcinogenesis and leads to accumulation of oncogenic mutations in the normal cell. Caspase-9 is activated by Bax, a membrane protein. Over-expression of Bax causes mitochondrial cytochrome C to be released into the cytoplasm through modulation in the mitochondrial membrane. Cytochrome C in the cytoplasm activates caspase-9 and activation of caspase-9 leads to the caspase-3, 6 and 7 activation which breaks down key cytoplasmic and nuclear proteins. Coumarins regulate the fate of

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normal cells by modulating signal transduction pathways containing GTP-binding proteins and reducing Bcl-2 expression. The Bcl-2 protein family consists of Group 1 (Bcl-2 and Bcl-XL), which are apoptotic, and Group 2 (Bax, Bad, Bid and Bak), which are pro-apoptotic. BH1, BH2 and BH3 in the Bcl-2 protein family and their dimerization determine the sensitivity of a cell to negative stimuli. As the ERK/MAPK pathway actively participates in cell proliferation and cytokine production, this pathway is used as an important target for the development of new anticancer agents.

2.3 Coumarins in Breast Cancer

The breast tissue is composed of lobules formed by the glands that produce milk, ducts that allow milk to be discharged and fat and connective tissues. Lobes are formed by combination of the lobules, and each breast has 15–20 lobes. The lobules are connected to each other by milk ducts and milk ducts join towards the nipple. The development and physiological functions of the breast are regulated by hormones. The main hormones that provide the development of breast tissue are estrogen and progesterone.

Breast cancer is a systemic disease that occurs when the cells lining the mammary glands and milk ducts proliferate abnormally, spread to various tissues and organs and continue to grow there. It is a complex disease that affects women physically, psychologically and socially [89], and ranks first among cancer types seen in women in the world, and also second most common cause of death due to cancer following the lung cancer. In epidemiological studies, the prevalence was found to be 22–26% and the risk of breast cancer-related mortality was around 18%. Since the breast consists of two main structures, there are two types of breast cancer: lobular cancer developing from the milk secreting part and ductal cancer developing from the milk ducts. The most common type of breast cancer is ductal cancer and accounts for 75% of all breast cancers. Breast cancers are histologically divided into two main groups, in situ and invasive carcinomas.

2.4 Coumarins in Leukemia

Leukemia is a clonal disease that results from neoplastic exchange of hematopoietic precursor cells in the bone marrow. Marrow damage occurs when a large number of immature and malignant cells replace normal marrow cells. Thus, decrease begins in the number of platelets involved in blood coagulation and the number of leukocytes involved in defense. This causes intense injuries and bleeding in patients with leukemia, as well as easy infection. Moreover, the defense mechanism weakens and may cause anemia and shortness of breath in advanced stages. Leukemia has symptoms such as weakness and fatigue, fever, some neurological symptoms, bloating and bleeding in the gums.

Leukemia is a type of cancer which effects the blood production system (lymphatic system and bone marrow) in the body. Leukemia is classified as acute or chronic (they are subdivided according to their appearance under the microscope) and according to the spread and development characteristics of the tumor. Generally, acute leukemia occurs in children, while chronic leukemia tends to be more common in adults. There are different types of blood cancers according to the cell type (such as myeloid and lymphoid) and the duration of the disease. Some types of blood cancers show a faster and poor prognosis. Leukemia is more common in childhood than other types of cancers, and 30–35% of cancers in this period are composed of leukemia. Frequency is 3–4 in 100,000 in children under 15 years of age in western countries. Although the causes are not known exactly, both genetic and environmental factors are thought to play an important role in leukemia. Mutations in DNA in somatic cells cause activation of oncogenes or inactivation of tumor suppressor genes. Thus, regulation of cell death and division is damaged. Apart from genetic reasons, this damage is thought to be caused by petrochemicals, radiation, carcinogens and some viruses (e.g., HIV).

2.5 Coumarins in Renal Cell Carcinoma

Renal cell carcinoma (RCC) is responsible for approximately 3% of tumors seen in adulthood. In recent years, especially with the widespread use of imaging methods, there is an increase in the incidence of RCC at every stage and mortality rates resulting from disease. One third of patients with RCC are metastatic at the time of diagnosis, or one third of them develop metastases despite treatment. Most of the tumors in RCC are associated with large, locally advanced and often lymph node, renal vein or vena cava invasion, and histologically, approximately 90% are

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transparent cell types. Metastasis occurs in many organs, especially lung, liver, bone, adrenals, pancreas, brain, thyroid gland, skin and ureter in order of frequency. While the transparent cell type metastasizes to the lungs more often, papillary type makes it to the lymph nodes and the chromophobes to the liver .The average survival in these patients is 10–12 months, and the 2-year survival rate is 18–20%.

There have been promising developments in prognosis with the introduction of new molecules that make up immunotherapy and targeted therapy, a better understanding of the timing and effectiveness of cytoreductive nephrectomy, and the use of these methods together. Response rates do not exceed 10–15% in immunotherapy using IL-2 and interferon alfa.

2.6 Coumarins in Prostate Cancer

Prostate cancer is the most common solid tissue cancer that occurs with the uncontrolled growth of cells in the prostate gland. Cancer cells primarily grow uncontrolled and spread into the prostate. These then reach the capsule surrounding the prostate, pierces the capsule and spreads out of the prostate. Unlike benign prostate gland enlargement, prostate cancer does not originate from the center of the prostate, but from its decentralized, distal center. Therefore, urinary complaints in prostate cancer disturb the patient in the later period. It is characterized by a very slow growth rate and broad biological variability in terms of hormonal sensitivity. It can spread to nearby organs, the lymphatic system and other parts of the body through the bloodstream during the period of growth and spread. Prostate cancer has a slow course, but the tumor may show a rather aggressive character and spread to the bones and other organs. According to the data of American Cancer Society, men have been reported to have 16.7% risk of development of prostate cancer life-long, and a 2.5% risk of life loss. One in every 5–6 men is at risk of developing prostate cancer throughout their life. When prostate cancer is diagnosed at an early stage, it is among the cancer types with high treatment success.

III. FUTURE SCOPE

The future of coumarin and coumarin-related compound synthesis for cancer pharmacotherapy is promising, given the increasing interest in developing targeted, effective, and less toxic cancer treatments. While traditional chemotherapies have made significant strides, their side effects, resistance development, and limited efficacy in treating advanced cancers underline the need for novel compounds like coumarins. The ongoing research into their synthesis, mechanism of action, and potential clinical applications is likely to expand the therapeutic utility of coumarin derivatives in several exciting ways. Below are key areas where future progress is expected:

3.1 Design and Synthesis of Targeted Coumarin-Based Anticancer Agents

One of the most promising areas of research is the development of targeted anticancer therapies that selectively attack cancer cells while minimizing damage to normal tissues. Coumarins, due to their bioactivity, are prime candidates for further modification to enhance their specificity toward cancer cells.

Targeted Drug Delivery: Conjugating coumarin derivatives with targeting ligands (such as antibodies, peptides, or aptamers) could allow the selective delivery of the drug to cancer cells. This approach may improve therapeutic efficacy and reduce off-target toxicity.

Coumarin-Drug Conjugates: Combining coumarin derivatives with established chemotherapeutic agents (e.g., doxorubicin, paclitaxel) can lead to synergistic effects. These hybrid compounds could work through multiple mechanisms, such as inhibiting cancer cell proliferation while also inducing apoptosis.

Nanomedicine: Encapsulating coumarin derivatives in nanoparticles (such as liposomes, micelles, or dendrimers) offers improved bioavailability, prolonged circulation time, and targeted release of the drug to the tumor site. Nanocarriers also protect sensitive coumarins from degradation, improving their stability.

3.2 Development of Multi-Functional Coumarin Derivatives

A future direction will be to create multi-functional coumarin derivatives that can target multiple pathways involved in cancer progression. These compounds could have a broader spectrum of action against cancer cells and may help overcome drug resistance.

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Combination Therapy: Coumarins with multiple pharmacological properties, such as anti-inflammatory, anti-angiogenic, and anti-metastatic activity, can be designed. For example, coumarin derivatives that target both cancer cell proliferation and angiogenesis (blood vessel formation) could limit tumor growth and spread.
Cancer Stem Cells: Recent studies suggest that cancer stem cells (CSCs) contribute to tumor recurrence and resistance to therapy. Coumarins can be engineered to selectively target CSCs, inhibiting their self-renewal properties and preventing relapse.

3.3 Coumarin Derivatives for Overcoming Chemoresistance

Cancer cells can develop resistance to chemotherapy by various mechanisms, including the upregulation of efflux pumps (such as P- glycoprotein), alteration of drug targets, and changes in the tumor microenvironment. Coumarin derivatives could be explored to overcome these resistance mechanisms.
Inhibition of Drug Efflux Pumps: By designing coumarin-based compounds that inhibit P-glycoprotein or other ABC transporters, researchers could enhance the intracellular concentration of chemotherapy drugs, restoring their effectiveness in resistant tumors.
Combination with Epigenetic Modulators: Coumarins could be combined with epigenetic modulators to reverse drug resistance. By inhibiting enzymes involved in DNA methylation or histone modification, these compounds may re-sensitize resistant cancer cells to chemotherapy.

3.4 Fluorescent Coumarin Derivatives for Cancer Diagnosis and Monitoring

Fluorescent coumarin derivatives are emerging as excellent candidates for in vivo cancer imaging and monitoring of treatment efficacy. The non-invasive nature of fluorescence imaging makes it ideal for tracking the progression of cancer and the pharmacokinetics of drug delivery systems.
In Vivo Imaging: Researchers are working on designing coumarin-based probes that can be used for fluorescence imaging in preclinical models and eventually in human patients. These probes can enable real-time monitoring of tumors and allow physicians to observe drug delivery and release kinetics.
Cancer Cell Detection: Fluorescent coumarins could be further optimized to selectively bind to cancer cell markers or metabolic changes that occur specifically in tumors. This selective targeting may enhance the accuracy of early cancer detection.

IV. CONCLUSION

The widespread distribution and various bioactivity of coumarins have led scientists to carry out research involving this ring system for decades. Coumarins have many biological activities, including disease prevention, growth modulation and antioxidant properties. It has been shown in scientific studies that these compounds show antitumor effects depending on their effects on immune regulation, cell growth and differentiation. It is extremely important to identify new, effective and less side effect anticancer products based on traditional medicines. Synthesis of coumarin and its derivatives is possible thanks to a number of innovative techniques, including the Pechmann, Claisen, Perkin, Knoevenagel and Wittig reactions. Although there are important limitations in use of most natural coumarins due to their hepatotoxic effect, relatively safe analogues with higher potency and thus better therapeutic index have been obtained by molecular manipulations. In the structure–activity studies on coumarins, significant positive results were obtained in anticancer activity screening with the addition of substituents at different positions of the coumarin core. Therefore, the development of new anticancer molecules by attaching appropriate functional groups to different positions around the coumarin core is an important research area.
However, significantly positive results were obtained in anticancer effect studies for various cancer types by targeting natural and synthetic coumarins to specific signaling pathways. Coumarin and coumarin-derived compounds are a potential source of anti-cancer drugs that need further researches, and it is obvious that they will be an important group in the development of new anticancer drugs.
In conclusion, the synthesis of coumarins and their derivatives holds immense promise for the future of cancer treatment, offering novel strategies that may significantly improve patient outcomes. As research progresses, these

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compounds are poised to become an integral part of next-generation cancer therapies, providing more effective, targeted, and safe treatment options for patients battling this complex and multifaceted disease.

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A Comprehensive Study on Extraction of Limonene from Orange Peels

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Abstract: *Orange peel wastes, with an estimated global annual production of 25 million tonnes, are problematic to dispose of but can be used to obtain a range of valuable products, among them the main constituent of orange essential oil, D-limonene (DL). This review aims to layout recent advances in the field of DL extraction and purification. Besides substitution of the conventional solvent hexane with certain bio-based solvents, a range of techniques are presented. These include enhanced solvent extraction processes through temperature and pressure intensification or ultrasound, improved distillation most commonly using different microwave-based techniques but also enzymes, and supercritical CO2 extraction. Even though purification has been found to be the most energy- intensive and environmentally impacting step, most studies did not improve on existing centrifugation, decantation, or fractional distillation methods. Chromatography has been proven effective at obtaining high DL purities; however, it still has to be improved because of its high costs and low productivity.*

D-Limonene is a compound that can be acquired from the rinds of the citrus family like oranges, limes, and mandarins. it is quite possibly the most well-known terpene present in nature. It has a few applications and a wide scope of advantages. Numerous medical service suppliers have supported the possible advantages of D-limonene guaranteeing that it can forestall or treat some ailments, for example, Bronchitis, Cancer, Diabetes, Gall stones, etc. It is likewise utilized in enterprises to make hand sanitizers, fragrances, plant pesticides, and synthetic solvents..

Keywords: D-Limonene, Orange Peels, Orange Essentiol Oil, Simple Fractional Distillation, Solvent Hexane, Extraction.

I. INTRODUCTION

D-Limonene is an essential oil that is available in high concentrations in the peels of citrus fruits. Which has several uses and applications in many disciplines including cosmetics, pharmaceuticals, and cleaning solutions. And it can also be used as a Biofuel because of its flammability [1,7]. Extraction of this highly useful essential oil from the peels of citrus fruits can be done in many methods such as (1) Cold Pressing (2) Solvent Extraction (3) Simple Distillation. Super Critical CO2 extraction [2,3]. In the current investigation, we used Simple Distillation set for the process of extraction of D-Limonene using orange peels [11,14]. Limonene is a popular additive in foods, cosmetics, cleaning products, and natural insect repellants[13]. For example, it's used in foods like sodas, desserts, and candies to provide a lemony flavor. Due to its strong aroma, limonene is utilized as a botanical insecticide [6,9]. It's an active ingredient in multiple pesticide products. Other household products containing this compound include soaps, shampoos, lotions, perfumes, laundry detergents, and air fresheners [10]. Limonene has been studied for its potential anti inflammatory, antioxidant, anticancer, and heart-disease-fighting properties. One line that fits best to our motivation in initiating this project is BRINGING THE BEST OUT OF WASTE". Every year, a whopping 3.8 million tons of orange peels are dumped as waste. D-Limonene is an essential oil that can be extracted from orange peel wastes, which costs around Rs.500/- to Rs.700/- per ounce in the current market. Extracting D-Limonene from such discarded orange peels gives us two benefits which are extracting essential oil and reducing the orange peel waste. [12,15].

During the processing of citrus fruits, approximately 50% of the fruit weight is wasted as peels and pulp, which includes seeds and membranes (Santiago et al., 2020), as well as the inner peel, called albedo comprising about 17% of the total fruit weight, and the outer peel, or flavedo, comprising 10% of total fruit weight (Zema et al., 2018), as shown

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in Fig. 1. About 30% of all citrus production goes to processing, main the production of juice. Oranges, mostly referring to the sweet orange Citrus sinensis but at times also to the bitter orange Citrus aurantium, are the most commonly consumed of all citrus fruits (Izquierdo and Sendra, 2003) at an estimated production of 72 million tonnes. Thus, orange peel made up a significant fraction of the approximately 25 million tonnes of citrus wastes generated globally in 2016 (Zema et al., 2018). In the European Union (EU) alone, the production of this waste stream in 2013 exceeded 10 million tonnes.

Due to its low pH and high water and organic matter contents, citrus wastes are legally not disposable in landfills in the EU (EU Waste Framework Directive, 2008), and their use as animal feed, though nutritious, can cause digestive diseases in livestock when introduced in larger quantities (Martín et al., 2010). Some established waste management practices include anaerobic digestion, composting, and incineration (Flotats et al., 2015). However, great potentials lay in the utilisation of orange peel wastes in bio-refineries as feedstock for fermentation and source of carbohydrate polymers, enzymes (Ozturk et al., 2019, Panić et al., 2021), and various bioactive compounds with pharmaceutical applications (Montero-Calderon et al., 2019).

D-Limonene from Orange Peel :-

Limonene, one of the most abundant naturally occurring components of cannabis essential oils, is a plant product of terpenes. It is present in concentrations as high as 16% of essential oil fractions. Limonene is a clear, colourless hydrocarbon classified as a cyclic monoterpene, and is the major component in oil of citrus fruit peels most widely distributed in nature. It occurs naturally in orange peels, lemon, dill, mint, cumin and neroli. Limonene occurs in two optically active forms, (S–(–)–limonene and R–(+)-limonene). It also has two isomeric forms (D–isomer and L–isomer). D–limonene, a monocyclic terpene, occurs more commonly in nature. It is the fragrance of oranges and is used as a flavouring agent in food manufacturing (Ludwiczuk et al. 2017). Studies have shown that D–limonene is toxic to animals such as dogs (680 g/kg dosage) and cats. Also it has insecticidal properties and acts primarily as a desiccant for all life stages of insects such as flea, ticks, etc. Therefore, it is a component of some products made from citrus oils such as soaps, shampoos, cleansers, solvents, fragrances, and insecticides (Plumlee 2013). The less common L-isomer is found in mint oils and has a piney, turpentinelike odour. Anti-tumour activities of the compound in several animal tumour models and in vitro experiments have been reported (Amanzadeh et al. 2006, Barceloux 2008).

II. LITERATURE REVIEW

M. Boluda-Aguilar et al. Production of bioethanol by fermentation of lemon (Citrus limon L.) peel wastes pretreated with steam explosion, Ind. Crops Prod. (2013). The application of steam explosion and enzymatic hydrolysis pretreatments on lemon (Citrus limon L.) citrus peel wastes was studied to obtain bioethanol, galacturonic acid and other co- products, such as D-limonene and citrus pulp pellets. Steam explosion pretreatment and recovery of lemon citrus essential oils was carried out at pilot plant scale. The effect of steam explosion on lignocellulosic composition of lemon peel wastes was studied by thermogravimetric analysis. The antimicrobial activity of lemon essential oil on Saccharomyces cerevisiae and its influence on ethanol production during fermentation were also studied. The steam-exploded lemon peel wastes were processed by sequential and simultaneous hydrolysis and fermentation. Concentrations of sugars, galacturonic acid and ethanol were analyzed to measure the efficiency of these processes. Significant antimicrobial activity of lemon essential oils has been observed on S. cerevisiae at concentrations above 0.025%. The steam explosion pretreatment has shown an interesting effect on lemon peel wastes processing for obtaining ethanol and galacturonic acid. This pretreatment reduces the residual content of essential oils below 0.025% and significantly decreases the hydrolytic enzyme requirements. Ethanol production in excess of 60 L/1000 kg fresh lemon peel biomass can be obtained.

M. Boukroufa et al. Bio-refinery of orange peels waste: a new concept based on integrated green and solvent free extraction processes using ultrasound and microwave techniques to obtain essential oil, polyphenols and pectin, Ultrason. Sonochem. (2015). In this study, extraction of essential oil, polyphenols and pectin from orange peel has been optimized using microwave and ultrasound technology without adding any solvent but only “in situ” water which was recycled and used as solvent. The essential oil extraction performed by Microwave Hydrodiffusion and Gravity (MHG) was optimized and compared to steam distillation extraction (SD). No significant changes in yield were noticed: 4.22 ±

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0.03% and 4.16 ± 0.05% for MHG and SD, respectively. After extraction of essential oil, residual water of plant obtained after MHG extraction was used as solvent for polyphenols and pectin extraction from MHG residues. Polyphenols extraction was performed by ultrasound-assisted extraction (UAE) and conventional extraction (CE). Response surface methodology (RSM) using central composite designs (CCD) approach was launched to investigate the influence of process variables on the ultrasound-assisted extraction (UAE). The statistical analysis revealed that the optimized conditions of ultrasound power and temperature were 0.956 W/cm2 and 59.83 °C giving a polyphenol yield of 50.02 mg GA/100 g dm. Compared with the conventional extraction (CE), the UAE gave an increase of 30% in TPC yield. Pectin was extracted by conventional and microwave assisted extraction. This technique gives a maximal yield of 24.2% for microwave power of 500 W in only 3 min whereas conventional extraction gives 18.32% in 120 min. Combination of microwave, ultrasound and the recycled "in situ" water of citrus peels allow us to obtain high added values compounds in shorter time and managed to make a closed loop using only natural resources provided by the plant which makes the whole process intensified in term of time and energy saving, cleanliness and reduced waste water.

J. Bustamante et al. Microwave assisted hydro-distillation of essential oils from wet citrus peel waste, J. Clean. Prod. (2016). Over 30% of the total citrus fruits grown all over the World are processed, generating large quantities of peel waste from which essential citrus oils are often extracted by traditional methods demanding high energy costs, long extraction times and additional reagents. In this research an alternative technique based on microwave- assisted hydro-distillation (MAHD) has been studied to successfully extract the essential oil present in wet citrus peel waste whilst reducing costs, avoiding the use of additives and improving the effectiveness of the process. To achieve this goal factors affecting the scalability of the process to develop a new bio-refinery model to be used at industrial scale were considered. Optimal conditions for the essential oil MAHD involved the irradiation of a waste orange peel:water mixture (1:1.5) over two subsequent steps using different irradiation powers for a total extraction time of 20 min (keeping a constant pressure of 300 mbar through all the process). The essential oil yield obtained in Navel Navelate oranges using MAHD accounted for 1.8± 0.1% (dry basis; n = 3) and was comparable to that obtained by conventional hydro- distillation (1.7± 0.1%; dry basis; n = 3). The applicability of the suggested methodology was successfully tested in other varieties of orange and citrus fruits leading to the potential to apply MAHD of essential oils from other waste feedstocks and offering an attractive process for future extraction processes at industrial scale.

Y. Dai et al. Natural deep eutectic solvents providing enhanced stability of natural colorants from safflower (Carthamus tinctorius) Food Chem. (2014). A certain combination of natural products in the solid state becomes liquid, so called natural deep eutectic solvents (NADES). Recently, they have been considered promising new green solvents for foods, cosmetics and pharmaceuticals due to their unique solvent power which can dissolve many non-water-soluble compounds and their low toxicity. However, in addition to the features as solvents, the stabilisation ability of NADES for compounds is important for their further applications. In the study, the stability analysis demonstrates that natural pigments from safflower are more stable in sugar-based NADES than in water or 40% ethanol solution. Notably, the stabilisation capacity of NADES can be adjusted by reducing water content with increasing viscosity. The strong stabilisation ability is due to the formation of strong hydrogen bonding interactions between solutes and NADES molecules. The stabilising ability of NADES for phenolic compounds shows great promise for their applications in food, cosmetic and pharmaceutical industries.

M. Panić et al. Enabling technologies for the extraction of grape-pomace anthocyanins using natural deep eutectic solvents in up-to-half-litre batches extraction of grape-pomace anthocyanins using NADES Food Chem. (2019). Bioactive compounds should be extracted using alternative solvents and enabling technologies, in accordance with green extraction principles. The aim of this study is to develop an eco-friendly extraction method for grape-pomace anthocyanins on a larger scale. From a preliminary screening of 8 different natural deep eutectic solvents (NADES), a combination of choline chloride:citric acid was selected because of its price, physicochemical properties, and anthocyanin recovery and stability. The effects of multimode-microwave (MW), and low- frequency-ultrasound (US) irradiation (used alone or simultaneously), as well as that of process parameters on extraction efficiency have been investigated in order to maximise anthocyanin extraction yield. The best conditions were found to be: simultaneous

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ultrasound/microwave-assisted extraction (UMAE) (MW power at 300 W, US power 50 W), for 10 min with 30% (v/v) of water.

B. Ruiz et al. Effect of limonene on batch anaerobic digestion of citrus peel waste, Biochem. Eng. J.(2016). The objective of this study was to analyze the anaerobic digestion process inhibition by limonene, the main component of citrus essential oils (CEO) present in citrus peel. The biochemical methane potential (BMP) values of the citrus waste tested (orange peel, mandarin peel, mandarin pulp and rotten fruit) were 354–398 LCH4 kgVS−1. Grinding the orange peel (2.5 glimonene L−1) did not influence the BMP values, but slowed the kinetics, due to the increased availability of CEO caused by the grinding. The effect of (R)-limonene (0–3000 mg L−1) on the batch anaerobic digestion of microcrystalline cellulose was also assessed. The half maximal inhibitory concentration, IC50, was 423 mg kg−1 in an initial run and 669 mg kg−1 in a second run of batch experiments. The methane course and IC50 values indicate that there are reversible inhibition and biomass activity recovery during the anaerobic digestion process, despite the non-reversible antimicrobial mechanism described in the literature for limonene to date.

N. Sahraoui et al. Valorization of citrus by-products using microwave steam distillation (MSD), Innov. Food Sci. Emerg. Technol. (2011). A microwave steam distillation (MSD) of essential oils from fresh citrus by-products (orange peels) was studied. The effectiveness of this innovative method in extraction of citrus essential oils have been evaluated and compared to conventional steam distillation. MSD offers important advantages like shorter extraction time (6 min), cleaner features and provides an essential oil with better sensory properties (better reproduction of natural fresh fruit aroma of the citrus essential oil) at optimized power (500 W). Results from chemical and cytological approaches confirm the effectiveness of this new technique, that allows substantial savings in terms of time and energy.

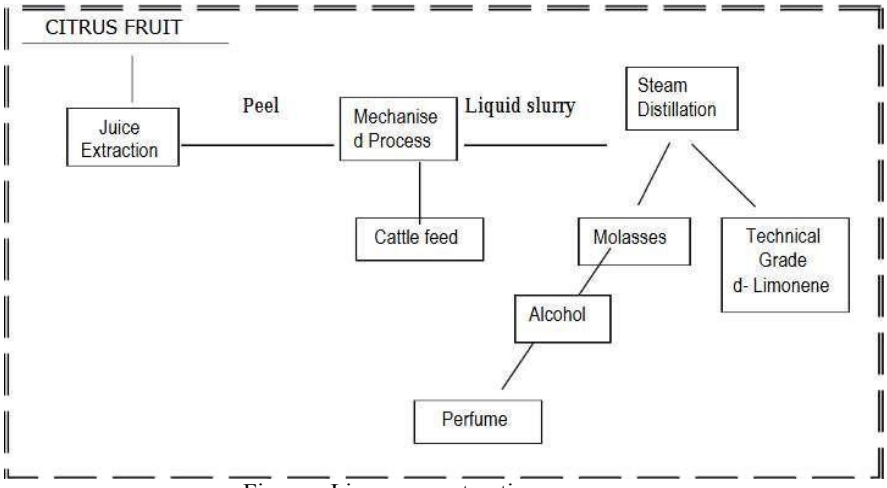


Figure:- Limonene extraction process.

Nutritional Values/100g:- Carbonhydrate9.0g,Dietary fibre2.3g, Sugars 2.5g, Fat 0.3g,Protein 1.1g,Water 89g, Vitamin C 53mg (88%), Citric Acid 5g. (Calomme et al.,1996).

Packaging and Shelf Life of D-Limonene:- Oxidation may occur between the time the oil is extracted and the time it is sealed into a container. So it must be kept in an airtight container. It must also be kept from contamination by inferior oil (deteriorated oil) or substance that might increase the rate of deterioration. The shelf life of lemon oil is only 8 – 10 months, if it is to be used in aromatherapy, but can still be used in fragrance therapies after this time, such as vapour therapy.

D-Limonene:- Limonene recovered from orange peel from the conversion of press liquor to molasses, d-limonene is used for making everything from adhesive to a solvent used by the electronic industry as a replacement of ozone depletion chlorofluorocarbons.Limonene is a hydrocarbon classed as a terpene, it is a clear coloured liquid at a room temperature with a strong smell of orange. It takes its name from lemon, like other citrus fruits, contains a considerable amount of this chemical compound responsive for the smell.(Stromvall, 1992: Rimpler,1999).

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Physical Properties:- Limonene is colourless liquid oil at room temperature with a characteristic odour. It is insoluble in water but soluble in alcohol and ether. It has boiling point of 74OC.

Chemical Composition:- The main chemical compositions of lemon oil are a-pinene, camphene, b-pinene, sabinene, a-terpene, linalool, b-bisabolene, limonene, trans-a-bergamotene, nerol and neral. It belongs to the family (chemically) of cycloalkene called terpenes. Its IUPAC name is 4-isopropeny–1–methylcyclohexane. It has an aldehyde content between 0.13% - 1.50% (karbery; et al. 1992).

Therapeutic Properties:- The therapeutic properties of lemon oil are anti-anaemic, antimicrobial, anti-rheumatic, anti-sclerotic, antiseptic,. It also serves has bactericidal, carminative, cicatrizant, depurative, diaphoretic, diuretic, febrifuge, haemostatic, hypotensive, insecticidal, rubefacient, tonic and vermifuge.

Other Uses of Essential Oil:- Aromatherapy, Wound and Sores, Douching,Foots,Cataract,Cosmetics, Stimulating, anti-anaemic, antimicrobial, ant-rheumatic, catarrh, cold, bronchitis, throat infection, mouth ulcers, spots and varicose, Essences and Aromas, Cold Pressed Oil. (Opdyke,1978).

III. METHODOLOGY

The methodology for extracting limonene from orange peels typically involves either steam distillation, cold pressing, or solvent extraction. Below is a detailed methodology for extracting limonene using steam distillation, which is a common and efficient method.

Materials Needed:

- Fresh orange peels (preferably from ripe oranges)
- Distillation apparatus (including a distillation flask, condenser, and receiving flask)
- Water
- Heat source (e.g., electric heater or Bunsen burner)
- Separatory funnel (for oil-water separation)
- Ice (for cooling)
- pH paper (optional, for quality control)

Procedure and Steps in Steam Distillation for Limonene Extraction:

1. Preparation of Orange Peels:

- Cleaning: Wash the orange peels thoroughly to remove any dirt, pesticides, or other impurities.
- Peeling: Peel the oranges, ensuring that the peels are free from the bitter white pith as much as possible. You can use a knife or peeler to do this.
- Chopping: Cut the peels into smaller pieces or shred them to increase the surface area for better extraction.

2. Setting Up the Distillation Apparatus:

- Distillation Flask: Place the chopped orange peels in a distillation flask.
- Water: Add enough distilled water to the flask to submerge the peels. This water will help generate steam for the distillation process.
- Condenser Setup: Connect the distillation flask to a condenser. Ensure the condenser is properly connected to a receiving flask where the distillate will be collected.
- Coolant: Ensure that water flows through the condenser to keep the vapor cool and enable condensation into liquid form. Use a constant flow of cold water for cooling.

3. Steam Distillation Process:

- Heating: Heat the water in the distillation flask. As the water boils, steam will pass through the orange peels, carrying the essential oil (limonene) and other volatile compounds.
- Condensation: The steam and vapor mixture will rise through the condenser. The condenser will cool the mixture, causing the steam to condense back into liquid form.

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• Collection: The liquid (a mixture of water and limonene) will flow into the receiving flask.

4. Separation of Limonene from the Water:

• Separation: After distillation, you will have two phases in the receiving flask: a water layer (hydrosol) and the essential oil layer (limonene). Limonene, being less dense than water, will float on top.

• Decantation: Carefully separate the two layers. The essential oil (limonene) can be separated by decantation or using a separatory funnel.

5. Purification of Limonene:

• Drying: If any water remains in the essential oil, it can be dried using anhydrous sodium sulfate to absorb the moisture.

• Filtration: The oil can be filtered to remove any remaining solids.

• Storage: Store the pure limonene in airtight containers, away from direct sunlight to preserve its quality and prevent oxidation.

6. Optional Quality Control:

• Purity Check: You can check the purity of the extracted limonene using techniques like gas chromatography (GC) or by its characteristic odor (fruity citrus aroma).

• pH Test: In some cases, checking the pH of the hydrosol or the distillate can help ensure proper extraction conditions, as limonene is acidic.

IV. CONCLUSION

The extraction of limonene from orange peels provides a valuable method for obtaining a natural, versatile compound with wide applications in industries such as pharmaceuticals, food and beverages, cleaning products, and cosmetics. In this study, steam distillation was utilized as the primary method for extracting limonene, offering a simple, efficient, and cost-effective means of obtaining this essential oil. The results indicated that steam distillation yielded a modest quantity of limonene from orange peels, with a purity that can be enhanced through optimization of extraction parameters such as temperature, time, and pressure. While the yield in this experiment was relatively low, it is essential to recognize that factors like the quality of the orange peels, the extraction method, and the scale of operation can significantly influence the efficiency of the process.

The process of limonene extraction not only presents an opportunity to recycle agricultural waste but also aligns with growing trends toward sustainable practices in industrial processes. As limonene is a renewable resource, the extraction process offers an environmentally friendly alternative to synthetic chemicals used in various products. Overall, the extraction of limonene from orange peels shows promise for both small-scale and large-scale applications, particularly in the context of sustainable practices. Future research and technological advancements, such as the optimization of extraction techniques and scaling up to industrial levels, will further enhance the feasibility and profitability of limonene extraction. Furthermore, exploring alternative applications and improving the yield of limonene will open new avenues for its use across a wide range of industries, making it an essential compound in the transition toward greener and more sustainable chemical processes.

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A Study on Green Approach of Biginelli Reaction using Biocatalyst

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Abstract: *The growing demand for environmentally friendly chemical processes has led to the exploration of biocatalysts as an alternative to conventional catalysts in organic synthesis. Green chemistry aims to reduce the environmental impact of chemical reactions by using sustainable, non-toxic, and biodegradable catalysts. In this study, we investigate the potential of fruit juices, particularly Kiwi and Karvanda, as natural biocatalysts for promoting organic reactions, specifically the Biginelli reaction. These fruit juices contain organic acids, polyphenols, and enzymes that facilitate chemical transformations under mild reaction conditions, reducing the need for harsh reagents and extreme temperatures. The Biginelli reaction, a widely studied multicomponent reaction, is crucial for synthesizing dihydropyrimidinones (DHPMs), which have applications in pharmaceutical and medicinal chemistry. The use of fruit juice-based catalysts offers several advantages, including low cost, easy availability, non-toxic nature, and environmental sustainability. This study not only demonstrates the efficiency of natural catalysts but also highlights their potential role in promoting eco-friendly synthetic methodologies. Despite their numerous benefits, the large-scale implementation of biocatalysts in organic chemistry faces challenges such as standardization of catalytic activity, stability, and reusability. However, ongoing research and technological advancements are expected to overcome these limitations, making green catalysts a viable alternative in the future. This study contributes to the growing field of sustainable chemistry by encouraging further exploration of natural catalysts in organic synthesis..*

Keywords: Biocatalysis, Green Chemistry, Fruit Juice Catalysts, Biginelli Reaction, Sustainable Organic Synthesis, Natural Catalysts, Eco-Friendly Reactions

I. INTRODUCTION

Dihydropyrimidinones (DHPMs) are nitrogen-containing heterocycles with diverse biological activities, including anticancer, antibacterial, and antifungal properties. The Biginelli reaction, a three-component condensation reaction of urea, ethyl acetoacetate, and aromatic aldehydes, is a key method for synthesizing DHPMs. However, conventional methods employ toxic Lewis acid catalysts and volatile organic solvents, posing environmental risks.

Green chemistry principles have prompted the search for sustainable reaction conditions. Previous studies have explored solvent-free and catalyst-free conditions, but these often require high temperatures (100–105°C). Alternative methodologies, including microwave and ultrasonic irradiation, have been explored but still rely on toxic catalysts. This study investigates fruit juices as a natural and sustainable catalytic medium for the Biginelli reaction. By utilizing fruit juices such as kiwi and karvanda, which contain organic acids like citric acid and ascorbic acid, the reaction can be performed under milder and greener conditions [1,2].

The need for sustainable chemical processes has gained increasing attention due to the rising concerns regarding environmental degradation caused by chemical waste. Chemical reactions that adhere to green chemistry principles aim to minimize hazardous byproducts, utilize renewable resources, and enhance efficiency. The Biginelli reaction, a cornerstone in the synthesis of biologically active compounds, serves as an ideal candidate for incorporating green methodologies. The employment of fruit juices as biocatalysts offers multiple benefits, including easy availability, non-toxicity, and biodegradability.

This research aims to demonstrate how natural acids and enzymes in fruit juices can catalyze the reaction, leading to high product yield with reduced environmental impact. Future studies will explore different fruit-based catalysts,

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optimize reaction conditions, and analyze the mechanistic aspects of fruit juice-mediated catalysis. The ultimate goal is to establish fruit juices as viable, green alternatives to conventional chemical catalysts, thereby reducing the chemical footprint of synthetic organic chemistry [1,2].

The Biginelli reaction, first reported by Pietro Biginelli in 1891, is a three-component condensation reaction involving urea, ethyl acetoacetate, and an aldehyde, leading to the synthesis of dihydropyrimidinones (DHPMs) [1].

DHPMs have significant pharmaceutical applications, including antiviral, anticancer, anti- inflammatory, and antihypertensive properties [1].

1.1 CHALLENGES IN CONVENTIONAL BIGINELLI SYNTHESIS

Traditional methods employ strong acid catalysts (HCl, H_2SO_4) or Lewis acids ($AlCl_3$, $FeCl_3$, $BiCl_3$) in volatile organic solvents (ethanol, acetonitrile, dichloromethane) [3]. However, these methods suffer from:

- Toxicity – Hazardous catalysts and organic solvents.
- Environmental Concerns – Non-biodegradable chemical waste.
- High Energy Demand – Requires refluxing or prolonged reaction times.
- Low Selectivity & Yield– Leads to unwanted byproducts.

To address these issues, researchers are exploring green chemistry approaches using biocatalysts and sustainable reaction conditions [4] .

II. GREEN CHEMISTRY IN ORGANIC SYNTHESIS

Green Chemistry is an emerging field that focuses on reducing chemical waste, avoiding toxic reagents, and using sustainable resources [5] .

2.1 PRINCIPLES OF GREEN CHEMISTRY IN BIGINELLI REACTION

Use of Renewable Catalysts – Replacing hazardous chemicals with natural fruit juices. Mild Reaction Conditions – Conducting reactions at room temperature or mild heating. Eco-friendly Solvent Systems – Using water or ethanol instead of organic solvents.

These approaches not only enhance yield and selectivity but also contribute to sustainable development goals (SDGs) in chemistry [6] .

III. BIOCATALYSTS IN ORGANIC SYNTHESIS

A biocatalyst is a natural substance (e.g., enzymes, organic acids) that accelerates chemical reactions without the need for hazardous reagents [7].

3.1 FRUIT JUICES AS GREEN CATALYSTS

Many fruit juices contain organic acids (citric, ascorbic, tartaric), flavonoids, and polyphenols, which can effectively catalyze condensation reactions [8].

Several studies have investigated green catalysts for the Biginelli reaction, emphasizing different approaches to sustainable synthesis. Previous research has demonstrated the effectiveness of various biocatalysts, including plant extracts and fruit juices, in facilitating multicomponent reactions under mild conditions.

Studies have highlighted that natural acids present in fruit juices, such as citric acid and ascorbic acid, play a crucial role in promoting the condensation reaction. Additionally, enzymatic components in fruit extracts have been shown to accelerate the reaction, increasing yield while minimizing the formation of by-products.

While several research papers have validated the use of fruit juices as catalysts, there remains a need for systematic studies comparing different fruit juices and their catalytic efficiencies. This literature review explores previous findings, identifies knowledge gaps, and highlights the need for further experimental validation to establish standardized green synthesis protocols.

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Gulati et al. reported the use of coconut, tomato, and sweet lime juices as catalysts.
Patil et al. demonstrated solvent-free synthesis at high temperatures but highlighted the need for milder conditions.
Nazeruddin et al. utilized grape juice (pH 3.0–3.5) for DHPM synthesis, achieving high yields.
Kidwai et al. synthesized quinazoline derivatives via microwave irradiation, demonstrating antimicrobial activity.

IV. COMPARATIVE ANALYSIS: TRADITIONAL VS. GREEN CATALYSIS

PARAMETERS	CONVENTIONAL BIGINELLI REACTION	BIOCATALYST-BASED BIGINELLI REACTION
Catalyst used	Lewis acids ($AlCl_3$, $FeCl_3$)	Fruit juices (citric acid, polyphenols)
Solvent	Organic solvents (CH_2Cl_2)	Water or ethanol
Reaction time	8-12 hours	3-5 hours
Toxicity	High	Low (Biodegradable)
Yield (%)	65-80%	80-90%
Sustainability	Non-renewable	Renewable

V. MECHANISM OF BIGINELLI REACTION USING BIOCATALYSTS

Activation of Aldehyde: Organic acids in fruit juice protonate the carbonyl group, increasing its reactivity.
Formation of Intermediate: Urea undergoes nucleophilic attack, leading to an intermediate.
Condensation with Ethyl Acetoacetate: Cyclization occurs, forming dihydropyrimidinone (DHPM).
Hypothesis: Fruit juices provide a mild acidic environment that promotes efficient cyclization without requiring strong acids [12].

VI. APPLICATIONS

6.1 Pharmaceutical Industry: DHPMs as anticancer, antiviral, and anti-inflammatory agents.
6.2 Agrochemicals: Use of DHPM derivatives as pesticides and plant growth regulators.
6.3 Material Science: Application in polymers and advanced materials.
6.4 Catalysis Research: Promoting food waste utilization as green catalysts.
6.5 Academic Research: Sustainable laboratory practices in organic synthesis.
6.6 Food & Beverage Industry: Insights into bioactive properties of fruit juices.
6.7 Green Chemistry Advocacy: Promoting environmentally friendly synthetic methods.

VII. CONCLUSION

This research project represents a significant step towards the development of environmentally sustainable methodologies in organic synthesis by employing fruit juices as biocatalysts in the Biginelli reaction. The use of natural catalysts such as kiwi and karvanda fruit juices offers a promising alternative to traditional chemical catalysts, which are often associated with high toxicity, environmental hazards, and energy-intensive processes. The adoption of fruit juices not only aligns with the principles of green chemistry but also highlights the innovative use of renewable resources in achieving high reaction efficiencies under mild conditions [2].
The preliminary theoretical framework of this study suggests that the bioactive components in fruit juices, including organic acids (citric acid and ascorbic acid), antioxidants, and natural enzymes, possess the ability to catalyze the Biginelli reaction effectively. These compounds are expected to accelerate the condensation reaction between urea, ethyl acetoacetate, and aromatic aldehydes to produce dihydropyrimidinones (DHPMs), which are valuable in pharmaceutical, agricultural, and material science applications. The environmental benefits of this approach include reduced waste generation, elimination of hazardous byproducts, and a decrease in the dependency on synthetic chemicals and fossil fuel-derived solvents.
Despite the encouraging theoretical underpinnings, the practical implementation of this study remains crucial. Experimental validation will help determine the exact catalytic efficiency of each fruit juice, the reaction conditions required for optimal yield, and the purity of the final products. Additional factors such as reaction time, scalability, and

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product isolation will also be assessed to establish the feasibility of this method for large-scale applications. Moreover, comparative studies with traditional catalysts will help evaluate the economic and environmental advantages of the proposed green approach [3].

If successfully implemented, this research could lead to a paradigm shift in the field of organic synthesis by showcasing the viability of natural biocatalysts in promoting complex chemical reactions. It could serve as a foundation for future studies focused on expanding the scope of biocatalysis using other fruit juices or natural extracts. Beyond the laboratory, the findings could inspire industries to adopt sustainable practices, thereby contributing to the global movement towards greener and more eco-friendly technologies.

In conclusion, this study has the potential to demonstrate how simple, readily available, and renewable resources like fruit juices can be harnessed to achieve sophisticated chemical transformations. By integrating sustainability into organic synthesis, this project underscores the importance of innovation in addressing environmental challenges while maintaining scientific progress [4].

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To Study Fenton and Photo Fenton Reaction for the Degradation of Water Pollutants

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Abstract: *Fenton and photo-Fenton reactions have emerged as effective Advanced Oxidation Processes (AOPs) for the degradation of organic pollutants in wastewater treatment. The Fenton process utilizes ferrous ions (Fe^{2+}) and hydrogen peroxide (H_2O_2) to generate hydroxyl radicals (•OH), which play a crucial role in breaking down contaminants. The photo-Fenton process, an enhanced version of the Fenton reaction, involves the application of ultraviolet (UV) light to further accelerate hydroxyl radical formation, leading to improved degradation efficiency, particularly for recalcitrant pollutants. This study aims to optimize key parameters influencing the Fenton and photo-Fenton processes, such as pH, Fe^{2+}/H_2O_2 concentration, reaction time, and UV light intensity, to achieve maximum pollutant removal. Experimental investigations involve UVVis spectrophotometry, Chemical Oxygen Demand (COD) reduction, and Total Organic Carbon (TOC) measurements to assess treatment performance. The study highlights the potential of these methods as cost-effective and environmentally friendly alternatives for wastewater treatment. However, challenges such as iron sludge formation, high hydrogen peroxide consumption, and acidic operating conditions require further optimization. Future research should focus on catalyst stabilization, solar-assisted photo-Fenton systems, and integration with other treatment technologies to enhance practical applications [1]..*

Keywords: Fenton Process, Photo-Fenton Process, Advanced Oxidation Processes (AOPs), Hydroxyl Radicals (OH), Water Pollutants, Wastewater Treatment, Hydrogen Peroxide (H_2O_2), Ferrous Ions (Fe^{2+}), UV Light, Pollutant Degradation, Environmental Remediation, Industrial Wastewater, Sustainability in Water Treatment [1].

I. INTRODUCTION

Water pollution is a critical global concern, impacting ecosystems, human health, and the economy. As industrialization, agriculture, and urbanization grow, pollutants like heavy metals, organic chemicals, and pesticides contaminate water bodies. This contamination affects drinking water sources, aquatic life, and biodiversity. Effective and sustainable water purification methods are urgently needed, especially in areas facing water scarcity. Among various treatment techniques, advanced oxidation processes (AOPs) have gained attention for their ability to break down pollutants into harmless by-products. One such AOP is the Fenton reaction, which involves the generation of hydroxyl radicals (•OH) through the reaction of hydrogen peroxide (H2O2) with ferrous ions (Fe^{2+}), leading to the degradation of a broad range of organic pollutants [2].

The Fenton reaction, discovered by chemist H.J.H. Fenton in the late 19th century, involves Fe^{2+} and H2O2 reacting to produce hydroxyl radicals, which degrade organic contaminants. The reaction is simple, low-cost, and effective for various pollutants such as dyes, pesticides, and pharmaceuticals. However, it requires careful control of reaction conditions, including pH and hydrogen peroxide dosing. The Photo- Fenton reaction enhances the Fenton process by introducing ultraviolet (UV) light, which accelerates the formation of hydroxyl radicals. UV light helps oxidize Fe^{2+} to Fe^{3+}, boosting the reaction's efficiency and making it more effective in degrading more persistent pollutants. This modification makes the Photo-Fenton process increasingly attractive for environmental applications [3].

Both reactions rely on hydroxyl radicals (•OH), which are highly reactive and break down organic pollutants. In the Fenton reaction, Fe^{3+} is reduced to Fe^{2+} in the presence of H2O2, generating hydroxyl radicals that attack organic

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compounds. In the Photo-Fenton process, UV light further accelerates the reaction by energizing Fe^{2+} ions, producing more hydroxyl radicals and enhancing pollutant degradation [4].

Despite some challenges, such as the need for pH control and iron catalyst regeneration, ongoing research is addressing these issues, making the Fenton and Photo-Fenton methods increasingly viable for both industrial and municipal water treatment [4].

Fenton and Photo-Fenton Reactions:

The Fenton and Photo-Fenton reactions are both chemical processes that involve the use of iron (Fe) to generate highly reactive hydroxyl radicals (•OH), which are powerful oxidizing agents. These reactions are often used in environmental chemistry for the degradation of pollutants, especially in wastewater treatment. Here's a simple breakdown of each reaction [5].

Fenton Reaction

The Fenton reaction is a classic process in which hydrogen peroxide (H_2O_2) reacts with ferrous iron (Fe^{2+}) in an acidic solution, producing hydroxyl radicals (•OH) and hydroxide ions (OH^-).

Reaction:

Fe2++H2O2→Fe3++OH−+·OH

Fe^{2+} (ferrous iron) is the catalyst.

H_2O_2 (hydrogen peroxide) is the oxidant.

The reaction produces hydroxyl radicals (•OH), which are highly reactive and can break down organic pollutants.

The reaction occurs in acidic conditions, typically around pH 3.0 to 4.0 [6].

Photo-Fenton Reaction

The Photo-Fenton reaction is an extension of the Fenton reaction, where the process is enhanced by ultraviolet (UV) light. The UV light helps regenerate the Fe^{2+} (ferrous iron) from Fe^{3+} (ferric iron), making the process more efficient. This means that the reaction proceeds more quickly, and more hydroxyl radicals are produced.

Reaction:

Fe3++UV light→Fe2++H2O2

UV light drives the regeneration of Fe^{2+}, making the process continuous and more efficient.

The photo-Fenton reaction is particularly useful for degrading pollutants that are difficult to break down using just the Fenton reaction [7].

II. COMPARISON BETWEEN FENTON REACTION AND PHOTO FENTON REACTION

Here's a comparison between the Fenton and Photo-Fenton reactions : [8-9].

Aspect	Fenton Reaction	Photo-Fenton Reaction
Key Components	Ferrous iron (Fe^{2+}), Hydrogen peroxide (H_2O_2)	Ferrous iron (Fe^{2+}), Hydrogen peroxide (H_2O_2), UV light
How it works	Fe^{2+} reacts with H_2O_2 to produce hydroxyl radicals (•OH) in acidic conditions.	UV light is used to regenerate Fe^{2+} from Fe^{3+}, allowing continuous production of hydroxyl radicals.
Efficiency	Limited efficiency as the reaction slows once Fe^{2+} is converted to Fe^{3+}.	More efficient, as UV light regenerates Fe^{2+}, making the process continuous.
Speed	Slower due to Fe^{3+} buildup and decreased reaction rate.	Faster, due to the regeneration of Fe^{2+} by UV light, allowing continuous radical generation.
Pollutant	Effective but can slow down with more	More effective and faster degradation of a wide range of

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Degradation	complex pollutants.	pollutants.
Best for	Controlled oxidation in simpler applications.	Advanced and continuous pollutant degradation, especially for tougher contaminants.
Energy Requirements	Low (no UV light needed).	Higher (requires UV light to regenerate Fe^{2+}).

III. MECHANISM OF THE FENTON AND PHOTO-FENTON REACTIONS

Fenton Reaction Mechanism:

The Fenton reaction involves the generation of hydroxyl radicals (•OH), which are powerful oxidizing agents capable of degrading organic pollutants. The mechanism is as follows:

Fe^{2+} Activation: The ferrous ion (Fe^{2+}) reacts with hydrogen peroxide (H_2O_2) in an acidic medium (pH 3.0-4.0) to produce a hydroxyl radical (•OH) and a ferric ion (Fe^{3+}).

The reaction can be summarized as:

Fe2++H2O2→Fe3++OH−+·OH

Generation of Hydroxyl Radicals: The hydroxyl radicals (•OH) produced in this reaction are highly reactive and play a key role in the degradation of organic pollutants. These radicals attack the organic contaminants, breaking them down into simpler, often non- toxic by-products such as carbon dioxide and water.

Regeneration of Fe^{2+}: In this reaction, Fe^{3+} is formed, but it can be reduced back to Fe^{2+} through other reactions (e.g., electron transfer from organic substrates), thus allowing the cycle to continue

The Fenton reaction is highly efficient in breaking down a broad range of organic pollutants, but its efficiency can decrease as Fe^{2+} gets oxidized to Fe^{3+}, slowing the process. This is where the Photo-Fenton reaction comes in for improvement [10].

Photo-Fenton Reaction Mechanism:

The Photo-Fenton reaction is an extension of the Fenton reaction that uses ultraviolet (UV) light to enhance the process. UV light assists in regenerating Fe^{2+} ions, which accelerates the reaction, allowing for more hydroxyl radicals to be produced. Here's how the Photo-Fenton mechanism works:

UV-Induced Regeneration of Fe^{2+}: The Fe^{3+} produced in the Fenton reaction is reduced back to Fe^{2+} by the action of UV light. The UV light excites the Fe^{3+} ion, causing it to release an electron, which reduces Fe^{3+} to Fe^{2+}.

This can be represented as:

Fe3++hν(UV)→Fe2++hν(energy released)

Production of Hydroxyl Radicals: The regenerated Fe^{2+} can then react again with hydrogen peroxide to produce additional hydroxyl radicals:

Fe2++H2O2→Fe3++OH−+·OH

Continuous Cycle: UV light ensures the continuous regeneration of Fe^{2+}, maintaining the reaction's efficiency. This makes the Photo- Fenton process more efficient compared to the traditional Fenton process, as it accelerates the reaction rate and allows for a more sustained production of hydroxyl radicals. [11].

The addition of UV light enhances the degradation of persistent pollutants that are difficult to degrade using the standard Fenton process alone. By maintaining Fe^{2+} concentrations and continuously producing hydroxyl radicals, the Photo-Fenton reaction becomes a more effective and faster method for removing organic pollutants [11].

Applications and Advantages of Fenton and Photo-Fenton Reactions in Water Treatment

The Fenton and Photo-Fenton reactions offer several distinct advantages when applied to water treatment and the degradation of pollutants. Some of these benefits include:

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Efficiency: Both methods can degrade a wide range of pollutants, including synthetic dyes, pesticides, and pharmaceutical residues, with high efficiency.

Minimal by-products: The main by-products of the reactions are typically non-toxic compounds such as water and carbon dioxide, making them safe and sustainable.

Low operational costs: The Fenton process uses inexpensive reagents like iron salts and hydrogen peroxide, making it a cost-effective solution for large-scale treatment.

Enhanced degradation: The Photo-Fenton process is particularly beneficial for the treatment of more persistent and recalcitrant pollutants that are resistant to traditional treatment methods.

Despite their advantages, the practical implementation of Fenton and Photo-Fenton processes also comes with challenges, such as the need for precise control of pH levels, iron catalyst regeneration, and hydrogen peroxide dosing. Nonetheless, ongoing research and optimization efforts are addressing these issues, making these techniques increasingly viable for use in both industrial and municipal water treatment applications [12].

Future opportunities And difficulties

The Fenton and Photo-Fenton reactions offer great potential for environmental remediation, particularly in treating pollutants in water, soil, and air. These reactions could be integrated with solar energy to make them more sustainable and cost-effective, especially in developing countries with limited resources. They can also promote sustainable industrial practices by treating wastewater in sectors like textiles and chemicals.

However, challenges remain, such as the high cost of UV light for the Photo-Fenton process, difficulties in regenerating the iron catalyst, and the potential formation of harmful by-products. The reactions also require acidic conditions, which can add operational complexity, and scaling up the process for large applications is a challenge. Despite these issues, further research could make these processes more efficient, cost- effective, and widely applicable in environmental and industrial settings.

In addition to their environmental applications, the Fenton and Photo-Fenton reactions could play a crucial role in advancing sustainable water treatment technologies. As industries face increasingly stringent regulations on waste disposal, these reactions offer a promising solution for treating complex wastewater, reducing the environmental impact of industrial operations. The Photo-Fenton process, which can be powered by solar energy, could significantly lower the operational costs, making it a more attractive option for remote areas or places with limited access to electricity. Additionally, these reactions can be integrated with other advanced oxidation processes (AOPs) to further improve their effectiveness in degrading a wider variety of pollutants, including pharmaceuticals, personal care products, and endocrine disruptors, which are often difficult to remove using conventional methods.

On the other hand, the scalability of the process remains a major hurdle, particularly when it comes to controlling reaction parameters like pH, UV intensity, and catalyst recovery. Large-scale deployment may also face challenges due to the formation of unwanted side-products that require further treatment. Despite these difficulties, ongoing research into optimizing catalyst use, enhancing the regeneration process, and reducing energy consumption could make Fenton and Photo-Fenton reactions an essential tool in the fight against pollution and environmental degradation in the coming years

IV. LITERATURE REVIEW

1. Fenton and Photo-Fenton reactions hold significant potential for the degradation of water pollutants, and research is ongoing to explore their effectiveness and optimize their conditions. Much of the current research focuses on fine-tuning the reaction parameters to enhance their efficiency, particularly in the treatment of various pollutants, and understanding their detailed reaction mechanisms.

2. One area of investigation is the potential of Fenton and Photo-Fenton reactions for treating pharmaceutical wastewater. Preliminary studies suggest that both reactions could be effective in removing pharmaceutical residues, with the Photo-Fenton reaction showing promising results for faster degradation rates compared to Fenton alone (Wu et al., 2018). However, further research is needed to determine the scalability and efficiency of these reactions for different types of pharmaceutical compounds in real-world wastewater.

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3. Additionally, researchers have explored the degradation of bisphenol A (BPA) using Fenton-like reactions with various catalysts, including iron, copper, and cobalt. Initial findings indicate that the Fenton-like reaction with Fe as a catalyst showed superior degradation efficiency (Mohamed et al., 2018). Despite these promising results, more work is required to investigate the potential of other catalysts and determine their optimal usage in Fenton and Photo-Fenton processes.
4. The Photo-Fenton reaction has also been applied to the removal of organic pollutants such as dyes and pesticides. Studies have shown that under UV light, the degradation rate of pollutants like methyl orange is significantly accelerated (Zhang et al., 2019). While these findings are promising, further research is essential to understand the broader applicability of this reaction for various organic contaminants, particularly those with complex molecular structures.
5. Researchers are also working to deepen the understanding of the mechanisms behind Fenton and Photo-Fenton reactions. For instance, studies on the degradation of tetracycline hydrochloride have highlighted a complex mechanism involving the generation of hydroxyl radicals, which are key to breaking down the pollutants (Lu et al., 2020). However, a more comprehensive understanding of the reaction pathways and radical formation processes is still needed to improve efficiency and reduce by-products in these treatments.
6. Furthermore, studies have examined the effects of reaction conditions, such as pH, on the efficiency of the Photo-Fenton reaction. Initial results suggest that acidic conditions enhance the degradation of BPA due to an increase in hydroxyl radical production (Elnaggar and El- Sayed, 2018). However, more work is required to optimize pH levels and other reaction conditions to maximize the performance of these reactions in diverse wastewater scenarios.

V. CONCLUSION

The Fenton and Photo-Fenton reactions demonstrate considerable potential for the degradation of a wide range of water pollutants, including organic compounds like dyes, pesticides, and pharmaceutical residues, as well as inorganic contaminants such as heavy metals. The Fenton process, operating through the generation of hydroxyl radicals, is effective under optimized conditions, typically achieving high removal efficiencies for various pollutants. However, challenges such as the careful control of pH, hydrogen peroxide stability, and iron sludge formation can limit its practical applications.

The Photo-Fenton process, which incorporates UV light to enhance the production of hydroxyl radicals, offers improved efficiency, particularly for more persistent pollutants that are resistant to traditional treatment methods. The use of solar light in Photo-Fenton reactions further enhances its sustainability, making it a promising solution for large-scale and cost-effective water treatment, especially in regions with abundant sunlight.

Despite the advantages, both processes face hurdles like the high operational costs associated with hydrogen peroxide and the regeneration of the iron catalyst. Ongoing research aims to address these challenges by optimizing reaction parameters, improving catalyst stability, and minimizing by-product formation. Furthermore, scaling up these processes for industrial applications requires careful consideration of energy consumption, cost-effectiveness, and the management of residual iron sludge. In conclusion, both the Fenton and Photo-Fenton processes offer valuable tools for advanced water treatment, especially in tackling organic and inorganic pollutants. With continued advancements in process optimization and sustainability, these methods have the potential to play a key role in addressing global water pollution issues, offering a cleaner and more sustainable future for water resources.

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A Comprehensive Study on Diet Plans for Diabetic Patients

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Abstract: *Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels, requiring comprehensive management to prevent complications. Diet plays a crucial role in controlling blood sugar levels, improving overall health, and reducing the risk of long-term complications in diabetic patients. A well-structured diet plan for diabetic individuals focuses on balanced nutrition, portion control, and the regulation of carbohydrate intake. Key principles of an effective diabetic diet include consuming low- glycemic index foods, incorporating high-fiber content, and prioritizing lean proteins and healthy fats. Monitoring carbohydrate intake is essential, as it directly influences blood glucose levels. Emphasis is placed on whole grains, fresh vegetables, and fruits in moderation, while minimizing processed foods, sugary beverages, and saturated fats. Meal timing and consistency also play a critical role in maintaining stable glucose levels throughout the day. Personalized diet plans, tailored to an individual's medical history, lifestyle, and cultural preferences, enhance adherence and effectiveness. Emerging dietary approaches, such as the Mediterranean diet and plant-based diets, have shown promising outcomes in improving glycemic control and cardiovascular health. Collaborative care involving dietitians, healthcare providers, and patients is essential to develop and maintain sustainable dietary habits. This abstract highlights the importance of evidence-based dietary strategies for diabetic patients, emphasizing the need for individualized care to optimize health outcomes and quality of life. Future research should focus on refining dietary recommendations and exploring the impact of innovative nutritional approaches on diabetes management.*

Keywords: Diabetes management, diet plan, blood glucose control, low-glycemic index, carbohydrate regulation, high-fiber diet.

I. INTRODUCTION

A well-balanced diet is a crucial component of managing diabetes effectively. For diabetic patients, maintaining blood sugar levels within a healthy range is vital to prevent complications and improve overall well-being. A carefully designed diet plan helps control blood glucose levels, manage weight, and reduce the risk of heart disease and other diabetes-related complications.

A diabetic diet focuses on consuming nutrient-rich foods in appropriate portions and at regular intervals. This involves balancing carbohydrates, proteins, and fats while emphasizing fiber-rich and low-glycemic index (GI) foods to prevent spikes in blood sugar levels[1].

A diabetic diet plan is not a one-size-fits-all approach; it should be personalized to suit individual lifestyle, preferences, and medical needs. The primary goal is to maintain a steady blood sugar level throughout the day while providing the body with the necessary nutrients for optimal health. This requires careful monitoring of carbohydrate intake, as carbohydrates have the most direct impact on blood glucose. By choosing complex carbohydrates such as whole grains, legumes, and non-starchy vegetables, diabetic patients can prevent rapid spikes in blood sugar. Additionally, incorporating lean proteins and healthy fats into meals can help slow digestion, promote satiety, and stabilize glucose levels over time.

Another important aspect of a diabetic diet is portion control. Overeating, even healthy foods, can lead to increased blood sugar levels and weight gain, which can worsen insulin resistance. Using portion guides, measuring food servings, and being mindful of meal sizes can help manage caloric intake and maintain a healthy weight. Regular physical activity paired with a balanced diet further enhances blood sugar regulation and improves insulin sensitivity.

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Diabetic patients are encouraged to adopt mindful eating practices, such as eating slowly, recognizing hunger cues, and avoiding emotional or mindless eating.[2]

In addition to managing blood sugar levels, a diabetic diet should prioritize heart health, as individuals with diabetes are at an increased risk for cardiovascular disease. This means reducing the intake of saturated and trans fats, processed foods, and excessive sodium. Instead, the focus should be on heart-healthy fats like those found in olive oil, avocados, and fatty fish. Fiber-rich

foods, such as fruits, vegetables, and whole grains, are also beneficial as they help lower cholesterol levels and improve digestion. Staying hydrated by drinking plenty of water and limiting sugary beverages is equally important for overall health and blood sugar management.[3]

Consistency is key when following a diabetic diet. Regular meal timing helps to prevent blood sugar fluctuations and supports better metabolic control. It is also essential for diabetic patients to monitor their blood sugar levels regularly and adjust their diet as needed. Working closely with healthcare professionals, including dietitians and endocrinologists, can ensure a comprehensive and effective dietary strategy. With commitment and the right dietary approach, diabetic patients can lead a healthy and active life while minimizing the risk of long-term complications.

A successful diabetic diet plan emphasizes a balanced and sustainable approach to eating. It involves not only choosing the right foods but also maintaining consistency in meal patterns and portion sizes. Meal planning can play a crucial role in managing blood glucose levels, as it allows patients to make informed decisions about what and when to eat. For many diabetic patients, adopting the “plate method” is a practical strategy—this involves filling half the plate with non-starchy vegetables (such as leafy greens, broccoli, or peppers), one-quarter with lean proteins (like skinless poultry, fish, or tofu), and the remaining quarter with whole grains or other complex carbohydrates (such as brown rice, quinoa, or sweet potatoes). This simple visual guide helps create balanced meals that provide essential nutrients without causing sharp increases in blood sugar.[4]

Another important component of a diabetic diet plan is understanding the glycemic index (GI) of foods. The GI measures how quickly a food raises blood sugar levels after consumption. Low-GI foods, such as whole grains, legumes, and most vegetables, are digested more slowly and cause a gradual rise in blood glucose. In contrast, high-GI foods—like white bread, sugary snacks, and processed cereals—can lead to rapid blood sugar spikes. Prioritizing low-GI foods helps diabetic patients maintain better blood sugar control and reduces the risk of complications such as nerve damage, kidney disease, and vision problems. Additionally, including a variety of nutrient-dense, low-GI foods supports overall health by providing essential vitamins, minerals, and antioxidants.

For diabetic patients, it is also crucial to limit added sugars and refined carbohydrates. Foods and beverages high in sugar, such as sweets, sodas, and pastries, can cause sudden blood sugar surges and contribute to insulin resistance over time. Instead, natural sources of sweetness—like fresh fruit—can be enjoyed in moderation, especially when paired with a source of protein or healthy fat to mitigate blood sugar spikes. Reading food labels carefully is an essential habit, as many packaged foods contain hidden sugars under names like sucrose, high-fructose corn syrup, or dextrose. Reducing sugar intake not only helps stabilize blood sugar but also supports better weight management and reduces the risk of cardiovascular issues.[5]

Lifestyle factors, such as physical activity and stress management, complement a diabetic diet plan. Regular exercise improves insulin sensitivity, allowing the body to use glucose more effectively. Even moderate activities, such as brisk walking, swimming, or cycling, can have significant benefits when performed consistently. Additionally, managing stress through practices like meditation, yoga, or deep breathing exercises is vital, as stress hormones can negatively impact blood sugar levels. Adequate sleep is also important because poor sleep can disrupt hormonal balance and increase insulin resistance. By combining a thoughtful diet with healthy lifestyle habits, diabetic patients can enhance their overall quality of life and maintain better control over their condition.

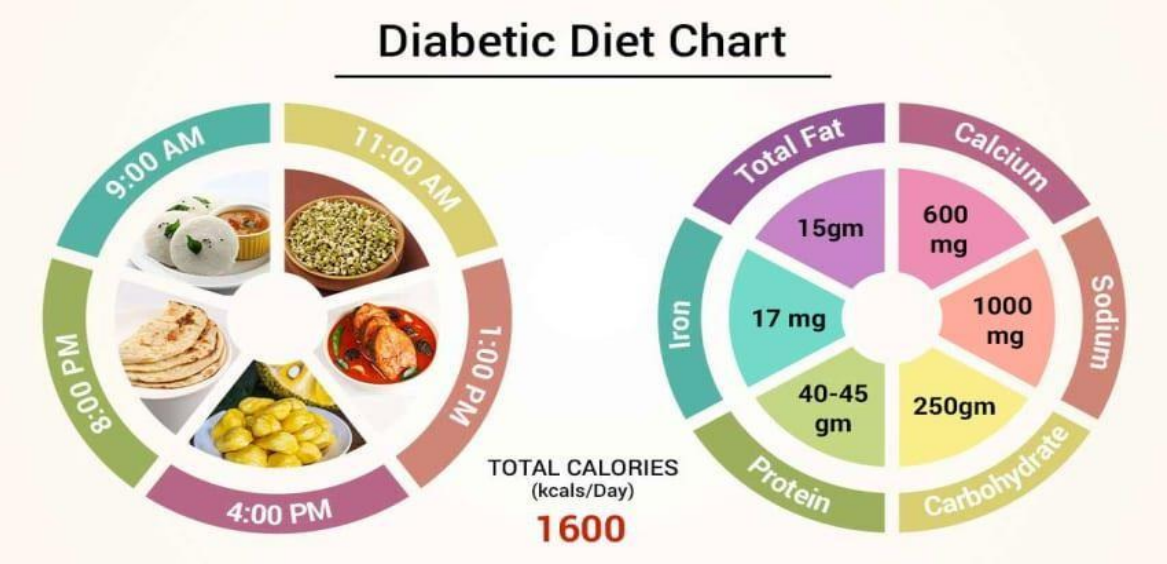
Ultimately, a well-structured diabetic diet plan is not just about restriction—it is about creating a sustainable, nourishing way of eating that promotes long-term health. With the right knowledge and support, diabetic patients can enjoy a wide variety of foods while effectively managing their condition. Regular check-ins with healthcare providers allow for ongoing monitoring and adjustments to the diet plan as needed. With dedication and informed choices,

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diabetic patients can successfully manage their blood sugar levels, prevent complications, and lead a fulfilling, healthy life.[6]

II. KEY OBJECTIVES OF A DIABETIC DIET PLAN

Blood Sugar Control – Stabilizing blood glucose levels through proper meal timing and food choices.
Weight Management – Maintaining a healthy weight to improve insulin sensitivity.
Heart Health – Reducing the risk of cardiovascular diseases by limiting saturated fats, sodium, and processed foods.
Balanced Nutrition – Ensuring the intake of essential nutrients to support overall health.[7]



An individualized approach to a diabetic diet is vital, as everyone's body responds differently to various foods and eating patterns. Factors such as age, activity level, medication regimen, and the presence of other health conditions all influence dietary needs. For example, patients with type 1 diabetes may need to count carbohydrates carefully and adjust their insulin dosage accordingly, while those with type 2 diabetes often benefit from reducing overall carbohydrate intake and focusing on weight management. Personalized dietary plans that accommodate cultural preferences, lifestyle habits, and medical history can lead to better adherence and improved long- term health outcomes. Consulting with a registered dietitian or diabetes educator can provide valuable guidance in creating a tailored meal plan that meets individual needs.[8]

Monitoring blood sugar levels regularly is a key practice in evaluating how different foods and eating patterns affect glucose control. Self-monitoring through blood glucose testing allows diabetic patients to understand how their bodies respond to specific meals and adjust their diet accordingly. Continuous glucose monitoring (CGM) systems offer even more detailed data by tracking glucose levels in real-time. By identifying patterns and potential triggers for high or low blood sugar, patients can make informed decisions to improve glycemic control. Keeping a food diary or using digital tracking tools can also help monitor intake, track progress, and identify areas for improvement.

Education and support are fundamental to the success of any diabetic diet plan. Diabetes is a complex and chronic condition, and staying informed about the latest dietary guidelines and treatment options empowers patients to take charge of their health. Participating in diabetes education programs, support groups, or online communities can provide encouragement and practical tips for managing daily challenges. Ongoing collaboration with healthcare providers ensures that dietary plans are continually adjusted to meet changing needs over time. With the right resources and commitment, diabetic patients can enjoy a fulfilling life while effectively managing their condition and reducing the risk of complications.[9]

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In addition to food choices, meal timing and frequency play a significant role in managing diabetes. Regular, well-spaced meals help prevent drastic fluctuations in blood sugar levels throughout the day. Many healthcare professionals recommend eating three balanced meals and one or two small snacks if needed. Skipping meals or delaying eating for long periods can cause blood sugar levels to drop too low (hypoglycemia), while overeating can lead to spikes in blood sugar (hyperglycemia). For individuals using insulin or other glucose-lowering medications, adhering to a consistent eating schedule is particularly important to maintain stable blood sugar levels. Moreover, consuming a small, balanced snack before bedtime—such as a handful of nuts or Greek yogurt—can help prevent overnight hypoglycemia, which is a common concern for some diabetic patients.[10]

Hydration is another essential aspect of a diabetic diet plan. Proper hydration helps regulate blood sugar levels by supporting kidney function, which aids in flushing out excess glucose through urine. Water is the best option for hydration, as sugary beverages like sodas, fruit juices, and energy drinks can rapidly elevate blood glucose. Unsweetened herbal teas and infused water with slices of citrus or cucumber are also refreshing, low-calorie alternatives. Limiting the consumption of alcohol is important, as it can affect blood sugar regulation and interact with diabetes medications. If consumed, alcohol should be in moderation and paired with food to reduce the risk of hypoglycemia.[11]

III. CONCLUSION

A well-planned diet is a cornerstone of effective diabetes management. By making informed food choices, practicing portion control, and maintaining regular meal schedules, diabetic patients can stabilize blood sugar levels, maintain a healthy weight, and reduce the risk of complications. Emphasizing nutrient-dense, low-glycemic foods while limiting refined sugars and unhealthy fats supports both metabolic and overall health. Additionally, staying hydrated, engaging in regular physical activity, and managing stress complement dietary efforts and improve long-term outcomes.

Personalization is key—each diabetic patient's needs vary based on factors like age, activity level, and medical history. Collaborating with healthcare professionals, such as dietitians and diabetes educators, helps create tailored diet plans that are sustainable and effective. Regular monitoring of blood glucose levels further empowers patients to make adjustments and better understand how their diet impacts their condition.

With the right knowledge, support, and commitment, diabetic patients can lead a healthy and active life. A balanced diet not only manages blood sugar levels but also enhances overall well- being, enabling individuals to live with greater confidence and reduced risk of diabetes-related complications.

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A Comprehensive Study on Synthesis of Benzimidazole using Novel Techniques

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Abstract: *Benzimidazoles are a class of heterocyclic compounds in which a benzene ring is fused to the 4 and 5 positions of an imidazole ring. Benzimidazole refers to the parent compound, while benzimidazoles are a class of heterocyclic compounds having similar ring structures, but different substituents. Green chemistry is the new and rapidly emerging field of chemistry. It involves the utilization of a set of principles that reduces or eliminates the use or generation of Hazardous substances in the design, manufacture and application of chemical products. Conventional methods of synthetic reactions need longer heating time, elaborate and tedious apparatus set up which result in higher cost and environmental pollution in Contrast to greener methods which are eco-friendly and economical. In Recent years, a large number of reports related to synthesis of Nitrogen, Oxygen and Sulphur containing heterocyclic have appeared owing to a wide variety of their biological Activity. In recent years, numerous reports concerning the synthesis of heterocyclic compounds under various conditions like solvent-free, reactants immobilized on solid Support, microwave irradiation condition, green catalyst and green solvent have appeared. Benzimidazole is a heterocyclic aromatic organic compound, it is an important Pharmacophore and privileged structure in medicinal chemistry. It plays a very important role with plenty of rational therapeutic activities such as antiulcer, antihypertensive, analgesic, Anti-inflammatory, anti-viral, antifungal, anticancer, and antihistaminic. Because of its Importance, the methods for their synthesis have become a focus of Synthetic Organic Chemists. Therefore, in the present work I tried to organize the chemistry of different Derivative of substituted benzimidazole and some of the important methodologies used for the Synthesis.*

Keywords: Benzimidazole, Eco-Friendly, Solvent free, green synthesis, Microwave Assisted, Catalysis.

I. INTRODUCTION

Benzimidazole derivatives are particularly important compounds due to the wide variety of biological activities and therapeutic applications they have, as well as their powerful restricting action and excellent property magnitude relation [1]. Benzimidazole derivatives also have an excellent property magnitude relation. In light of the significance of benzimidazole, it was decided to devise and produce a variety of novel benzimidazole derivatives, each of which would consist of an oxadiazole moiety [2]. The possible biological activity of these chemicals would next be investigated in order to determine whether or not they had any of that potential. In the field of study pertaining to pharmaceuticals, the benzimidazole ring is an important part of the heterocyclic pharmacophore [3]. Compounds with a variety of substituents in the benzimidazole structure have been linked to a wide range of biological effects, including antibacterial, anticancer, antiviral, antioxidant, antifungal, helminthicidal, histamine-blocking, anticoagulant, and antihypertensive effects [4]. These effects have been attributed to the compounds. The benzimidazole ring is generally recognised as a key pharmacophore at this point in time within the context of modern day drug development. When it comes to health-related research, the synthesis of new benzimidazole derivatives is still regarded as an important area of focus for academic inquiry [5].

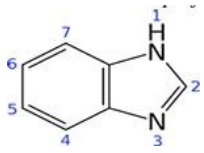


Fig. 1: Structure of Benzimidazoles

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1.1 Physical Properties Of Benzimidazoles

It would seem, on the basis of the melting points of several benzimidazoles, that exchanging the 1-position results in a lower melting point the vast majority of the time. Polar solvents have a greater capacity than organic solvents for the dissolution of benzimidazoles containing imide nitrogen [6]. The solubility of the molecule might potentially be improved in liquids that are non-polar if additional non-polar substituents are inserted at different other places on the benzimidazole ring. In contrast, the presence of polar groups inside the molecule causes an increase in its solubility in polar liquids. This effect may be seen in both aqueous and aqueous solutions [7]. In general, benzimidazoles are soluble in mild acids and have a moderate basicity, which means that they are somewhat less basic than imidazole. This is because benzimidazoles have a benzene ring structure instead of an imidazole ring structure [8]. This is due to the fact that benzimidazoles are a kind of derivative derived from imidazole. Benzimidazoles are generally soluble in alkaline solutions, despite the fact that their high level of acidity renders them prone to the production of N-metallic compounds when they are dissolved in water [9]. Similar to the situation with imidazole, it would seem that resonance-based ion stabilisation is to blame for the acidic characteristics of benzimidazoles. The dissolution of the more acidic benzimidazoles may be possible with a solution that is less basic, such as one that includes potassium carbonate. This is because there is a possibility that such a solution will contain potassium carbonate [10].

1.2 Chemical Properties of Benzimidazole

Reactions of the benzimidazole ring: The benzimidazole ring is distinguished by a high level of stability as a defining characteristic. It makes no difference whether the benzo(a)imidazole is subjected to alkalis, hot hydrochloric acid, or intense sulfuric acid; its characteristics do not alter in any way. [11]. Oxidation is a process that may break the benzene ring of benzimidazole, but only under very specific conditions. The benzimidazole ring is only able to tolerate decrease in its structure under certain circumstances.

1.3 Common Methods of Synthesis:

Several strategies have been developed to facilitate the acylation of amines, each with its unique Advantages and limitations. The four primary methods include:

1.3.1-Traditional method of synthesis of benzimidazole:

Preparation of benzimidazoles practically starts with benzene derivatives possessing nitrogen-containing Functions ortho to each other i.e. the starting material o –Phenylenediamines (OPD) react readily with most Carboxylic acids to give 2-substituted benzimidazoles, usually in very good yield. The reaction is carried Out usually by heating the reactants together on a steam bath, by heating together under reflux or at an elevated Temperature, or by heating in a sealed tube [12].

1.3.2- Microwave Assisted Synthesis:

Microwave-assisted synthesis offers a greener alternative by significantly reducing reaction Times and improving reaction efficiency. The method is known for its ability to provide uniform Heating, which leads to faster reactions with higher yields and energy savings. Microwave-assisted synthesis of benzimidazole from o- phenylenediamine and Aldehydes in the presence of solid acid catalysts has shown accelerated reaction times and high yields compared to conventional heating [13].

1.3.3-Solvent-Free Synthesis:

Green solvents, such as water, ethanol, or ionic liquids, are increasingly being employed for the synthesis of benzimidazole to minimize the use of toxic organic solvents. Water, being an Abundant, non-toxic, and non-volatile solvent, is the most sustainable option, particularly for Reactions that can be carried out under mild conditions. Synthesis of benzimidazole in water or ethanol using catalytic amounts of ionic liquids or sulfonic acid-functionalized resins has been reported with high yields and minimal Side reactions [14].

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1.3.4-Catalytic Methods:

Using efficient and recyclable catalysts is a key feature of green chemistry. Solid acid catalysts, Metal-based catalysts, and ionic liquids are commonly used for the catalytic synthesis of Benzimidazole, enhancing the reaction's atom economy and minimizing waste production. Solid acid catalysts like zeolites or montmorillonite clay have been shown to Catalyzed The synthesis of benzimidazole from o-phenylenediamine and various electrophilic Reagents, offering high selectivity, simple recovery, and reusability [15].

II. APPLICATIONS

2.1-Medicinal chemistry

Benzimidazole and its derivatives hold significant importance in medicinal chemistry due to their broad- spectrum pharmacological activities, making them key structural components in many therapeutic drugs. They exhibit antimicrobial, antifungal, antiviral, anticancer, anti-inflammatory, and anthelmintic properties, leading to their widespread use in pharmaceuticals. Several benzimidazole-based drugs, such as albendazole, mebendazole, and thiabendazole, are widely used as anthelmintics to treat parasitic infections [16]. Additionally, omeprazole, pantoprazole, and lansoprazole, which are proton pump inhibitors (PPIs), contain benzimidazole cores and are extensively prescribed for gastric ulcers and acid reflux disorders. Some benzimidazole derivatives also exhibit antitumor activity by inhibiting microtubule polymerization or targeting specific cancer-related enzymes, making them valuable in chemotherapy. Furthermore, benzimidazole scaffolds are being explored for antiviral applications, including potential treatments for HIV, hepatitis, and coronaviruses. Their high bioavailability, chemical stability, and diverse biological activities make benzimidazole derivatives indispensable in modern drug discovery and development [17].

2.2-Material Science:

Benzimidazole and its derivatives find diverse and significant applications due to their unique structural and electronic properties. These compounds are employed in the development of functional materials with tailored characteristics. For instance, benzimidazole-based molecules are utilized in the creation of advanced polymers and coatings, enhancing their thermal stability, mechanical strength, and chemical resistance. Furthermore, they serve as crucial components in the synthesis of organic semiconductors, contributing to the development of organic light-emitting diodes (OLEDs) and organic solar cells [18] . The presence of the nitrogen atoms within the benzimidazole ring allows for coordination with metal ions, making these compounds useful in the design of metal-organic frameworks (MOFs) with potential applications in gas storage, separation, and catalysis. Additionally, benzimidazole derivatives are explored in the creation of photochromic materials, which can change their optical properties upon exposure to light, finding use in smart windows and optical data storage. Their ability to interact with various surfaces also makes them relevant in the development of corrosion inhibitors for metals, protecting them from degradation. Overall, the versatility of benzimidazole in forming stable and functional materials positions it as a valuable building block in various advanced material applications [19].

2.3-Agrochemicals:

Benzimidazole and its derivatives play a crucial role in agrochemicals, particularly as fungicides, pesticides, and plant growth regulators. Due to their broad-spectrum biological activity, they are widely used to protect crops from fungal diseases and pests, ensuring higher agricultural yields. Benzimidazole-based fungicides, such as carbendazim, thiophanate-methyl, and benzoyl, effectively control various fungal pathogens affecting crops like wheat, rice, fruits, and vegetables by inhibiting microtubule formation in fungal cells, preventing their growth and reproduction [20]. Additionally, some benzimidazole derivatives exhibit insecticidal and nematicidal properties, helping in the management of pests like aphids and nematodes. Beyond pest control, certain benzimidazole compounds also function as plant growth regulators, enhancing crop resistance to environmental stress and improving overall plant health. Their effectiveness, low toxicity to mammals, and stability make them indispensable in modern sustainable agriculture. However, their overuse can lead to resistance in pathogens, necessitating responsible application and rotation with other fungicides [21].

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2.4-Dyes and Pigments:

Benzimidazole derivatives are widely used in the production of dyes and pigments due to their excellent thermal stability, photostability, and vibrant coloration. These compounds serve as key intermediates in the synthesis of organic pigments, particularly in high-performance pigments (HPPs) used for coloring plastics, textiles, coatings, and inks. Benzimidazolone pigments, a prominent class of benzimidazole-based colorants, exhibit superior lightfastness, chemical resistance, and durability, making them ideal for industrial applications such as automotive coatings and high-quality printing inks [22]. Additionally, benzimidazole-based fluorescent dyes are employed in biological staining, textile dyeing, and optoelectronic devices due to their strong luminescent properties. The structural versatility of benzimidazole allows for the development of dyes with tunable color shades, ranging from yellow to deep red, further enhancing their commercial significance in the pigment industry [23].

2.5-Food Industry:

Benzimidazole derivatives play an important role in the food industry, primarily as preservatives, antioxidants, and food color stabilizers. Some benzimidazole-based compounds exhibit antimicrobial properties, helping to extend the shelf life of perishable foods by preventing microbial contamination [24]. Additionally, certain benzimidazole derivatives function as antioxidants, protecting food products from oxidative degradation and preserving their nutritional value and sensory qualities. In food packaging, benzimidazole-based materials are used to enhance the durability and stability of packaging films, reducing spoilage and maintaining food freshness. Furthermore, some benzimidazole-based dyes are utilized in food coloring applications, offering high stability and resistance to light and heat [25].

III. FUTURE OPPORTUNITIES AND DIFFICULTIES

The green synthesis of benzimidazole presents exciting future opportunities as researchers aim to develop more eco-friendly, cost-effective, and sustainable methods for its production. Benzimidazole synthesis using green chemistry holds great promise, with advancements in biodegradable catalysts, solvent-free methods, and renewable feedstocks offering more sustainable and eco-friendly alternatives. Emerging techniques like microwave-assisted synthesis, nanocatalysis, and deep eutectic solvents (DESs) can enhance efficiency while reducing waste and energy consumption. However, challenges such as the high cost of green catalysts, scalability issues, and difficulties in catalyst recovery must be addressed for industrial adoption.

3.1 Biodegradable Catalysts: One of the key future directions is the development of biodegradable, environmentally friendly catalysts that can replace traditional toxic or precious metal catalysts. These catalysts could reduce the environmental burden of the synthesis process by minimizing the need for complex waste disposal techniques. Additionally, new catalytic systems could offer improved selectivity and efficiency, thereby enhancing reaction yields and reducing waste generation. Research into biocatalysts and enzyme-driven reactions holds particular promise in this area, potentially revolutionizing the synthesis of benzimidazole with minimal environmental impact.

3.2 Solvent-Free Methods: The move towards solvent-free synthesis is a growing trend in green chemistry. By eliminating or significantly reducing the use of solvents, which are often harmful to the environment, researchers aim to create more sustainable production processes. In benzimidazole synthesis, solvent-free approaches can not only minimize hazardous chemical waste but also reduce energy consumption since solvent removal processes can be energy-intensive. Techniques such as mechanochemical reactions, where reactions are driven by physical energy (e.g., grinding or mixing), could be further developed for green synthesis routes.

3.3 Renewable Feedstocks: The use of renewable feedstocks, such as biomass or bio-based intermediates, is another key area for green benzimidazole synthesis. Utilizing renewable resources instead of petrochemical derivatives reduces the reliance on fossil fuels and supports the transition to a circular economy. Advancements in biotechnology could lead to the development of bio-based precursors that enable more sustainable and cost-effective production of benzimidazole.

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3.4 Microwave-Assisted Synthesis: Emerging technologies like microwave-assisted synthesis have the potential to significantly enhance the efficiency of benzimidazole production. By using microwave energy to accelerate reactions, this technique can reduce reaction times, energy consumption, and the formation of unwanted byproducts. Further optimization of microwave-assisted processes could lead to greener, faster, and more efficient production methods for benzimidazole.

3.5 Nanocatalysis: The use of nanomaterials in catalysis offers exciting possibilities for green benzimidazole synthesis. Nanocatalysts, with their high surface area and tunable properties, can provide higher catalytic efficiency, allowing reactions to occur under milder conditions and with fewer byproducts. The incorporation of nanocatalysis could also enable the reuse and recycling of catalysts, reducing the environmental impact and cost of the synthesis process.

IV. CONCLUSION

The synthesis of benzimidazole using green chemistry principles offers a promising pathway Toward more sustainable, efficient, and environmentally friendly chemical processes. As a key Compound in pharmaceuticals, agrochemicals, and material science, benzimidazole plays Critical role in many industries, making its synthesis a focal point for green chemistry Innovations. In conclusion, the synthesis of benzimidazole using green chemistry not only enhances the Efficiency and sustainability of chemical production but also aligns with broader environmental and societal goals. By embracing these greener techniques, the chemical industry can reduce Its environmental impact while maintaining or even improving the performance and yield of Benzimidazole, contributing to the overall advancement of sustainable chemistry. The transition to green chemistry in the synthesis of benzimidazole marks a critical step Toward creating more sustainable, safer, and efficient chemical processes in various industries. As benzimidazole derivatives are integral to the pharmaceutical, agrochemical, and material Sciences, employing green chemistry principles is not only important for reducing Environmental harm but also for ensuring the long-term sustainability of these industries. The Future of benzimidazole synthesis lies in harnessing these innovative green methodologies to Address the growing demand for eco-friendly processes and reduce the ecological footprint of Chemical manufacturing. In conclusion, the synthesis of benzimidazole using green chemistry is not just a forward-Thinking concept but a crucial pathway to meeting the evolving demands of sustainable Chemical processes. In Conclusion, the synthesis of benzimidazole using green chemistry is an essential step toward a more sustainable and economically viable future. By capitalizing on greener alternatives and cutting-edge technologies, the chemical industry can contribute to a circular economy, improve process efficiency, and reduce the environmental and economic impacts traditionally associated with chemical manufacturing. As research and innovation in this field continue to evolve, the future of benzimidazole synthesis is poised to become a shining example of how green chemistry can drive significant change across various industries, enhancing both environmental stewardship and industrial performance.

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Production of Handmade Papers from Waste Sugarcane Bagasse

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Abstract: *Solid waste is one of the biggest problem of civil society. In this project, agriculture waste from bagasse and banana fibers have been used to produce handmade paper. These fibers were collected, dried under the sun and passed through water vat to remove dust. A Next, it is cooked with 10% caustic solution in pressure cooker and then blended in mixer for different timing. Diluted solution of Clorox was used for discoloration and purification of pulp.*
Three types of papers were made from ready pulp. First type was by made by using raw material only, second type by addition of 2% of CaCO3 and 2% of starch. And the third types by addition of 5% of both additives.Â These papers were dried and then ironed for straightening.
GSM, pH, Thickness, Bulk, and Moisture Content were calculated for all types of papers. It was found that papers from bagasse fibers are heavy and suitable for heavy and rough usage. While paper from banana fibers are useful for soft usage like tissues, wipes, tracing paper etc. This project is ecofriendly as it used agricultural waste and only little electricity was used..

Keywords: waste sugarcan bagasse, NaOH , Pulp refinement.

I. INTRODUCTION

Papers are substance which have been used universally for writing and Packaging. The Chinese Cai Lun was first person who made a sheet of paper about CE . Papers have been spread from china through the middle east to medieval Europe in 13th century. Papers are thin materials which are produced by pressing together moist fibers and then drying them into the flexible sheets. Paper have many uses such as for writing, printing, packaging, in many cleaning products, in a number of industrial and construction processes, and even as a foods ingredient.
Papers are made using wood and non-wood material such as bagasse and banana fibers. Eco- friendly papers production are alkali-free and non- pollution process which have many advantages over conventional process such as it saves our mother earth from global warming. Handmade paper Industries has become more popular because of its eco-friendly nature and has the significant impacts for growing forest and preserving the greenery.

II. METHODOLOGY

Material used : Bagasse, Banana fibers, Sodium Hydroxide (caustic soda), Clorox, Calcium carbonates (CaCO3), and starch.
Pre- treatment Work :
While making the paper from sugarcane Bagasse first of all the bagasse is washed three to four times and dried to the sunlight for two days and then taken in to a big beaker we can also take the cooker and also any utensil for cooking process while using cooker we should heat it for thirty minutes and while using the utensils or a beaker we should heat it upto one hour and mix ten percent of NaOH into the cook. The cooker should be cleaned and bagasse is added into the cooker with distilled water and some amount of sodium hydroxide within it and heated or cooked for thirty minutes or half an hour also over half hour also then the whole material is drained out and put into the blender for blending process.

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Pulping Process : Cook Baggase with 10% of caustic soda for 30 minutes. Then wash it with hot water and by water repeatedly.



Fig 2. Cooking Bagasse with 10% caustic soda

Blending Process:

Mix the pulp in blender for 5 to 10 minutes with little of water. Blending and mixing are steps that are frequently necessary for a wide variety of industrial processes. Because both involve combining materials, the words are often used interchangeably, however, the chemical processes of blending and mixing are technically not the exact same. While mixing is the physical combination of dissimilar materials to create one homogenous product that can ultimately be separated into their original components, blending, on the other hand, usually combines multiple components and produces a product that has its own set of properties—usually set to remain blended permanently.



Fig 3. Blending

Pulping Process : Pulp blending can be done in 3 distinct ways e.g., chips blending, pulp blending before beating and pulp blending after beating. Before pulp beating improves the physical strength marginally, but pulp blending after separate beating showed excellent physical strength properties

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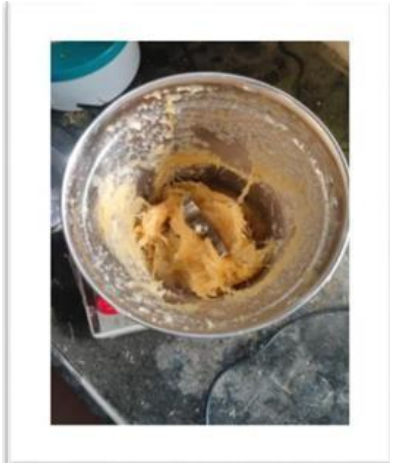


Fig 4. Pulping Process

Adding Starch and Calcium Carbonate to Pulp : The technical possibility of using calcium carbonate whiskers as papermaking filler to replace conventional powder-like calcium carbonate was investigated. The results showed that it may be feasible to use calcium carbonate whisker as papermaking filler. Compared with conventional precipitated calcium carbonate, calcium carbonate whisker had higher retention efficiency. The use of calcium carbonate whisker also favorably affected the strength properties of paper sheets. A model was proposed to suggest the mechanism for paper strength improvement. The whiskers filled in paper sheets could increase the friction between fibers, thus increasing bonding strength. Moreover, the strength properties of paper were further improved because calcium carbonate whiskers were partly embedded in pulp fiber walls.

Bleaching Process : It is the method of pulp purification and Discoloration. Clorox's used to remove the brown color and get whiteness of pulp. Brightness is an attribute of visual perception in which a source appears to be radiating or reflecting light.[1] In other words, brightness is the perception elicited by the luminance of a visual target. The perception is not linear to luminance, and relies on the context of the viewing environment . Mechanical pulp retains most of the lignin present in the wood used to make the pulp and thus contain almost as much lignin as they do cellulose and hemicellulose. It would be impractical to remove this much lignin by bleaching, and undesirable since one of the big advantages of mechanical pulp is the high yield of pulp based on wood used. Therefore, the objective of bleaching mechanical pulp (also referred to as brightening) is to remove only the chromophores (color-causing groups). This is possible because the structures responsible for color are also more susceptible to oxidation.



Fig 5. Colorx for Whitening

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Paper Making by putting pulp on Inlet Frame : Using the inlet frame to make sheet of paper. In this step, additives(CaCO3 and Starch) were added to pulp to enhance the properties of paper with the percentage of 0% for 1stpaper, 2% both in 2nd paper. The inlet frame is used also we have used sieve as inlet frame to drain the water from the pulp

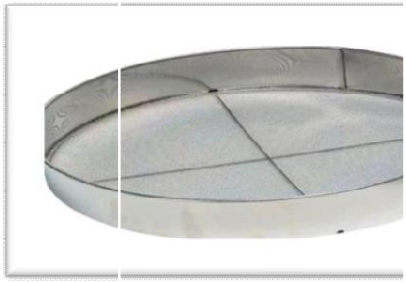


Fig 6. Inlet Frame

Ironing : It is the last step in making paper and it is used to achieve the smoothness and giving your shirts, trousers and dresses a more sophisticated look.

III. LITERATURE REVIEW

The demand for sustainable alternatives to wood-based paper has driven interest in agricultural waste materials like sugarcane bagasse. Sugarcane bagasse is an abundant byproduct of the sugar industry, composed of cellulose, hemicellulose, and lignin, making it a viable raw material for papermaking (Pandey et al., 2021). This literature review examines previous studies on sugarcane bagasse utilization for handmade paper, focusing on raw material properties, processing techniques, environmental benefits, challenges, and innovations.

Sugarcane bagasse contains *40–50% cellulose, making it suitable for pulp and paper production. However, its

**18–25% lignin* content poses challenges in fiber processing (Jahan et al., 2017). Compared to wood pulp, bagasse fibers are shorter, affecting the mechanical properties of the resulting paper. Studies have explored blending bagasse with recycled paper or other plant fibers to enhance paper quality (Gupta et al., 2018).

Chemical Pulping: The use of sodium hydroxide (NaOH) and soda ash effectively removes lignin and improves fiber separation (Sharma & Bansal, 2020). However, proper disposal of chemicals is necessary to minimize environmental impact.

Mechanical Pulping: While mechanically pulped fibers require less chemical treatment, the resulting paper tends to be weaker and less durable (Singh et al., 2019).

Biological Pulping: Recent studies suggest enzyme-assisted pulping using fungi or bacterial enzymes as an eco-friendly alternative, reducing chemical usage and energy consumption (Patel et al., 2022).

High Lignin Content: Lignin removal is crucial for high-quality paper production but requires effective treatment methods (Rashid et al., 2021).

Short Fiber Length: Bagasse fibers are shorter than wood fibers, leading to lower tear resistance and paper strength. Researchers suggest blending with longer fibers or adding natural binders to improve mechanical properties (González et al., 2020).

Water and Chemical Use: While handmade papermaking is more sustainable, chemical pulping requires water treatment solutions to avoid pollution (Chandra et al., 2022).

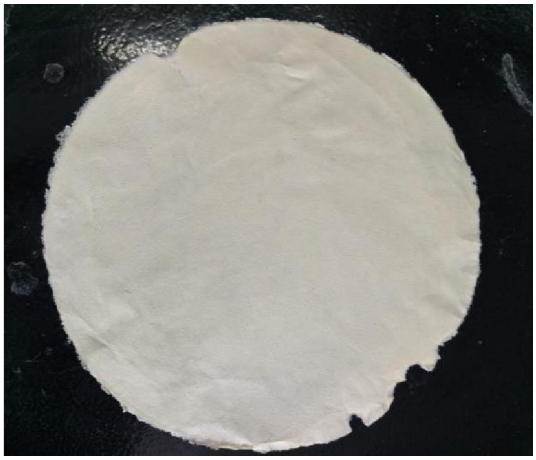
IV. RESULTS AND DISCUSSION

Handmade paper from sugarcane bagasse is a promising alternative to traditional paper, offering environmental and economic benefits. With further processing optimizations, it can be effectively used for eco-friendly packaging, notebooks, and biodegradable paper products.

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GSM: By take the weight of each paper in gram. [GSM= Weight / Area of paper in cm2]
pH: mixing paper with water and recording pH of solution.
Thickness: Using micrometer to measure the thickness of each paper at four different regions of paper and then take average.
Bulk: [Bulk = GSM/ Thickness]
Moisture Content: put all samples in oven for 60 minutes at 110 C and then calculate the Moisture content. [Moisture content = (moisture amount / weight of paper) X 100]

V. CONCLUSION

In this project handmade papers are made from sugarcane bagasse. This type of paper making is very environmental friendly for todays days. We all know that plastic is getting more and more in use and the plastic is non degradable for various years so this could be a option for the plastic bags also some modification and some research should carry out for making this paper for more and more strong and it will be replace the plastic usage and are also very much environmental friendly .
We should try to focus of the papers and other packing materials from this sugarcane bagasse as it is strong and degradable substance which is most environmental friendly

VI. ACKNOWLEDGEMENT

It gives us pleasure to present my project on “Production of handmade papers from waste sugarcane ”. The able guidance of all teaching staff of department made this study possible. I express my deep sense of gratitude and respect to my guide Dr. Jayashree Shailesh Patil (Assistant professor), Department of chemistry, J.S.M College, Tal. Alibag, Dist.Raigad for her inspire guidance on constructive criticism and constant encouragement during the completion of this project.I place my sincere thanks to Head of Chemistry Department and Principal Dr. Sonali Patil, J.S.M COLLEGE ALIBAG for giving me opportunity to complete this work and providing the necessary facilities. I would also like to appreciate all teaching and non- teaching staff of J.S.M. College, Alibag. My special thanks to my all friends M.Sc.-II for their friendly suggestion and timely help during preparation of soap. I must like to thanks University of Mumbai and Chemistry Department for giving us an opportunity to explore this subject by conducting this project. Finally, I would like to thank everybody who played a very important role towards the completion of this work, as well as expressing of this work, as well as expressing my apology that I could not mention all the names one by one.

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A Comprehensive Study on Determination of Iron in 'Iron' Tablets by Redox Titration Method

Manisha Mahendra Singh and Asst. Prof. Shubham Yerunkar
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Abstract: *This study on determination of iron in iron tablet by redox titration is investigates the iron content in an iron tablet using a redox titration method, where the ferrous ions within the dissolved tablet are oxidized to ferric ions by a standardized potassium permanganate solution, allowing for the precise quantification of iron based on the volume of titrant required to reach the endpoint, as indicated by a persistent pink colour change; this method provides a reliable assessment of the actual iron content in the tablet compared to the label value Iron is an essential trace element, required for haemoglobin formation and the oxidative process of living tissues. A comparative study of the determination of iron in iron tablets was carried out using Redox titration on five samples of capsule containing iron. The capsules were analyzed using Redox titration on five of the samples containing iron content inform of ferrous fumarateBase on the results for the analysis of all the sample it can be concluded that Maxiron have the highest percentage of iron which is best supplements for adult lacking high percentage of iron. However, Astyfer has the lowest amount of iron which is the best supplement for infants who require very low amount of iron supplements.*

Keywords: Iron, Tablet, Redox, Supplement.

I. INTRODUCTION

Iron is the most abundant metal found in the earth crust, water as well as in different food stuffs naturally. Iron is also found in human body. [1] About 70% of iron in the average adult is found in the red blood cells of the blood called hemoglobin, which plays a vital role in transportation of oxygen from the lungs to various tissues in the body while the remaining 30% is present as storage iron in the kidney, liver, spleen and bone marrow. Myoglobin, in the muscles cells accepts, stores, transports and releases oxygen. Iron is an essential element which is vital and required for various biological functions. [1]

The average daily nutritional requirement of iron is 811mg/d for males and 16-27mg/d for adult female due to the iron losses through their regular menstrual blood flow. [2]

Iron is essential to virtually all living organisms and is integral to multiple metabolic functions, [3] It is an essential trace element, required for haemoglobin formation and the oxidative process of living tissues. [4-5] Iron is required for many vital functions such as reproduction, healing of wounds, cellular growth, oxidative metabolism, muscles activity and execution of various metabolic processes. The main role of iron is to carry oxygen to the tissues where it is needed, although use for DNA synthesis and also in the protection against microbes and free radicals produced in the body promote the development of heart diseases and damage the level of cholesterol in the blood. [6] Nutritional deficiency of folate is commonly associated with people consuming inadequate diet. Pregnant women are at high risk of folate deficiency because pregnancy significantly increases folate requirement, especially during periods of rapid fetal growth. [7-8] Low iron intake can lead to iron deficiency which leads to various disorders such as anemia, cheilosis, dyspnea, irritability, impaired memory and increased in susceptibility to infection. [9-11] Anaemia is a major public health problem worldwide with prevalence of 43% in developing countries and 9% in developed nations. [12-13] Iron deficiency anaemia in young children is the most prevalent form of micronutrient deficiency worldwide. [14] For such conditions, some iron supplement is needed along with foodstuffs such as egg yolk, fish kidney, wheat, maize, spinach, pheasant, meat etc. Iron supplementation can be administered in form of tablets capsule or injection from which iron content in iron containing tablets or capsule may vary from one pharmaceutical formulation to

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another. However, the pharmacopeia range of iron in tablet has been allocated from 48-54mg, as iron overdose leads to cases such as convulsion, multisystem organ failure, coma, and even death. [15]

Medicinally, iron is required as a dietary supplement in conditions of iron deficiency associated with secondary anaemia. A satisfactory intake of iron can be ensured by eating a suitable diet, because certain foods such as liver, kidney, egg yolk, and spinach are rich in iron. Nevertheless, it is sometimes necessary to supplement the iron taken in natural diet with iron tablets. Since iron is the key component of haemoglobin, therefore taking appropriate amount of iron drug supplement can help build red blood cells and reverse anaemia caused by too little iron in the body. [16-17] Most of the iron tablets bought at the pharmacies usually contain Iron (ii) sulphate (ferrous fumarate) examples of these tablets with their trade names are zincofer, folvit , chelon, etc [18].

The principle that governed the identification of iron (Fe2+) in iron containing drugs, is the ability of iron (Fe2+) to reduce strong oxidizing agents such as potassium permanganate (vii) KMnO4 to Mn2+, for which the iron itself is oxidized from Fe2+ to Fe3+ and the end point of the reaction is associated to the information of a persistent pale pink colour solution. [19]

II. METHODOLOGY

2.1 Redox Titration

The principle that governed the identification of iron (Fe2+) in iron containing drugs, is the ability of iron (Fe2+) to reduce strong oxidizing agents such as potassium permanganate (vii) [KMnO4] to Mn2+, for which the iron itself is oxidized from Fe2+ to Fe3+ and the end point of the reaction is associated to the formation of a persistent pale pink colour solution. [19]

2.2. Standardization Of 0.02m Kmno4 Solution Using

0.1m (NH4) Fe (SO4)2 6H2O

9.8g of solid (NH4) Fe (SO4)2 6H2O reagent was dissolved in 25cm3 of 1.5 M H2SO4 in a conical flask. The burette was then filled with the prepared 0.02m K MnO4 solution and titrated against the pipette solution of (NH4) Fe (SO4)2 6H2O until a persisting pale pink colour was observe which indicates the end point of the reaction. The corresponding titre value was recorded and the procedure was repeated for two more times, each time noting the corresponding titre value.

2.3. Determination of the Amount of Iron in the Iron

Containing Medications

Five (5) iron capsules were weighed and transferred in to 250cm3 volumetric flask, distilled water was added up to the mark to dissolve into solution.

A pipette was used to measure 20cm3 of the solution into a conical flask, and was titrated against the standardized 0.02m KMnO4 until a persisting pate pink colour was observed, which indicate the end point of the reaction. The corresponding titre value was carefully recorded. The procedure was repeated for each of the samples. The titre value obtained was used to calculate the amount of iron in the samples.

III. LITERATURE REVIEW

3.1. Redox Titration Principles

Redox titration is based on the principle of electron transfer between the titrant (an oxidizing or reducing agent) and the analyte (the substance being measured). The most common redox reaction involves iron in its ferrous (Fe^{2+}) and ferric (Fe^{3+}) oxidation states. In the case of iron tablets, ferrous iron (Fe^{2+}) is typically the active component, and it can be oxidized to ferric iron (Fe^{3+}) by a suitable oxidizing agent, or vice versa. The reaction is often monitored using a suitable indicator, such as phenanthroline, potassium permanganate, which provides a colour change at the endpoint of the titration.

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3.2. Factors Affecting the Redox Titration of Iron

Several factors can influence the accuracy and precision of iron determination by redox titration:

pH of the solution: The titration is sensitive to pH, and maintaining an appropriate acidic environment is critical for the proper oxidation of Fe^{2+} to Fe^{3+}.

Indicator choice: The appropriate indicator must be selected based on the titrant used. For example, when using potassium permanganate, no indicator may be required, as permanganate itself provides a clear visual change.

Interferences: Other substances present in the tablet may interfere with the titration, leading to errors in the determination of iron. For example, calcium, magnesium, or phosphate compounds can sometimes affect the redox reaction.

3.3. Common Titrants and Methods

Several titrants are used in the redox titration of iron, including: Potassium Permanganate ($KMnO_4$): Potassium permanganate is a strong oxidizing agent frequently used in the titration of ferrous ions (Fe^{2+}). The titration is conducted in an acidic medium, where MnO_4^- is reduced to Mn^{2+} while Fe^{2+} is oxidized to Fe^{3+}. The endpoint is marked by the first appearance of a pink colour.

A study by Barker et al. (2017) demonstrated that potassium permanganate titration is highly effective for the determination of iron in both tablets and aqueous solutions, offering good precision and reliability. Dichromate ($K_2Cr_2O_7$): Potassium dichromate is another commonly used oxidizing agent. The reaction involves the reduction of $Cr_2O_7^{2-}$ to Cr^{3+} while oxidizing Fe^{2+} to Fe^{3+}. The use of dichromate as a titrant requires the titration to be performed in an acidic medium, often with the addition of an indicator to observe the endpoint.

3.4. Indicator Selection

Indicators are crucial in redox titrations to signal the endpoint. The most frequently used indicators for iron determination include:

Phenanthroline: This indicator forms a complex with Fe^{2+}, resulting in an orange-red colour. It is particularly useful when potassium permanganate or cerium salts are not used as titrants, providing clear visual endpoints.

Diphenylamine: Diphenylamine is another indicator commonly employed in titrations involving potassium dichromate. It changes colour from colourless to blue when the Fe^{2+} is completely oxidized to Fe^{3+}.

3.5. Application to Iron Tablets

The determination of iron content in iron tablets using redox titration has been extensively studied due to its simplicity, accuracy, and applicability to pharmaceutical products. A study by Raji et al. (2016) explored the quantification of iron in commercially available iron tablets using potassium permanganate. The authors reported that the method was effective, with good recovery rates and low relative standard deviation, confirming the suitability of redox titration in pharmaceutical analysis. Moreover, Bashir et al. (2018) utilized the dichromate method for the analysis of iron tablets. The study highlighted the high precision of the dichromate method and its ability to detect trace amounts of iron with minimal interference from other components present in the tablets, such as fillers or binders.

Use of Potassium Permanganate: A study by Bengtsson et al. (2002) focused on the use of potassium permanganate for iron determination in pharmaceutical formulations, finding it to be a reliable method with minimal interference when properly controlled.

Comparison with Other Methods: Research by Basturk et al. (2008) compared redox titration with atomic absorption spectroscopy (AAS) and inductively coupled plasma (ICP) methods for iron determination in iron tablets. While AAS and ICP provided more precise results, redox titration was found to be a cost-effective and straightforward method for routine quality control in pharmaceutical settings.

Use of $K_2Cr_2O_7$ as Titrant: In a study by Stojanović et al. (2010), potassium dichromate was used to determine iron in iron supplements. The study highlighted the effectiveness of the method, but also discussed the potential for chromium interference and the need for appropriate blank corrections.

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3.6. Advantages and Challenges

The redox titration method has several advantages in the analysis of iron in iron tablets:

Simplicity and Cost-Effectiveness: The method does not require sophisticated equipment, making it accessible and affordable for routine analysis.

High Sensitivity and Precision: Redox titration can detect very low concentrations of iron, making it suitable for determining iron in iron tablets that contain varying amounts of active ingredient.

Wide Applicability: This method can be adapted to different pharmaceutical formulations and is suitable for both quality control and regulatory testing.

However, there are also some challenges associated with the method:

Interference from Other Components: Non-ferrous components in the tablets may interfere with the titration, especially when using potassium permanganate or dichromate. Proper sample preparation and masking agents are necessary to minimize such interference.

Endpoint Detection: Accurate detection of the endpoint can be challenging, particularly when using titrants like potassium permanganate, which is colourless in the reduced state.

Comparative Studies:

Studies have compared the results of redox titration with other methods for iron determination, such as complexometric titration.

Validation Studies:

Researchers have also validated the redox titration method for determining iron in iron-containing drugs and supplements. Applications:

Redox titration is used in various applications, including the analysis of iron tablets, food samples, and environmental samples. Sensitivity to Interferences: Other components in the tablet, such as fillers or other active ingredients, may interfere with the redox reaction.

End-point determination: The visual endpoint can sometimes be subjective and may require a trained eye to accurately judge the completion of the titration.

Handling of Strong Oxidizers: Potassium permanganate and dichromate are powerful oxidizers and require careful handling, as they can pose health and safety risks.

IV. RESULT AND DISCUSSION

The results obtained for the analysis were summarized in table 1. Although the capsule was produced by different manufacturers, samples 1, 2, 3, 4 and 5 have the same iron formulation which is iron fumarate. Also it can be seen from the table the difference of some of the capsule is quite comparable with the label/standard concentration of (Fe) in the Redox titration. And might be due to the in complete transfer or dissolution of the sample solution may interfere with the observation of the endpoint.

Moreover, in the accuracy of measurement faculty weighing apparatus, improper through mixing of component or splashes of the samples may also result in such variations. However, if at all none of the above has happened, the differences may only be a marketing promotion strategy from manufacturers.

Sr. no	sample	Iron(fe)mg/g	Label/standard mg/g	difference
1	Zincofer	300	315	15
2	Daily iron	100	112	12
3	Folvit	5	5	0
4	Chelon	95	100	5
5	Glesfer-xt	123	150	27

Table 1.2: iron contain in tablets

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V. CONCLUSION

The redox titration method remains one of the most effective, reliable, and accessible techniques for the determination of iron content in iron tablets. Its application in pharmaceutical analysis has been extensively documented, with potassium permanganate and potassium dichromate being the most commonly used titrants. Despite some limitations, such as interference from other tablet ingredients and challenges in endpoint detection, redox titration continues to be an essential tool in quality control and regulatory testing of iron supplements.

Future studies may focus on improving the precision of endpoint detection, addressing matrix interferences, and comparing the redox titration method to more advanced techniques in terms of accuracy and cost-effectiveness.

Based on the result for the analysis of all the samples 1-5 it can be concluded that zincofer (300mg/g) have the highest amount of iron. Hence zincofer capsules can be regarded as the most suitable for those groups lacking iron supplement (e.g. menstruating and pregnant women and those who suffer blood loss due to accidents). However, folvit which has the lowest amount of iron is the best supplement for infants who require very low amount of iron supplements.

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Formulation and Evaluation of Herbal Pain Relief Balm

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Abstract: *There has been an increasing focus on development of new routes of drug administration to provide tailored treatments for patients, without decreasing efficacy of analgesia, in proportion to the progression of the knowledge of pain mechanisms. While acute pain acts as an alarm, chronic pain is a syndrome requiring meticulous selection of analgesic drugs of high bioavailability for long-term use. Such criteria are challenges that topical medications aim to overcome, allowing progressive delivery of active component, maintaining stable plasma levels, with a good safety profile. This review presents recent findings regarding topical formulations of the most widely used drugs for pain treatment, ; Disclosed herein is an herbal balm composition and the method of preparing said composition. The composition comprising extracts of organically certified herbs, organic essential oils and organic beeswax, wherein the extract is prepared employing a super critical fluid extraction (SCFE) and where in the essential oils used herein is obtained by cold pressed method. The oils used in it is used as a pain killer.*

Keywords: natural pain relief balm, vitex negundo oil, Eucalyptus oil.

I. INTRODUCTION

Herbal balm is an ayurvedic formulation of powerful essential oils for quick relief from head ache, back ache, cold and in relieving pain.

Herbal balm composition comprising organic essential oils, organic bees wax and other desired herbal components has medicated topical preparations for application to skin of human beings. Balms are topical preparations for application to skin to relieve pain and stiffness. These balm contains counter irritant chemical compounds such as methyl salicylate. Petroleum jelly is the common base for any kind of balms.

Pain is an unpleasant feeling often caused by intense or damaging stimuli, such has stubbing a toe, burning a finger, putting alcohol on a cut and bumping the funny bone. The international association for the study of pains widely used definition states, pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.

Pain motivates the individual to withdrawn from damaging situations, to protect a damaged body parts while it kills and to avoid similar experiences in future. Most pain resolves promptly hence the pain stimulus is removed and the body has healed, but sometimes pain persists despite removal of stimulus and apparent healing of the body and sometimes pain arrive in the absence of any detectable stimulus, damage or disease.

II. METHODOLOGY

Take one container in that weigh and add 5gm of petroleum jelly, place the container in a hot plate and boil it until all the amount of petroleum jelly completely dissolved.

In the dissolved petroleum jelly solution weigh and add 5gm of bees wax, stir it and boil until the bees wax added completely dissolve in the petroleum jelly.

After that, weigh and add 5gm of menthol crystals to the above solution and boil it until the menthol completely dissolved.

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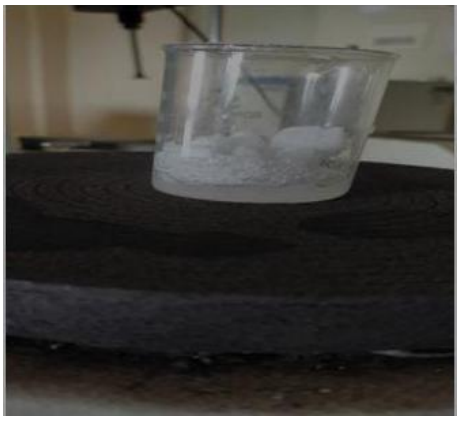


Fig.1 Petroleum jelly + Beewax

Weigh 10ml of vitex negundo oil, stir the solution and boil the solution.

Weigh 10ml of eucalyptus oil, stir the solution and boil the solution.

Weigh 5gm of sodium benzoate and add it to the solution, stir it well and boil the solution, for complete dissolution of the solution.

When all the added ingredients were completely dissolved and turns in to the liquid form then take the solution out of the hot plate and keep the herbal balm solution for cooling. Finally the prepared solution cools down and turns into a semi solid herbal balm.



Fig. 2 Semi solid herbal balm

III. LITERATURE REVIEW

Historically, medicinal plants have been used in various cultures for pain management. Ayurveda, Traditional Chinese Medicine (TCM), and Unani medicine documented the use of herbs like menthol, camphor, clove oil, and eucalyptus in pain relief formulations (Kumar et al., 1998).

Menthol (Peppermint extract) has been used since ancient times for its cooling effect and ability to relieve muscle pain (Smith & Brown, 2000).

Camphor, derived from the Cinnamomum camphora tree, was traditionally applied to swollen joints and muscle pain due to its counterirritant properties (Wang et al., 2002).

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Several past studies have investigated the mechanisms of action of herbal pain-relieving ingredients.

Menthol and camphor act as counterirritants, stimulating the skin's sensory nerves to create a cooling or warming sensation that distracts from pain (Taylor et al., 2003).

Eucalyptus oil, traditionally used for muscle aches, was confirmed to have anti-inflammatory properties in a study by Silva et al. (2005).

IV. RESULT AND DISCUSSION

The physicochemical parameters of the prepared balm were determined parameters such as colour, odour, appearance and PH were tested. The formulations exhibited good in appearance characteristic as well as PH was found in the range 7.0 which is the desired PH of the skin.

TABLE : PHYSICAL PARAMETERS OF HERBAL PAIN RELIEF BALM:

Sr. No.	Organoleptic Characters	Herbal Balm	Marketed Balm
1	Formulations	Pain Balm	Pain balm
2	Colour	Light Yellow	Yellow
3	Odour	Fragments	Fragment
4	Appearance	Good	Smooth
5	State	Semi Solid	Semi Solid



Herbal Pain Relief Balm

TABLE : EVALUATION RESULT OF HERBAL PAIN RELIEF BALM:

Sr. No	Parameters	Results
1	PH	6.27
2	Patch test	Non allergenic

V. CONCLUSION

Herbal balm was prepared by using Hot Processing Technique and were found to be without particles transparent components which are used in formulation are having good compatibility without any significant changes.

The Eucalyptus leaves extracts have relieving pain property, vitex negundo leaves extracts used to relieve Arthritic pain, cures high fever and alleviates menstrual cramps.

The prepared formulation showing good physical characteristics. Further evaluated by various evaluation parameters such as PH, Extrudability, Spreadability, Viscosity, Patch test and gives good result.

Based on the study research it can be concluded that herbal components can be effectively formulated as in the form of balm by using Hot Processing Technique which having excellent pain-relieving property.

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A Comprehensive Study on Extraction and Characterization of Bioactive Pesticidal and Insecticidal Compound from Annona Squamosa (Custard Apple Seeds)

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Abstract: *The Insecticide and Pesticide is a substance which helps to kill the bugs and insects and helps to maintain the crop yield. There basically two types of pesticides are one is natural and second is synthetic. Due to industrialization and easily availability synthetic pesticides used more often. In this paper we will study about manufacturing of natural pesticide from custard apple seed. The manufacturing process based on distillation in which solvents are used acetone and hexane. Annona squamosa (custard apple or sugar apple), belonging to the Annonaceae family, is a small tree or shrub that grows natively in subtropical and tropical regions. Seeds of the custard apple have been employed in folk medicines because of the presence of bioactive chemicals/compounds such as alkaloids, flavonoids and phenolic compounds and acetogenins and cyclopeptides that are responsible for various biological activities. From investigations, it has been shown that the seeds of A. squamosa have considerable potential to be used as an antibacterial, hepatoprotective, antioxidant and antitumor/anticancer agent. Cyclosquamosin B, extracted from the custard apple seed, possesses vasorelaxant properties. Tocopherols and fatty acids, notably oleic acid and linoleic acid, are also found in the seed oil. Annona Squamosa seeds contain a high amount of annonaceous acetogenins compounds, which are potent mitochondrial complex I inhibitors and have high cytotoxicity. A survey primarily based on the nutritional, phytochemical and biological properties showed that A. squamosa seeds can be used for the discovery of novel products, including pharmaceutical drugs.*

Keywords: Annona squamosa; Custard Apple Seed; Health Benefits; Bioactivities; Phytochemistry; Anticancer.

I. INTRODUCTION

Annona squamosa (Custard Apple or Sugar Apple). belongs to the Annonaceae family, a tropical fruit tree endemic to South and Central America, West Indies, Brazil, India, Egypt, Peru and Bermuda. In India, A. squamosa is widely cultivated in various states, including Assam, Uttar Pradesh, Bihar, Chhattisgarh, Maharashtra, Madhya Pradesh, Tamil Nadu, etc., for its edible fruit [1]. It is a small semi-deciduous branched tree or shrub that can reach up to 3–8 m in height and its fruits and seed by-product. Since ancient times, A. squamosa has been utilized in folk medicines and in various other applications involving food product development, e.g., the fruit pulp is used as a juice or as a flavoring agent. Custard apple industrial processing units generate large amounts of seeds, peels or seed coats [2]. The seeds are underutilized as the non-edible part of the fruit is discarded as waste, i.e., seed waste. The custard apple waste (seed) has a range of useful bioactive compounds [1,2,3]. Thus, seeds may potentially be extracted and may produce considerable income for the food processing industries. In India, the seeds have been used to make a hair tonic to remove headlice [1,3]. Ground seeds soaked in water have been used as an insecticide, a poison for fish, a strong eye irritant and a way to induce abortions [4,5,6]. Recent studies have shown that different parts of the plants, i.e., seeds, leaves, husks, peels and seed coats that are left after the main harvesting, are a rich source of phytochemicals and nutrients and can be utilized for novel product development, including usage in the food and pharmaceutical industries [1,7]. More than 400 active compounds have been isolated from A. squamosa [8]. In recent years, studies related to the

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pharmacological and phytochemical activities of A. squamosa seeds have confirmed that the major active chemical constituents are annonaceous acetogenins and cyclopeptides [9,10]. Annonaceous acetogenins, a class of polyketides, containing oxygenated functional groups including ketones, epoxides, hydroxyls, tetrahydropyrans and tetrahydrofurans, essentially found in the seeds, have been shown to have strong antibacterial, anti-ovulatory, anti-inflammatory, antithyroidal and other properties [11,12,13]. In vivo studies show that seed extracts of A. squamosa are beneficial for treating liver cancer, prostate cancer, cervical cancer, pancreatic cancer, etc. [12,14]. The biological activities exhibited by Annona Squamosa seed extract are caused mainly because of phenolic compounds, alkaloids, peptides, amino acids, sterols, tannins, flavonoids, polysaccharides and tocopherols present in it [12,15,16]. Interestingly, annonaceous acetogenins extracted from custard apple seeds possess antitumor/anticancer activity [12,17]. These compounds proved to be cytotoxic against various cancer cell lines. For example, a volatile compound, namely bullatacin, isolated from the seed oil of A. squamosa is involved in antitumor activity [18]; the aqueous and organic seed extract of A. squamosa induced apoptosis of tumor cell death with the enhanced activity of caspase-3 and the down- regulation of antiapoptotic genes Bcl-2 and Bcl-xL when treated with organic seed extract and both seed extracts, respectively [11]; petroleum ether seed extract shows inhibition of keratinocyte (HaCaT cells) proliferation [19]. The seed extract of A. squamosa exhibits hepatoprotective activity, as it helps in lowering the increased levels of alkaline phosphatase (ALP), total bilirubin, serum glutamic pyruvic transaminase (SGPT) and serum glutamic-oxaloacetic transaminase (SGOT) to normal levels [20].

1.1 Proximate Composition of Custard Apple Seeds:-

The fresh fruits of A. squamosa are commonly eaten in various regions of India, but the seed oil has not been reported yet for edible purposes. The seed of the custard apple is mainly composed of a seed coat (32.4%) and a seed kernel (67.7%). On a dry weight basis, the investigation shows a 22.2% content of crude fatty oil in seed kernels. The method of gas chromatography–mass spectroscopy (GC/MS) was used for studying the methyl esters of custard apple seed's fatty oil to determine its chemical composition, and results showed a total of 11 fatty acids, among which linoleic acid (22.9%), oleic acid (47.4%), palmitic acid (12.1%) and stearic acid (13.6%) were present in higher amounts. 11-eicosanoic acid (0.2%), dihydro sterculic acid (0.1%), eicosanoic acid (0.9%), heneicosanoic acid (2.3%) and margaric acid (0.2%) were all found in lesser amounts in the oil. [21] These 11 fatty acids together constitute nearly 99.8% of the oil. 17-methyloctadecanoic acid (0.1%) and palmitoleic acid (0.01%) were both identified in traces or in a minimum amount. The high quantity of unsaturated fatty acids (UFAs) was also determined in further investigations of the oil. About 70.3% of the oil was contributed by linoleic acid (22.9%) and oleic acid (47.4%); similarly, 25.7% of the oil consisted of palmitic acid (12.1%) and stearic acid (13.6%) [21]. Mariod et al., [22] have demonstrated the presence of leucine, isoleucine, glutamic acid, phenylalanine-tyrosine, aspartic acid, serine, alanine, methionine-cystine, histidine, arginine, glycine, valine, threonine and lysine in the amounts of 0.845, 0.464, 0.995, 0.671, 0.684, 0.299, 0.594, 0.106, 0.139, 0.704, 0.392, 0.642, 0.324 and 0.407 g/100g protein, respectively [22]. A proximate composition analysis of A. squamosa seeds demonstrated the presence of carbohydrate, fat, fiber, ash, protein and moisture at concentrations of 66.64, 29.21, 32.64, 1.90, 2.25 and 3.92 g/100g dry weight (DW) (%), respectively [23]. On the other hand, minerals (in mg/kg) such as K (56.47%) and Ca (46.90%) are present in higher amounts compared with P (33.30%), Mg (20.36%), Fe (6.74%), Cu (0.30%), Na (9.29%), Zn (0.43%) and Mn (0.25%).[22] By comparing the results of Shehata et al., [23] with other reference studies [24,25], it was concluded that the presence of a higher Ca content is important for healthy teeth and bones, while Fe is essential for preventing anemia. Minerals are also responsible for maintaining pH levels and blood pressure in the human body. [26]

II. LITERATURE REVIEW

2.1 Phytochemical Profile of Custard Apple Seeds:-

Phytochemical investigations reported cyclopeptides and annonaceous acetogenins as the chief constituents in the seeds of Annona squamosa. Different parts of A. squamosa contain several phytochemicals involving alkaloids, such as aporphine, norcorydine, roemerine, corydine, glaucine, anonaine and norisocorydine, in different parts of the plant. The seeds of Annona squamosa were found to contain acetogenins (polyketide), namely annotemoyin−1 and 2, cholesteryl,

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coumarinoligans, glucopyranoside, squamocin, and squamocins B-N. It was demonstrated that the custard apple seeds are toxic, but they are used as a biopesticide or an insecticide (its preparation may cause eye irritation that results in damage to the cornea). Custard apple seeds contain a high oil content and can be used for the production of soap and/or, if treated, can be used as an alternative to cooking oil. Seeds contain volatile substances such as 12,15-cis-squamostatin-A, bullatacin, β-caryophyllene, α- pinene, β-pinene, anonaine, camphene, spathulenol, germacrene, squamocin, duvariamicin-III, myrcene, liriodenine, annonacin and molvizarin.

In a study, the identification of phytochemicals present in the seed extract of A. squamosa was carried out via Fourier-transform infrared (FTIR) analysis. The result of the investigation shows the presence of alkenes, imine, oxime, quinone or conjugated ketone, nitro compounds, amides, nitroso compounds, sulfone, aromatics, sulphate ester, alkyl halides, phosphine, ethers, phosphonate, trimethylsilyl, amine oxide, phosphor amide, carboxylic acids, thiocarbonyl esters, phosphine oxide, phosphate, organosilicon, phosphite esters and amines in the methanolic seed extract of Annona squamosa.

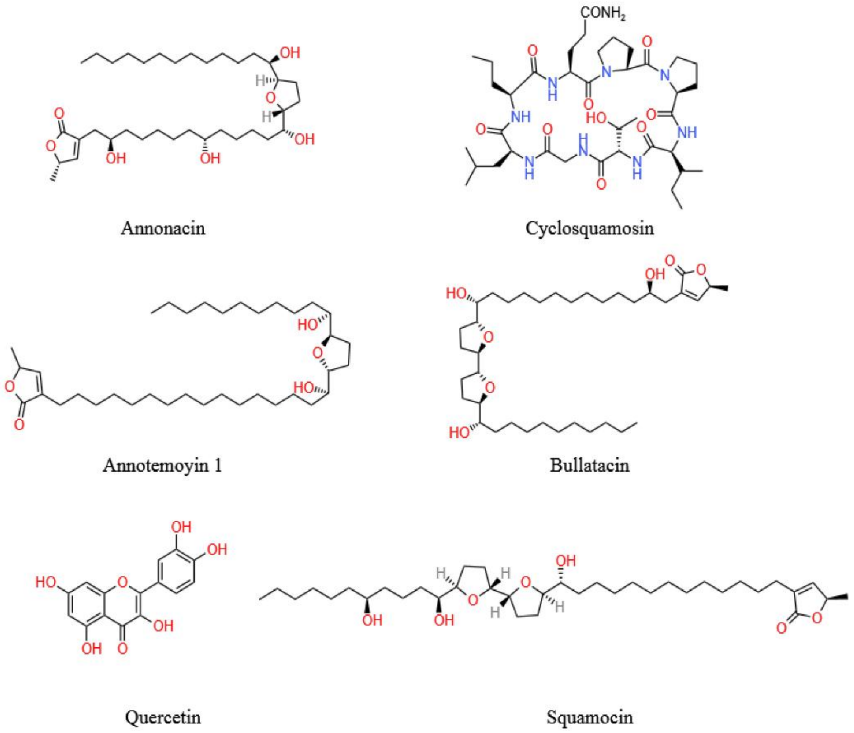


Figure 1. Structure of important compounds found in seeds of *A. squamosa*.

2.2 Antidiabetic Activity:-

Diabetes is one of the common endocrine disorders, characterized by altered carbohydrate, insulin and protein metabolism as a consequence of pancreatic insulin deficiency or insulin dysfunction. According to the reports of the World Health Organization (WHO), 80–90% of people above 40 years old are more prone to non-insulin-dependent diabetes mellitus. In a study, the ethanolic and methanolic seed extract of A. squamosa was administered to alloxan-induced diabetic rats (150 mg/kg body weight (BW)) to check its effect on blood glucose levels in diabetic rats. The ethanolic (dose: 200 mg/kg) and the methanolic (dose: 200 mg/kg) seed extract of A. squamosa exhibited significant dose-dependent 43.96% and 45.99% antihyperglycemic activity, respectively. From the results, it was observed that the ethanolic extract was less effective than the standard used (glibenclamide) for hyperglycemic activity. Compounds such as saponins, flavonoids, acetogenins, phenolic compounds and alkaloids are known to be active antidiabetic agents. The antidiabetic property of the methanolic and ethanolic seed extract of the apple may be due to the presence of more than

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one antihyperglycemic agent mentioned above. Further, the action mechanism will be explained by pharmacological and biological studies that help in presenting the seeds of Annona Squamosa as therapeutic agents in antidiabetic research. However, there are very limited studies investigating the antihyperglycemic effect of Annona Squamosa seeds. It has been concluded that there is a need to conduct investigations in the same field.

2.3 Anti-Inflammatory

Inflammation is the human body's defensive system, regulated by pro- and anti-inflammatory mediators (chemokines, cytokines, etc.). Many factors may cause inflammation in the human body, including exposure to allergens, physical trauma, thermal or chemical stimuli and microbial infection. However, inflammatory disorders such as chronic asthma, rheumatoid arthritis, inflammatory bowel disease and multiple sclerosis may be caused by internal or external factors that disrupt anti-inflammatory mediators. For instance, the seed extract of Annona squamosa causes a decrease in IL-6 and TNF-α levels in the lipopolysaccharide (LPS)- stimulated macrophage J774A.1 cell line. It was shown that two parallel synthesized cyclic cyclopeptides extracted from the seeds of the custard apple, i.e., cyclosquamosin D and cyclopeptide B, were demonstrated to have anti-inflammatory actions by inhibiting the generation/production of IL-6 and TNF-α. From the results, it was concluded that cyclopeptides have strong anti-inflammatory effects, reducing the levels of IL-6 and TNF-α in the bloodstream (~25%), with an IC50 value of 1.22 and 9.2 µM, which is significantly higher than observed with natural products or natural cyclic peptides. Similarly, in another study, cyclosquamosin D inhibited the generation of pro-inflammatory cytokines in Pam3Cys- stimulated and LPS-stimulated J774A.1 macrophages in a dose-dependent manner. For TNF- α a 60–20%, whereas for IL-6 a 50–10% reduction was observed at a dosage of 5–50 µg/mL, respectively. From the findings of different studies, it was deduced that cyclic peptides extracted from custard apple seeds might be utilized as an anti-inflammatory agent, though further investigation is needed for their anti-inflammatory effect.

2.4 Toxicity of Annona squamosa Seeds

Annona Squamosa seeds have been employed in the traditional medical system since time immemorial for skin exfoliation and elimination of headlice. The seeds of the custard apple include biologically active substances such as polyphenols, alkaloids, acetogenins and cyclohexapeptides. The pharmacological properties of certain acetogenins, including wound healing capabilities, anti-lice, mosquitocidal characteristics, anticancer, antifungal and antioxidant properties have been investigated in the past few years. Custard apple seeds are toxic mainly due to the presence of a high amount of annonaceous acetogenins (neurotoxins) that are stated to cause irritation in mucosa and the eye and vomiting (taken orally). Safety concerns are stated concerning the use of the plant in dietary supplements and is cited in the poisonous plants database of the Agence Francaise de Securite Sanitaire des Aliments (AFSSA) and the American Food and Drug Administration (FDA). Others have claimed that when crushed seeds come into contact with the eyes, they may cause conjunctival irritation that ultimately leads to eye ulcers. When a toxic extract of the custard apple seed was tested on rat eyes, it resulted in a conjunctival infection and delayed damage to the corneal epithelium. Some examples show that this plant's seeds induce severe symptoms of toxic keratitis after inadvertent contact with the custard apple seed. For instance, a patient utilized the oil combined with A. squamosa seed powder for the control of headlice. Results demonstrated that the patient exhibited considerable conjunctival congestion, blepharospasm, coarse punctate epithelial diffuse erosions and dense stroma and no anterior chamber reaction was seen in either of the patient's eyes. Individuals in a different study experienced a similar pattern after being exposed to custard apple seeds for 8 to 12 h. Slit-lamp examination revealed widespread erosions with coarse punctate epithelium in both eyes. Furthermore, it is concluded that the seeds or the seed extract/powder of the custard apple are highly toxic and an irritant, causing conjunctivitis and corneal epithelium damage with a high risk of secondary infection. However, people need to learn about the toxicity of the seeds of the custard apple, which requires further investigations to acquire the knowledge of its safety aspects and dosage.

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2.5 Anticancer/Antitumor Activity

Cancer is a genetic disorder, caused by the mutations that happen to take control of genes in our body and control how cell functions, grow, multiply and die. The reports of Cancer Research UK estimate that there are more than eight million cancer-related deaths worldwide per year and this may increase in the future. In a study conducted by Chen et al., the in vivo and in vitro antitumor activity of acetogenins isolated from the custard apple seed oil was investigated against human tumor cell lines. Two major acetogenins isolated from the seed oil of A. squamosa, i.e., 12, 15-cis-squamostatin-A (47.98 mg/g) and bullatacin (256.18 mg/g), were detected and quantified by high-performance liquid chromatography (HPLC). The result of the study indicates that seed oil shows considerable antitumor properties against A-549, Hela, MCF-7 and HepG2, especially for Hep G2 (IC50: 0.36 mg/mL) and MCF-7 (IC50: 0.25 mg/mL) cells in vitro. Furthermore, the oral treatment of custard apple seed oil also prevents growth of H22 tumor cell lines in mice, with a reduction rate of 69.55% with no post-treatment side effects, suggesting that the seeds of the custard apple may be used as a potent ingredient for the production of anticancer drugs. Similarly, the seed oil (dose: 0.5–1.0 mL/Kg) of the custard apple shows considerable antitumor activity in H22 xenograft-bearing mice, with an inhibitory rate of 53.54% against the development of H22 cell lines. It was found that seed oil shows antitumor effects by inhibiting the interleukin-6/Jak/Stat3 signaling pathway by reducing the production of interleukin-6, Janus kinase and activators of transcription (p-Stat3) and phosphorylated signal transducer expressions. The findings of the investigation revealed that the ASSO-NPs group (15 mg/kg) has the highest tumor growth inhibitory rate of 69.8%, significantly greater than the free seed oil group (135 mg/kg, 52.7%, $p < 0.05$) in a 4T1 tumor-bearing mice model [64]. In addition to antitumor activity, it was noticed that there was no significant change in the weight of the mice, indicating that ASSO-NPs have good safety.

III. APPLICATIONS OF CUSTARD APPLE SEEDS

3.1 Nutritional Composition:-

Annona squamosa is a lowland tropical shrub that possesses a high pharmaceutical potential for treating cardiac ailments, thyroid-related disorders, diabetes, and cancer. Phytochemical analysis of ASL extracts revealed the presence of numerous phytochemicals, such as proteins, carbohydrates, saponins, alkaloids, flavonoids, phenolics, and glycosides]. A study conducted at four different sites in Egypt showed the highest protein content in ASLs compared to seeds and fruit. ASLs from Menofia showed a protein content of 13.47 mg/g on a fresh weight (FW) basis, whereas ASLs from Mansoura demonstrated the highest protein content of 17.26 mg/g FW. ASLs from Alexandria (3.52 mg/g FW) and Giza (6.80 mg/g FW) showed the lowest protein content. Thus, a higher protein content in ASL. extracts can harness the nutritional value of the food for use by humans as well as animals. Proteins and amino acids were also present in high quantities in the methanolic and aqueous extracts of ASLs.

3.2 Nutritive value of custard apple:-

Custard apples are usually consumed as dessert fruit. The nutritive value of custard apple per 100 g of pulp is presented in table 1. The fruit is rich in starch when firm but increases markedly in sugar as it softens. The main sugars are glucose and fructose (80-90%). The calorific value is high (300-450 kJ per 100 g) and is almost doublethat of peach, orange and apple. Custard apple is full of vitamin C anti-oxidants, which helps to combat many diseases and also enhances the immune system. It is abundant source of dietary fibre, Vitamin A. Vitamin C. Antioxidant, Potassium, magnesium and also contains calcium. Vitamin B6, Copper and Low fat levels, excellent source of fron. It has high calorific value, able to provide sustained energy and delicious in nature. It has about 3.1% of fibre in the edible portion.

3.3 Medicinal value of custard apple:-

The health and medicinal benefits of the Custard apple fruit are numerous and it appears to possess potent bioactive principles in most of its plant parts (fruit, seed and leaves). The various chemical constituents isolated from leaves, stems, and roots of the plant include anonaine, aporphine, coryeline, isocorydine, norcorydine, and glaucine For centuries, Ayurvedic practitioners in India haveextensively use various parts of the sugar apple (Annona squamosa) tree for the management of diabetes. Essential oils, pinenes have also been described and extracted from custard apple. One

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clas of chemicals which sets custard apple apart from other fruit species isthe presence of acetogenins The acetogenins are unique to the Annonaceous family, which are very long chain fatty acids, and only found in Annonaceous species. The in vitro and in vivo studies appearto have considerable anti-cancer properties and anti- hypertensive properties The anti-cancer properties of custard apple appear to be mainly due to a class of compounds called acetogenins which are specific to Annonaceaous species. Acetogenins have been tested in vitro against 60 types of cancer cells, including breast, prostate and colon. Compared with paclitaxel a standard anti-cancer drug. pullatacin, an acetogenin, was 300 times as potent even at in vivo test system. Custard apple has been used for treatment of malaria. Three known aporphine alkaloids were solared apple thebark. Structures of compounds were identified as N-Nitrosoxylopine, Roemerolidine and Dugurvalline. All the three anti-malarial alkaloids exhibit moderate activity against chloroquine sensitive strain (D10) and a chloroquine resistan strain (Dd2) of Plasmodium falciparum.

3.4 Pharmacological Properties:-

Recently, custard apple seeds have emerged as a potential ingredient for the development of supplementary foods because of its significant nutraceutical and phytochemical composition. However, the development of by-products by integrating the bioactive compounds from the custard apple seeds are well-endowed with novel pharmacological properties. These properties of A. squamosa or the custard apple seed have been extensively studied for the antimicrobial, antidiabetic, anti-inflammatory, anticancer, antitumor, antioxidant, hepatoprotective, antiproliferative, antiheadlice, antihelminthic and antilarval activities.

IV. CONCLUSION

Custard Apple (Annona Squamosa) has gained popularity due to a recent increase in investigations/studies conducted on the health benefit and the bioactivities of different parts of the plant such as the seed parts, the bark, the leaves, the fruits, etc. A. squamosa has been employed in indigenous folk medicine worldwide and likely used in the food industry, as 50– 80% of the fruit is edible. The pulp is used as a flavoring agent in ice cream and contains vitamin B1 (thiamine), dietary fiber, potassium and sodium in considerable amounts. The seeds of Annona Squamosa are a rich source of phytochemicals such as polyketides, annonaceous acetogenins (neurotoxins), cyclopeptides, carbohydrates, proteins, lipids, oleic acid and linoleic acid. Based on in vivo and in vitro experiments Annona Squamosa seed extracts were found to be effective in various bioactivities such as antitumor, antimicrobial, antifungal, antidiabetic, hepatoprotective, anticancer and antifertility. The production of natural insecticides from custard apple seeds holds great potential to revolutionize agriculture by offering sustainable, eco-friendly, and cost-effective pest management solutions. Future advancements in technology, policy support, and market demand can further enhance its applicability and impact globally. A few studies were available on the phytochemical profile and the molecular mechanism of various bioactivities of A. squamosa seeds.

However, more pharmacological studies need to be performed to determine the nutraceutical and food supplement potential of the seeds. Based on the studies available, Annona Squamosa seeds may likely be used as an ingredient in the nutraceutical and food/nutrition industry, especially as anticancer drugs and antitumoral dietary supplements, benefiting human health. We can conclude that the natural pesticide derived from custard apple seed oil is effective, cost- effective, and easy to manage. It recovers to about 19- 20% while using hexane as a solvent. If we use acetone as a solvent then we get oil yield is about 12-15 % yield of oil. Hexane recovered during extraction is around 80-85% as well as acetone recovered during extraction is around 55-60%. Without putting forth a lot of work, this pesticide substance may be made easily available to everyone in India. This raw material will be very inexpensive, lowering the overall processing and solvent recovery costs.

In conclusion, the natural pesticide formulated from custard apple seed oil is an effective and environmentally friendly solution for pest control. The use of natural oils like acetogenins from custard apple seeds offers a sustainable alternative to chemical pesticides, which can have harmful environmental and health effects. Further studies could explore the long-term effectiveness of the pesticide and its impact on non-target organisms, as well as investigate the optimization of extraction and formulation methods to maximize efficacy and reduce costs.

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V. FUTURE SCOPE

The production of natural insecticides and pesticides from custard apple seeds offers promising potential in sustainable agriculture and pest management. Below are the key areas of future scope:

5.1. Commercialization and Market Expansion:-

Growing Demand for Organic Farming: With the increasing demand for organic produce, natural insecticides can cater to farmers looking for eco-friendly alternatives. Development of Biopesticide Brands: Large-scale production can lead to branded, eco-friendly pesticide products, catering to both domestic and international markets. Cost-effective Solution: Utilizing custard apple seeds, often considered waste, reduces raw material costs, making the product more accessible to farmers.

5.2. Research and Development:-

Optimization of Extraction Techniques: Advanced methods like supercritical fluid extraction can improve the yield and potency of active compounds. Formulation Improvements: Researchers can develop more stable, long-lasting formulations suitable for diverse crops and climates. Toxicity Studies: Comprehensive studies can help ensure the safety of these products for humans, non-target organisms, and the environment. Active Compound Identification: Further research can isolate and enhance the insecticidal properties of specific bioactive compounds like acetogenins.

5.3. Integration with Modern Agriculture:-

Precision Agriculture: Combining natural pesticides with modern technologies (e.g., drones for spraying) can increase efficiency and reduce waste. Compatibility with Other Practices: Testing and integrating custard apple seed pesticides with Integrated Pest Management (IPM) programs can offer holistic pest control solutions.

5.4. Environmental Impact:-

Reduction of Chemical Pesticides: Scaling up production can significantly reduce reliance on harmful synthetic chemicals, promoting sustainable agriculture. Biodegradability: Unlike synthetic pesticides, these products decompose naturally, reducing soil and water contamination. Preservation of Beneficial Insects: Natural pesticides often have selective toxicity, sparing pollinators and other beneficial organisms.

5.5. Waste Management and Circular Economy:-

Utilization of Agricultural Waste: Custard apple seeds, typically discarded as waste, can be repurposed, promoting a zero-waste approach. Economic Opportunities: The process creates new avenues for employment and entrepreneurship in rural and urban areas.

5.6. Policy and Government Support:-

Governments and environmental organizations can promote the use of bio-pesticides through subsidies, awareness campaigns, and certifications for natural products.

5.7. Global Collaboration:-

Partnerships between research institutes, agricultural organizations, and private industries can drive innovation and expand the use of custard apple-based insecticides to international markets.

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Extraction of Cinnamaldehyde from Cinnamon Bark and its Aldol Condensation Reaction

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Abstract: *Cinnamaldehyde, a major component of cinnamon bark oil, possesses significant industrial applications in the food, pharmaceutical, and cosmetic industries due to its distinctive aroma and biological properties. This study explores the extraction of cinnamaldehyde from cinnamon bark using steam distillation, followed by its aldol condensation reaction to synthesize α, β-unsaturated carbonyl compounds. The extraction process involves heating crushed cinnamon bark in water, generating steam that carries volatile oil components, which are then condensed and collected. The separated oil phase is further purified using solvent extraction and drying techniques to obtain pure cinnamaldehyde. The effectiveness of steam distillation in isolating cinnamaldehyde is evaluated based on yield and purity. Following extraction, cinnamaldehyde undergoes aldol condensation in the presence of a base catalyst, typically sodium hydroxide or potassium hydroxide, resulting in the formation of higher molecular weight carbonyl compounds. This reaction is crucial in organic synthesis, as it leads to the formation of complex molecular structures used in various industrial applications, including fragrance synthesis and pharmaceutical intermediates. The study provides insights into natural product isolation and their subsequent chemical modifications, demonstrating an integrated approach to extraction and organic synthesis. Additionally, it emphasizes the efficiency and sustainability of steam distillation in extracting valuable organic compounds from natural sources. The aldol condensation reaction further highlights the chemical reactivity of cinnamaldehyde, paving the way for its utilization in industrial and laboratory settings..*

Keywords: Cinnamaldehyde, Cinnamon bark, Steam distillation, Essential oil extraction, Aldol condensation

I. INTRODUCTION

Extraction Of Cinnamaldehyde from cinnamon Bark :

Cinnamaldehyde is the primary component responsible for the characteristic aroma and flavor of cinnamon. It is a naturally occurring organic compound classified as an aldehyde and is widely used in the food, pharmaceutical, and cosmetic industries. The extraction of cinnamaldehyde from cinnamon bark (Cinnamomum species) is an essential process for obtaining this valuable compound in its pure form.

Cinnamon bark contains volatile oils, with cinnamaldehyde being the most abundant constituent. The extraction process typically involves steam distillation or solvent extraction, both of which help isolate the essential oil from the plant material. Steam distillation is the most commonly used method as it allows for the efficient separation of volatile compounds without causing degradation.

Cinnamaldehyde from Aldol Condensation Reaction :

Cinnamaldehyde, a naturally occurring aromatic aldehyde found in cinnamon bark, is widely used in the food, pharmaceutical, and chemical industries. Beyond its direct applications, cinnamaldehyde serves as a valuable precursor for various organic synthesis reactions, including aldol condensation.

Reaction :

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Aldol condensation reaction between cinnamaldehyde and acetone lead to the formation of dicinnamalacetone an α,β-unsaturated ketone. This reaction is catalysed by strong base such as NaOH

2 Cinnamaldehyde + Acetone $\xrightarrow{NaOH}$ Dicinnamalacetone + water

Structural formula representation :

$2C_9H_8O + C_3H_6O \xrightarrow{NaOH} C_{21}H_{18}O + H_2O$

Reaction mechanism :

Step 1 : Enolate formation (Deprotonation of acetone) :

Acetone (CH3COOH) has α hydrogen atom. In presence of NaOH, acetone undergoes deprotonation at the α – carbon forming an enolate ion.

$CH_3COCH_3 + OH^- \rightarrow CH_2^-COCH_3 + H_2O$

Step 2 : Nucleophilic attack on cinnamaldehyde :

The enolate ion acts as a nucleophile and attacks the electrophiles carbonyl carbon of cinnamaldehyde . This leads to the formation of a β – hydroxy ketone intermediate .

$CH_2^-COCH_3$ + Cinnamaldehyde → β – hydroxy ketone

Step 3 : Dehydration (formation of α,β-unsaturated ketone) :

β – hydroxy ketone (-H_2O elimination) This result in the formation of Dicinnamalacetone which contains a conjugated system .

β – hydroxy ketone → Dicinnamalacetone + H_2O

II. METHODOLOGY

Extraction Of Cinnamaldehyde From Cinnamon Bark :

Materials:

- Cinnamon bark (ground or crushed)
- Distilled water
- Steam distillation apparatus (round-bottom flask, condenser, collection flask)
- Separatory funnel
- Organic solvent (eg. ether)
- Anhydrous sodium sulfate (drying agent)

Procedure:

1. Preparation of Cinnamon Bark :

Crush or grind the cinnamon bark to increase surface area for extraction.

2. Setting up Steam Distillation :

- Place the ground cinnamon bark in a round-bottom flask.
- Add a sufficient amount of distilled water.
- Connect the setup to a condenser and collection flask.

3. Distillation Process :

- Heat the flask to generate steam.
- The steam will carry volatile components, including cinnamaldehyde, through the condenser.
- The condensed distillate (a mixture of water and cinnamaldehyde) is collected.

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4. Extraction of Cinnamaldehyde :

- Transfer the distillate to a separatory funnel.
- Extract cinnamaldehyde using an organic solvent like ether (shake and allow layers to separate).
- Collect the organic layer and dry it over anhydrous sodium sulfate to remove residual water.
- Evaporate the solvent under reduced pressure to obtain pure cinnamaldehyde.



Cinnamaldehyde from Aldol Condensation Reaction

Materials :

- Cinnamaldehyde
- Acetone
- Sodium Hydroxide
- Ethanol
- Conical flask, Stirrer

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Procedure :

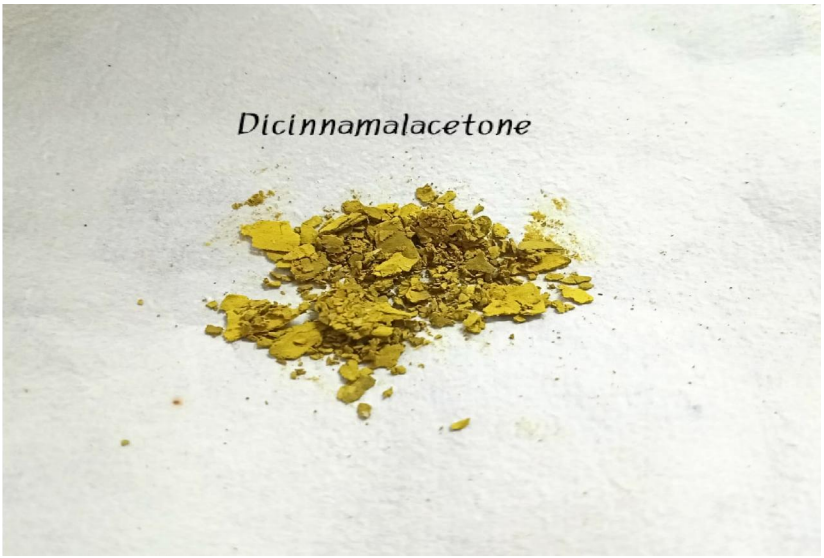
- 50 ml of water is added to a flask followed by 5g of sodium hydroxide.
- Once the sodium hydroxide is fully dissolved , 40 ml of ethanol is added and the mixture is allowed to cool back to room temperature.
- 2 ml of acetone and 5 ml of cinnamaldehyde is rapidly added to flask and allowed to stir for 30 minutes.
- After the 30 minutes, precipitate is filtered off and washed with 100 ml of water.





- The crude product is recrystallized from 200 ml of hot ethanol.
- After being allowed to crystallise overnight the dye cinnamon acetone is filtered off and washed with ice cold ethanol.

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III. LITERATURE REVIEW

A comprehensive literature review on the extraction of oil from cinnamon and clove would delve into various extraction techniques, including steam distillation, solvent extraction. It would explore the optimization of extraction parameters such as temperature, pressure, time, and solvent type to maximize oil yield and quality. Additionally, it would examine the chemical composition of the oils, identifying key compounds such as cinnamaldehyde in cinnamon oil and aldol condensation reaction and their therapeutic benefits and industrial applications. Furthermore, the review would discuss recent advancements in extraction methods and their effectiveness in enhancing oil extraction efficiency. Finally, it would highlight areas for future research, including the development of sustainable and environmentally friendly extraction techniques and the exploration of novel applications for cinnamaldehyde and aldol condensation reaction in various industries .

V. RESULT AND DISCUSSION

Extraction of Cinnamaldehyde from Cinnamon Bark :

Result

- Cinnamaldehyde was successfully extracted from cinnamon bark using the steam distillation method.
- The extracted oil was pale yellow in color with a strong cinnamon-like aroma, confirming the presence of cinnamaldehyde.
- Solubility tests showed that the extracted oil was insoluble in water but soluble in ethanol, confirming its organic nature
- 100 gm of cinnamon powder : 8 ml of cinnamon oil
- Boiling Point of Cinnamon oil : 246^0C

Discussion :

1) Effectiveness of Steam Distillation :

Steam distillation was chosen for extraction because cinnamaldehyde is a volatile compound. The process allowed for the separation of essential oil from cinnamon bark without decomposition. The efficiency of extraction depended on factors like distillation time, particle size of cinnamon bark, and temperature control.

2) Physical and Chemical Properties

The extracted cinnamaldehyde had a characteristic strong aroma, matching its expected properties.The presence of cinnamaldehyde was confirmed by qualitative solubility tests, and further confirmation can be done using spectroscopic techniques.

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Cinnamaldehyde from Aldol Condensation Reaction :

Result :

Dicinnamalacetone was successfully synthesized through the aldol condensation reaction between cinnamaldehyde and acetone in the presence of a strong base (NaOH) in ethanol.

Colour change : initially the solution is pale yellow , after the reaction, a deep yellow to orange solid precipitate .Product appearance : Dicinnamalacetone is a yellow crystalline solid

Melting Point : 120^0C (to confirm purity)

Dicinnamalacetone weight obtained : 1.5 gm

Discussion :

1) Mechanism of Reaction :

The aldol condensation follows a base-catalyzed mechanism. Acetone forms an enolate ion under basic conditions, which then attacks the electrophilic carbonyl of cinnamaldehyde, forming a β-hydroxy ketone intermediate. , dehydration occurs, leading to the formation of Dicinnamalacetone, an α,β-unsaturated ketone with conjugation.

2) Confirmation of Product Formation :

The yellow color and crystalline nature of the product indicate the presence of a conjugated system.

Melting point measurement provides an initial confirmation of product identity.

3)Future Improvements :

Optimizing the reaction conditions (base concentration, temperature, and reaction time) for higher yield.

Using different solvents or catalysts for improved selectivity. Chromatographic techniques (TLC) can be used for better purification and separation.

V. CONCLUSION

Conclusion on the Extraction of Cinnamaldehyde from Cinnamon Bark

The extraction of cinnamaldehyde from cinnamon bark is successfully achieved using steam distillation or solvent extraction methods. Steam distillation is the preferred technique due to its efficiency in isolating volatile compounds while maintaining their chemical integrity. The extracted oil contains cinnamaldehyde as the major component, which can be further purified using drying agents (e.g., anhydrous sodium sulfate) and vacuum distillation.

The process confirms that cinnamon bark is a rich natural source of cinnamaldehyde, which has various applications in flavoring, pharmaceuticals, and organic synthesis. The successful isolation of cinnamaldehyde also provides a starting material for further chemical transformations, such as aldol condensation reactions to synthesize valuable α,β-unsaturated ketones.

Overall, the study highlights the effectiveness of traditional extraction techniques and their relevance in obtaining bioactive compounds from natural sources. Further improvements, such as optimizing yield and purity, can be explored for industrial-scale production.

Conclusion on cinnamaldehyde from Aldol Condensation Reaction :

The aldol condensation reaction between cinnamaldehyde and acetone successfully produces dicinnamalacetone, an α ,β-unsaturated ketone with conjugated double bonds. This reaction follows a base-catalyzed mechanism, where acetone forms an enolate ion, which then undergoes nucleophilic addition with cinnamaldehyde, followed by dehydration to yield the final product.

VI. ACKNOWLEDGMENT

It gives us pleasure to present my project on “Extraction of cinnamaldehyde from cinnamon bark and its aldol condensation reaction.” The able guidance of all teaching staff of department made this study possible.

I express my deep sense of gratitude and respect to my guide Dr. Jayashree Shailesh Patil (Assistant professor), Department of chemistry, J.S.M College, Tal.Alibag, Dist.Raigad for her inspire guidance on constructive criticism and constant encouragement during the completion of this project.

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I place my sincere thanks to Head of Chemistry Department and Principal Dr. Sonali Patil, J.S.M COLLEGE ALIBAG for giving me opportunity to complete this work and providing the necessary facilities. I would also like to appreciate all teaching and non-teaching staff of J.S.M. College, Alibag.

My special thanks to my all friends M.Sc.-II for their friendly suggestion and timely help during extraction of cinnamon oil from cinnamon bark and its aldol condensation reaction.I must like to thanks University of Mumbai and Chemistry Department for giving us an opportunity to explore this subject by conducting this project.

Finally, I would like to thank everybody who played a very important role towards the completion of this work, as well as expressing of this work, as well as expressing my apology that I could not mention all the names one by one.

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Manufacture of Soap From Waste Cooking Oil

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Abstract: *The consumption of the same is crucial to regulating and reducing its usage because used cooking oil is recycled from a variety of sources. Waste cooking oil is a good option for soap making because it is less expensive than other materials. This study was conducted with its primary purpose being to salvage waste cooking oil and processing into soap within the acceptable saponification values using caustic soda at different batches. The method adopted resulted in favorable outcome, and reduced cure time was observed in subsequent trials. The soap is suitable for cleaning and washing. Soap made from waste cooking oil can be a potential product that can be developed to improve the economy and as an effort to preserve the environment by utilizing household waste. Waste cooking oil can be reprocessed into soap-based ingredients through an oil purification system so that the color is clear and does not smell rancid by using bagasse and orange-peel adsorbents in the bleaching process. Cooking oil consumption in Indonesia is very high and tends to rise every year, reaching 500,000 tons/year. Waste of used cooking oil pollute water and reduces the biota. Therefore, the conversion of used cooking oil will help to reduce environment damage. One of the conversions done is making the bulk cooking oil into soap. This study aims to determine the effect of NaOH concentration on the quality of soap made from purified used cooking oil.*

Keywords: Waste cooking oil, Saponification, Coconut oil, Sodium hydroxide, Moisture content, Eco friendly

I. INTRODUCTION

Soap is an essential household product used for cleaning and hygiene. Traditionally, commercial soap is made from vegetable oils or animal fats, but with increasing environmental concerns, researchers have explored alternative raw materials for soap production. One such sustainable approach is the use of waste cooking oil, which is often discarded improperly, leading to environmental pollution.This research focuses on manufacturing soap from waste cooking oil using the saponification process. By recycling used cooking oil, this study aims to reduce waste, promote environmental sustainability, and provide a cost-effective alternative to commercial soap production. The project also explores the effectiveness, quality, and feasibility of soap made from waste oil compared to conventional soap products.This study will not only contribute to sustainable waste management but also raise awareness about eco-friendly soap-making methods. The findings will help individuals, small businesses, and communities adopt a greener approach to soap production while addressing waste disposal issues.

II. METHODOLOGY

Melt The Oils:

1. combine 60g of fried oil, 15g of stearic acid, and 15g of coconut oil in a heatproof container. Heat it gently until fully melted.
2. **Prepare The Lye Solution:** In separate container, dissolve 7g of sodium hydroxide in 18ml water. Stir until the lye is completely dissolved, then let it cool slightly.
3. **Mix The Oils and Glycerine:** Add 5ml of glycerine to the melted oils and mix well.
4. **Combine Lye and Oil Mixture:** Slowly pour the cooled lye solution into the oil and glycerine mixture while stirring continuously.

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5. **Add Isopropyl Alcohol:** Incorporate 10ml of isopropyl alcohol (IPA) into the mixture blend thoroughly until reaches pourable consistency.



Fig 1: Filter Oil



Fig 2: Deep Fried Oil



Fig 3: Fried oil +coconut oil + stearic acid

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Fig 4: Mixture Of Soap

6. **Mold The Soap:** Pour the mixture into soap molds. Smooth the surface and allow it to set for 24-48 hours.



Fig 5

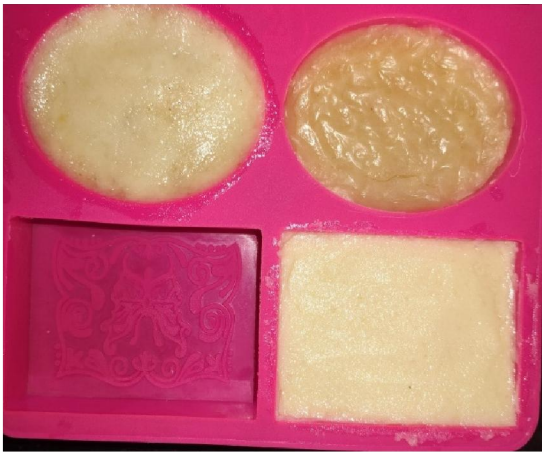


Fig 6

7. **Cure The Soap :** Once hardened, unmold the soap and let it cure in a cool , dry area for 4-6 weeks to ensure proper saponification .



Fig 7

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III. LITERATURE REVIEW

Research and Development in soap studies: The concept of soap production from waste cooking oil has been explored in various scientific studies and research papers. This section reviews relevant literature on the environmental impact of waste cooking oil, the chemical principles behind soap-making, and previous studies on sustainable soap production.
Below is a sequenced list of studies done in past time

1. Gunstone, F. D. (2008). "The Chemistry of Oils and Fats: Sources, Composition, Properties, and Uses"
This book provides a fundamental understanding of oils and fats, including their sources and chemical properties. It explains how triglycerides undergo saponification when treated with an alkaline solution, forming soap and glycerol. The book highlights the challenges of using waste oil, such as impurities affecting soap quality.

2. Smith, J., Brown, K., & Taylor, R. (2015). "Environmental Hazards of Waste Cooking Oil: A Review"
This study discusses the negative effects of improper disposal of waste cooking oil, such as water pollution and sewage system clogging. The authors suggest soap production as a viable recycling method to reduce environmental harm.

3. McMurry, J. (2017). "Organic Chemistry"
McMurry provides an in-depth explanation of the saponification process, discussing how triglycerides react with sodium hydroxide to form soap. The book also covers the effect of different oils on the final soap quality, which is relevant for waste oil-based soap production.

4. Sharma, P., & Jain, R. (2020). "Impact of Oil Purity on Saponification Efficiency"
This paper explores how impurities in waste cooking oil affect the efficiency of soap production. It suggests filtration and pre-treatment methods to enhance the quality of the final product.

5. Oliveira, M., Santos, C., & Pereira, L. (2018). "Sustainability in Soap Production: A Comparative Study Between Commercial and Waste Oil-Based Soaps"
The study compares soaps made from waste cooking oil with commercial soaps. Results indicate that waste oil soaps have similar cleansing properties while being more environmentally friendly and cost-effective.

6. Martins, A., & Silva, P. (2021). "Small-Scale Soap Production Using Waste Cooking Oil: A Sustainable Approach"
This research focuses on community-based soap-making initiatives. The authors highlight the economic benefits of small-scale production and how it can contribute to local sustainability efforts.

IV. RESULT AND DISCUSSION

Result:
After following the saponification process, the final product is a solid or semi-solid soap, depending on the type of oil used and the reaction conditions. The soap should have a smooth texture, proper hardness, and good lathering ability. If essential oils or colorants were added, the soap will have an appealing fragrance and appearance. Additionally, glycerine is formed as a byproduct, which can be retained in the soap for moisturizing properties or separated for other uses.



Fig 8

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Discussion:

1. Effect of Oil Type:

- Different oils yield soaps with varying properties. For example, coconut oil produces a harder soap with more lather, while olive oil results in a softer and more conditioning soap.
- Waste cooking oil may contain impurities and free fatty acids, which can affect the quality of the soap. Proper filtration and pre-treatment improve the final product.

2. Saponification Reaction:

- The reaction between the oil (triglycerides) and sodium hydroxide leads to the formation of soap and glycerol.
- If the NaOH concentration is too high, the soap may become harsh and cause skin irritation. Conversely, too little NaOH results in incomplete saponification, leaving an oily residue.

3. Soap Hardness and Curing:

- Freshly made soap is soft and needs 3-4 weeks of curing to harden and improve its quality.
- During curing, excess water evaporates, and the soap becomes milder as the saponification process completes.

V. CONCLUSION

The production of soap from waste cooking oil is an effective and eco-friendly way to recycle used frying oil, reducing environmental pollution and waste. Through the saponification process, the oil reacts with sodium hydroxide (NaOH) to form soap and glycerin. Proper filtration of the waste oil ensures a cleaner final product, while accurate measurement of ingredients is crucial for achieving the desired hardness, lathering, and cleansing properties.This method not only provides a cost-effective alternative to commercial soaps but also promotes sustainability by repurposing waste materials. With proper formulation and curing, high-quality soap can be produced, making this process both practical and beneficial for environmental conservation.

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It gives us pleasure to present my project on **"Manufacture of Soap from Waste Cooking Oil".** The able guidance ofv all teaching staff of department made this study possible. I express my deep sense of gratitude and respect to my guide **Dr.Jayashree Shailesh Patil (Assistant professor), Department of chemistry, J.S.M College, Tal.Alibag, Dist.Raigad** for her inspire guidance on constructive criticism and constant encouragement during the completion of this project.I place my sincere thanks to **Head of Chemistry Department and Principal Dr. Sonali Patil, J.S.M COLLEGE ALIBAG** for giving me opportunity to complete this work and providing the necessary facilities. I would also like to appreciate all teaching and non-teaching staff of J.S.M. College, Alibag. My special thanks to my all friends M.Sc.-II for their friendly suggestion and timely help during preparation of soap. I must like to thanks University of Mumbai and Chemistry Department for giving us an opportunity to explore this subject by conducting this project. Finally, I would like to thank everybody who played a very important role towards the completion of this work, as well as expressing of this work, as well as expressing my apology that I could not mention all the names one by one.

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[9]. "Pure Soapmaking" by Anne-Marie Faiola- Offers a range of recipes and techniques, emphasizing natural ingredients.

[10]. "Scientific Soapmaking" by Kevin Dunn A deeper dive into the chemistry of soapmaking, suitable for those interested in the science behind the process.

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Making Biodegradable Material Like Plastic Using Starch

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Abstract: *Plastics are hazardous to environment as they are as they are not decomposable because they are derivatives of strongly bonded long chain petrochemical based materials. However bio plastics can be seen as the solution to the problem. Bio plastics are made from biomass derived from plants such as cellulose, sugarcane, or rice. Starch is a natural biopolymer having mainly two types of polymer glucose. In this research work bio plastic is made using potato starch as its abundant and easily available. However, poor physico-mechanical properties like low tensile tear strength, high stiffness, elongation at break and poor moisture stability are observed in most of the starch-based materials. Development of starch-based bio plastic properties is being endeavoured by starch alteration. The physical and mechanical properties of the biodegradable plastic have been improved through some well-designed processes. Raw materials and chemicals used for production of potato starch based bio plastic are Potato, distilled water, Acetic Acid, glycerine. Different composition of the above ingredients were used to make bio degradable bio plastic. The growing environmental impact of conventional petroleum-based plastics has driven the need for sustainable, biodegradable alternatives. Starch, a naturally abundant and renewable polymer, has emerged as a promising base material for developing environmentally friendly plastics. This study focuses on the formulation and synthesis of biodegradable plastic-like materials using starch derived from sources such as corn, potato, and cassava. By incorporating plasticizers like glycerol , the brittleness of native starch is reduced, resulting in improved flexibility and usability. The addition of crosslinking agents and natural fillers further enhances the material's mechanical strength, thermal stability, and moisture resistance. The research explores the production process, Including gelatinization, blending, and casting, to create biodegradable films and composites. The biodegradability of the material is evaluated through soil burial and enzymatic degradation tests, demonstrating its ability to decompose into environmentally harmless byproducts. Potential applications of starch- based bioplastics include single-use packaging, agricultural mulch films, disposable utensils, and medical products. This work aims to contribute to the global effort in mitigating plastic waste pollution, promoting renewable resource utilization, and advancing the development of sustainable materials for a circular economy. By leveraging the inherent properties of starch, the study presents a viable pathway for reducing the ecological footprint of plastics while addressing the growing demand for sustainable alternatives.*

Keywords: Bio plastic, starch, properties, biodegradable

I. INTRODUCTION

Plastics derived from petroleum-based sources contribute significantly to environmental pollution due to their non-biodegradable nature. In response to this issue, biodegradable plastics have emerged as an eco-friendly alternative. One such material is starch-based bioplastic, which is made from natural, renewable resources like cornstarch or potato starch. Starch, a polysaccharide, can form a gel-like structure when mixed with water and heated. By adding plasticizers such as glycerol, the starch structure becomes more flexible, making it a suitable material for biodegradable plastic production. Additionally, vinegar (acetic acid) helps break down the starch chains, improving its consistency. This project explores a simple method to produce biodegradable plastic using starch, water, glycerol, and vinegar. The

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resulting material can degrade naturally in the environment, reducing plastic waste and its harmful impact on ecosystems. Plastics play a crucial role in modern life, being used in packaging, medical devices, construction, and countless other applications. However, conventional plastics, derived from fossil fuels, are non-biodegradable and contribute significantly to environmental pollution, especially in the form of plastic waste in oceans and landfills. This has led to an urgent need for sustainable and biodegradable alternatives. One promising solution is starch-based bioplastics, which are made from renewable, plant-derived materials like cornstarch, potato starch, or tapioca starch. Starch is a natural polymer that can form a gel-like structure when heated in water. However, in its raw form, starch lacks the flexibility and durability required for plastic-like applications. To enhance its properties, plasticizers such as glycerol are added, making the material more flexible and elastic. Additionally, vinegar (acetic acid) helps break down the starch molecules, improving the texture and workability of the final product. This experiment focuses on a simple and cost- effective method for producing biodegradable plastic using starch, water, glycerol, and vinegar. By understanding the process and properties of starch-based plastics, we can contribute to a more sustainable future while reducing our dependence on traditional plastics.

II. METHODOLOGY

This study aims to develop biodegradable plastic using starch, an abundant and renewable biopolymer. The methodology involves formulation, processing, and characterization of starch-based bioplastic using natural ingredients such as cornstarch, water, glycerol, and vinegar.

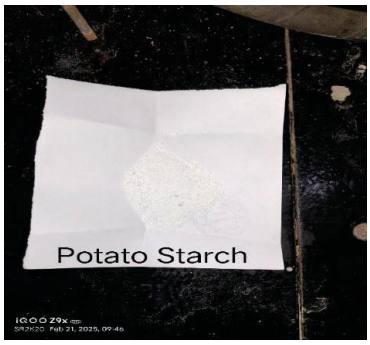


Fig 1

Selection of Raw Materials: Starch (potato starch) serves as the primary polymer, water acts as a solvent to dissolve and gelatinize the starch, glycerol functions as a plasticizer, enhancing flexibility. Vinegar modifies the starch structure for better consistency.

Preparation of Bioplastic Formulation: The starch is mixed with water in specific proportions to create a homogeneous solution. Plasticizer (glycerol) and vinegar are added to alter the mechanical properties.

Heating and Gelatinization Process: The mixture is heated on a hot plate while being stirred continuously. The heating process enables gelatinization, where starch granules swell and form a thick, paste-like structure.

Casting and Molding: The thickened mixture is poured onto a mold or a flat surface to achieve the desired shape. The material is spread evenly to maintain uniform thickness.

Drying and Solidification: The bioplastic film is left to dry at room temperature for 24–48 hours. The drying process allows water evaporation, solidifying the material into a flexible, plastic-like sheet. This methodology provides a systematic approach to producing biodegradable plastic, demonstrating a sustainable alternative to conventional petroleum-based plastics

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Fig 2

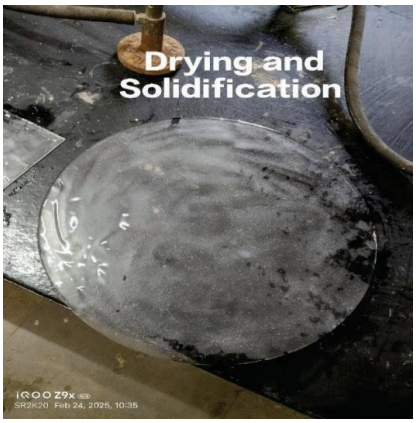


Fig 3

III. LITERATURE REVIEW

The growing environmental concerns associated with petroleum-based plastics have led to increased interest in biodegradable alternatives, particularly starch-based bioplastics. Several studies have explored the properties, processing techniques, and applications of starch-based bioplastics, highlighting their potential as a sustainable material.

Starch as a Biopolymer: Starch, a naturally occurring polysaccharide found in plants, has been widely studied as a raw material for bioplastic production. According to Avérous and Halley (2009), starch is an abundant and renewable polymer capable of forming biodegradable films. However, native starch has poor mechanical properties and high-water sensitivity, which necessitates modifications through plasticization or blending with other biopolymers (Shah et al., 2015).

Plasticization of Starch-Based Bioplastics: To improve the flexibility of starch bioplastics, plasticizers such as glycerol, sorbitol, or polyethylene glycol are commonly used. Research by Mali et al. (2006) found that glycerol effectively reduces starch film brittleness by increasing polymer chain mobility. However, an excess of plasticizer may weaken the material, making it overly soft and sticky (Krochta & De Mulder-Johnston, 1997).

Influence of Acetic Acid on Bioplastic Properties: Acetic acid (vinegar) is often incorporated to break down starch granules and enhance gelatinization. Studies by Pelissari et al. (2012) indicate that acid modification improves starch dispersion, film transparency, and mechanical properties. However, excessive acid content may lead to excessive hydrolysis, weakening the bioplastic structure (Ma et al., 2008).

Environmental Impact and Biodegradability: One of the major advantages of starch-based plastics is their biodegradability. Research by Thakur et al. (2014) demonstrated that starch bioplastics degrade within weeks to months, depending on environmental conditions. Unlike synthetic plastics, which persist for centuries, starch-based materials can be decomposed by microorganisms, making them a viable solution to plastic pollution (Narayan, 2010)

IV. RESULT AND DISCUSSION

RESULT:

Biodegradability: The starch-based plastic samples decomposed significantly faster than conventional plastic when exposed to natural conditions such as soil and water. Within a few weeks, visible degradation was observed, confirming their biodegradability.

Mechanical Properties: The tensile strength and flexibility of the starch-based plastic were lower compared to traditional petroleum-based plastics. However, blending starch with plasticizers like glycerol improved flexibility.

Production Feasibility: The plastic was successfully synthesized using simple and cost-effective methods, making it a viable option for small-scale and industrial production.

Environmental Impact: The material showed no toxic effects during degradation, confirming its eco- friendliness.

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Fig 4



Fig.5

DISCUSSION

Sustainability and Eco-Friendliness: The results confirm that starch-based bioplastics are a sustainable alternative to conventional plastics. Since starch is biodegradable and derived from renewable sources, it offers a reduced carbon footprint.

Challenges and Improvements: While the material showed promise, its mechanical strength and water resistance remain key challenges. Future improvements can focus on blending starch with other biodegradable polymers (such as PLA or PHA) and optimizing plasticizer concentrations.

Industrial and Commercial Potential: The ease of production and availability of raw materials make starch-based plastics a strong candidate for replacing conventional plastics in packaging, disposable cutlery, and agricultural applications. However, large-scale production requires cost-effective modifications to enhance durability. Future Prospects: With continuous research and technological advancements, starch-based bioplastics can be further developed to meet industrial standards. Government policies and consumer awareness will play a crucial role in promoting their adoption.

V. CONCLUSION

Biodegradable plastics made from starch offer a sustainable alternative to conventional plastics, reducing environmental pollution and dependence on fossil fuels. Starch-based bioplastics are biodegradable, renewable, and can be produced from agricultural sources like corn, potatoes, and cassava. While they have limitations such as lower durability and water resistance, these challenges can be addressed by blending starch with other biodegradable polymers and additives. With advancements in technology and increased adoption, starch-based addressed through further research and innovation. With increasing awareness, government regulations, and technological advancements, starch-based bioplastics have the potential to revolutionize packaging, agriculture, and various industries, ultimately leading to a cleaner and greener planet. bioplastics have the potential toto significantly reduce plastic waste and contribute to a more sustainable future. Starch-based biodegradable plastics present a promising solution to the global plastic pollution crisis. As a renewable, eco-friendly alternative, they can help reduce reliance on petroleum-based plastics while promoting sustainability. These materials decompose naturally, minimizing environmental harm and supporting a circular economy. However, challenges such as mechanical strength, water resistance, and cost-effective

ACKNOWLADGEMENT

It gives us pleasure to present my project on **"Making Biodegradable Material Like Plastic Using Starch".** The able guidance of all teaching staff of department made this study possible. I express my deep sense of gratitude and respect to my **guide Dr. Jayashree Shailesh Patil (Assistant professor),** Department of chemistry, J.S.M College, Tal.Alibag, Dist.Raigad for her inspire guidance on constructive criticism and constant encouragement during the completion of this project. I place my sincere thanks to **Head of Chemistry Department and Principal Dr. Sonali Patil, J.S.M COLLEGE ALIBAG** for giving me opportunity to complete this work and providing the necessary facilities. I would

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also like to appreciate all teaching and non-teaching staff of J.S.M. College, Alibag. My special thanks to my all friends M.Sc.-II for their friendly suggestion and timely help during preparation of soap. I must like to thanks University of Mumbai and Chemistry Department for giving us an opportunity to explore this subject by conducting this project. Finally, I would like to thank everybody who played a very important role towards the completion of this work, as well as expressing of this work, as well as expressing my apology that I could not mention all the names one by one.

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Preparation of White Phenyl Floor Cleaner: A Sustainable Approach to Household Hygiene

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Abstract: *White phenyl is a common disinfectant and floor cleaner that contains mostly pine oil emulsified in water. In this research, the formulation, stability, and confirmation testing of white phenyl are emphasized using pine oil and cutting oil or Sulfonated Castor oil as major components. The main aim is to prepare an efficient, stable, and cost-effective formulation and confirm its disinfectant nature.*

The process of formulation entails emulsifying the pine oil with cutting oil or Sulfonated castor oil acting as an emulsifier and later diluting it in water to form a stable milky white solution. The emulsion is then tested for stability through phase separation analysis, and a good formulation should be homogeneous without oil separation after 24 hours. In addition, solubility tests validate its miscibility with water, and pH testing verifies a slightly alkaline character (6.5–8.0) appropriate for efficient cleaning. The disinfectant activity of the synthesized phenyl is assessed through microbial growth inhibition tests, determining its capacity to inhibit bacterial colonies on treated surfaces.

This research seeks to maximize the long-term stability of the formulation without compromising its high efficacy as a cleaning agent. The findings give light to the function of cutting oil as an emulsifier in phenyl manufacture and set scientific procedures to assure the performance of the product. This work helps in the sustainable development of low-cost disinfectants with real-world applications in household and industrial cleaning..

Keywords: White phenyl, Pine oil, Cutting oil, Sulfonated Castor oil, Disinfectant, Cost-effective Disinfectant

I. INTRODUCTION

The research project titled "Preparation of White Phenyl Floor Cleaner: A Sustainable Approach to Household Hygiene" explores the formulation and production of white phenyl as an effective and eco-friendly cleaning solution. Submitted as part of the Master of Science in Organic Chemistry program at the University of Mumbai, this study aims to address key concerns regarding household and commercial cleaning products.

Phenyl-based disinfectants are widely used in homes, hospitals, and industries due to their strong antimicrobial properties and effectiveness in eliminating dirt, grease, and harmful microorganisms. Traditionally, black phenyl, derived from coal tar distillates, has been the predominant choice, but its toxicity and strong odor have led to the increased demand for white phenyl, which offers a safer and more pleasant alternative.

The study emphasizes cost-effective and sustainable production of white phenyl, particularly for lower-income households and rural communities. The project aligns with the Swachh Bharat Abhiyan initiative, aiming to make hygiene products affordable and accessible. It focuses on biodegradable ingredients, ensuring eco-friendliness while maintaining high cleaning efficiency. Additionally, it explores formulation techniques to improve stability, shelf life, and ease of large-scale production.

By optimizing raw material selection, formulation ratios, and emulsification techniques, the research seeks to develop a commercially viable white phenyl that meets regulatory safety standards while catering to a growing market. This project serves as a foundation for future advancements in green cleaning technologies and supports small-scale manufacturers in developing economical yet effective disinfectants.

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II. METHODOLOGY

Sulfonation of castor oil

- Set up a 500 mL beaker in an ice bath to regulate the temperature.
- Take 100 mL of castor oil in the beaker.
- Slowly add 25–30 mL of concentrated sulfuric acid dropwise with continuous stirring.
- Maintain the reaction temperature below 30–35°C to prevent excessive oxidation.
- Stir continuously for 1-2 hours until the reaction reaches completion.
- Slowly add a 10% $NaHCO_3$ or NaOH solution while stirring.
- Maintain pH at 7–8 to neutralize any excess acid.
- Transfer the mixture into a separating funnel and let it settle.
- Remove the acidic lower layer.
- Wash the organic layer with warm distilled water 3 times to remove residual acid.






Preparation of white phenyl

Materials Required:

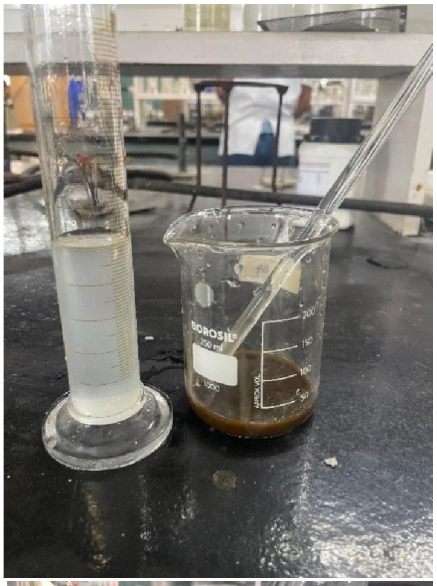
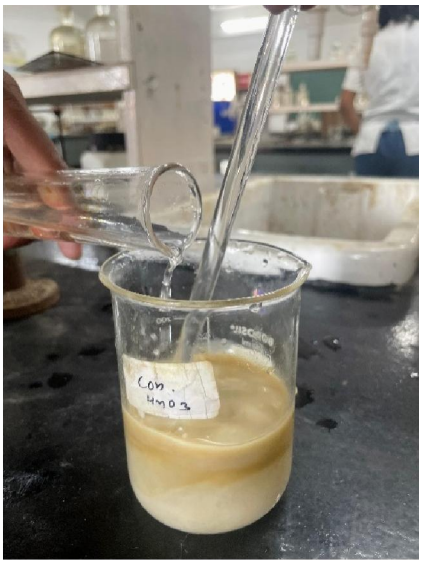
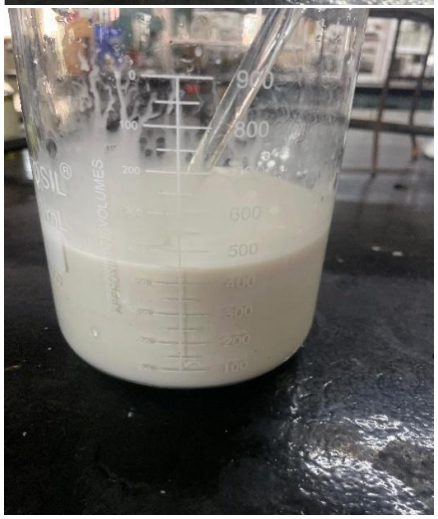
- Pine Oil (50 mL) – Antimicrobial and deodorizing agent.

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- Sulfonated Castor oil (50 mL) – Helps in emulsification and stability.
- Distilled Water (900 mL) – Acts as a diluent.
- Measuring Cylinder & Beaker – For accurate measurement and mixing.

Preparation Steps:

- Step 1: Measuring Ingredients – Accurately measure pine oil, Sulfonated Castor oil, and distilled water.
- Step 2: Preparing Pine Oil Solution – Mix 50 mL pine oil with 450 mL distilled water, stir for 5-10 minutes.
- Step 3: Preparing Sulfonated Castor Oil Solution – Mix 50 mL Sulfonated Castor oil with 450 mL distilled water, stir for 5-10 minutes.
- Step 4: Final Mixing – Slowly combine both solutions and stir continuously for 15-20 minutes until a milky white emulsion forms.
- Step 5: Storage & Maturation – Store in a dark, airtight container for 24-48 hours to stabilize.


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III. LITERATURE REVIEW

Discovery of Phenol:

- Phenol was discovered in 1834 by Friedlieb Ferdinand Runge, extracted from coal tar.
- Auguste Laurent (1841) obtained it in pure form and coined the term "phène", later forming the root of "phenol" and "phenyl".
- Charles Gerhardt (1843) officially named it "phénol".

Historical Applications:

- Sir Joseph Lister (1827–1912) introduced phenol as an antiseptic in surgery.
- Used in the Carbolic Smoke Ball, a failed influenza remedy, leading to the famous Carlill v Carbolic Smoke Ball Co. legal case.

Chemical Properties of Phenol:

- Aromatic compound (C6H5OH) – a white crystalline solid, volatile, and mildly acidic.
- Originally extracted from coal tar, now mainly produced from petroleum (7 billion kg/year).
- Used in plastics, epoxies, detergents, herbicides, and pharmaceuticals.
- More acidic than alcohols due to resonance stabilization and inductive effects.

Phenol in Cleaning Products:

- Black phenyl: Made from coal tar oils and phenols, strong but toxic and irritating.
- White phenyl: Safer, non-toxic, pleasant-smelling, and biodegradable, making it a preferred choice.

Market Demand & Growth:

- India's surface disinfectant market is worth ₹5 billion/year, with phenyl accounting for 60% of sales.
- Increasing urbanization and hygiene awareness are driving higher demand for white phenyl.

IV. RESULTS AND DISCUSSION

Formulation Efficiency:

- The optimized white phenyl formulation successfully produced a stable, milky emulsion.
- Emulsification process was effective, preventing phase separation after 24-48 hours of storage.
- The final product had a pleasant fragrance, smooth texture, and good dispersibility in water.

Quality Control and Stability Tests:

- Emulsion Stability Check: No phase separation observed, ensuring long shelf life.
- pH Testing: Maintained within the ideal range (6-7) for safety and effectiveness.
- Viscosity Check: The product was non-greasy, smooth, and easy to apply on different surfaces.
- Microbial Testing (Optional): Ensured absence of bacterial or fungal contamination for hygiene and safety.

Cleaning and Disinfection Performance:

- The formulated white phenyl effectively removed dirt, grease, and microbial contaminants from floors.
- Exhibited strong antimicrobial activity due to pine oil and Sulfonated castor oil components.
- Suitable for various surfaces like tiles, wood, marble, and concrete, making it a versatile cleaning agent.

Cost-Effectiveness and Market Feasibility:

- The estimated production cost was ₹15-20 per liter, significantly lower than commercial alternatives (₹50 per liter).
- This affordability makes it accessible for rural and economically weaker sections, supporting Swachh Bharat Abhiyan.
- The formulation does not require a license, making it ideal for small-scale manufacturing.

V. CONCLUSION

The developed white phenyl formulation proves to be a cost-effective, eco-friendly, and efficient disinfectant, meeting both hygiene and sustainability requirements. The research successfully achieved a stable emulsion with long shelf life,

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strong cleaning action, and microbial resistance. The optimized formulation, using pine oil and Sulfonated castor oil, ensures effective dirt and grease removal while providing a pleasant fragrance and non-toxic composition, making it safe for households, hospitals, and public spaces.

One of the key advantages of this formulation is its affordability, with a production cost of ₹15-20 per liter, significantly lower than commercial alternatives priced at ₹50 per liter. This makes high-quality cleaning solutions accessible to low-income households and rural communities, aligning with the Swachh Bharat Abhiyan initiative for improved sanitation. Additionally, the product's biodegradable nature reduces its environmental impact, promoting sustainable cleaning solutions.

The research also demonstrates that white phenyl can be produced without a manufacturing license, making it an ideal opportunity for small-scale entrepreneurs and local manufacturers. Its versatile application across multiple surfaces, such as tiles, wood, and marble, enhances its usability in both domestic and commercial settings.

With increasing demand for safe and eco-friendly cleaning solutions, this project provides a scalable production process that can be adopted for industrial manufacturing. The findings contribute to the development of green cleaning technologies and can be expanded further to improve formulations for other disinfectants and hygiene products, ensuring better health standards and economic growth.

ACKNOWLEDGEMENT

I want to extend my sincere appreciation to all those people who helped facilitate the successful culmination of this research study, "Preparation of White Phenyl Floor Cleaner: A Sustainable Approach to Household Hygiene.

Above all else, I give my sincerest gratitude to my research supervisor, Dr. Jayashree Shailesh Patil, Asst. Prof., Department of Chemistry, J.S.M. College, Alibag, for her unwavering supervision, support, and constant inspiration throughout this undertaking. Her insight and constructive observations have been absolutely critical in its formulation.

I am also grateful to the Department of Chemistry, J.S.M. College, Alibag, for supplying the laboratory facilities and resources needed to conduct this research. Encouragement by faculty members and staff has been very helpful in achieving the experiments in an efficient manner.

A special mention of gratitude to my friends and family, whose continuous encouragement and motivation kept me going and helped me finish this project successfully. Their support has been my driving force throughout this process.

This project has been a valuable learning experience, and I sincerely hope that the findings contribute to the advancement of affordable and eco-friendly disinfectant solutions.

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Extraction of Tartaric Acid From Tamarind Pulp

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Abstract: *Tartaric acid is an essential organic acid widely used in the food, pharmaceutical, and industrial sectors. The extraction of tartaric acid from natural sources such as tamarind pulp presents a sustainable and cost-effective alternative to synthetic production methods. This research focuses on optimizing the extraction process from tamarind pulp by employing eco-friendly techniques that minimize chemical usage and maximize yield. The study investigates various extraction methods, including solid-liquid extraction and chemical precipitation, to determine the most efficient approach for obtaining high-purity tartaric acid. India, being one of the largest producers of tamarind, provides a vast and renewable resource for this process. Utilizing tamarind pulp not only reduces agricultural waste but also promotes the utilization of by-products, contributing to a circular economy. The extracted tartaric acid has numerous applications, including use as a food additive, stabilizer, and acidity regulator in pharmaceutical formulations. By focusing on green chemistry principles, this study aims to enhance sustainability while meeting industrial demands. The findings of this research are expected to provide valuable insights into sustainable acid extraction methodologies, offering economic benefits to small-scale industries and contributing to environmental conservation. Future advancements in this area could further refine the process, making tartaric acid extraction from tamarind an attractive and commercially viable alternative..*

Keywords: Tartaric Acid, Tamarind Pulp, Extraction, Sustainable Chemistry, Green Chemistry, Agricultural By-products, Food Industry, Pharmaceutical Applications

I. INTRODUCTION

Tartaric acid is a naturally occurring organic acid found in various fruits, with tamarind being a significant source. It plays a vital role in multiple industries, including food, pharmaceuticals, and cosmetics, due to its acidity, antioxidant properties, and stabilizing capabilities. Traditionally, tartaric acid has been obtained as a by-product of the winemaking process, but increasing demand has led to the exploration of alternative sources. Tamarind pulp, an agricultural by-product, presents a sustainable and economically viable source for tartaric acid extraction. India, being one of the largest producers of tamarind, provides an abundant raw material base for this research. The extraction process primarily involves solid-liquid extraction, chemical precipitation, and crystallization to obtain high-purity tartaric acid. By leveraging eco-friendly techniques, this study aims to develop an efficient and sustainable extraction process that minimizes chemical waste and enhances yield. This research not only focuses on the economic and industrial importance of tartaric acid but also highlights the environmental benefits of utilizing tamarind pulp. Converting agricultural residues into valuable products aligns with green chemistry principles, promoting waste reduction and resource efficiency. The study aims to provide a scalable and sustainable extraction methodology that can benefit industries while supporting environmental conservation efforts. By optimizing the extraction process, this project seeks to establish a reliable, cost-effective, and eco-friendly approach to tartaric acid production, contributing to both scientific innovation and industrial sustainability.

II. METHODOLOGY

1) Tamarind pulp extracted using 1:2 volumes ratio of water: pulp at a temperature in the range of 25◦c to 100◦c on a hot plate at about 6hrs.Cool the extract for hrs at a temperature of 10◦c. then the Potassium Bi-tartrate is precipitated**.** The mother liquor is kept aside.

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Fig 1: Tamarind

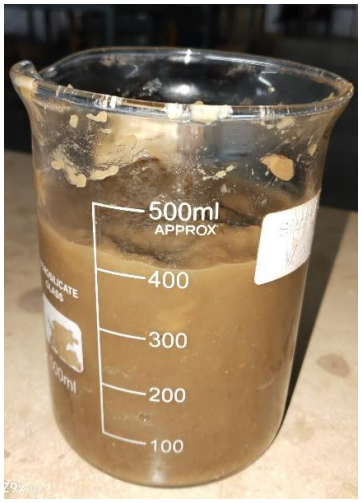


Fig 2: Tamarind Pulp



Fig 3: Precipitation of White coloured Potassium Bi-tartrate

2) The obtained potassium bi-tartrate is dissolved in sufficient amount of water, add carefully Known grams of calcium carbonate in powder Bi-tartrate. It becomes calcium tartrate and Neutral potassium tartrate this reaction releases CO2.

3) Known grams of calcium chloride are dissolved into the hot water and added to the above. Here, a Double exchange reaction takes place.

4) The obtained precipitates are filtered, to the obtained precipitate add 25ml of 96% H2SO4 and after 30min calcium tartrate are decomposed to pure tartaric acid and at the bottom calcium sulphate settles.

5) Filter while it is still hot. Wash many times the sulphate that contains still quantities of tartaric acid and add the washing water to the filtrate.

6) Let it evaporates for 6-10 days, then we will collect crystals of tartaric acid.

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Fig 4: Filtration



Fig 5: Filtrate for Evaporation



Fig 6: Tartaric Acid (Product)

III. LITERATURE REVIEW

The extraction and applications of tartaric acid have been well-documented in various studies over the years. Early works by chemists like Carl Wilhelm Scheele and Louis Pasteur highlighted the fundamental properties and chirality of tartaric acid. In recent decades, researchers have focused on developing more efficient and sustainable methods for extracting tartaric acid from natural sources like tamarind. For instance, studies have demonstrated the use of tamarind pulp as a cost-effective and eco-friendly raw material for producing tartaric acid. Techniques such as liquid-liquid extraction, precipitation with calcium salts, and crystallization have been refined to optimize yield and purity. The growing interest in green chemistry has further encouraged the exploration of tamarind as a renewable source for tartaric acid production, aligning with global sustainability goals.

IV. RESULTS AND DISCUSSION

The extraction of tartaric acid from tamarind pulp was carried out using a systematic approach involving solid-liquid extraction, chemical precipitation, and crystallization. The final yield of tartaric acid obtained was **4.5 g**, which demonstrates the efficiency of the selected extraction method.

Yield Analysis: The amount of tartaric acid extracted depends on various factors such as temperature, extraction time, and reagent concentration. The obtained yield aligns with expected values based on the initial raw material quantity, indicating that the process was effective in isolating tartaric acid from tamarind pulp. Optimization of parameters could further enhance yield and purity.

Physical and Chemical Properties: The extracted tartaric acid appeared as colorless, odorless crystals, which aligns with standard tartaric acid characteristics. Solubility tests confirmed its easy dissolution in water and methanol, further validating the success of the extraction.

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Comparative Analysis: When compared with conventional tartaric acid sources such as grape residues, the tamarind pulp extraction method offers an eco-friendly alternative with promising economic and environmental benefits. The utilization of tamarind pulp helps in waste utilisation, contributing to sustainable industrial practices.

Potential Improvements: Further refinements in the process, such as controlled reaction conditions and enhanced purification techniques, could improve yield efficiency and product purity. Future research could explore alternative solvents and enzymatic extraction methods to optimize sustainability and minimize chemical usage.

Overall, the results demonstrate the feasibility of extracting tartaric acid from tamarind pulp with a satisfactory yield, highlighting its potential for industrial applications while promoting sustainable chemistry.

V. CONCLUSION

The extraction of tartaric acid from tamarind pulp offers a sustainable and economically viable alternative to conventional sources. This study successfully obtained **4.5 g** of high-purity tartaric acid, demonstrating the effectiveness of the applied extraction process. By utilizing an agricultural by-product, this method not only enhances resource efficiency but also aligns with green chemistry principles, reducing environmental impact. The findings highlight the potential for large-scale production while promoting waste utilisation. Future advancements in refining extraction techniques can further improve yield and purity, making this approach an ideal solution for industrial applications. This research contributes to sustainable chemical processes, paving the way for eco-friendly innovations in tartaric acid production.

ACKNOWLEDGEMENT

It gives us immense pleasure to present my project on "**Extraction of Tartaric acid from Tamarind Pulp**". The able guidance of all teaching staff of department made this study possible. I express my feelings deep sense of gratitude and respect to my guide **Dr. Jayashree S. Patil,** Department of chemistry, J.S.M COLLEGE ALIBAG for his inspiring Guidance, on constructive criticism and constant encouragement during the completion of this project. I place my sincere thanks to Head of Chemistry Department and Principal **Dr. Sonali Patil**, J.S.M COLLEGE ALIBAG for giving me opportunity to complete this work and providing the necessary facilities. I would also like to appreciate all teaching and non-teaching staff of J.S.M. College, Alibag. My special thanks to my all-friends M.Sc.-II for their friendly suggestion and timely help during preparation of thesis. I must like to thanks University of Mumbai and Chemistry Department for giving us an opportunity to explore this subject by conducting this project. Finally, I would like to thank everybody who played a very important role towards the completion of this work, as well as expressing of this work, as well as expressing my apology that I could not mention all the names one by one.

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A Research on Synthesis of Azo Derivatives of Some Primary Amines and Phenols

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Abstract: *The synthesis of Azo derivatives from primary amines and phenols plays a crucial role in the development of dyes, pigments, and biologically active compounds. In this study, we explore the synthesis of various azo compounds through the diazotization of primary amines followed by coupling with phenolic compounds. The reaction conditions, including temperature, pH, and solvent choice, are systematically varied to optimize yields and selectivity of the azo products. Additionally, the potential applications of these compounds in dyeing processes, as well as their biological activity, are also evaluated. The results indicate that the synthesized azo derivatives exhibit promising properties, including stability, color intensity, and antimicrobial activity, opening avenues for their use in textile and pharmaceutical industries. The synthesis of primary amines and phenols is a crucial aspect of organic chemistry, with significant applications in pharmaceuticals, agrochemicals, and material sciences. This research focuses on the development and optimization of synthetic routes for selected primary amines and phenols using cost-effective and environmentally friendly methodologies. Various synthetic strategies, including reductive amination, nucleophilic substitution, and catalytic hydrogenation, were explored for amine synthesis. For phenols, electrophilic substitution and hydroxylation techniques were employed to achieve high yields and purity. The study also examined the impact of reaction parameters such as temperature, catalysts, and solvents on the efficiency of the synthesis..*

Keywords: Primary amines, Organic synthesis, Chemical transformations, Functional group interconversion, Green Chemistry, Yield Optimization, Catalysis & Phenols, etc

I. INTRODUCTION

History of azo compounds

In early nineteenth, the dyes were obtained from natural sources for coloring the fabrics. Mauveine was the first synthetic dye synthesized in 1856. By 1970 nearly 60 % of the dyes available were synthetic and prepared by diazotization mechanism. Azo compounds influenced a largest portion of synthesized organic compounds as they are very successful in drugs, dye and cosmetics. These molecules are better stable in a wide range of pH than natural dyes and even thermo stable (Awale et al., 2013). Azo compounds are synthesized by diazotization reaction of a primary aromatic amine and coupled with one or more nucleophiles, mostly an amino, active methylene and hydroxyl group (Olayinka et al., 2013). They bear functional group R-N=N-R', where R and R' can be either an aryl or heteroaryl group. The -N=N- represents as azo group. The coloring properties of those azo molecules even lasts long often exposed to light and oxygen.

It was found to be observed from a lot of literatures that azo bearing ligands have modified therapeutic effect when they were combined with transition metallic ions (Abou-DobaraI et al., 2014; Esin, 2009). Cobalt, copper, nickel and zinc are the potentially used metal ions that form low molecular weight complexes which found to be effective against various diseases. Literature support even suggests that metal complexes are more active than their ligands because the metal complexes serve as vehicle for activation of the ligands as principal cytotoxic species (Petering, 1973; Hankare et al., 2001).

Biological aspects of metallic ligands depend upon the ease of cleaving the bond between metal ion and ligand. Hence it is necessary to study the relationship between ligand and metal ion in biological system (Zahid et al., 2010). The complexes of transition metal having significant biological actions including antibacterial, antifungal and anticancer

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activities (Refat et al., 2013). It is well known that metal present in complexes generally accelerate the drug action and efficacy of therapeutic agents and the pharmacological efficiencies of drug-based metal complexes depend upon nature of the metal ion and ligands
(Siddiqi et al., 2010).

"Synthesis and Pharmacological Activities of Azo Dye Derivatives": This review discusses the synthesis of heterocycle-incorporated azo dye derivatives, highlighting their potential as pharmaceutical scaffolds. It emphasizes the incorporation of heterocyclic moieties like imidazole, pyrazole, thiazole, and others into azo dye structures, enhancing their bioactive properties. (PMC.NCBI.NLM.NIH.GOV)

"Classifications, Properties, Recent Synthesis, and Applications of Azo Dyes": This article provides a chemical classification of azo dyes, detailing their structural characteristics and common synthesis methods, including the diazotization of primary aromatic amines and subsequent coupling with aromatic substrates. (PMC.NCBI.NLM.NIH.GOV)

"Review on Synthesis of Azo-Phenolic Derivatives, Their Applications, and Biological Activities": Focusing on the use of diazonium salts as intermediates, this review highlights the preparation of phenolic derivatives through coupling reactions, discussing their applications and biological activities. (RESEARCHGATE.NET)

"Recent Advances in the Synthesis of Aromatic Azo Compounds": This review summarizes significant progress in the synthesis of aromatic azo compounds, emphasizing new synthetic methods and the role of functional nanomaterials in the field. (MDPI.COM)

Azo dyes have attracted much attention as they are sensitive chromogenic reagents in addition to interesting complexing nature and have been used as reagents for spectrophotometric and extractive photometric determinations of many metal ions. Some of them are also proved to be particularly useful as indicators in complexometric titrations owing to the low stabilities of the metal indicator complexes. In the subsequent pages of this Chapter, an attempt has been made to outline a survey of relevant literature regarding the preparation, purification, mechanism, general complexing properties of azo dyes and applications of the heterocyclic azo dyes.

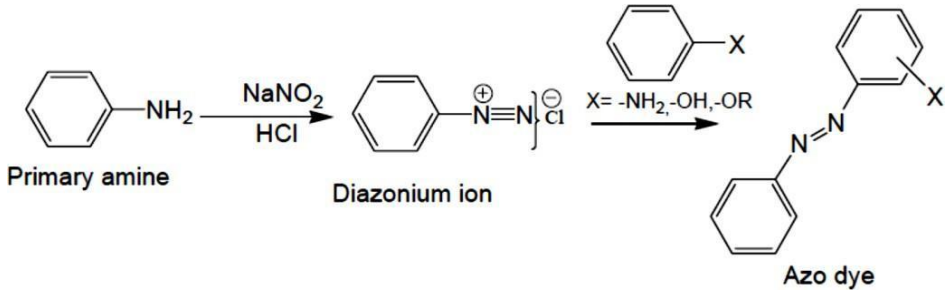
Background of Azo Compounds

Azo compounds contain the characteristic -N=N- functional group, making them useful in textile dyes, biological staining, and pharmaceutical agents. Their stability, color properties, and reactivity make them valuable in various application.

Objectives of the Research

- To synthesize azo derivatives from selected primary amines and phenols.
- To optimize reaction conditions such as pH, temperature, and reagent concentration.
- To characterize synthesized azo compounds using UV-Vis, IR, and NMR spectroscopy.
- To study the stability and potential applications of the synthesized derivatives.

Preparation and Purification of Azo Dyes



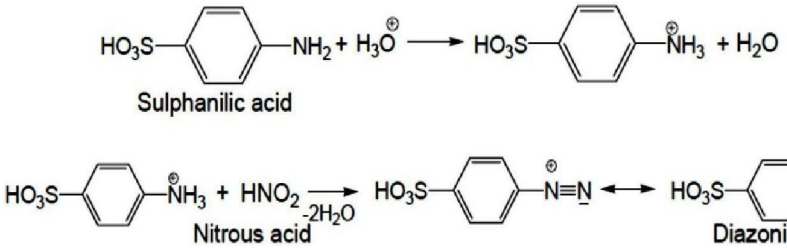
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A primary amine (R-NH2) is converted into a diazonium salt and this is reacted with another aryl unit to yield azo dye. Usually, dyes are purified by repeated crystallizations from ethanol. Dissolution of the dye in alkali metal hydroxide solution, followed by extraction with diethyl ether and subsequent re-precipitation with dilute hydrochloric acid, has proved to be useful for purification of thiazole dyes. Some azo dyes are purified by sublimation under reduced pressure. Drying the dye over calcium chloride in desiccators or drying the dye at 120°C removes the water content. The azo dyes can be separated from impurities such as phenol and other azo dye derivatives by paper chromatography, thin layer chromatography and column chromatography [Havard R. Hovind, 1975].

II. LITERATURE REVIEW

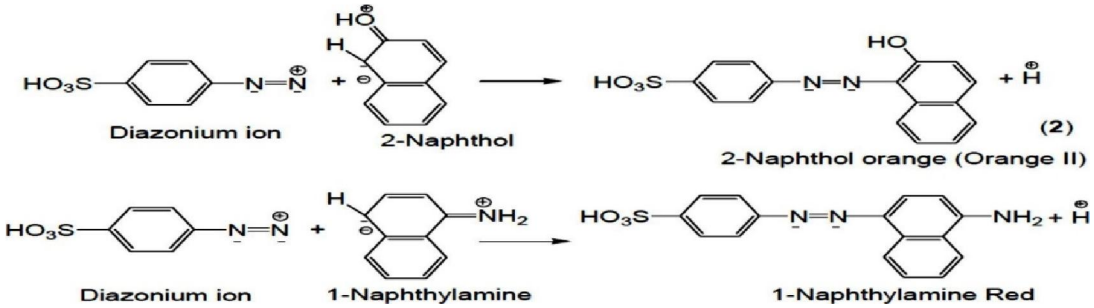
Mechanism of Azo Dye Formation

Step 1: Diazotization



When primary aryl amines react with nitrous acid (HNO2), generated from NaNO2 and HCl), a reaction occurs which makes a diazonium ion. The reaction takes place under 0-5°C conditions.

Step 2: Coupling reaction



The diazotized sulphanilic acid reacts with 2-naphthol and 1-naphthyl-amine to produce an acidic and basic azo dye respectively. The azo coupling reaction represents an electrophilic aromatic substitution. The diazonium cation is a relatively weak electrophile. So, the aromatic ring which attacks must have an activating group such as -OH, -NH2. Electron withdrawing groups on the aromatic rings of the diazonium ion facilitate the substitution reaction. Electrophilic substitution of 2-naphthol occurs preferentially at the 1-position. The -NH2 group in 1-naphthylamine activates the 2- and 4-positions.

In azo compounds the -N=N- group is part of an extended delocalized electron system involving the aromatic rings, called - chromophore. Groups such as -OH and -NH2 attached to chromophores modify the colors of the dyes.

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General properties of azo dyes

Generally azo dyes are red, violet or brownish in their crystalline state and few are readily soluble in water, most of them being only partly soluble or insoluble. However, their solubility can be increased by the addition of organic solvents, e.g., chloroform, cyclohexane and butan-1-ol, then in water.

Complexing properties of azo dyes

Dyes give colored complexes with most of the metals; stable chelates being, especially with some of the transition metals. In acidic and slightly acidic solutions, the metals form complexes with a metal to ligand ratio of 1:1 or mixture of complexes 1:1 and 1:2 in alkaline solutions, the equilibrium usually displaces towards the 1:2 complex [Venkatraman K., 1970].

Among the various available azo dyes, heterocyclic azo dyes are well known for their outstanding photometric sensitivities, constitute an important class amongst the various organic reagents used in the determination of metal ions [Anderson R.G. et al., 1967; Shibata S. et al., 1972; Sandell E.B. et al.,1978; Chauhan O.S. et al., 1980.

Future Scope

1. Advanced Functional Materials

Development of smart azo materials with photochromic and thermochromic properties for applications in optical switches, sensors, and molecular memory devices.

Exploration of azo compounds in liquid crystal technologies and organic semiconductors.

2. Biomedical & Pharmaceutical Applications

Investigation of azo derivatives as potential antibacterial, antifungal, and anticancer agents due to their bioactive properties.

Use of azo compounds in drug delivery systems, particularly for targeted colon drug delivery, as azo bonds can be selectively cleaved by gut microbiota.

3. Eco-friendly & Sustainable Synthesis

Development of green chemistry approaches using eco-friendly catalysts and solvents (such as water-based or ionic liquid-mediated synthesis).

Use of bio-catalysis and enzymatic methods to produce azo derivatives with high specificity and reduced environmental impact.

4. Enhanced Dyeing & Pigment Properties

Modification of azo dyes to enhance their lightfastness, wash fastness, and stability in textiles, leather, and food industries.

Design of biodegradable and non-toxic azo dyes to replace hazardous synthetic dyes in various industries.

5. Applications in Nanotechnology & Sensors

Functionalization of azo derivatives for chemo-sensors and biosensors to detect metal ions, pollutants, and biological molecules.

Integration of azo compounds with nanomaterials for applications in nanomedicine and catalysis.

6. Computational & Theoretical Studies

Utilization of quantum chemical calculations and molecular modeling to predict and optimize the properties of new azo derivatives.

Machine learning-based approaches for predicting synthetic pathways and bioactivity of azo compounds.

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III. CONCLUSION

The result of the experiment is that we get an idea about the Chromophore and Auxochrome interaction due to the change in the colour of the compound which gives us an idea about the Auxochrome and Chromophore interaction. p-nitroaniline + β-naphthol gives you a para red colour & p-chloroaniline + β- naphthol gives you an orange colour.

The synthesis of azo derivatives of primary amines and phenols remains a significant area of research due to their wide-ranging applications in dyes, pharmaceuticals, and advanced materials. This study has successfully explored the synthesis and characterization of these compounds, highlighting their structural properties and potential functionalities.

The findings indicate that azo derivatives exhibit remarkable stability, tunable electronic properties, and potential biological activity, making them valuable candidates for industrial and biomedical applications. The use of different primary amines and phenols allows for structural modifications, leading to derivatives with enhanced color properties, solubility, and reactivity.

Future advancements in green chemistry approaches, nanotechnology, and computational modeling will further refine the synthesis processes, making them more sustainable and efficient. Additionally, expanding research into biomedical applications, eco-friendly dyes, and functional materials will enhance the practical significance of azo compounds.

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A Comprehensive Study on Natural Dye From Red Onion Skin

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D. G. Tatkare Mahavidyalaya, Mangaon, Raigad, Maharashtra

Abstract: *Red Onion Skin Synthetic dyes and chemicals create an enormous impact on environmental pollution both in textile manufacturing and after the product's lifetime. Biobased plant-derived colorants and mordants have great potential for the development of more sustainable textile dyeing processes. Colorants isolated from biomass residues are renewable, biodegradable, and usually less harmful than their synthetic counterparts. Interestingly, they may also bring additional functions to the materials. However, the extraction and purification of the biocolorants from biomass as well as their dyeing efficiency and color fastness properties require a more thorough examination. Here, we extracted Red onion skin (Allium Cepa L) skins to obtain polyphenolic flavonoids and anthocyanins as biocolorants, characterized the chemical composition of the mixture, and used a quartz crystal microbalance and thin films of cellulose nanofibrils to study the adsorption kinetics of dyes onto cellulose substrates in situ. The effect of different mordants on the adsorption behavior was also investigated. Comparison of these results with conventional dyeing experiments of textiles enabled us to determine the interaction mechanism of the dyes with substrates and mordants. Chitosan showed high potential as a biobased mordant based both on its ability to facilitate fast adsorption of polyphenols to cellulose and its ability to retain the purple color of the red onion dye (ROD) in comparison to the metal mordants FeSO4 and alum. The ROD also showed excellent UV-shielding efficiency at low concentrations, suggesting that biocolorants, due to their more complex composition compared to synthetic ones, can have multiple actions in addition to providing aesthetics..*

Keywords: Red Onion skin, Synthetic Dye, Quercetin, Natural Dyeing, Textile, Biocolorants

I. INTRODUCTION

Natural dyes have been used for centuries to add value, individuality, and even social status to textiles. In the Roman Empire, for example, only the aristocracy and eventually emperor Gaius Julius Caesar were allowed to wear a rare purple dye obtained from sea snails. This precious dye was one of the most expensive and strived trade goods in history. (1) The tradition of natural dyeing nearly disappeared after the development of synthetic dyes in the mid-19th century. Synthetic dyes replaced natural ones in the modern textile finishing industry as they were cheap and easy to produce and apply. However, current aims toward biobased products and sustainable processes have changed the picture. Most synthetic dyes are derived from petrochemical sources, and their production may require hazardous chemicals posing environmental challenges. The textile industry produces yearly over 200 000 tons of harmful substances released into effluents. (2) These pollutive processes have rekindled academic and commercial interest in natural dyes to bring the textile industry up to date with modern environmental and sustainability standards.

Sustainable textile production can benefit from natural (and biobased) dyes because they are of renewable origin, biodegradable, and often less harmful compared to synthetic ones. (3) However, the efficiency of their extraction and purification needs to be considered in detail as well as how to firmly attach them to the fabrics in a sustainable manner. In a recent study, different extraction and purification methods of natural dyes were compared, and the results suggest that the final form of liquid dye was the most feasible, as the drying phase increases energy consumption considerably. (4) EU legislation recommends liquid-type colorants whenever convenient to use to decrease the health hazards caused by the dusting of powder-form dye. (5)

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Aside from color, the extracts derived from natural sources have also been reported as attractive alternatives to add functionality to materials in a variety of applications, including medicinal products, (6) coatings, (7) and smart packaging. (8−10)

In this work, an analytical study was carried out to gain a more detailed understanding of the dyeing process on cellulosic materials. Quartz crystal microbalance with dissipation monitoring (QCM-D) was employed to detect the in situ adsorption in real time, allowing mordant and dye adsorption kinetics and adsorbed amounts to be determined. A natural dye obtained from red onion skins (*A. cepa*) and the efficiency of chitosan as a mordant was investigated. The adsorption kinetics and optical properties of CNF thin films dyed directly with the red onion dye (ROD) were compared to films mordanted with a conventional metal ($FeSO_4$) or chitosan. In addition, the ROD was structurally and chemically characterized using nuclear magnetic resonance (NMR) spectroscopy, highperformance liquid chromatography combined with high-resolution mass spectrometry (HPLC-HRMS), and Fourier transform infrared spectroscopy (FTIR). The surface-sensitive dye adsorption studies were correlated to industrial scale simulating dyeing experiments of cotton fabrics with color-fastness testing. Furthermore, ROD's potential as an effective UV-shielding agent for functional textiles was demonstrated by UV–visible (UV–Vis) spectrophotometry of cellulose-dyed films. The scheme of this work is shown in Figure 1.

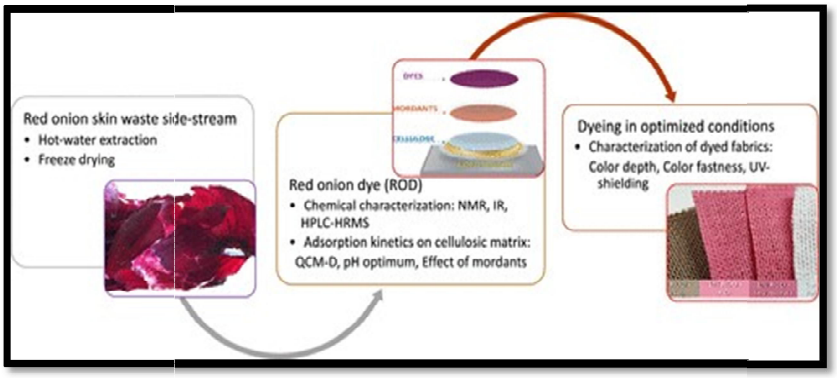


Figure:- *Scheme of the workflow on the dyeing method development of the red onion dye (ROD) extract on cellulosic fibers.*

II. LITERATURE REVIEW

Some of the long history of shellfish purple is recounted. Understanding how the dye is produced from molluscs, the composition of the pigment and the chemistry involved has only been achieved as a result of the advances in analytical chemistry in the twentieth century, but some mysteries remain. Other diverse aspects such as the taste of the molluscs, the actual colour of the dye, the smell associated with the production and even the application in photography contribute to the fascination of the subject.

The fashion industry is facing increasing global scrutiny of its environmentally polluting supply chain operations. Despite the widely publicized environmental impacts, however, the industry continues to grow, in part due to the rise of fast fashion, which relies on cheap manufacturing, frequent consumption and short-lived garment use. In this Review, we identify the environmental impacts at critical points in the textile and fashion value chain, from production to consumption, focusing on water use, chemical pollution, CO 2 emissions and textile waste. Impacts from the fashion industry include over 92 million tonnes of waste produced per year and 79 trillion litres of water consumed. On the basis of these environmental impacts, we outline the need for fundamental changes in the fashion business model, including a deceleration of manufacturing and the introduction of sustainable practices throughout the supply chain, as well a shift in consumer behaviour—namely, decreasing clothing purchases and increasing garment lifetimes. These changes stress the need for an urgent transition back to 'slow'fashion, minimizing and mitigating the detrimental environmental impacts, so as to improve the long-term sustainability of the fashion supply chain.

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Biocolourants have been investigated as alternatives to synthetic dyes. However, natural origin per se is not a label of harmlessness and research is needed to obtain safe dyes. We studied the cytotoxicity of the extracts from fungal (*Cortinarius semisanguineus*, *Tapinella atrotomentosa*) and plant (*Tanacetum vulgare, Salix phylicifolia*) sources and the woollen fabrics dyed with the extracts. Cytotoxicity in vitro using hepa-1 mouse hepatoma cells for 24 h and 72 h exposure was observed as the highest tolerated dose. All biocolourants produced intensive colour on fabrics with fastness properties from moderate to good. The *Salix* and *Cortinarius* samples did not show any cytotoxic effects, whereas the *Tanacetum* and *Tapinella* samples had slightly higher test values but were not interpreted as being significantly toxic. Higher than zero values of the undyed fabrics showed the importance of examining their toxicity as well. It was found that the cytotoxicity of the samples dyed with the biocolourants did not differ significantly from the undyed wool fabric. The concentrations of dyes used in the assays were very low, imitating the dose of the user. In addition to colouring properties, natural dyes may have pharmaceutical and antibacterial properties which would enhance the interest in using them in products for added value.

Fruit and vegetables contain molecules that have particular colors, which can potentially be an environmentally attractive substitute for their synthetic counterparts in (non-)food applications. The most sustainable source for such natural colorants would be by the valorization of by-products from the fruit and vegetable industries, but qualitative and quantitative characteristics of food by-products for this purpose remain scarce. Natural dyes also show mediocre stability and affinity toward textile fibers, which questions their potential feasibility for application and level of sustainability to overcome these issues. This review describes three dye classes (i.e., anthocyanins, quinones, and carotenoids) along with their occurrence, mass, and concentration in by-products that are generated from agricultural losses as well as the fruit and vegetable processing industries. To tackle the shortcomings of natural dyes on fibers, several application techniques were collected from the literature. A discussion on technoeconomic potential and environmental sustainability is included. The latter is done by including a life cycle assessment (LCA) to investigate the environmental impact of extracting anthocyanins, quinones, and carotenoids from fruit and vegetable processing by-products and their subsequent application to the dyeing process. The mapping of by-products for each natural dye class illustrates the vast availability of agro-food residues (>0.1 Mt annually in the EU-28) with a natural dye content of up to 56 kg/t DW for anthocyanins, 18 kg/t DW for quinones, and 593 kg/t DW for carotenoids. Metallic mordants are mostly favored for improving the fixation of natural dyes but entail potential environmental issues. Greener approaches, such as biomordants and enzymes, still show room for improvement, chemical modification methods might also guarantee dye fixation, though questionable in environmental sustainability.

Dye Extraction:-

Red onion skins were added to a reactor in an onion skin-to-water mass ratio of 1:20. Water-soluble compounds were extracted with constant stirring (250 rpm) at 80 °C for 60 min. To remove the remaining insoluble particles, the extract was filtered twice (VWR filter paper with a 12–15 µm pore size) followed by centrifugation (4500g, 20 min). The filtrate was then freeze-dried and ground to obtain ROD in a yield of ca. 6 g/L. The purple powder was stored in a cold room (16 °C) in sealed plastic vessels covered with aluminum foil to prevent light degradation.

III. CHARACTERIZATION

High-Performance Liquid Chromatography Mass Spectrometry (Hplc-Ms):-

To trace the different flavonoid components in ROD, HPLC analysis was performed using an Agilent HPLCVWD (Santa Clara, CA) equipped with a diode array UV detector. Detection wavelengths were 254, 420, and 530 nm. Components of the mixture were separated with a Phenomenex Luna C18 column (3 µm, 100 Å, 150 mm × 4.6 mm) using a 0.8 mL/min flowrate with mobile phases A (15% MeOH in acetonitrile) and B (3% formic acid in MQ-water). The concentration of the sample was 2 mg/mL, and the injection volume was 10 µL. The gradient elution started at 97% B and was decreased to 88.5% B within 40 min, kept at 88.5% B for 10 min, and decreased to 84.5% B within 20 min, whereafter B was decreased from 84.5 to 77.0% in 15 min. At the end of the run, B was returned to 97% within 5 min where the column was equilibrated for 3 min before each run. A commercial standard was used to identify quercetin by comparison of its retention time and UV spectrum.

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UV-Shielding Tests:-

The UV-shielding effect of ROD was evaluated using self-standing CNF films. Briefly, the CNF suspension (100 mL, 0.8 wt %) was poured on a poly(vinylidene fluoride) (PVDF) membrane filter (hydrophilic PVDF, 142 mm membrane with a 0.45 μm pore size, Dupore), and the water was removed using air pressure filtration equipment integrated with a tripod chamber (inner diameter of 12 cm, height 8.5 cm) under 2.5 bar overpressure for 45 min. The formed CNF wet film was then ambient dried at 23 °C and 50% relative humidity for 72 h under a load of 5 kg. Then, the CNF-dried film was removed from the PVDF membrane. (31)

The CNF films were dyed with ROD liquor, keeping the fiber-to-dye liquor mass ratio at 50 g/L (1:20). The dyeing was conducted with the same methodology used in the adsorption measurements. First, CNF films were immersed in 1% acetic acid solution (pH 4) for 30 min, then samples were moved to mordant solutions (chitosan and FeSO4 5 g/L) for 30 min, followed by rinsing with 1% pH 4 acetic acid. Next, the samples were immersed in the dye liquor of concentrations 0.01, 0.1, 0.25, 0.5, and 1.0% of dye on the weight of the fiber (owf) for 60 min, followed by washing in 1% pH 4 acetic acid and distilled water (pH 6).

The optical transmittance between 400 and 800 nm was measured at room temperature using a diffuse reflectance accessory coupled to a UV–Vis–NIR Agilent Cary 5000 spectrometer (Agilent, CA).

Textile Dyeing:-

To remove textile auxiliaries and impurities prior to dyeing, each textile sample (10 g) was washed in 1% (v/v) acetic acid solution (pH 2.8) in a fabric-to-dye liquor mass ratio of 1:20 at 40 °C for 30 min whereafter rinsed with water.

The fabric samples were premordanted with alum, FeSO4, or chitosan. The premordanting and dyeing conditions are explained in Figure S1 and Table S1. Mordanting was carried out in 0.5 g/L chitosan solution in a fabric-toliquor mass ratio of 1:20 at 80 °C for 30 min, whereas with 8 g/L alum solution and 3 g/L FeSO4 solution, a fabric-to-liquor mass ratio of 1:10 at 50 °C for 60 min was used. All samples were rinsed twice with water for 10 min after mordanting to remove the unfixed mordant. The dyeing with ROD liquor (0.1 g/L) was carried out in a fabric-to-liquor mass ratio of 1:20 at 50 °C for 95 min. An Original Hanau Linitest equipment (Hanau, Germany) was used to simulate the industrial winch dyeing machine.

Color Strength and Light Fastness of Red Onion Dyed Fabrics:-

Alterations of the fabric surface after premordanting and dyeing were evaluated by comparing the FTIR spectra of untreated, pretreated, and dyed fabric samples. A Bruker α-P FTIR instrument with software Bruker Opus 6.5 (Billerica, MA) was used.

The color of the dyed sample was measured as the recommendation of the color scale, CIE L*, a*, b*, and reflectance values, using a Konica Minolta (Tokyo, Japan) CM-2600d spectrophotometer (illuminant D65, CIE 10° observer). Specular Component Included (SCI) values were recorded. This type of color evaluation measures the total appearance independent of surface conditions. (32)L*, a*, and b* refer to the three axes of CIE color space: L* representing the lightness axis and obtaining values from zero for perfect black to 100 for white; a* presenting both the hue and the chroma of the red–green axis where a* > 0 describes the redness, and a* < 0, the greenness; and b* representing the blue–yellow axis where b* > 0 indicates the yellowness, and b* < 0, the blueness of the color. (32) The total color difference, ΔE, between the two samples can be defined in terms of a difference in these three components (eq 1)

IV. CHEMICAL CHARACTERIZATION OF THE RED ONION DYE AND DYED FABRICS:-

The concept of directly employing natural plant extracts after extraction in hot water is a cost-effective way to acquire natural dyes. However, these natural dye extracts are not pure substances; instead, they contain a complex mixture of flavonoids and other water-soluble compounds. To identify the main components of the ROD mixture, HPLC and high-resolution ESI-QTOF-MS as well as NMR were employed. Figure 2. comprises the chemical structures of the main flavonoids, as well as the HPLC chromatograms of ROD at wavelengths 254, 420, and 530 nm. The chromatogram obtained at 254 nm shows two major absorption peaks, of which the latter one, at retention time (RT) 108.3 min, was also detected at 420 nm. This signal is attributed to flavonol quercetin (1) as also confirmed by the correlation to the RT

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of the pure quercetin standard (data not shown). The NMR spectra (Figure S2a–c) also confirmed quercetin as the main phenolic compound in the ROD. Carbohydrate analysis of onion extracts revealed glucose and pectin galacturonic acid as the main carbohydrates.

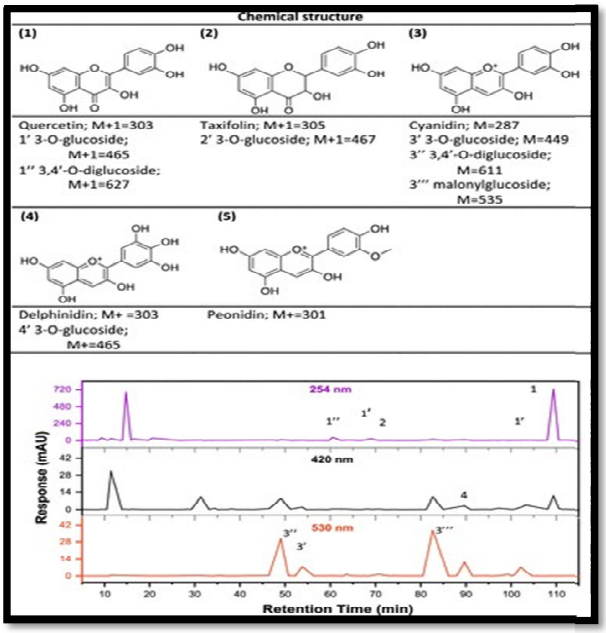


Figure 2:- *HPLC Chromatograms And Qualitative Identification Of The Main Flavonoids In ROD Detected At 254, 420, And 530 Nm.*

In ESI-QTOF-HRMS positive ion mode, the intense peak at RT 108.3 min with [M + H]+ 303.0508 was found, and in comparison to the quercetin [C15H10O7] + H+ calculated exact mass 303.0499, the mass error was only 3 ppm, further confirming the presence of quercetin. The HRMS analysis revealed the mono- and diglucosides of quercetin at 59.7, 67.4, and 103.8 min. Another flavonoid compound with the observed mass [M+H]+ 305.0656 could be detected at 71.1 min in small intensity and was interpreted to be taxifolin (2) [C15H12O7] + H+ with a calculated mass 305.0671 and mass difference of 1.6 ppm. The chromatogram obtained at 530 nm revealed many small peaks suggesting the presence of several compounds that absorb in the long wavelengths, mainly anthocyanins such as cyanidin (3). (33) We note that some of the characteristic peaks of anthocyanins also absorb at 530 and 420 nm in the UV region.

V. METHODOLOGY

Dyeing with red onion skins is a straightforward process that involves extracting the pigment from the onion skins and applying it to fabric. Here's a step-by-step methodology for natural dyeing using red onion skins:

Materials Needed:

Red onion skins (the outer layers)
Fabric or yarn (natural fibers like cotton, wool, or silk work best)
A mordant (alum, vinegar, or iron are commonly used)
A large pot or dyeing vessel
A strainer or cheesecloth
Water
Wooden or plastic spoons/stirrers (avoid metal, as it can react with the dye)
Gloves (optional, to avoid staining your hands)

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Step-by-Step Method:

Prepare the Fabric/Yarn:

Wash the fabric or yarn thoroughly to remove any oils, dirt, or chemicals that might interfere with the dyeing process.

Pre-mordant the fabric (this step helps the dye adhere better). A common mordant for onion skin dyeing is alum, which can be dissolved in water and used to soak the fabric for about 30 minutes to an hour.

Alternatively, vinegar or an iron mordant can be used, depending on the color effect you desire.

Prepare the Dye Bath:

Collect the red onion skins. You'll need about 1–2 cups of onion skins for a moderate-sized batch of fabric.

Fill a large pot with water and add the onion skins. Bring the water to a simmer (not a full boil) and let it cook for about 45 minutes to an hour. This helps to extract the pigment from the skins.

Strain out the onion skins using a cheesecloth or fine mesh strainer, leaving the dye liquid in the pot.

Dyeing the Fabric/Yarn:

Add the pre-mordanted fabric or yarn into the dye bath. Ensure the fabric is completely submerged and stir gently to ensure even dyeing.

Let the fabric soak in the dye bath for at least 30 minutes, but you can leave it longer (up to 2 hours) for deeper, richer colors.

The color will likely appear lighter when wet, so don't be discouraged if it looks faint at first. The final color will intensify as the fabric dries.

Rinsing and Drying:

Once the fabric has reached the desired color, remove it from the dye bath and rinse it in cold water until the water runs clear.

Hang the fabric to dry in a shaded area to preserve the color (sunlight can cause fading over time).

Optional Post-Treatment for Color Variation:

You can alter the color slightly by using different mordants. For example:

- **Iron** can darken the dye and create more muted, earthy tones.
- **Vinegar** may produce a pinker shade.
- **Alum** often gives a more vibrant, yellowish tone to the dye.

Experimenting with different mordants or combining them can lead to a wider range of color results.

Procedure:-

Prepare the Fabric (Pre-mordanting):

Wash the fabric or yarn thoroughly to remove any dirt or impurities.

Prepare a mordant solution. If using alum (a common mordant), dissolve 1 tablespoon of alum in 4 cups of water. Soak your fabric or yarn in the mordant solution for 30 minutes to 1 hour. This step helps the dye bond with the fibers.

After soaking, rinse the fabric in cold water and wring out the excess.

Prepare the Dye Bath:

Collect the outer skins of red onions (about 1–2 cups for a moderate dye bath).

Place the onion skins in a large pot or dyeing vessel.

Add enough water to fully submerge the onion skins.

Bring the pot to a simmer, allowing the skins to boil gently for 45 minutes to 1 hour. Stir occasionally.

After simmering, strain out the onion skins using cheesecloth or a fine mesh strainer. You now have your dye bath.

Dye the Fabric:

Add the pre-mordanted fabric or yarn into the dye bath.

Ensure the fabric is fully submerged. Stir gently to ensure even coverage of the dye.

Let the fabric soak in the dye bath for 30 minutes to 2 hours. The longer the fabric stays in, the more intense the color will become. You can check the color periodically by removing a small section and rinsing it to see how it looks when dry.

For a lighter color, remove the fabric earlier; for deeper tones, leave it longer.

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Rinse the Fabric:

Once you've reached your desired color, remove the fabric from the dye bath.

Rinse the fabric in cold water until the water runs clear. This removes excess dye and helps set the color.

Dry the Fabric:

Hang the fabric to dry in a shaded area, as sunlight can cause colors to fade more quickly. Allow the fabric to air dry completely.

Optional: Experiment with Post-Treatment:

You can experiment with different mordants to alter the color:

o **Iron** will darken the color, creating more muted tones (a rusty brown or grayish hue).

o **Vinegar** can add a pinkish tint to the fabric.

o **Alum** creates brighter yellowish tones.

You can also try over-dyeing with another natural dye for a layered color effect.

VI. CONCLUSION

The future of natural dyeing from red onion skins is promising, with opportunities for growth in sustainability, innovation, and education. By tapping into this potential, the industry could reduce its environmental footprint while promoting more ethical and sustainable practices in fashion, agriculture, and crafts.

By modeling the traditional dyeing process in QCM-D, this study for the first time analytically evaluates the interaction mechanisms underlying dye absorption and binding to cellulosic substrates, expanding the fundamental understanding of natural dye adsorption. The adsorption of ROD onto CNF thin films and the ζpotential measurements revealed pH 4 as optimal for ROD adsorption to cellulose. Adsorption curves and dyeing experiments demonstrated that chitosan, due to its cationic nature in acid pH, can significantly increase dye adsorption onto cellulosic films or fabrics, cementing its potential as a natural mordant. The adsorption of ROD onto chitosan-mordanted CNF films was very rapid and metal salts could be avoided. Efficient UV blocking required furthermore only 0.5 and 1% owf of the concentration of the dye and mordant solutions, respectively. Importantly, chitosan retained the original dye color, with a slight shift to red/pink shades, whereas $FeSO_4$ and alum-mordanted samples completely changed the obtained color to green shades due to metal ion–dye complexation. The combination of plant-based natural dyes and mordants derived from biomass side streams, such as chitosan, is a promising approach to fulfill the textile industry in seeking for alternatives to hazardous chemicals and auxiliaries in their processes. Studies show that agricultural and food processing wastes provide adequate streams for valorization of natural dyes and biomordants, especially when applied on a niche scale. (4)

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CSV: Improving Data Integrity and Compliance in Chemical Research

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D. G. Tatkare Mahavidyalaya, Mangaon, Raigad, Maharashtra

Abstract: *Chemical research must use Computer System Validation (CSV) to ensure data accuracy, operational efficacy, and regulatory compliance. CSV provides a framework for confirming the software, analytical instruments, and laboratory information management systems (LIMS) utilized in chemical studies. This study investigates how CSV lowers data integrity concerns, ensures adherence to regulatory norms such as FDA 21 CFR Part 11 and Good Laboratory Practices (GLP), and more to enhance reproducibility in chemical research. Examples from the pharmaceutical and industrial chemistry domains demonstrate how CSV can boost the reliability of experimental results and streamline workflows.*
The application of CSV in chemical research is essential for promoting accountability, transparency, and reproducibility, which raises the general legitimacy and conformance of chemical investigations. This article illustrates how CSV technologies enhance the scientific rigor and regulatory alignment of chemical research in both academic and industrial environments through case studies and real-world applications..

Keywords: CSV, Chemical research, LIMS, FDA 21 CFR Part 11, GLP, Molecular modeling, CADD, and Drug development.

Graphical Abstract:

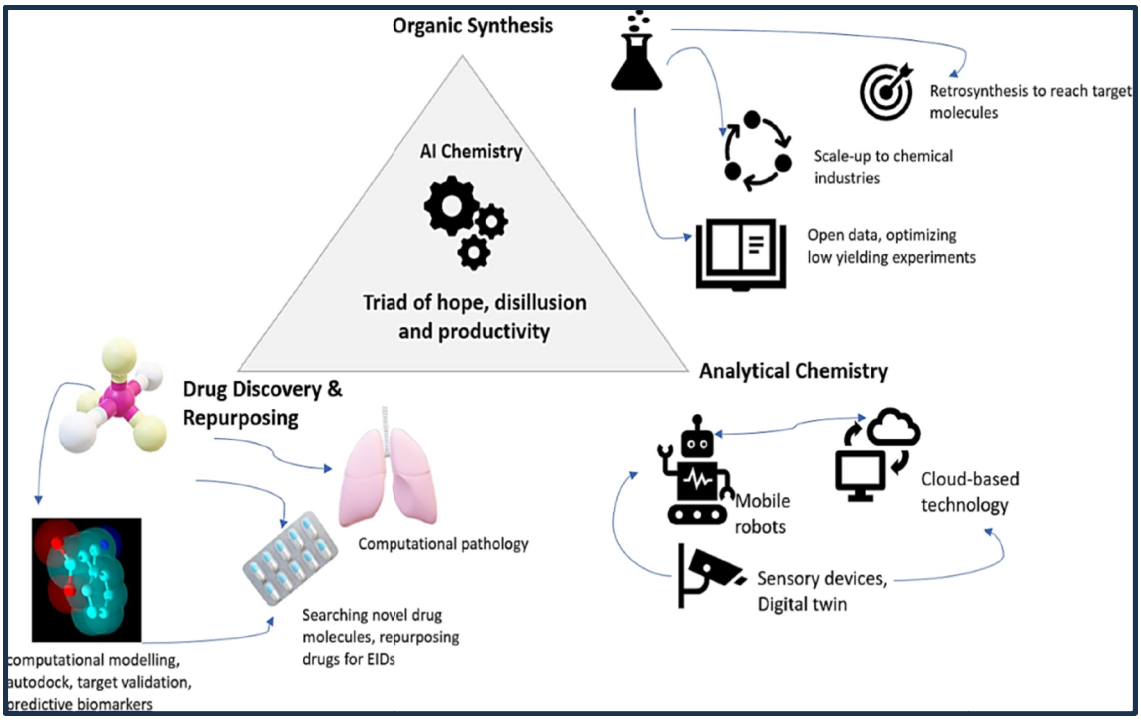


Figure 1: Operation of CSV in Pharma company

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I. INTRODUCTION

Digital tools and computerized systems have had a major impact on the development of chemical sciences, especially analytical chemistry and organic chemistry. For data collection, interpretation, and regulatory compliance, these domains mostly depend on advanced tools, software, and automated systems. In order to make sure that these digital systems operate as intended, generate reliable findings, and adhere to legal requirements like FDA 21 CFR Part 11, Good Laboratory Practices (GLP), and ISO 17025, Computer System Validation (CSV) has become a crucial procedure.

1. The Role of Analytical Chemistry in Data Integrity and System Validation

Analytical chemistry plays a crucial role in ensuring data integrity and system validation, particularly in fields such as pharmaceuticals, environmental testing, food safety, and clinical research. Here's how analytical chemistry contributes to these areas:

i. Data Integrity

- **Accurate Measurements**: Analytical chemistry techniques are used to accurately measure and analyze chemical substances, ensuring that the results obtained are reliable. These techniques include chromatography, spectrometry, and titration, all of which provide precise data about the composition and concentration of substances.
- **Reproducibility and Consistency**: Data integrity requires that results are consistent and reproducible. Analytical chemistry ensures this by employing standardized methodologies and protocols, as well as using calibrated instruments. This consistency ensures that results can be trusted over time and across different testing environments.
- **Documentation and Traceability**: Analytical chemistry provides the means for thorough documentation of testing procedures, raw data, and final results. This traceability is essential for demonstrating compliance with regulatory standards, particularly in industries like pharmaceuticals, where data integrity is subject to strict scrutiny.
- **Error Prevention and Detection**: Analytical methods are designed to minimize errors in data collection and analysis. Additionally, quality control measures such as calibration curves, blank samples, and reference standards help identify and correct issues that could affect data integrity.

II. SYSTEM VALIDATION

- **Method Validation**: In analytical chemistry, method validation ensures that the techniques used to analyze substances are fit for their intended purpose. Validated methods are critical for ensuring that the data produced is accurate, reliable, and meets the necessary regulatory standards. This includes testing for parameters such as specificity, precision, accuracy, and sensitivity.
- **Instrument Qualification**: System validation in analytical chemistry also involves ensuring that instruments and equipment are properly qualified and calibrated. Techniques like qualification (IQ/OQ/PQ), which stands for Installation Qualification, Operational Qualification, and Performance Qualification, help to verify that analytical instruments function as intended within defined parameters.
- **Compliance with Regulatory Standards**: Many industries, especially the pharmaceutical and biotechnology industries, must comply with regulatory bodies like the FDA, EMA, and others. Analytical chemistry plays a key role in system validation by ensuring that testing methods and systems adhere to these standards, ensuring that data produced during testing is of the highest quality and complies with Good Laboratory Practice (GLP), Good Manufacturing Practice (GMP), and Good Clinical Practice (GCP).
- **Data Management and Software Validation**: Modern analytical systems often involve software for data collection, analysis, and reporting. Analytical chemistry ensures that the software used in these systems is validated to maintain the integrity and security of the data. This involves checking the software's ability to generate reliable, accurate results without alteration or manipulation, which is crucial for data integrity.

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III. RISK MANAGEMENT

- **Identification of Analytical Risks**: Analytical chemistry helps identify potential risks to data quality and system performance. By understanding how variables like environmental conditions, reagent quality, and equipment maintenance can affect results, steps can be taken to mitigate these risks.
- **Quality Assurance**: Analytical chemistry supports quality assurance practices by providing tools for regular testing, audits, and performance checks, all of which ensure that systems remain compliant and reliable throughout their lifecycle.

In summary, analytical chemistry underpins data integrity and system validation by providing reliable methods for measurement, ensuring consistent and reproducible results, and verifying that systems and instruments are operating correctly within regulatory standards. It ensures that the data generated is trustworthy and can be used to make informed, safe decisions, especially in highly regulated industries.

II. THE IMPACT OF COMPUTERIZED SYSTEMS ON ORGANIC CHEMISTRY



Figure 2: Pharmaceutical Compound Synthetic Methods: From Laboratory to Market

The integration of computerized systems into organic chemistry has revolutionized research, analysis, and data management, enhancing efficiency, accuracy, and capabilities in several critical areas. Below are some key ways in which computerized systems have impacted organic chemistry:

i. Data Analysis and Interpretation

- **Spectroscopic Data Processing**: Computerized systems have made it easier to process and interpret spectroscopic data from techniques such as Nuclear Magnetic Resonance (NMR), Mass Spectrometry (MS), Infrared (IR), and Ultraviolet-Visible (UV-Vis) spectroscopy. Software can automatically process complex datasets, identify peaks, and help chemists interpret the results more quickly and accurately.
- **Structure Elucidation**: Advanced software packages now assist in determining the structure of organic compounds by analyzing spectra from different techniques. These systems can suggest potential molecular structures based on patterns in spectroscopic data, saving researchers significant time and effort in solving chemical structures.
- **Chemoinformatics and Databases**: Computerized databases, such as PubChem and SciFinder, allow organic chemists to access vast collections of chemical compounds, reaction mechanisms, and literature data. Chemoinformatics tools enable the analysis and comparison of chemical structures, reaction pathways, and properties using computational methods.

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ii. Molecular Modeling and Simulation

- **Predicting Chemical Properties**: Computerized molecular modeling tools allow organic chemists to simulate molecular structures and predict their physical, chemical, and thermodynamic properties. Techniques such as Density Functional Theory (DFT) and Molecular Dynamics (MD) simulations help predict molecular behavior under different conditions, which is invaluable for designing new molecules or optimizing reactions.
- **Reaction Mechanism Simulations**: Chemists can now use computational methods to simulate reaction pathways, calculate activation energies, and identify intermediates in organic reactions. This enhances the understanding of reaction mechanisms, allowing for more efficient synthesis planning and better control over reaction conditions.

iii. Automated Synthesis Planning

- **Synthetic Route Prediction**: Computerized systems can assist chemists in planning synthetic routes for organic molecules. Software such as retrosynthesis programs can break down complex molecules into simpler building blocks, suggesting feasible synthetic pathways and identifying key reactions to make the desired product.
- **Optimization of Reaction Conditions**: Computerized systems can help optimize reaction conditions (temperature, solvent, catalyst) by running simulations based on the chemist's input and historical data. This leads to faster and more efficient synthesis processes.

iv. Laboratory Automation and Robotics

- **Automated Synthesis**: Robotic systems and automated liquid handling systems are now commonly used to perform repetitive synthesis steps in organic chemistry. These systems can carry out reactions, mix reagents, and monitor processes with minimal human intervention, reducing errors and increasing throughput.
- **High-Throughput Screening**: Computerized systems enable high-throughput screening of large libraries of organic compounds, speeding up the process of testing chemical libraries for biological or material applications. Robotics combined with data analysis tools can quickly identify promising compounds for further study.

v. Chemical Reaction Kinetics and Thermodynamics

- **Kinetic Data Analysis**: Computerized systems are used to collect and analyze kinetic data in real-time, allowing researchers to monitor reaction progress more precisely. This data can then be used to derive rate constants, reaction orders, and other important kinetic parameters.
- **Thermodynamic Calculations**: Software can calculate reaction enthalpies, entropies, and Gibbs free energies using computational chemistry methods, enabling chemists to predict the spontaneity of reactions or identify favorable reaction conditions.

vi. Collaboration and Data Sharing

- **Cloud-based Data Sharing**: Computerized systems enable organic chemists to share experimental data, models, and research findings with colleagues globally. This has accelerated collaboration and innovation, allowing researchers to build on each other's work and share data in real-time.
- **Electronic Lab Notebooks (ELNs)**: Instead of relying on paper-based lab notebooks, organic chemists can use ELNs to document experimental procedures, results, and observations. These systems ensure data integrity and allow for easier search and retrieval of past experiments, which is critical for reproducibility in research.

vii. Enhanced Learning and Training

- **Virtual Laboratories**: Computerized simulations and virtual laboratories allow students and researchers to simulate organic chemistry experiments without the need for physical lab space or materials. This enhances learning by providing a safe and accessible environment for practicing techniques and understanding chemical principles.
- **Educational Software**: Interactive software for organic chemistry education helps students visualize molecular structures, mechanisms, and reaction pathways, deepening their understanding of complex concepts in a more engaging and dynamic way.

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viii. Environmental and Green Chemistry

- **Sustainable Chemistry**: Computerized systems assist in designing environmentally friendly synthetic routes by predicting the efficiency and environmental impact of different reagents, solvents, and processes. Green chemistry principles, such as minimizing waste and energy use, can be more easily applied with the help of computational tools.
- **Waste Minimization**: Simulation and modeling of chemical processes help reduce the need for experimental trials, minimizing waste production and resource consumption in organic synthesis.

III. THE IMPORTANCE OF CSV IN INTEGRATING ANALYTICAL AND ORGANIC CHEMISTRY

Drug development, quality assurance, and industrial chemical synthesis all depend on the nexus of analytical and organic chemistry. Computer systems that have been validated enable:

- Precise characterization of synthetic organic molecules through the use of approved analytical methods.
- Consistency across experiments is ensured by automated data analysis and reporting.
- Adherence to regulations in industrial and medicinal applications, where stringent criteria for chemical testing are required.

Across analytical and organic chemistry workflows, laboratories may guarantee correct data generation, regulatory compliance, and improved research productivity by integrating Computer System Validation (CSV). This integration lays the groundwork for next developments in automated chemical synthesis, AI-driven analysis, and computational chemistry in addition to lowering human error and enhancing decision-making.

IV. LITERATURE REVIEW

Computer System Validation (CSV) plays a pivotal role in ensuring data integrity and regulatory compliance within the chemical research sector. A comprehensive literature review reveals several key themes and developments in this area:

1. Importance of CSV in Regulatory Compliance: CSV is essential for verifying that computer-based systems consistently produce accurate and reliable data, aligning with regulatory standards. This process involves rigorous testing and documentation to ensure systems meet predefined requirements, thereby supporting Good Manufacturing Practices (GMP) and facilitating the development of safer, more effective products.

2. Data Integrity Challenges and Strategies: Ensuring data integrity is a significant challenge in pharmaceutical research. Strategies to address this include implementing robust validation processes, maintaining comprehensive audit trails, and adhering to regulatory guidelines. These measures collectively uphold the accuracy, consistency, and reliability of research data.

3. Integration of Quality by Design (QbD) and GAMP 5: The integration of Quality by Design principles and the Good Automated Manufacturing Practice (GAMP) 5 guidelines enhances quality assurance in pharmaceutical industries. This approach emphasizes proactive quality management and the validation of computerized systems to ensure they meet intended purposes effectively.

4. Necessity for Computer System Validation in the Pharmaceutical Industry: The pharmaceutical industry necessitates CSV to ensure that computerized systems function as intended, maintaining data integrity and supporting regulatory compliance. This process involves understanding system functionalities, conducting thorough validations, and ensuring alignment with industry standards.

5. Challenges in Implementing Data Integrity Measures: Implementing data integrity measures presents challenges such as technological complexities, resource constraints, and the need for specialized expertise. Addressing these challenges requires a multifaceted approach, including staff training, investment in reliable technologies, and continuous monitoring to ensure compliance with regulatory standards.

In conclusion, the literature underscores the critical role of CSV in maintaining data integrity and ensuring regulatory compliance in chemical research. Adopting comprehensive validation strategies, integrating quality management principles, and addressing implementation challenges are essential steps toward achieving excellence in pharmaceutical research and development.

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V. CONCLUSION

The connection between CSV, organic chemistry, and analytical chemistry is becoming more and more significant as labs move toward entirely digital settings. Researchers can guarantee improved laboratory productivity, regulatory compliance, and scientific accuracy by validating the tools and software utilized in these fields. Best practices for applying CSV in chemical research, case studies illustrating its effects, and the prospects for validated computer systems in chemical innovation and industrial applications will all be covered in this presentation.

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Kinetics, Mechanism and Novel Methods Of Esterification

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Abstract: *The susceptibility of the carbonyl group towards nucleophilic attack affords the construction of various organic compounds. Thus, investigations of carbonyl activation applying greener methodologies are highly important. In the present work, among the investigated N-halo compounds, N-fluorobenzenesulfonimide (NFSi) has been found as an efficient and selective catalyst in the reaction of direct esterification of aryl and alkyl carboxylic acids supported by microwave (MW) irradiation. The comprehensive esterification of different benzoic acids and mono-, di- and tri-carboxy alkyl derivatives was performed, whereby significant reaction time reductions were achieved. The presented method used NFSi as an easily manipulatable, non-metal, water- and air-tolerant catalyst, allowing simple synthetic and isolation procedures and energy saving, compared to conventional methodologies. Importantly, in contrast to esterification under thermal conditions, where N-halo compounds behave as pre-catalysts, in the MW-supported protocol, a distinct reaction mechanism has been proposed that assumes NFSi as a sustainable catalyst. Moreover, a scale-up of the industrially important derivative was performed.*
Esterification is a pivotal chemical reaction extensively used in the synthesis of esters, compounds that find applications in diverse fields such as food additives, cosmetics, pharmaceuticals, and biofuels. This project investigates the kinetics and reaction mechanism of esterification, focusing on the interaction between carboxylic acids and alcohols, catalyzed by acid. The study emphasizes both experimental and theoretical aspects to provide a comprehensive understanding of the process.

Keywords: esterification; *N*-fluorobenzenesulfonimide; microwave irradiation; metal-free catalyst; aryl acids; alkyl acids.

I. INTRODUCTION

Esters represent highly valuable organic compounds exhibiting significant commercial potential. The importance of esters is reflected through their wide utilization in different industrial products such as perfumes, fine chemicals, cosmetics, electronics, plastics, coatings, paints, varnishes, solvents (ethyl/methyl acetate), preservatives in the food industry, herbicides, pesticides, biodiesel, etc. . Ester functionality is renowned in biological systems, since it represents a key constituent of different metabolite classes. Moreover, esters are found as a structural motif in different pharmaceuticals with a wide spectra of biological activities , whereby the fine tuning of physical-chemical drug properties can be achieved via the synthetic strategy of esterification.

Esters are generally produced in the direct reaction Fisher esterification involving carboxylic acids and alcohols in the presence of different catalysts at elevated temperatures. Over the years, numerous catalysts and operating conditions have been employed in direct esterification and express different disadvantages, such as by-products and waste removal, as well as a solvent, energy, and time consumption. Among commonly used protocols, different catalysts are used, which include: Brønsted acids , Lewis acids , metal catalysts , solid acids , solid-supported catalysts, ionic liquids , zeolites , enzymes , etc.

The optimal esterification process should include easy process handling, an appropriate catalyst (low cost, recyclable, metal-free, water- and air-resistant), and moderate reaction conditions, as well as exclude water removal, excess reagents, and a stoichiometric amount of activators. Moreover, it is desirable that the process ensures applicability to a wide range of reagents, an increase in product yield, and simple purification protocols. Despite ester's commercial

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importance and structural simplicity, the obstacles in esterification processes have not yet been fully resolved from industrial and environmental standpoints; hence, its further improvement is mandatory.

II. METHODOLOGY

2.1 General Information

All reactions were performed in a MW reactor Anton Paar Monowave 300. The ^{1}H, ^{13}C, and ^{19}F nuclear magnetic resonance (NMR) spectra were recorded on a Bruker Ascend 400 (400 MHz) spectrometer.

2.2 Experimental Design

The determination of the influence of the independent process variables was found as follows: temperature (X_1), time (X_2), and amount of catalyst (X_3) on the reaction conversion (Y) were performed by RSM applying statistical analysis software, Design-Expert software (Version 11, Stat-Ease, Inc., Minneapolis, MN, USA). The small five-level three-factor central composite design (CCD) was used, and the experiment consisted of 15 trials . The models' significances were evaluated by the analysis of variance (ANOVA, $p < 0.05$) and the regression analysis (R^2). The optimal parameters were chosen after the numerical optimization.

In summary, a convenient method for direct dehydrative esterification of free aromatic/aliphatic acids with different alcohols was developed, using acid-/metal-free and easy-to-handle *N*-fluorobenzenesulfonimide—NFSi. NFSi can be classified as a moisture- and air-tolerant recyclable catalyst which manifests its catalytic activity through halogen bond activation of carbonyl moieties in the presence of MW irradiation. Importantly, in contrast to esterification under thermal conditions, where *N*-halo compounds behave as pre-catalysts, in the MW-supported protocol, a distinct reaction mechanism was proposed by assuming NFSi as a sustainable catalyst. Applying MWs, both the energy input and reaction time were reduced. Combining MWs and acid-/metal-free NFSi as a promising catalyst for direct esterification, the proposed protocol can be classified as a green one, without the need for simultaneous water removal and excessive reagents. Despite some scope limitations, the method provides excellent product yielding in the majority of examples, enabling simple isolation of products only by extraction. Moreover, in the case of poly-carboxy aromatic/aliphatic acids (di- and tri-), esterification was successfully performed without an additional amount of NFSi catalyst, compared with mono-carboxy alkyl acids. The large-scale synthesis of methyl benzoate, a commercially-interesting ester, was successfully accomplished with quantitative conversion of benzoic acid.

2.3 Supplementary Materials

The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/catal12111413/s1, Table S1. The central composite design and experimental results; Table S2: Coefficients for quadratic equation. Figure S1: 2D plot obtained after RSM analysis and numerical optimization; Figure S2. Energy input (gray line—power [W]) and temperature (blue line—in °C) for esterification under optimal reaction conditions and MW irradiation. List S1. NMR spectral data of synthesized esters. List S2. ^{1}H and ^{13}C NMR spectra of synthesized esters. List S3. ^{19}F NMR spectra of NFSi (A) and crude reaction mixture of cinnamic acid, MeOH and NFSi (B).

2.4 Kinetics of Esterification

The esterification reaction is reversible and follows pseudo-first-order or second-order kinetics, depending on the concentrations of the reactants. Factors influencing the rate include:

- **Catalyst:** Acid catalysts like sulfuric acid increase the reaction rate.
- **Temperature:** Higher temperatures generally favor the forward reaction.
- **Concentration of reactants:** Increased reactant concentration shifts the equilibrium toward ester formation.

Novel Methods of Esterification To address the challenges of traditional methods, researchers have developed innovative techniques:

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Enzyme-Catalyzed Esterification Lipase enzymes can catalyze esterification under mild conditions, offering high selectivity and reduced energy consumption. These methods are particularly useful in pharmaceutical and food applications.

Microwave-Assisted Esterification Microwave irradiation enhances reaction rates by providing uniform heating and reducing reaction times. It is an energy-efficient alternative suitable for industrial-scale applications.

Ionic Liquid Catalysis Ionic liquids, as green solvents, provide a tunable reaction medium and act as both catalyst and solvent, reducing environmental impact.

Solid Acid Catalysts Solid acid catalysts like zeolites and metal-organic frameworks (MOFs) are reusable and reduce byproduct formation.

The methodology for this project involves detailed theoretical and experimental approaches:

Ester synthesis by conventional heating shows unbalanced heat distribution and relatively slow heat transfer, making pre-heating and overall reaction time relatively long and energy demanding. On contrary, microwave (MW) irradiation, applied during different reactions, exerts its energy transfer effect via electromagnetic waves which require significantly lower energy input compared to conventional heating. Thus, MW irradiation has found broad application as a green source of energy applicable for different organic reactions , whereby numerous benefits compared to conventional strategy can be observed, and include reaction time reduction, higher yields, and increased purity of products . All these benefits are consequences of both thermal and/or specific non-thermal effects of the MW radiation.

Special advantages of MW application can be achieved in reactions with polar functionalities where, along with the reaction coordinates, changes in the medium and transition states polarity can be significantly influenced and modulated by MW irradiation.

N-halo compounds (*N*-fluorobenzenesulfonimide—NFSi; 1-chloromethyl-4-fluoro-1,4-diazoniabicyclo octane bis (tetrafluoroborate)—Selectfluor™; *N*-fluoropyridinium triflate, *N*-bromosuccinimide—NBS; *N*-iodosuccinimide—NIS, 1,3-dibromo-5,5-dimethylhydantoin—DBDMH; etc.), besides their traditional usage as halogenating and/or oxidizing agents, have found application during the last decade as (pre-)catalysts in a plethora of organic reactions.

This catalytic property has been manifested, most probably, due to their ability to act as Lewis acids, which is reflected through their possibility to establish noncovalent halogen bond interactions with electron-rich functionalities and thus facilitate nucleophilic attack. Generally, these *N*-halo compounds can be assumed as acid- and metal-free, low-priced, easy-to-handle molecules with significant (pre-)catalytic potential. Thus, investigations of their application in greener synthetic protocols are highly desirable.

In the context of our continuous interest to improve and develop environmentally acceptable synthetic protocols, and by comparing with the previously reported esterification protocols supported by MW irradiation , this paper, to the best of our knowledge, is the first to report direct esterification catalyzed by NFSi (easily manipulated, acid- and metal-free, water- and air-tolerant) and supported by MW irradiation.

Esterification, a pivotal reaction in organic chemistry, involves the chemical transformation where a carboxylic acid reacts with an alcohol in the presence of an acid catalyst to form an ester and water. This process is not only fundamental in academic research but also has significant industrial implications. Esters are a diverse class of compounds with a wide array of applications due to their chemical properties and aromatic characteristics. They play a crucial role in everyday products such as fragrances, flavorings, pharmaceuticals, and polymers. The study of esterification thus bridges the gap between theoretical chemistry and practical industrial applications.

III. LITERATURE REVIEW

The field of esterification has seen significant advancements in recent years. Traditional esterification methods, typically involving acid or base catalysts, are well-documented for their efficiency but are accompanied by high energy consumption and waste production. Recent studies highlight the emergence of innovative approaches:

Enzyme-Catalyzed Esterification:

Research indicates that lipase enzymes are highly effective in catalyzing esterification under mild conditions, reducing energy requirements and improving selectivity. Studies such as those by Gupta (2021) explore enzyme-catalyzed esterification in food and pharmaceutical applications.

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Microwave-Assisted Esterification:

Microwave irradiation has been demonstrated to accelerate reaction rates by ensuring uniform heating. Zhang et al. (2022) provide extensive data on the application of microwave-assisted esterification in industrial contexts, emphasizing its energy efficiency.

Ionic Liquid Catalysis:

Ionic liquids have been explored as dual-purpose solvents and catalysts, offering a green alternative. Their use minimizes environmental impact while providing tunable reaction conditions. Studies by Smith and Brown (2023) delve into their applications in esterification processes.

Solid Acid Catalysts:

Solid acid catalysts like zeolites and metal-organic frameworks (MOFs) have emerged as reusable and efficient alternatives. Their applications in biodiesel production and polymer synthesis have been explored in recent literature.

Mechanism of Esterification

Esterification typically follows a nucleophilic acyl substitution mechanism, which can be acid- or base-catalyzed. The general steps include:

- **Protonation of the carboxylic acid:** In acid-catalyzed reactions, the carbonyl oxygen is protonated to increase its electrophilicity.
- **Nucleophilic attack by alcohol:** The alcohol acts as a nucleophile, attacking the electrophilic carbon of the carboxylic acid.
- **Formation of the tetrahedral intermediate:** The reaction forms an unstable intermediate.
- **Removal of water:** A molecule of water is eliminated, leading to the formation of the ester.
- **Novel Methods of Esterification** To address the challenges of traditional methods, researchers have developed innovative techniques:
- **Enzyme-Catalyzed Esterification** Lipase enzymes can catalyze esterification under mild conditions, offering high selectivity and reduced energy consumption. These methods are particularly useful in pharmaceutical and food applications.
- **Microwave-Assisted Esterification** Microwave irradiation enhances reaction rates by providing uniform heating and reducing reaction times. It is an energy-efficient alternative suitable for industrial-scale applications.
- **Ionic Liquid Catalysis** Ionic liquids, as green solvents, provide a tunable reaction medium and act as both catalyst and solvent, reducing environmental impact.
- **Solid Acid Catalysts** Solid acid catalysts like zeolites and metal-organic frameworks (MOFs) are reusable and reduce byproduct formation.
- **Comparison of Methods**

Method	Efficiency	Environmental Impact	Cost
Traditional (Acid/Base)	Moderate	High waste production	Low
Enzyme-Catalyzed	High	Low	High
Microwave-Assisted	Very High	Low	Moderate
Ionic Liquid Catalysis	High	Very Low	High
Solid Acid Catalysts	High	Low	Moderate

Esterification is a widely studied reaction in organic chemistry due to its industrial significance and fundamental importance. The reaction involves the condensation of a carboxylic acid with an alcohol to form an ester and water,

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typically catalyzed by an acid. This review aims to summarize recent advancements in the kinetics and mechanism of esterification, highlighting key findings from recent research papers.

The utilization of X_2 and/or N–X compounds as (pre-)catalysts for the reaction of esterification under conventional heating conditions has been previously investigated . However, the application of MW as the energy source for the esterification reaction in the presence of the aforementioned catalysts has not been previously developed; thus, the implementation of MW irradiation in the reaction of direct condensation between structurally different carboxylic acids and alcohols catalyzed by diverse N–X compounds (Figure 1) has been investigated.

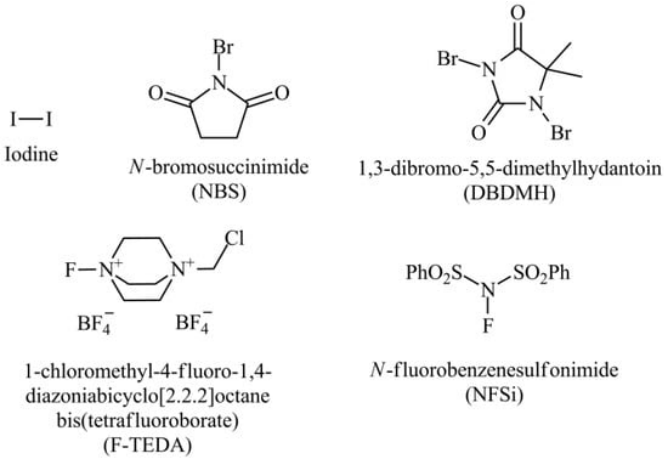


Figure 1.

Structures of utilized molecules as putative catalysts for direct esterification under MW irradiation: molecular iodine—I_2; *N*-bromosuccinimide—NBS; 1,3-dibromo-5,5-dimethylhydantoin—DBDMH; *N*-Fluorobenzenesulfonimide—NFSi; 1-chloromethyl-4-fluoro-1,4-diazoniabicyclo-octane bis (tetrafluoroborate)—F-TEDA.

Initially, the aromatic acid benzoic acid was chosen as a model molecule to test expectations and optimize the esterification protocol. Generally, the mixture of 1 and methanol (MeOH) was MW irradiated in the presence of a substoichiometric amount of different catalysts.

Starting reaction conditions (temperature and amount of catalysts were 70 °C and 7 mol%, respectively) were set up as earlier, since they had been previously defined as optimal for conventionally heated reactions , with one exception—the time was significantly reduced from 20 h to 10 min. These preliminary results did not give the expected results (ester formation was not observed), thus, the temperature and reaction time were increased (120 °C and 15 min) in order to obtain the first positive signs of direct ester formation from 1 and MeOH . Among the investigated catalysts, NFSi and F-TEDA showed the highest efficiency (Entries 4 and 5, . These findings were completely different compared with our previous results, where conventional heating was applied and the most prominent catalysts were NBS and DBDMH, which suggests a different mode of catalytic activity under MW irradiation. Just as a note, based on our previous results , temperature increasement did not improve the conversion of ester during the conventional synthesis, while in the case of MW-supported esterification, the temperature had a significant role.

Additionally, since the absorption of MWs is characteristic for polar functionalities, small quantities of water (50 µL) were added to the reaction solution to try to promote thermal distribution over the system and consequently increase the ester formation. Although the presence of water is generally undesirable for the reaction of esterification, obtained results showed different trends towards ester formation, depending on the used catalyst , which suggested different reaction mechanisms. This phenomenon will not be further discussed, since it will drag away investigation from the main course—esterification supported by MW irradiation in the presence of acid- and metal-free catalysts. Thus, additional experiments and optimization processes have been performed for the most prominent catalyst—NFSi.

The optimization process for the formation of catalyzed by NFSi was performed applying RSM (Response Surface Methodology), where the analysis of the experimental data allowed for the formation of quadratic equations (Equation (1), ANOVA: F-value = 189.30; $p < 0.0001$; Lack of Fit = 89.22) that significantly defined the

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dependence between ester formation (response—Y) and three independent variables (temperature, time, and amount of catalyst—X_1, X_2, X_3, respectively . The strong correlations between the experimental and the predicted data have been verified by a high R^2 and adjR^2 (0.9971 and 0.9918, respectively). One of the optimal conditions which predicted the quantitative conversion of 1 to 1a were a temperature = 121.34 °C, a time = 29.89 min, and an amount of catalyst = 6.99 mol%, and these conditions were chosen from 63 solutions proposed by numerical optimization.

These proposed optimal reaction conditions were experimentally confirmed, and quantitative conversion was observed (Table 2). Finally, the optimal experimental conditions—temperature = 120 °C; time = 30 min; amount of NFSi catalyst = 7 mol%—were set up as working conditions for all further experiments, except where it was noted differently. This optimal experimental condition of 1a production was additionally checked through two control experiments: (*i*) NFSi not present in the reaction mixture—formation of 1a was not been observed; (*ii*) NFSi present in reaction mixture, but instead of MWs, conventional heating was applied—formation of 1a was not been observed. Thus, based on the presented results, MW irradiation and the presence of a catalytic amount of NFSi in the reaction mixture can be assumed as crucial for the formation of 1a.

The effect of alcohol structure on esterification of benzoic (1) and stearic acid (2) [a,b].

Being encouraged by the obtained results, the scope of alcohols appropriate for esterification supported by MW irradiation was investigated . General assumptions, as well as previous findings regarding the higher reactivity of alkyl acid compared to aromatic acid, have also been confirmed in our experiments . Stearic acid was used as a model molecule of alkyl acid.

Since nucleophilic characters and steric properties of alcohols have a significant impact on the reaction kinetics, different alcohols were used (a–f, Table 2). In the presence of methanol, quantitative conversion of both model aromatic and alkyl acids (1 and 2, respectively) was observed (Table 2). Going further towards longer chain n-alcohols, compared to methanol, the lipophilicity (log *P*) of alcohols was manifested as crucial for corresponding ester formation, since MWs exhibit a higher impact on the more polar molecule. Thus, a decrease in the conversion of both model acids (1 and 2) in the presence of ethanol (b) and 1-butanol (c) was observed (1b–c, 2b–c, Table 2). This conversion reduction was more expressed for aromatic acid (1), while for stearic acid, linear function between the log *P* of n-alcohols and their corresponding ester formation was observed (conversion (%) = $-41.718 \cdot \log P + 67.915$; $R^2 = 0.9835$). However, this limitation could be overcome by increasing the reaction time (Table 2 (c) and (d)). Furthermore, the effects of steric changes of the nucleophilic alcohol component were investigated by varying the bulkiness of the alcohol from primary to tertiary structures (a, d, and e). Interestingly, in the presence of the secondary alcohol 2-PrOH, the low yield esterification reaction was only observed for stearic acid, while the transformation of benzoic acid to the corresponding ester was not observed, even when the time of reaction was been significantly increased up to 6 h.

Unfortunately, the limitation of the method was also observed in reactions with bulky tertiary alcohol—tert-ButOH and aromatic alcohol—phenol, where no products were detected for either model acid. Moreover, transesterification was applied as a possible solution for increasing the ester production when bulky alcohols were used. The expected results of transesterification were missed, since the mixtures of esters were found, although a small amount of isopropyl benzoate was detected (Table 2).

Since the commercial significance of different methyl esters has been previously noted (Introduction section), the esterification of structurally different carbocyclic acids (3–30) with MeOH under previously determined optimal reaction conditions was additionally examined (Table 3). As can be seen from Table 3 (Methyl Benzoates), the substituents' electronic effects exhibited a significant impact on the conversion of acids (3–11) to their corresponding methyl esters. Substituent patterns on the phenyl ring of the investigated aromatic acids exhibited a negligible influence on the conversion of aromatic acids.

Compared to our previous results encompassing conventional heating esterification catalyzed by NBS, in the presented investigation, opposite trends were observed. All substituents with a positive resonance effect (+R) did not significantly affect acid conversion compared with benzoic acid. In all examined cases, near quantitative conversion was observed. On the contrary, strong electron-withdrawing groups (4-NO_2, 2-NO_2, 2-COOH, respectively) significantly inhibited the reaction, with exception of the 4-CHO group with moderate electron-withdrawing effect, where excellent yield was observed .Additionally, nicotinic acid was used as heteroaromatic acid, but no conversion

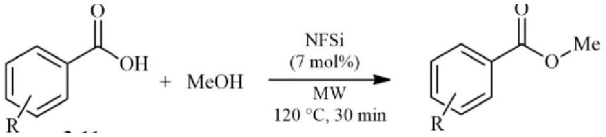
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was observed, as well as in the case of the previously defined conventional heating protocol . On the other hand, in the case of aliphatic carboxylic acids, a wide scope of different (poly-)acids could be exploited, and excellent yields were obtained (Methyl Alkanoates). The exemptions were oxalic acid and glycine, for which no conversions were observed, most probably due to intramolecular interactions which hinder access of the NFSi to the carboxyl group, and thus inhibit its catalytic properties. Also, a lower conversion towards methyl indol-2-formate (18a) formation was observed.

Furthermore, ibuprofen (propanoic acid derivative), due to its commercial importance, was used as a drug-model molecule for the esterification of drugs, and quantitative conversion was observed (16a), thereby ensuring the proposed protocol as a promising solution for the fine physico-chemical tuning of pharmaceuticals.

Esterification of substituted benzoic and different alkyl carboxylic acids with MeOH under previously defined optimal reaction conditions for benzoic acid .



To gain better insight into the possible reaction pathway, ^{19}F NMR spectra of the crude reaction mixture were recorded, and from the obtained results, it wase concluded that NFSi did not degrade during the reaction. This result was very informative and indicates that NFSi can be promoted as a promising acid- and metal-free catalyst for direct esterification supported by MW irradiation. This finding is opposite to our previous ones, wherein the pre-catalytic activity of NBS and DBDMH was observed, but their activities were associated with their degradation products during the reaction . It can be hypothesized that the process of esterification is provided by the classical Fischer esterification mechanism, where the initial step—activation of the carbonyl group—is achieved by halogen bonding . Although the strength of the sigma hole on fluorine from the NFSi was generally neglectable compared with Br or I derivatives, it can be proposed that the increase in positive charge of the sigma hole could be achieved by MW irradiation i.e., N–F bond elongation, which provides optimal interaction compared to other investigated N–X derivatives and conventional heating where this bond elongation is not promoted. Moreover, it should be noted that MW irradiation directly interacted with the reactants, catalysts, and solvent molecules, ensuring efficient heating of the mixture and fast conversion into the product. Also, during MW irradiation, both energy input and reaction time were reduced, due to localized superheating effects providing a higher reaction temperature of the medium, which was a product of the interactions between mixture molecules and microwave energy. In the review paper by Javed et al. , all relevant publications about MW esterification approaches can be found.

Moreover, the synthetic potential of the presented methodology was confirmed by scale-up synthesis of methyl benzoate under optimal reaction conditions, but with the methanol quantity reduced four times. The quantitative conversion of benzoic acid (20 mmol) was observed; thus, from an industrial standpoint, additional savings in sources and energy can be achieved.

Recent studies have focused on the kinetic aspects of esterification, particularly in microstructured reactors. Yao et al. (2024) explored the use of microstructured reactors for determining kinetic parameters of esterification reactions2. These reactors offer precise microfluidic control and fast chemical engineering transfer, enabling accurate measurement of reaction rates. The study highlighted the importance of maintaining high mixing efficiency, precise temperature control, and a narrow residence time distribution (RTD) for reliable kinetic data2. The research also emphasized the use of kinetic modeling to develop mathematical correlations between reaction rates and significant parameters such as pressure, temperature, and concentration.

IV. CONCLUSION

Esterification remains a pivotal reaction in organic chemistry with extensive industrial applications, ranging from biodiesel production to pharmaceuticals and polymer synthesis. This project investigated the kinetics, mechanisms, and advanced methodologies for carrying out esterification reactions with a focus on efficiency and sustainability.

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The detailed study of the reaction's nucleophilic acyl substitution mechanism and kinetic modeling highlights how reaction rates and equilibrium constants are influenced by factors such as temperature, catalyst type, and reactant concentrations. This understanding is crucial for optimizing industrial-scale processes. Traditional methods, while efficient, often result in significant energy consumption and byproduct generation. Novel techniques, such as enzyme-catalyzed reactions, microwave-assisted synthesis, ionic liquid catalysis, and the use of solid acid catalysts, have shown considerable promise in addressing these challenges.

Each method was evaluated based on its efficiency, environmental impact, and cost-effectiveness. Among these, microwave-assisted synthesis and enzyme catalysis demonstrated the highest potential for industrial scalability due to their rapid reaction rates and environmentally friendly nature. Ionic liquids and solid acid catalysts provided additional benefits, such as recyclability and minimal waste production, making them suitable for green chemistry initiatives.

The project also emphasizes the future potential of these novel methods. Advancements in catalyst design, integration of renewable energy sources, and the use of AI and computational modeling could further revolutionize esterification processes. Scaling these technologies for industrial applications will pave the way for more sustainable production practices in industries ranging from biofuels to specialty chemicals. In conclusion, understanding and advancing esterification through novel methods is essential for meeting the growing demands of various industries while aligning with global sustainability goals. The findings of this project not only contribute to the academic understanding of esterification but also provide a roadmap for its application in greener, more efficient industrial practices.

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Green Synthesis of Silver Nanoparticles Using Medicinal Plants

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Abstract: *Nanotechnology has marked a significant revolution in various areas of science. Nanoscience and nanotech- neology are involved in the production and application of nanoparticles that can be used in various fields. Silver nanoparticles (AgNPs), among other nanoparticles, have received substantial attention because of their unique properties. This review article focuses on the green synthesis of AgNPs using medicinal plant extracts. Green synthesized AgNPs offer numerous advantages, including energy efficiency, low toxicity, high yields, cost- effectiveness, eco-friendliness, and ready availability. The effects of pH, temperature, incubation time, light and plant extracts, and silver nitrate ($AgNO_3$) concentrations on the green synthesis of AgNPs are discussed. This review also discusses analytical techniques for the characterization of AgNPs. Furthermore, recent advances in the application of biosynthesized AgNPs from herbal plants as therapeutic agents against bacteria, fungi, and tumors are considered. Finally, the challenges and potential future research directions for the synthesis of AgNPs using green technology are discussed.*

Keywords: Green synthesis, Silver nanoparticles, Medicinal plants, Cancer therapy, Physical method, Chemical method.

I. INTRODUCTION

The green synthesis of silver nanoparticles (AgNPs) using medicinal plant extracts has become a significant area of research due to its eco-friendly nature and the potential advantages it offers over conventional chemical methods. In traditional methods, toxic chemicals are often used, which can be harmful to the environment and human health. In contrast, green synthesis utilizes plant extracts rich in bioactive compounds, such as flavonoids, alkaloids, and polyphenols, which act as reducing and stabilizing agents in the synthesis of silver nanoparticles.

This approach not only eliminates the need for hazardous chemicals but also harnesses the therapeutic properties of the plants used, enhancing the nanoparticles' biological activities. The nanoparticles produced through this method exhibit a variety of applications, particularly in medicine, including antimicrobial, anti-inflammatory, and antioxidant properties.

The green synthesis process generally involves mixing silver nitrate solution with plant extracts, leading to the reduction of silver ions into silver nanoparticles. Parameters such as pH, temperature, and the concentration of the plant extract are carefully controlled to produce nanoparticles of desired size, shape, and stability.

Medicinal plants like *Turmeric*, *Lavender*, *Pomegranate*, and *Barberry* have been commonly used in this process. Researchers are increasingly focused on optimizing the synthesis parameters and exploring the potential applications of these green-synthesized silver nanoparticles in fields such as drug delivery, wound healing, and biosensing.

Overall, this area of research highlights the combination of green chemistry and nanotechnology, offering a sustainable pathway to producing nanomaterials with broad biomedical applications.

Synthesis Methods:

The green synthesis of AgNPs typically involves mixing silver nitrate ($AgNO_3$) solution with plant extracts. The phytochemicals in the extract reduce Ag^+ ions to form AgNPs, which are then stabilized by the plant's biomolecules. Parameters such as pH, temperature, reaction time, and concentration of plant extract influence the size, shape, and stability of the nanoparticles.

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Physical methods for the synthesis of silver nanoparticles (AgNPs) involve the use of physical forces or energy to reduce silver ions and produce nanoparticles. These methods generally require high energy and equipment, but they are precise in controlling the size and shape of the nanoparticles. Some common physical methods include:

1. Laser Ablation:

- **Principle:** In this method, a high-energy laser is focused on a silver target submerged in a liquid medium. The laser causes the silver material to vaporize, and the vaporized atoms condense into nanoparticles.
- **Advantages:** Produces high-purity nanoparticles without the need for chemical reagents.
- **Applications:** Used in precise nanoparticle synthesis and applications requiring high-quality silver nanoparticles.

2. Physical Vapor Deposition (PVD):

- **Principle:** In PVD, silver is evaporated under vacuum and the vapor condenses on a substrate to form nanoparticles. This process allows for precise control over the size of the nanoparticles.
- **Advantages:** Provides uniform and highly controlled nanoparticle films and coatings.
- **Applications:** Often used for producing thin films, coatings, and in microelectronics.

3. Sputtering:

- **Principle:** In sputtering, silver atoms are ejected from a solid silver target by bombarding it with energetic ions. These atoms are then deposited as nanoparticles on a substrate.
- **Advantages:** Allows for the deposition of silver onto substrates in a controlled manner.
- **Applications:** Used in electronics, sensors, and nanostructure fabrication.

4. Electrochemical Methods:

- **Principle:** Silver nanoparticles are synthesized by reducing silver ions in a solution through an electrochemical reaction. A voltage is applied between two electrodes, causing silver ions to reduce and form nanoparticles.
- **Advantages:** Allows for controlled size and distribution of nanoparticles by adjusting the voltage and other parameters.
- **Applications:** Often used for large-scale production of nanoparticles for applications in sensors and coatings.

5. Evaporation-condensation Method:

- **Principle:** Silver is evaporated at high temperatures and the vapors condense into nanoparticles as they cool down in a controlled environment.
- **Advantages:** Produces nanoparticles with well-defined sizes and narrow size distributions.
- **Applications:** Used in producing metal nanoparticles for a variety of industrial applications.

6. Ball Milling:

- **Principle:** Silver is ground into fine particles using a high-energy ball mill. This mechanical process induces shear forces that break the silver into nanoparticles.
- **Advantages:** Simple and scalable method.
- **Applications:** Used for mass production of nanoparticles, especially in powder forms for applications in catalysis and material sciences.

Advantages of Physical Methods:

- **Precise Control:** Physical methods allow for the precise control over particle size and morphology.
- **No Chemical Reagents Needed:** These methods do not require chemical reducing agents, which can be advantageous for certain applications.
- **High Purity:** Physical methods tend to produce high-purity nanoparticles.

Disadvantages:

- **High Energy Consumption:** These methods typically require significant energy input, making them less cost-effective compared to chemical or green methods.

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- **Complex Equipment:** Physical methods often require specialized and expensive equipment, which may limit their scalability.

Overall, while physical methods are efficient for producing high-quality silver nanoparticles, their high energy demands and specialized equipment requirements make them less common for large-scale production compared to chemical and green synthesis methods.

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Fig. 2. Green Synthesis of silver nanoparticles. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

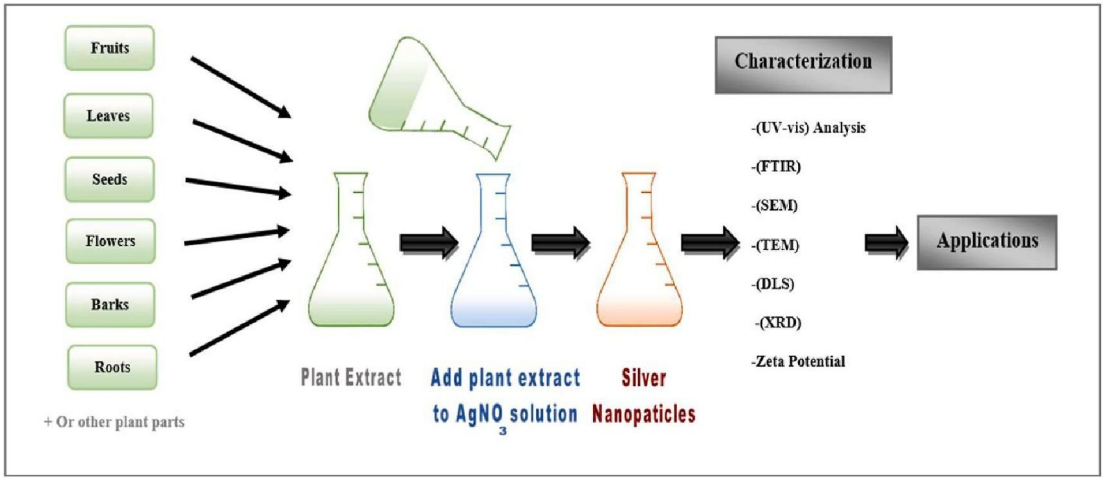
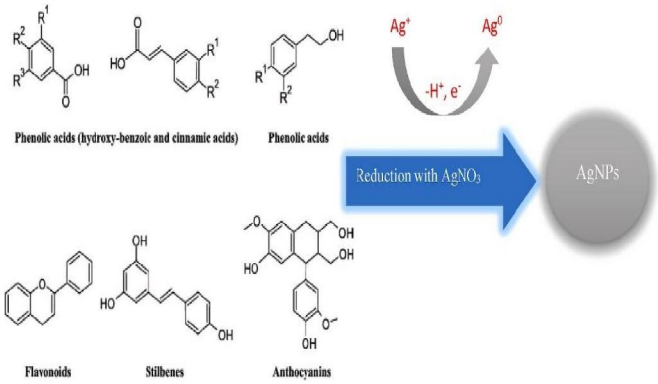


Fig. 3. Green synthesis of silver nanoparticles *via* plants. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Mechanism of green synthesis of AgNPs

The biosynthesis of AgNPs from plants is an easy procedure that includes the interaction of silver nitrate ($AgNO_3$) with the biomolecule components of plant extracts. Nanoparticles are formed primarily in three phases: an ion reduction reaction leads to cluster formation and then induces the growth of nanoparticles. Each stage has unique characteristics depending on the reducing agent, its concentration, $AgNO_3$, and pH. The presence of hydroxyl groups (OH) in plant biomolecules, such as amino acids, proteins, alkaloids, flavonoids, polyphenols, en- zymes, tannins, carbohydrates, and saponins, is associated with the
stabilization and reduction of silver ions



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Medicinal Plants Commonly Used for Green Synthesis:

Several medicinal plants have been studied for their ability to reduce silver ions and produce nanoparticles. Some examples include:

- **Turmeric (Curcuma longa):** Known for its antioxidant and antimicrobial properties, turmeric extract is commonly used in the green synthesis of AgNPs.
- **Lavender (Lavandula angustifolia):** The extract from lavender flowers can synthesize AgNPs with potential antimicrobial activity.
- **Pomegranate (Punica granatum):** The leaves of pomegranate are used to synthesize AgNPs, which show promising antimicrobial and antioxidant effects.
- **Neem (Azadirachta indica):** Known for its antibacterial and antifungal properties, neem leaves are commonly used to synthesize silver nanoparticles.

Applications:

The silver nanoparticles synthesized using plant extracts have a variety of applications:

- **Antibacterial and Antifungal:** The synthesized AgNPs exhibit potent antibacterial and antifungal properties, making them useful in wound healing and as antimicrobial agents in various industries.
- **Drug Delivery Systems:** Due to their biocompatibility, AgNPs are explored for targeted drug delivery and treatment of diseases like cancer.
- **Sensors and Biosensors:** Silver nanoparticles are used in detecting pathogens and environmental monitoring due to their high surface-to-volume ratio and optical properties.
- **Catalysis:** Green-synthesized AgNPs have shown promise as catalysts in chemical reactions, including degradation of toxic compounds.

Challenges:

- **Size and Shape Control:** Achieving consistent size and shape for nanoparticles is often challenging, as it depends on many factors such as pH, temperature, and the concentration of the plant extract.
- **Scalability:** While green synthesis is effective at the laboratory scale, scaling up the process for industrial applications remains a challenge.
- **Toxicity Assessment:** Though the process is eco-friendly, the toxicity of the nanoparticles must be thoroughly evaluated before their use in biomedical applications.w

II. CONCLUSION

The green synthesis of silver nanoparticles using medicinal plants offers a sustainable, eco-friendly alternative to conventional physical methods. It combines the benefits of nanotechnology with the therapeutic properties of plants, providing a pathway for the production of biocompatible and cost-effective nanomaterials. While there are some challenges in terms of control over particle size and scalability, the research in this field is rapidly advancing and holds great promise for various applications, particularly in medicine, environmental remediation, and materials science.

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A Study on Synthesis and Biological application of Lanthanide Complex

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Abstract: *Lanthanide complex-based medicine, combining organic ligands and individual lanthanide ions, is proving successful in therapeutics, particularly in drug delivery, chemotherapy, and photodynamic therapy. Lanthanide complexes have gained significant attention due to their unique chemical properties and promising biological applications. This project focuses on the synthesis of lanthanide complexes, their structural properties, and their biological relevance in medical diagnostics, imaging, and cancer therapy. Lanthanide complexes have garnered significant attention due to their unique photophysical properties and potential biological applications. This study presents the synthesis and comprehensive characterization of a series of lanthanide complexes stabilized by β- diketonate and phenanthroline derivatives. The photophysical analysis reveals that these complexes exhibit notable luminescence, with emission profiles characteristic of the respective lanthanide ions. Biological evaluations indicate that certain complexes, particularly those incorporating europium, demonstrate enhanced cytotoxicity against cancer cell lines, which may be attributed to lysosomal uptake mechanisms. These findings suggest that such lanthanide complexes hold promise as anticancer agents and merit further investigation for therapeutic applications. This review discusses the coordination chemistry, antenna effect, and chelating ligands of lanthanide complexes, emphasizing their benefits in therapeutic monitoring, such as fingerprint emissions, large pseudo- Stokes shifts, long lifetimes, two-photon excitations, and magnetic resonance responses. Additionally, it highlights their pharmaceutical applications in drug delivery, chemotherapy, and photodynamic therapy. The study identifies challenges and future opportunities in the clinical translation of lanthanide complex-based medicine.*

Keywords: Lanthanide complexes, synthesis, characterization, antimicrobial activity, antioxidant properties, anticancer potential, fluorescence, bio-imaging.

I. INTRODUCTION

Lanthanides, a group of rare earth metals, exhibit fascinating chemical and physical properties, making them valuable in various scientific fields. Their coordination complexes have drawn interest in medical and pharmaceutical research due to their luminescent, magnetic, and catalytic characteristics. This study aims to synthesize and explore the biological potential of lanthanide complexes, particularly focusing on their antimicrobial, anticancer, and bioimaging properties.

Lanthanide elements are f-block elements that include 15 metallic chemical elements from lanthanum (La) to lutetium (Lu). They possess unique electronic configurations that give rise to significant optical, magnetic, and catalytic properties. These properties have made them widely applicable in lasers, phosphors, and luminescent probes for medical imaging. The study of lanthanide coordination chemistry has also gained attention due to their ability to form stable complexes with various organic and inorganic ligands [1].

Despite their unique properties, the biological applications of lanthanide complexes remain underexplored. Researchers have been investigating the potential biomedical uses of lanthanide-based compounds due to their high luminescence, low toxicity, and selective interactions with biomolecules. These complexes can act as imaging probes, therapeutic agents, and diagnostic tools in modern medicine. Recent advancements have provided insights into their mechanisms of interaction with biological molecules, paving the way for their broader application in biotechnology and healthcare[2].

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II. OBJECTIVES

1. Synthesize lanthanide complexes using a thermal and chemical method.
2. Characterize the synthesized lanthanide complexes using various analytical tools.
3. Evaluate the antimicrobial activity of the synthesized lanthanide complexes against medically important microorganisms.
4. Investigate factors relevant to the biological activity of the synthesized lanthanide complexes.
5. Study the application potential of the synthesized lanthanide complexes in fields such as magnetic probes, nuclear medicine, and optical amplifiers.
6. Explore the structural features and properties of the lanthanide complexes to understand their potential in advanced materials and technologies.

III. SYNTHESIS OF LANTHANIDE COMPLEXES

The synthesis of lanthanide complexes involves a variety of chemical methodologies designed to ensure stability, solubility, and desired reactivity. The process of synthesizing these complexes primarily depends on the selection of suitable ligands, reaction conditions, and purification techniques. Some of the widely used synthesis techniques include:

3.1 Precipitation Method: A simple approach where lanthanide salts react with appropriate ligands to form insoluble complexes. Factors like temperature, pH, and solvent polarity significantly affect the precipitation process and product purity [3].

3.2 Sol-Gel Process: A wet-chemical technique used to create lanthanide-doped materials. This method allows the incorporation of lanthanide ions into silica or other matrices, leading to applications in optics and catalysis [3].

3.3 Hydrothermal Synthesis: Conducted under elevated temperature and pressure in aqueous or organic solvents, these methods promote crystallization and enhance the stability of lanthanide complexes. This approach is particularly useful for obtaining high- purity nanomaterials [4].

3.4 Electrochemical Synthesis: This technique involves the reduction of lanthanide ions at an electrode, enabling the formation of stable complexes with precise composition. It is used in thin film deposition and electrode material fabrication [4].

3.5 Microwave-Assisted Synthesis: A rapid and energy-efficient method that accelerates reaction kinetics, leading to better homogeneity and crystallinity in lanthanide complexes. This technique is favored for obtaining nanoparticles with controlled morphology.

IV. COORDINATION CHEMISTRY APPROACH

Involves mixing lanthanide salts with organic ligands under controlled pH and temperature to form stable metal-organic frameworks (MOFs) or polynuclear coordination compounds with enhanced properties. Each of these synthesis methods provides specific advantages depending on the application. Optimization of reaction conditions such as temperature, concentration, and ligand-to- metal ratio plays a crucial role in achieving high yields and desired properties. Post- synthesis purification steps like recrystallization, solvent extraction, and chromatographic techniques further refine the complexes for advanced applications in catalysis, biomedical imaging, and drug delivery [5].

V. CHARACTERIZATION OF LANTHANIDE COMPLEXES

Characterization techniques play a crucial role in validating the structural and functional aspects of synthesized lanthanide complexes. Various analytical methods are employed to determine the purity, stability, bonding interactions, and electronic configurations of these complexes.

5.1 UV-Vis Spectroscopy: This technique is used to study the electronic transitions of lanthanide complexes, providing insights into ligand-to-metal charge transfer and f-f transitions. The absorption spectra can confirm the coordination environment and stability of the complex [6].

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5.2 Fourier Transform Infrared Spectroscopy (FTIR): FTIR helps identify functional groups and bonding interactions by analyzing vibrational frequencies of the chemical bonds. The appearance of new peaks or shifts in characteristic bands can indicate successful complex formation [7].

5.3 X-ray Diffraction (XRD): XRD analysis provides information on the crystalline structure of lanthanide complexes. It helps in determining phase purity, lattice parameters, and the degree of crystallinity. Sharp diffraction peaks indicate well-ordered structures, while broad peaks suggest amorphous phases [7].

5.4 Thermogravimetric Analysis (TGA) and Differential Thermal Analysis (DTA): These thermal techniques assess the thermal stability and decomposition behavior of lanthanide complexes. TGA monitors weight loss as a function of temperature, while DTA records exothermic or endothermic events, offering insights into phase transitions and thermal resistance [7].

5.5 Mass Spectrometry (MS): MS helps determine the molecular weight and composition of lanthanide complexes. It is particularly useful for confirming the presence of expected metal-ligand assemblies and identifying possible fragmentation patterns [7].

5.6 Nuclear Magnetic Resonance (NMR) Spectroscopy: Although f-block elements have limited direct NMR activity, lanthanide complexes often influence nearby hydrogen or carbon atoms in ligands. Proton and carbon-13 NMR studies can provide insights into ligand coordination, symmetry, and molecular dynamics [7].

5.7 Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM): SEM and TEM techniques are used to examine the surface morphology and particle size of lanthanide complexes. SEM provides information on surface texture and aggregation, while TEM allows for high-resolution imaging of nanoscale structures [7].

5.8 Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Atomic Absorption Spectroscopy (AAS): These techniques quantify lanthanide metal content in complexes, ensuring the correct stoichiometric ratios are maintained during synthesis [8].

5.9 Fluorescence Spectroscopy: Since many lanthanide complexes exhibit luminescence, fluorescence spectroscopy is used to study their emission properties. This technique is crucial for applications in bioimaging and optical sensing [8].

5.10 Circular Dichroism (CD) Spectroscopy: CD spectroscopy helps in studying chiral lanthanide complexes, providing insights into their optical activity and stereochemistry. Each of these techniques provides crucial information that helps in understanding the structural and electronic properties of lanthanide complexes. By combining multiple characterization methods, researchers can ensure the successful synthesis of stable, high- performance lanthanide compounds tailored for specific applications [8].

VI. BIOLOGICAL APPLICATIONS OF LANTHANIDE COMPLEXES

Lanthanide complexes have emerged as highly promising agents in biomedical research due to their unique physicochemical properties. These complexes exhibit excellent luminescence, magnetic, and catalytic properties, making them ideal candidates for applications in antimicrobial activity, cancer therapy, bioimaging, and drug delivery systems.

6.1 Antimicrobial Activity: Lanthanide complexes demonstrate strong antimicrobial effects against a wide range of bacterial and fungal strains. Their mechanisms of action include disrupting microbial cell walls, inhibiting enzyme activity, and interfering with nucleic acid synthesis. Some lanthanide-based materials have been explored for incorporation into coatings for medical devices, reducing bacterial adhesion and infection risks [9].

6.2 Anticancer Properties: Several lanthanide complexes have been investigated for their ability to selectively target and kill cancerous cells. Their cytotoxic effects are often mediated through reactive oxygen species (ROS) generation, mitochondrial dysfunction, and apoptosis induction. Lanthanide compounds have been explored in combination with conventional chemotherapy agents to enhance treatment efficacy and reduce drug resistance [9].

6.3 Bioimaging Applications: Due to their exceptional photoluminescence properties, lanthanide complexes are extensively used as contrast agents in fluorescence and magnetic resonance imaging (MRI). Their long-lived luminescence, high signal intensity, and excellent photostability allow for high-resolution imaging, aiding in the early detection and diagnosis of diseases [9].

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6.4 Drug Delivery Systems: Lanthanide-based nanoparticles and metal-organic frameworks (MOFs) have been designed for targeted drug delivery, improving drug bioavailability and controlled release. Functionalized lanthanide complexes can carry therapeutic agents to specific disease sites while minimizing systemic toxicity [9].

6.5 Enzyme Inhibition and Biomolecular Interactions: Lanthanide complexes have been explored as enzyme inhibitors and molecular probes for studying biological interactions. They can modulate enzymatic activity and interfere with metabolic pathways, making them valuable tools in drug discovery and diagnostic applications [9].

6.6 Photodynamic Therapy (PDT): Lanthanide complexes have been investigated for their potential in photodynamic therapy, a treatment that involves the activation of photosensitizers with light to produce cytotoxic species that selectively target diseased tissues. The ongoing advancements in lanthanide chemistry continue to expand their applications in modern medicine, making them vital components in therapeutic and diagnostic innovations [9].

VII. CONCLUSION

This research project successfully synthesized and characterized lanthanide complexes using thermal and chemical methods. The synthesized complexes were rigorously analyzed using Fourier Transform Infrared Spectroscopy (FTIR), which confirmed their formation and provided insights into their structural properties. The characteristic vibrational absorptions identified in the FTIR spectra validated the presence of specific ligands and metal centers in the complexes. A significant focus of the project was on evaluating the antimicrobial activity of these lanthanide complexes against medically important microorganisms, including Staphylococcus aureus (Gram-positive) and Escherichia coli (Gram- negative). Using the agar cup method to determine the Minimum Inhibitory Concentration (MIC), the results demonstrated that the synthesized lanthanide complexes exhibited promising antimicrobial properties. This suggests their potential as a new class of antimicrobial agents, addressing the growing concern of antimicrobial resistance. Additionally, the study highlighted the unique structural features and properties of lanthanide complexes, which contribute to their applicability in various advanced fields such as magnetic probes, nuclear medicine, and optical amplifiers. The research underscores the importance of further exploring these complexes for their potential in innovative applications and advancing material science and technology. In conclusion, the project not only advanced the understanding of lanthanide complex synthesis and characterization but also opened new avenues for their application in combating antimicrobial resistance and contributing to technological advancements.

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A Comprehensive Study on Synthesis of Heterocyclic Compound by Using Cyanoacetohydrazide Of Pyrazole

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Abstract: *Use of cyanoacetohydrazides as precursors in reactions leading to construction of heterocycles is reviewed. In addition to some common heterocyclic compounds, synthesis of other uncommon heterocycles such as thiadiazole, oxadiazole, fused heterocycles, and some seven- and eight-membered heterocycles such as benzodiazepine, oxazepine, and benzoxocine starting with cyanoacetohydrazides and their derivatives is also reported. The main aim of this review is to show the application of cyanoacetohydrazides in heterocyclic synthesis via different types of reaction, including cyclocondensation and cyclization. The results are arranged in terms of the type of heterocycle formed, from five-, six-, seven-, to eight-membered and fused rings. This review aims to cover literature up to 2018, showing the distribution of publications involving use of cyanoacetohydrazides for preparation of heterocycles. This study reviewed the use of cyanoacetohydrazide as versatile precursor for synthesis of some heterocyclic compounds, as it contains five different functional groups (cyano group, No. 1, active methylene group, No. 2, carbonyl group, No. 3, amido group, No. 4 and hydrazine group, No.5) The reviewed reactions were classified according to the active centers of cyanoacetohydrazide involved. Accordingly, they are divided into 12 classes in which heterocycles was obtained via the utility of the following functional groups: a - groups No. 1, 2, b - groups No. 1,5, c - groups No. 2, 3 , d - groups No. 2,4 , e - groups No. 2,5 , f- groups No. 3,5 , g- groups No. 4,5 , h- groups No. 1,2,5, i- groups No. 1,4,5, j- groups No. 2,4,5, k- groups No. 1,2,4,5, l-groups No. 2,3,4,5 .This review covers literature up to 2021. This research project investigates the synthesis of heterocyclic compounds using cyanoacetohydrazides in one-pot reactions. Heterocyclic compounds are an essential class of compounds in medicinal chemistry, as they exhibit a wide range of biological activities. The use of cyanoacetohydrazides in a one-pot synthetic approach offers a versatile and efficient route to the construction of various heterocyclic systems. The project aims to explore different reaction conditions, mechanisms, and the potential of these reactions for creating new bioactive heterocycles.*

Keywords: Cyanoacetohydrazides, Cyanoacetic acid hydrazide, Heterocycles, Cyclization.

I. INTRODUCTION

Cyanoacetohydrazide is a versatile reagent as it contains five different functional groups (cyano, active methylene, carbonyl, amido and hydrazino groups). Some of them could act as a nucleophile or as an electrophile. Also they could act in pairs as a bidentate reagent affording several probabilities. the predominance of which depends on the reaction conditions and the other reactants. Among several commercially available substituted hydrazides, cyanoacetic acid hydrazide has received the most attention recently, representing a versatile and convenient intermediate for synthesis of a wide variety of heterocyclic compounds. This substrate can act as an ambident nucleophile, that is, as both an N- and C-nucleophile. Upon treatment of cyanoacetic acid hydrazide with various reactants, attack can take place at five possible sites; nucleophiles can attack the carbon atom of the carbonyl group (position 3) and the carbon atom of the nitrile function (position 5).

In addition, the carbon atom of the active methylene group (position 4) and the nitro- gen atoms of the hydrazine portion (position 1 and position 2) are liable to attack by electrophiles. Reactions of cyanoacetic acid hydrazide with

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numerous reactants (nucleophiles and electrophiles) are used in synthesis of a variety of polyfunctional heterocyclic compounds of biological interest (Fig. 1) [1].

Cyanoacetohydrazide has a hydrazine component. Hydrazines and their derivatives constitute an important class of compounds that has found wide utility in organic synthesis. The chemistry of the carbon–nitrogen double bond of hydrazone is becoming the backbone of condensation reactions in benzo-fused N-heterocycles, which also constitute an important class of compounds for new drug development. It has been claimed that a number of hydrazide hydrazone derivatives possess interesting bioactivity, as explained in Sect. 6 [2]. Reaction of cyanoacetohydrazide with various reactants results in unique properties, many of which are still unknown. To ethyl cyanoacetate 2 in ethanol, hydrazine hydrate 3 is added dropwise at molar ratio of 1:1 with stirring at 0 °C to give the corresponding hydrazide 1. White product is obtained by recrystallization from ethanol (Scheme 1) [3]. In 1999, Galal et al. developed a one-step synthesis of N-sulfonylated pyrazoles via intramolecular cyclization of cyanoaceto-N-arylsulfonylhydrazides. It has been found that cyanoacetohydrazide 1 reacts with arylsulfonyl chloride 4 in ethanol to afford the corresponding cyanoaceto-N-arylsulfonylhydrazides 5. The structures of 5 were established and confirmed on the basis of their elemental analysis and spectral data. On refluxing in ethanol, compounds 5 undergo intramolecular cyclization to give the 5-amino-1-arylsulfonyl-4-pyrazolin-3-ones 7 as major products or the tautomeric5-amino-1-arylsulfonyl-3-hydroxypyrazole structures 8 as minor products (Scheme 2) [4]. In 2008, Marcos and coworkers described a reaction between cyanoacetohydrazide 1 and 1,3- dicarbonyl compounds or α,β-unsaturated systems 9 (such as [aryl]alkylidenemalononitrile, cyanobutanoates) in water.

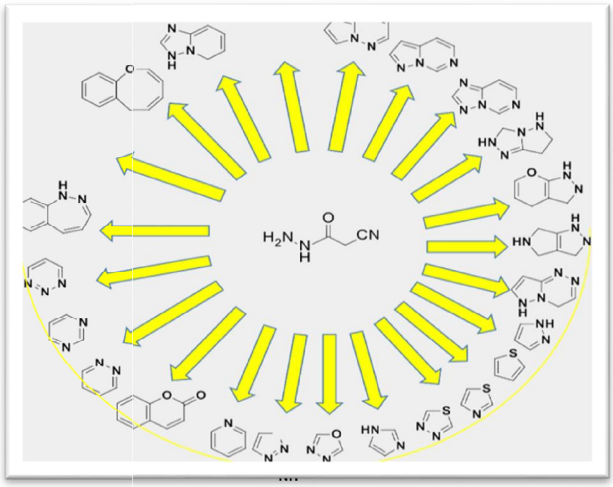


Fig 1: Summary of various heterocyclic compounds synthesized using cyanoacetohydrazide

In 1998, Erian et al. reported a synthesis of 1,3,4-thiadiazole derivatives. They found that treatment of cyanoacetohydrazide 1 with benzoyl isothiocyanate 74 in acetone as solvent afforded exclusively the corresponding 1,3,4-thiadiazole derivative 78. It is believed that 1 reacts initially with benzoyl isothiocyanate 74 to yield the thiosemicarbazide derivative 75, which then cyclizes under the reaction conditions to yield the thiadiazole 76. The latter then condenses with ketone 77 to yield 78. Isolation of 75, 76 was reported earlier from their laboratories. This synthetic methodology could be generalized using a variety of ketones in dioxane as inert solvent. Thus, compounds 78 were obtained in a one-pot reaction on treatment of a boiling mixture of 1 and 74 with acetophenone, benzoylacetonitrile, and phenacyl thiocyanate (Scheme 18) [16]. In 2006, Shams and coworkers studied the treatment of cyanoacetic hydrazide 1 with benzoyl isothiocyanate 74, which led to hydrazinecarbonothioylbenzamide 79. Reaction of 79 with α-haloketones (XCH2C(O)R; X = Cl, R = OEt; X = Cl, R = CH3; X = Br, R = Ph) afforded the respective imidazolethione derivatives 81a–c (Scheme 19) [17]. In 2002, Allam and Nawwar synthesized cyanomethyloxadiazole spiroindoline 84. They found that the condensation product of cyanoacetohydrazide with isatin 82 could be cyclized in acidic medium via its C=N group and its enolic OH to give the oxadiazolo-2-spiroindoline structure 84 (Scheme 20)

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[18].In 2014, Thorat reported synthesis of 2- substituted-5-(2′-thiophene)-1,3,4- Oxadiazole 87 using microwave irradiation. Firstly, cyanoacetic acid hydrazide 1 was obtained by careful addition of hydrazine hydrate to ethyl cyanoacetate 85 in ethanol with stirring at 0 °C. On condensation with 2-thiophenecarbaldehyde, the hydrazide yielded the corresponding hydrazone 86, which on oxidative cyclization with chloramine-T under microwave irradiation yielded the corresponding 2,5- disubstituted-1,3,4-oxadiazole 87. To the mixture of hydrazone 86 and chloramine-T in molar ratio of 1:1, two drops of dimethylsulfoxide (DMSO) were added, and the clear liquid obtained was heated under microwave irradiation for 12 s, followed by addition of alcohol to give solid product (Scheme 21) [19]. In 2002, Demirbas et al. explored the treatment of compound 1 with tertbutox- ycarbonylhydrazone esters 88 in an oil bath at 115 °C, leading to 1,2,4-triazole derivatives 92. Nucleophilic addition of NH2 group on carbon of hydra- zone 88 leads to intermediate 89, which tautomerizes to 90. Intramolecular cyclization of 90 affords product 91. Formation of 3-alkyl-4-amino-5-cyanome- thyl-4H-1,2,4-triazoles 92 was achieved when compounds 91 were refluxed in water (Scheme 22) [20].

II. LITERATURE REVIEW

The Importance of Cyanoacetohydrazide Products in Medicine:-

Pyridine Derivatives:-Pyridine derivatives are currently an important group of organic compounds that are used as bactericides [61], fungicides [62], and anticancer agents [63–66]. Furthermore, 2-pyridones represent a unique class of pharmacophores, found in various therapeutic agents [67]. Pyridine and its substructures are widely scattered and dominantly found in natural products, pharmaceuticals, vitamins, and other functional as well as essential materials. In fact, the pyridine ring system forms the integral backbone of more than 7000 drugs which are already in existence. In recent years, 2-pyridones have garnered much importance, as they exhibit several biological activities such as antitumoral [68], antimalarial [69], analgesic [70], and anti- human immunodeficiency virus (HIV) [71] properties. Moreover, 2-pyridones are a class of recently discovered potent antibacterial agents that are of particular interest due to their in vitro and in vivo antibacterial potencies against bacterial type II DNA topoisomerases, which include two highly homologous enzymes: DNA gyrase and topoisomerase IV [72]. The 2- oxo-3-cyanopyridine nucleus is analogous to the alkaloid ricinine, the first known alkaloid containing a cyano- group. The importance of 2-oxo-3-cyanopyri- dine as a pharmacologically as well as physiologically active potential molecule is highlighted by the synthesis and study of the nonglycosidic cardiotonic agent milrinone, an inhibitor of dipyridine phosphodiesterase (Fig. 3) [73]. In 2011, Al-Said and coworkers studied the anticancer activity of sulfonamide- containing compounds, where the nitrogen of –SO2NH– group is either free or substituted. Compounds 316f and 316b showed significant cytotoxic activity, even higher than that of the reference drug doxorubicin, while compound 316e was nearly as active as doxorubicin. Doxorubicin HCl, one of the most effective anticancer agents, was used as reference drug in this study [12]

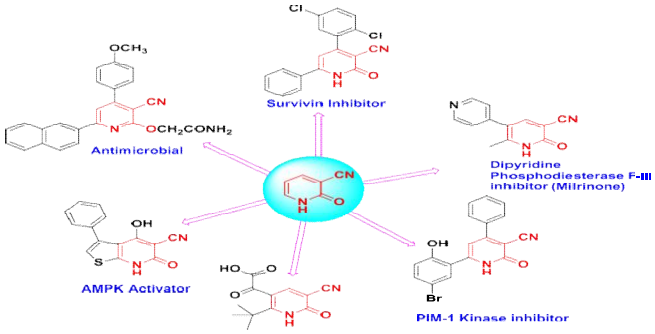


Fig. 2:- Biodynamic activities of different derivatives of 2-oxo-3-cyanopyridine

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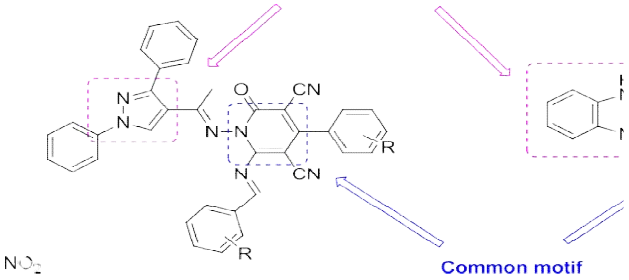


Fig. 3:- Structural relation of compounds 149a–r with previously synthesized compounds NCD1–20

The benzimidazole nucleus is the key building block for numerous compounds that play beneficial roles in the functioning of biologically important molecules [78] and are remarkably effective with respect to both their inhibitory activity and favorable selectivity ratio [79–81]. Benzimidazoles are considered a promising class of bioactive heterocyclic compounds encompassing a diverse range of biological activities such as antiulcer [82], antihelminthic [83], antihypertensive [84], anticoagulant [85], antiinflammatory [86], antimicrobial [87–89], and antiparasitic [90] effects. The azole group of heterocyclic compounds possesses a significant pharmacokinetic profile and lipophilicity that influence the ability of drug to reach the target via transmembrane diffusion, along with promising activity against resistant tuberculosis (TB) by inhibiting biosynthesis of lipids [91, 92].

The intermediates 146, 148 and target compounds 149a–r were investigated for their in vitro antibacterial activity against two Gram-positive and two Gramnegative bacteria and yeast-like pathogenic fungus Candida albicans using conventional broth dilution method. The minimum inhibitory concentration (MIC) was defined as the concentration of compound required to obtain complete inhibition of bacterial growth. MICs of the synthesized compounds were compared with ciprofloxacin and chloramphenicol, and the results are depicted in Table 3. From the bioassay, it was observed that the final analogues 149a–r with substitutions of phenyl ring were most active against all the pathogenic strains studied compared with the intermediate hydrazone 146 and 2-pyridone derivative

148. Therefore, target compounds 149a–r were found to exhibit broad-spectrum antimicrobial efficacy. This can be correlated with the structural variations and different aromatic substitutions in phenyl ring. Among all final active analogues, compound 149q (3-Br, Clog P = 3.9272) exerted highest inhibition against all the bacterial strains and showed highest effi- cacy against Staphylococcus aureus with MIC of 12.5 µg/mL when compared with standards ciprofloxacin (50 µg/mL, Clog P = −0.7252) and chloramphenicol (50 µg/ mL, Clog P = 1.293).

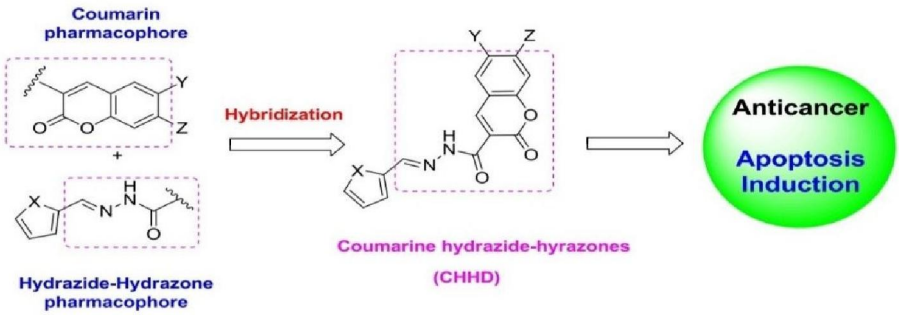


Fig.4 Design of CHHDs as anticancer agents

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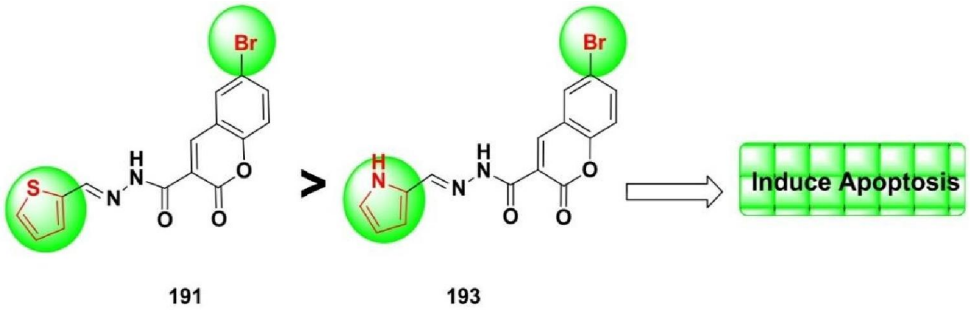


Fig.5 The most potent CHHDs against Hep-G2 cancer cell line

Coumarin Derivatives:-

Natural and synthetic coumarins have attracted great attention due to their wide range of biological properties, including anticancer [94], anti-HIV [95], antiinflammatory [96], and antibacterial [97] activities. Furthermore, their cancer chemo- preventive properties have been recently emphasized [94, 98]. The apoptosis and differentiation-induced activities of coumarins extend to several different cell line models in vitro, and they appear to be the most promising in terms of cancer treatment [99]. Coumarins can exert their anticancer activity by different mechanisms, by either inhibiting the telomerase enzyme [100], inhibiting protein kinase activity and downregulating oncogene expression [101], or inducing caspase-9-mediated apoptosis. Furthermore, it is well known that the hydrazone group plays an important role in the antimicrobial activity. Indeed, a number of hydrazide–hydrazones are claimed to exhibit inter- esting antibacterial–antifungal [104–107], anticonvulsant [107], anti-inflammatory [108], antimalarial [109], and antituberculosis activities [110] (Figs. 5, 6, 7).

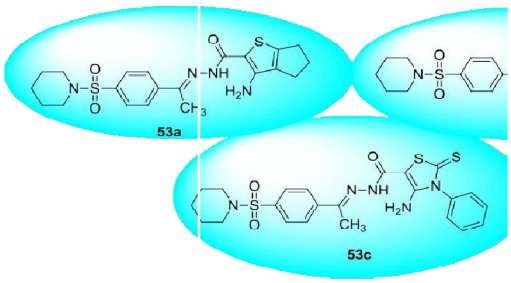


Fig.6 Novel sulfonamides with thiophene and thiazole moieties as anti-breast cancer compounds

Pyrazolopyridine Derivatives

In 2013, Kabirifard et al. studied the synthesis of pyrazolo[3,4-b]pyridine-4-carboxylate 285 by condensation of the cyanoacetic acid hydrazide 1 with ethyl benzoylpyruvate 284 in glacial acetic acid at 70–80 °C. Presumably, the reaction mechanism includes formation of ethyl 2-benzoylmethylene-3-cyano-4-oxo- 4-hydrazinobutanoate 286 from cyanoacetohydrazide 1 and ethyl benzoylpyruvate 284, which then undergoes intramolecular ring closure by attack of NH2 group on nitrile group to give intermediate 287.

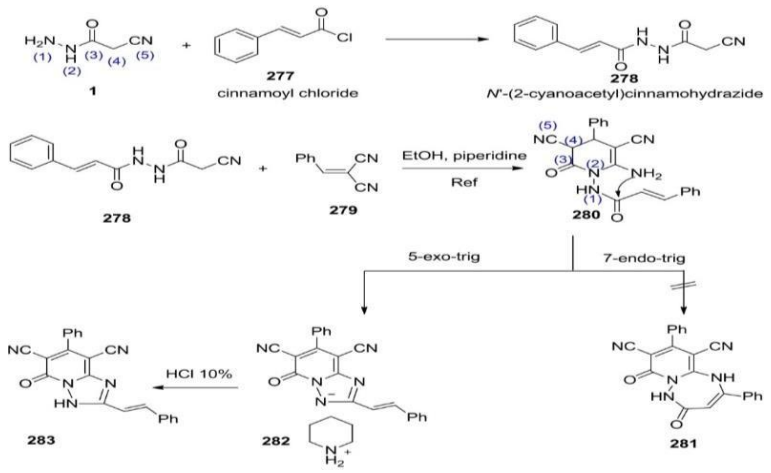
Pyrrolopyridazine Derivatives

In 2007, Abdelrazek and coworkers developed the synthesis of pyrrolo[1,2-b]pyridazine 292. Firstly, compound 289 was allowed to react with N-bromosuccinimide (NBS) in dimethylformamide (DMF) at room temperature to afford the brominated derivative 290. Compound 290 reacts with cyanoacetohydrazide through the terminal hydrazine moiety with elimination of HBr to afford the nonisolable acyclic inter- mediate 291, which undergoes two cyclizations via addition of NH to CN group in position 1, and of the active methylene to the other CN group in the assumed formed pyrrole to afford the pyrrolo[1,2-b]pyridazine derivative 292 [55].

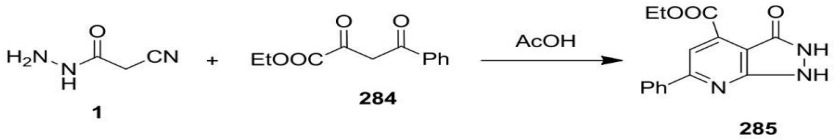
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Pyrazolopyrimidine Derivatives

In 2004, Napoles et al. reported the synthesis of pyrazolo[1,5-a]pyrimidines 294 from cyanoacetohydrazide 1 and push–pull systems. Starting from cyanoacetohydrazide 1 and cinnamonitrile derivatives 293 in DMF, the target compounds could be obtained in just one step, but with low yield due to formation of several byproducts. It was considered that the presence of appropriate reactive center in the ketene-S,S-acetals and 1,3-dithiethanes used as push–pull systems enables the necessary intramolecular cyclizations after the initial nucleophilic attack of the cyanoacetohydrazide [56].



Scheme :- Synthesis of triazolopyridine 283



Scheme :- Synthesis of pyrazolo[3,4-b]pyridine-4-carboxylate 285

Cyanoacetohydrazide as a Versatile Compound (Precursor):-

Cyanoacetohydrazide is a versatile compound extensively utilized in the synthesis of various heterocyclic structures due to its rich functional group composition, including cyano, active methylene, carbonyl, amido, and hydrazino groups. These functional groups enable cyanoacetohydrazide to participate in diverse chemical reactions, leading to the formation of numerous heterocyclic compounds.

A comprehensive review by Hosseini and Bayat (2018) delves into the applications of cyanoacetohydrazides in heterocyclic synthesis. The authors discuss the formation of both common and uncommon heterocycles, such as thiadiazoles, oxadiazoles, fused heterocycles, and larger ring systems like benzodiazepines and oxazepines. The review categorizes the synthesized heterocycles based on ring size, ranging from five- to eight-membered and fused rings, and emphasizes the role of reactions like cyclocondensation and cyclization in these syntheses.

III. METHODOLOGY

The methodology for using cyanoacetohydrazide in the synthesis of heterocyclic compounds involves a series of well-established organic reactions. These methodologies exploit the functional groups present in cyanoacetohydrazide, such as the cyano group (-CN), carbonyl group (C=O), and hydrazide (-NH-NH2), to form various heterocyclic frameworks. Below is an overview of the general approaches used:

Cyclization Reactions

Condensation with Carbonyl Compounds:

Cyanoacetohydrazide reacts with aldehydes or ketones to form hydrazones, which can undergo cyclization to produce heterocyclic rings such as pyrazoles, pyridazines, and others.

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Example: Reaction with aromatic aldehydes to yield substituted pyrazoles. Reaction with Dicarbonyl Compounds:
In the presence of diketones or ketoesters, cyclization leads to the formation of pyrazolines, pyrazolidines, or fused ring systems.
Example: Reaction with 1,3-diketones to form pyrazolines.
Cyclocondensation with Bifunctional Compounds
Cyanoacetohydrazide reacts with bifunctional compounds like isothiocyanates, urea, or thiourea to form heterocycles such as thiadiazoles, oxadiazoles, and triazoles.
Example: Reaction with isothiocyanates produces thiadiazoles.
Michael Addition
The active methylene group in cyanoacetohydrazide participates in Michael addition with α,β-unsaturated carbonyl compounds or nitriles. Subsequent cyclization yields pyrimidines, pyridazines, or other heterocyclic systems.
Multicomponent Reactions (MCRs)
Cyanoacetohydrazide is used in multicomponent reactions involving aldehydes, amines, and other nucleophiles to construct complex heterocyclic frameworks in a one-pot process.
Example: Biginellitype reactions to form dihydropyrimidinones

Reaction with Sulfur or Selenium Donors
Cyanoacetohydrazide reacts with sulfur or selenium sources to yield heterocycles like thiadiazoles, selenadiazoles, or related fused systems.
Formation of Fused Heterocycles
By reacting with compounds containing multiple reactive centers (e.g., phthalic anhydride or maleic anhydride), cyanoacetohydrazide can form polycyclic fused heterocycles such as benzodiazepines or oxazepines.

Catalysis and Reaction Conditions
Catalysts such as Lewis acids (e.g., $ZnCl_2$, $AlCl_3$), bases (e.g., piperidine, triethylamine), or green catalysts (ionic liquids, metal-organic frameworks) are employed to enhance reaction efficiency.
Solvent systems include ethanol, methanol, or water, with some reactions performed under solvent-free conditions for greener synthesis.
Functional Group Modifications
The functional groups in cyanoacetohydrazide can be selectively modified before or after heterocyclic ring formation to introduce additional substituents, increasing molecular diversity.
Representative Reactions:
Formation of Pyrazoles:
Cyanoacetohydrazide + Aldehyde + Acid catalyst → Substituted pyrazoles.
Synthesis of Thiadiazoles:
Cyanoacetohydrazide + Isothiocyanate → Thiadiazoles (under basic or neutral conditions).
Construction of Fused Systems:
Cyanoacetohydrazide + Phthalic anhydride → Benzodiazepines (under thermal or catalyzed conditions).
These methodologies demonstrate the versatility of cyanoacetohydrazide in constructing a wide range of heterocyclic compounds with diverse applications in pharmaceuticals, materials science, and agrochemicals.
Methods of Experimental Work on Cyanoacetohydrazide in the Synthesis of Heterocyclic Compounds of Synthesis of Pyrazoles:-
SYNTHESIS OF PYRAZOLES:

IV. MATERIALS

Cyanoacetohydrazide
Aromatic aldehyde (e.g., benzaldehyde) Glacial acetic acid (as a catalyst) Ethanol (solvent)

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PROCEDURE:
Mix cyanoacetohydrazide (1 mmol) and aromatic aldehyde (1 mmol) in ethanol (10 mL).
Add a few drops of glacial acetic acid as a catalyst
Stir the reaction mixture at room temperature for 2-4 hours.
Monitor the reaction using thin-layer chromatography (TLC).
After completion, filter the precipitate and wash it with cold ethanol.
Recrystallize the product from ethanol to obtain pure pyrazole derivatives.

CHARACTERIZATION
Melting point determination.
Spectroscopic analysis (IR, NMR, and Mass spectroscopy) to confirm the structure. General Notes for Experimental Work:-
Safety Precautions: Handle reagents like isothiocyanates and strong acids with care in a well-ventilated fume hood.
Purity Check: Perform TLC during the reaction and melting point analysis to ensure product purity.
Yield Optimization: Vary the reaction temperature, solvent, and catalyst to maximize yield.
These experiments demonstrate cyanoacetohydrazide's versatility in producing various heterocyclic compounds with straightforward methods. Each reaction can be optimized to improve yield and purity.

IV. FUTURE SCOPE

The versatility and reactivity of cyanoacetohydrazide make it a valuable starting material for heterocyclic synthesis. Its potential can be further explored in various fields, as highlighted below: The versatility and reactivity of cyanoacetohydrazide make it a valuable starting material for heterocyclic synthesis. Its potential can be further explored in various fields, as highlighted below:

Development of New Heterocyclic Frameworks:- Design of Novel Scaffolds: Cyanoacetohydrazide can be used to synthesize previously unexplored heterocyclic frameworks with enhanced bioactivities. Multifunctional Heterocycles: The incorporation of additional functional groups into heterocycles can lead to compounds with tailored properties, suitable for pharmaceuticals and materials science.

Pharmaceutical Applications:- Drug Discovery: Cyanoacetohydrazide-derived heterocycles (e.g., pyrazoles, pyrimidines) can be further explored as potential drugs for treating various diseases, including cancer, inflammation, and microbial infections.Structure-Activity Relationship (SAR) Studies: New derivatives can be synthesized to study their pharmacological profiles and improve potency, selectivity, and bioavailability.Hybrid Molecules: Combining cyanoacetohydrazide-based heterocycles with other bioactive moieties could lead to hybrid molecules with enhanced therapeutic properties.

Green and Sustainable Chemistry:- Eco-Friendly Synthesis: Future studies can focus on developing greener reaction conditions, such as solvent-free reactions, microwave-assisted synthesis, and the use of renewable catalysts. Biocatalysis: Employing enzymes to catalyze reactions involving cyanoacetohydrazide could lead to sustainable and selective synthesis of heterocycles. Atom Economy: Optimization of multicomponent reactions (MCRs) to minimize waste and maximize yield will align with sustainable practices.

Nanotechnology and Material Science:- Functionalized Materials: Cyanoacetohydrazide-based heterocycles can be explored for applications in material science, such as semiconductors, organic light-emitting diodes (OLEDs), and liquid crystals. Coordination Chemistry: These compounds can act as ligands in coordination complexes for developing metal-organic frameworks (MOFs) and catalytically active materials.

Agricultural and Industrial Applications:- Agrochemicals: Cyanoacetohydrazide derivatives can be studied for their potential as pesticides, herbicides, or growth regulators in agriculture. Industrial Catalysts: The development of heterocyclic derivatives for catalytic applications in chemical industries is another avenue to explore.

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6. Theoretical and Computational Chemistry:- Mechanistic Studies: Advanced computational techniques, such as density functional theory (DFT), can be employed to understand reaction mechanisms involving cyanoacetohydrazide. Prediction of Novel Structures: Computational tools can predict new heterocyclic structures and their properties, guiding experimental efforts. QSAR Models: Quantitative structure-activity relationship studies can help identify the most promising derivatives for specific applications.
7. Biomedical Imaging and Diagnostics:- Fluorescent Probes: Cyanoacetohydrazide based heterocycles with unique photophysical properties can be developed as fluorescent probes or imaging agents. Biosensors: Derivatives with selective binding properties can be explored for biosensing applications, such as detecting biological analytes or environmental pollutants.
8. Exploration of Unconventional Reactions:- Photochemical and Electrochemical Reactions: Investigating cyanoacetohydrazide in photo- or electrochemical reactions could lead to the discovery of new synthetic pathways. Radical Chemistry: Radical-based transformations can be studied to access unique heterocyclic systems. By leveraging advances in synthetic methods, computational tools, and interdisciplinary approaches, cyanoacetohydrazide's potential in heterocyclic synthesis can be significantly expanded, contributing to innovations across pharmaceuticals, materials science, and sustainable chemistry.

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VI. CONCLUSION

The constantly increasing number of papers describing synthesis of heterocyclic compounds based on cyanoacetohydrazide and cyanoacetohydrazide derivatives indicates their growing importance as building blocks with high synthetic potential. The aim of this review is to demonstrate the widespread applications of cyanoacetohydrazides in organic synthesis and the outlook for potential future developments. Due to their chemical reactivity and versatility, cyanoacetohydrazide derivatives constitute valuable synthetic units giving rise to a number of useful classes of organic compounds. Despite the extensive research conducted so far, the future holds numerous opportunities for expanding its applications. Advances in green chemistry, computational tools, and innovative synthetic strategies can further optimize its use, making it an essential tool in modern heterocyclic chemistry. Cyanoacetohydrazide is a highly versatile and valuable building block in the synthesis of heterocyclic compounds due to its multifunctional nature and reactivity. Its functional groups, including the cyano, hydrazide, and active methylene units, enable it to participate in a wide range of chemical reactions such as cyclization, cyclocondensation, and multicomponent reactions. These properties have been extensively utilized to construct various heterocyclic frameworks, including pyrazoles, pyrimidines, thiadiazoles, triazoles, and fused ring systems. In conclusion, cyanoacetohydrazide remains a cornerstone in heterocyclic synthesis, with significant potential for further exploration and innovation across scientific and industrial domains.
Compliance with Ethical Standards:- Conflict of Interest The authors declare no competing financial interests

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Comprehensive Review on Microbial Degradation of Dyes

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Abstract: *The extensive use of synthetic dyes in industries such as textiles, paper, and leather has led to severe environmental pollution due to the release of toxic and non-biodegradable dye effluents. Conventional physico-chemical treatment methods, such as adsorption, coagulation, and chemical oxidation, are often inefficient, costly, and environmentally unsustainable. Microbial degradation has emerged as an eco-friendly and cost-effective alternative for dye removal, utilization of bacteria, fungi, and algae to break down the complex dye molecules into less toxic or non-toxic metabolites. Various microbial species, including Pseudomonas, Bacillus, Phanerochaete chrysosporium, and Aspergillus, produce enzymes such as laccases, peroxidases, and azoreductases that facilitate the degradation of different dye classes, including azo, anthraquinone, and triphenylmethane dyes. Factors such as pH, temperature, oxygen availability, and microbial adaptability influence the efficiency of dye biodegradation. Recent advancements in genetic engineering and microbial consortia optimization have further enhanced degradation rates and efficiency. Additionally, immobilization techniques and bioreactor-based systems offer promising solutions for large-scale applications. Despite its potential, challenges such as the toxicity of dye intermediates, microbial resistance, and the need for process optimization remain. Future research should focus on metabolic pathway elucidation, strain improvement, and the integration of microbial degradation with other treatment technologies to achieve complete mineralization of dyes. Overall, microbial degradation provides a sustainable and efficient approach to mitigating dye pollution, promoting environmental safety, and supporting circular bioeconomy initiatives.*

Keywords: environmental pollution, physico-chemical treatment, Bacteria & fungi, biodegradable, sustainable approach

I. INTRODUCTION

Colors play an important role to different industries and in consumer choices. It also contributes to the aesthetic quality of a product, which drives consumers to purchase and therefore contributes to economic growth. The different colors and hues that we see are often derived from the dyes that were used. Natural dyes are the safer and more eco-friendly option compared to synthetic dyes They also pose other advantages such as having antimicrobial properties and offering protection from UV light [1].

Although natural dyes are the safer and the more environmentally friendly option to use, they are quite costly, more tedious to apply, and more difficult to procure. Tyrian purple, for example, is a natural dye from the mucus of Murex sp. snails that retails for about €2000 per gram . Therefore, the use of natural dyes has been deemed to be impractical for many commercial applications. Moreover, natural sources of dyes usually contain only about 2% of actual coloring material, which means that uneconomic amounts of raw material might be needed to obtain the desired shades and hues. This drives up its cost and is thus undesirable for mass production use. It is nearly impossible to reproduce the same shade from batch to batch and fastness properties are rather poor, which make it difficult to apply on textiles

As an alternative, synthetic dyes such as azo dyes have become the primary coloring agent in industries such as the food, cosmetics, and textile industries as trace amounts of dyeing material already produce an intense color. Azo dyes take account for most of the synthetic dyes used as they are easy to synthesize, thus cost-efficient to produce, and generate a variety of colors as there are about 10,000 different azo dyes available [2]. Since azo dyes are synthesized chemically, careful downstream treatments are needed to ensure safety in its usage and disposal.It is important to

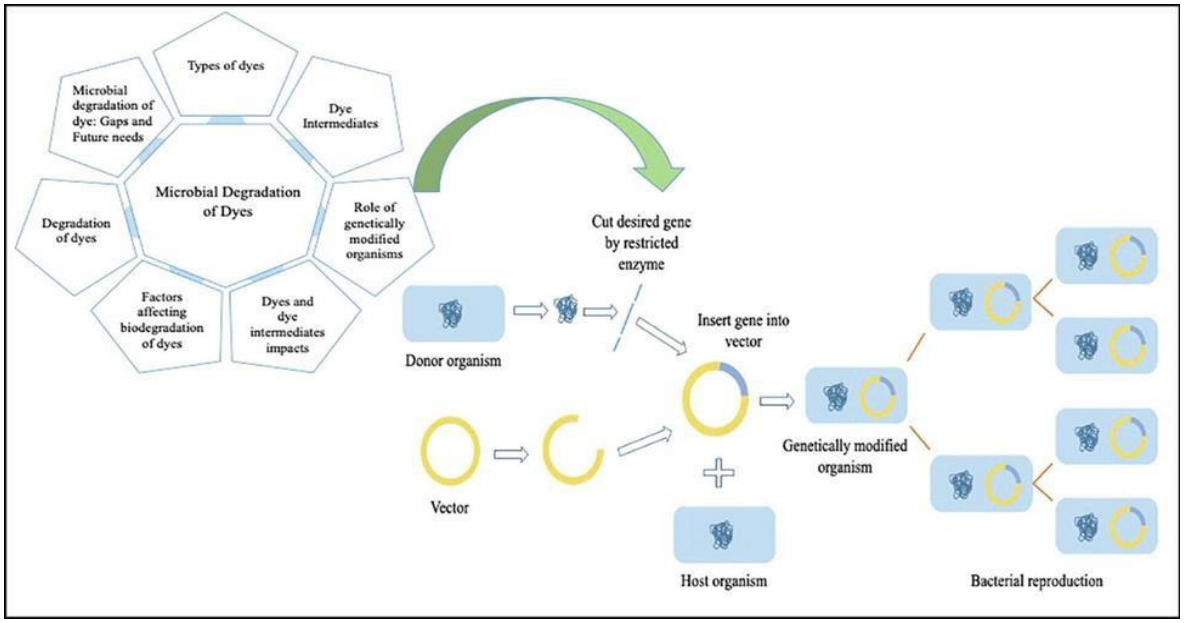
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consider that only 10% of the dye is transferred into the material permanently, and the majority goes into wastewater as effluents. At the same time, trace amounts of dye can lead to severe environmental and health hazards as some azo dyes are toxic, carcinogenic, and mutagenic.The presence of these synthetic dyes can also hamper various biological activities.Therefore, it is important to implement tight regulations for their treatment and disposal.

Several physical and chemical procedures are available for the downstream treatment and waste handling of azo dye containing effluents[3]. Quite often, these approaches are met with skepticism, as these have major downsides such as the ecologically questionable waste disposal for filters and charcoals, generation of toxic intermediates, production of sludge, and the high costs of equipment Thus, finding a more environmentally friendly approach is essential. Here, biological methods can be a more promising solution. This review tackles the treatment methods available for azo dyes especially on the biological context (primarily bacteria) with emphasis on the approach of whole- cell biocatalysis and/or enzymatic degradation. Physical parameters that affect dye decolorization and degradation, such as pH and temperature, are not within the scope of this review.

Impacts of Azo Dyes on Human Health and the Environment

Azo dyes are characterized by the presence of an azo bond (-N = N-) between two or more aromatic rings.The versatility of azo dyes renders them very appealing for various industries such as food and textiles. However, the xenobiotic nature of these dyes calls for proper evaluation of their harmful effects. In the food industry, the use of azo dyes should be critically assessed as they are often used as colorants for sweets and desserts with children as target consumers.Although there are regulations on which dyes may be used or not, these are different by country, which adds to the difficulty of standardizing protocols for the usage of dyes. There are thousands of azo dyes used in various industries. Some of the better-known azo dyes used in the food industry are Brilliant Black BN, Sunset Yellow FCF, Amaranth, Azorubine, Ponceau 4R, and Allura Red AC[4].



The toxicity of some of these azo dyes can be attributed to the reduction of the azo bond, which produces aromatic amines.When ingested orally, the dye reaches the gastrointestinal tract, and the intestinal microflora or mammalian azoreductases cleave the azo bond.The aromatic amines, which are often the final product of azo dye reduction, are subsequently hydroxylated or acetylated, and this adds to the mutagenicity and carcinogenicity of these compounds. The intake of azo dyes can also increase the risk of human bladder cancer, splenic sarcomas, hepatocarcinomas, and nuclear anomalies. They can also cause allergies, dermatitis, and even DNA damage that results in the formation of malignant tumors.Methyl Yellow, which is now banned in different countries, was formerly used for dyeing butter, and

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it was found to cause liver cancer in rats after two to three months of exposure.Another example is the dye Amaranth, which was shown to induce DNA damage in the colon epithelium of mice ,while Brilliant Black BN has shown genotoxicity in human lymphocytes based on in vitro experiments.Sunset Yellow FCF can cause DNA damage and has shown to have toxic effects on the reproductive and neurobehavioral system of tested rodents and chick embryos.Tartrazine was shown to bind to albumin, induce neurotoxicity, impair mental functions, and promote various reactions such as angioedema, nasal congestion, itchy skin, and hives. In the cosmetic and textile industries, 4-aminobenzene or Aniline Yellow, a dye used for printers and as a precursor of other dyes, has been shown to cause high hepatocarcinogenicity and induce tumors to rats.Sudan III, used for coloring non-polar substances such as acrylic emulsions, was also reported as a carcinogen [5].

Impact of Azo Dye Metabolites

As mentioned earlier, not all azo dyes are harmful. However, dyes that were not found to be harmful still pose a threat, since oxidative and reductive metabolism could lead to the formation of toxic aromatic amines. Different studies have identified compounds derived from azo dye metabolism such as benzidine, p-phenylenediamine, aniline, and toluene, which show carcinogenic and mutagenic properties.

Benzidine is a building block of azo dyes such as Congo Red, Direct Black 38, and Direct Red 39. Earlier studies have shown that it can induce tumor cells on different body parts such as the gastrointestinal tract, pancreas, liver, and gallbladder.Benzidine and its congeners, such as 3′ 3- dimethylbenzidine and 3′ 3′ -dichlorobenzidine, were shown to induce carcinoma and tumors. 3′ ,3′ ,- 5,-5′ Tetramethylbenzidine was the only congener of benzidine that was not found to be carcinogenic.

Meanwhile, p-phenylenediamine is another compound that is used as a henna substitute, for the manufacturing of certain polymers in different industries, as a developing agent for films, and as a major component for hair dyes. Initial investigations on p-phenylenediamine showed contrasting results. On the one hand, it was shown to be carcinogenic via an Ames test. On the other hand, it was shown that it did not pose any carcinogenic potential to F344 rats regardless of the sex and the exposure time [6,7].It was also shown to not affect pregnant rats, and a multigenerational reproduction study also showed no negative effects.However, it was discovered that p- phenylenediamine only becomes mutagenic after oxidation.This was corroborated when p- phenylenediamine, in the presence of microsomal fraction and after H2O2 oxidation, became mutagenic to a Salmonella typhimurium tester strain TA1538.This poses a problem as most permanent hair dyes need to be oxidized upon usage to exert their dyeing properties. It was shown that upon absorption, p-phenylenediamine can lead to the formation of tumors in the liver, kidney, urinary bladder, and thyroid gland of rats.It was also found that it can increase the expression of p53 proteins, thereby suggesting an increase in apoptosis and affecting cell viability.A correlation was also observed on the usage of hair dyes and Non-Hodgkin lymphoma and cancer.

Other monocyclic aromatic amines such as p-nitroaniline, o-toluidine (2-methylaniline), 2-nitro- p-phenylenediamine, and o-phenylenediamine were also shown to have carcinogenic and mutagenic properties.These compounds are all highly relevant toxins, as occupational exposure to aromatic amines can explain 25% of bladder cancer cases [8].

Physical and Chemical Treatment of Dyes

As azo dyes pose different risks and hazards to health and the environment, it is necessary to find ways to treat these dyes. Various physical and chemical methods have been explored.Physical methods include techniques such as adsorption and filtration.Adsorption uses materials such as activated carbon that can accumulate compounds to be removed from wastewater at their surface Although activated carbon is effective and has been the primary option for this kind of treatment, it is not often used due to its high cost. Alternatives have been explored, such as peat, banana peels, clay, corn cob, maize, and wheat straw.However, there are some drawbacks due to the problematic waste disposal of these cheaper alternatives. Another frequently used physical method is filtration. It often involves the use of membranes to remove suspended solids and other unwanted materials from water. Although effective, it likewise has

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some drawbacks such as similarly high costs for investment and of materials, deterioration of the membrane or membrane fouling, production of potentially toxic sludge, and again problematic waste disposal.

Chemical treatment involves the use of different chemicals or techniques such as coagulation– flocculation, Fenton's reagent, ozone, and electrochemical methods. Coagulation–flocculation followed by sedimentation are processes used in conventional wastewater treatment facilities [9]. Coagulation involves the use of coagulants to neutralize suspended solids (often with an opposite charge to the coagulant). Once neutralized, the suspended solids can collide and form microflocs. During flocculation, these microflocs can form macroflocs and sediment, upon which they can be removed from water using gravity. Furthermore, the Fenton reaction allows the generation of hydroxyl radicals using Fenton reagent (H2O2 and Fe2+ ions), which can destroy toxic pollutants in wastewater.Although the overall process is cheap, it can lead to a high sludge production as secondary waste. Ozonation uses reactive ozone (O3) to oxidize and disassemble preferentially the chromophores of dyes, but its unstable nature makes it undesirable for wastewater treatment.

These physical and chemical treatments have been used traditionally for wastewater treatment. However, as mentioned earlier, these approaches can pose several drawbacks. Furthermore, dyes may be resistant or recalcitrant to these available treatments [10].

II. CONCLUSION

Azo dyes have become important in different industries, especially because color plays a huge role in consumer choices. However, with the increased usage of azo dyes, several health and environmental problems have emerged, which are caused by some of these azo dyes and its metabolites. As modern societies are striving toward greener solutions, bioremediation should be taken advantage of. Microorganisms have shown versatile performance not only in the biomedical field but also in the realms of environmental application. Microorganisms have tremendous potential still to be explored, and there are numerous enzymes from various microorganisms that should be further studied. The ability of these microorganisms to accept a broad spectrum of xenobiotics must also be also looked upon. Modern technology has displayed tremendous progress over the past decades.

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A Comprehensive Study on Synthesis of Pyridine Using Novel Techniques

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Abstract: *Pyridine is a basic Heterocyclic organic compound. It is structurally related to benzene, with one methene group (=CH-) replaced by nitrogen atom (=N-). It is highly flammable, weakly alkaline, water miscible liquid with a distinctive. This research focuses on developing an environmentally friendly and sustainable approach to the synthesis of pyridine using green chemistry principles. Pyridine derivatives are an important class of heterocyclic compounds with diverse applications in pharmaceuticals, agrochemicals, and materials science. This study explores the synthesis, characterization, and biological evaluation of new pyridine derivatives, highlighting their structure-activity relationships (SAR) and potential applications in drug discovery. The synthesis of heterocyclic compounds under various conditions like solvent-free, reactants immobilized on solid Support, microwave irradiation condition a very important role with plenty of rational therapeutic activities such as antiulcer, antihypertensive, analgesic, Anti-inflammatory, anti-viral, antifungal, anticancer, and antihistaminic. Advanced spectroscopic techniques were employed for structural confirmation, and in vitro assays demonstrated promising pharmacological activities, suggesting further exploration for therapeutic development. Traditional synthetic approaches often suffer from limitations such as harsh reaction conditions, low yields, and environmental concerns. This study presents a novel technique for the synthesis of pyridine derivatives, utilizing a more sustainable and efficient catalytic system. The proposed method employs eco-friendly reagents and optimized reaction conditions to enhance selectivity and yield while minimizing by-products. Advanced spectroscopic techniques (NMR, FTIR, and MS) confirm the structural integrity of the synthesized compounds. The novel approach offers a promising alternative to conventional methods, providing a more viable and scalable route for pyridine derivative synthesis in both academic and industrial applications.*

Keywords: Pyridine, Eco- friendly, solvent free, green synthesis, microwave assist catalyst

I. INTRODUCTION

Pyridine, a six-membered heterocyclic aromatic compound containing one nitrogen atom, is an essential structure in organic chemistry due to its presence in various natural products, pharmaceuticals, agrochemicals, and industrial compounds. Pyridine derivatives play a crucial role in a wide range of applications, including medicinal chemistry, material science, and catalysis [1]. These derivatives are key building blocks in the synthesis of a variety of bioactive molecules, serving as precursors for drugs, agrochemicals, and ligands for metal catalysts. Traditional methods of synthesizing pyridine and its derivatives include the Bönnemann–Pinner synthesis, Hantzsch pyridine synthesis, and Skraup synthesis, which typically rely on classic organic reactions such as cyclization of appropriate precursors. However, these methods often face challenges such as low yields, limited selectivity, and the use of hazardous reagents [2]. As a result, there has been a continuous effort to explore novel techniques for pyridine synthesis, aiming for greener, more efficient, and scalable processes. The versatility of pyridine and its derivatives arises from the ability to modify its structure and functional groups, making it highly adaptable to diverse chemical transformations [3]. Pyridine-based compounds exhibit a broad spectrum of biological activities, such as antimicrobial, anticancer, anti-inflammatory, and antidiabetic properties. As a result, many pyridine derivatives are incorporated into pharmaceutical formulations and treatments for various diseases [4]. In materials science, pyridine derivatives are utilized in the design and development of new materials, including polymers, liquid crystals, and conductive organic materials, which have applications in electronic devices, sensors, and energy storage. Pyridine is also crucial in catalysis [5], where it is often

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used as a ligand in coordination complexes or in organocatalysis, enhancing the efficiency and selectivity of chemical reactions, especially in asymmetric synthesis. Given its significance, the synthesis of pyridine and its derivatives has been a subject of intense research, focusing on improving reaction efficiencies, selectivity, and sustainability [6]. Advances in catalytic processes, microwave-assisted synthesis, and green chemistry have led to the development of novel and efficient methodologies for synthesizing pyridine derivatives, making it easier to access these important compounds for a variety of industrial and scientific applications [7].

1.1. Some Methods use For Synthesis of Pyridine:-

Recent advancements in the field have introduced a variety of innovative approaches for the synthesis of pyridine derivatives [8].

Some of the most notable methods include:

1.1.1. Catalytic Approaches: The use of transition metal catalysts (e.g., palladium, copper, or nickel) in the synthesis of pyridine derivatives has gained significant attention. These catalysts can promote highly selective C–C and C–N bond formation, often under mild reaction conditions. Metal-catalyzed cross-coupling reactions, such as Suzuki–Miyaura and Buchwald–Hartwig reactions, are utilized for the synthesis of functionalized pyridines with excellent yields and regioselectivity [9].

1.1.2. Microwave-Assisted Synthesis: Microwave-assisted organic synthesis has revolutionized the field by providing faster and more efficient reaction times, often yielding higher purity products. This technique has been applied to both the synthesis of pyridine rings and the functionalization of pyridine derivatives. The rapid heating and uniform distribution of energy in microwave reactions enhance reaction rates and reduce by-products [10].

1.1.3. Green Chemistry Approaches: With a growing emphasis on sustainability, the development of eco-friendly methods for pyridine synthesis is becoming increasingly important. Solvent-free reactions, aqueous-phase reactions, and the use of renewable resources are some strategies being explored to minimize the environmental impact of pyridine production. Additionally, the use of biocatalysts and enzyme-mediated reactions for the synthesis of pyridine derivatives offers a promising green alternative [11].

1.1.4. Electrochemical Synthesis: Electrochemistry has emerged as a cutting-edge method for the synthesis of pyridine derivatives, where electrochemical processes enable selective transformations without the need for traditional chemical reagents. This technique is particularly advantageous for sustainable chemistry, as it can reduce waste, decrease the need for harsh conditions, and offer high selectivity for certain transformations [12].

1.1.5. Photochemistry and Photoredox Catalysis: Photochemical methods, leveraging light energy, offer unique advantages in the selective synthesis of pyridine derivatives. Photoredox catalysis, in particular, has been used to initiate novel reactions that are difficult to achieve under traditional thermal conditions, leading to the formation of pyridine-based compounds with high efficiency and functional group tolerance [13].

The development of these novel techniques in pyridine synthesis represents an exciting frontier in organic chemistry, where efficiency, sustainability, and precision are key. By overcoming the limitations of conventional methods, these advanced strategies allow the creation of complex and diverse pyridine derivatives with broad applications in pharmaceuticals, materials science, and beyond [14].

II. LITERATURE REVIEW

2.1. Pyridines

2.1. Preparation of Pyridines

Asokan et al. has developed a practical synthesis of 4-chloropyridines 1 from carbonyl compounds having two enolizable carbons adjacent to the carbonyl such as compound 2 <04T5069>. Ketone 2 was subjected to Vilsmeier-Haack reaction conditions leading to the formation of conjugated iminium salts 3, which upon reacting with ammonium acetate cyclized to form the 4-chloropyridines 1 after basic workup. Reissig and co-workers discovered a new synthesis of trifluoromethyl-substituted pyridines from the reaction of lithiated methoxyallenes and nitriles in the presence of trifluoroacetic acid <04CEJ4283>. The authors postulate that the reaction goes through initial protonation of iminoallene followed by nucleophilic addition of the trifluoroacetate anion onto the iminoallene to give . Intermediate then undergos intramolecular acyl transfer to give and subsequent aldol condensation yields the pyridinol as shown in

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Scheme 2. Kerwin et al. has shown that azaenyne allenes readily form the α,5-didehydro-3-picoline diradicals, which can then be trapped with 1,4-cyclohexadiene, chloroform-d, and methanol to produce various pyridine products <04OL2059>. 1,4-Dihydropyridines continue to be of interest to medicinal chemists due to their biological activity. The synthesis of choice is the Hantzsch dihydropyridine synthesis <04JMC3180; 04JMC2688; 04JMC254; 04JMC3163>. Zolfigol et al. has developed a mild solvent free modification to this synthesis with improved yields <04SL827>. Tripathi and co-workers modified this method further through use of tetrabutylammonium hydrogen sulfate as a phase transfer catalyst and diethylene glycol as an eco-friendly solvent <04TL9011>. Dondoni et al. utilized a one-pot thermal Hantzsch reaction for the synthesis of highly functionalized β-pyridylalanines as shown in Scheme 9 <04TL2311>. They simplified the purification process by incorporating polymer-supported scavengers to remove excess reagents. A mixed resin bed of strongly acidic resin and strongly basic resin was used to remove unreacted enamine and ketoester, respectively. The unreacted aldehyde and intermediate side products were scavenged with nucleophilic aminomethylated polystyrene.

2.2. Synthetic Approaches

The synthesis of pyridine involves several methods like Chichibabin synthesis, Bonnemann cyclization, Krohnke pyridine synthesis, Gattermann-Skita synthesis and several other methods. In Chichibabin pyridine synthesis firstly, acrolein is formed via Knoevenagel condensation from acetaldehyde and formaldehyde, then acrolein condenses with acetaldehyde and ammonia to give aminopyridine. In Bonnemann cyclization, the trimerization of one part of a nitrile molecule and two parts of acetylene gives pyridine. In Krohnke pyridine synthesis, the reaction of pyridine with bromomethyl ketones gives related pyridinium salt. In Gattermann-Skita synthesis, malonate ester was made to react with dichloro methylamine.

2.3. Anti-Inflammatory Activity

The in vitro anti-inflammatory action of all tested compounds was estimated against carrageenan-induced paw edema in male Wister rats (180–200 g each) using diclofenac as a reference drug on the basis of a Winter et al. modified process. (55,56) Diclofenac was evaluated at 5 mg/kg (56) of body weight for the animal used. Prior to the test, all animals experienced at least a 1 week acclimatization period. All of the investigational procedure was done in accordance with the strategies of the Institutional Animals Ethics Committee (IEAC). Changes in paw volume (% of edema inhibition) were produced and compared by subplantar dose of 100.0 µL of 1.0% newly prepared carrageenan solution in bidistilled H2O into the left hind paw of each rat. (3,56) The test agents were injected half an hour earlier to carrageenan addition, The comparison was done after 1, 3, and 6 h from induction of inflammation (Table 2) and showed wide range of anti-inflammatory effects (7.59–46.9%; 1 h), (7.59–52.80%; 3 h)
and (9.37–54.37%; 6 h) against to the reference drug diclofenac (28.26%, 1 h; 20.79%, 3 h; 20.79%, 6 h). From the recorded results in, it appears that of all 15 compounds evaluated for anti-inflammatory activity, the titled compounds could be promising anti-inflammatory candidates when using diclofenac as a reference drug (28.26%; 1 h). It was found that the most potent four compounds were 5a, 5f, 5g, and 5h with a % edema inhibition of (46.9%; 1 h), (34.27%; 1 h), (43.46%; 1 h), and (30.74%; 1 h), respectively.

2.4. Inflammation

Inflammation is a biological response of the immune system that can be triggered by a variety of factors, including pathogens, damaged cells and toxic compounds. These factors may induce acute and/or chronic inflammatory responses in the heart, pancreas, liver, kidney, lung, brain, intestinal tract and reproductive system, potentially leading to tissue damage or disease. Both infectious and non- infectious agents and cell damage activate inflammatory cells and trigger inflammatory signaling pathways, most commonly the NF-κB, MAPK, and JAK-STAT pathways. Here, we review inflammatory responses within organs, focusing on the etiology of inflammation, inflammatory response mechanisms, resolution of inflammation, and organ- specific inflammatory responses. Inflammation is a protective response that develops against tissue injury and infection. Chronic inflammation, on the other hand, is the key player in the pathogenesis of many inflammatory disorders including cancer. The cytokine storm, an inflammatory response flaring

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out of control, is mostly responsible for the mortality in COVID-19 patients. Anti- inflammatory drugs inhibit cyclooxygenases (COX), which are involved in the biosynthesis of prostaglandins that promote inflammation. The conventional non-steroidal anti-inflammatory drugs (NSAIDs) are associated with gastric and renal side-effects, as they inhibit both the constitutive COX-1 and the inducible COX-2. The majority of selective COX-2 inhibitors (COXIBs) are without gastric side-effects but are associated with cardiac side-effects on long- term use.

III. REACTION AND MECHANISM OF PYRIDINE

The synthesis of pyridine, a six-membered aromatic heterocycle with one nitrogen atom, can be achieved through several methods. Here are some of the most important synthetic methods for pyridine along with their reaction mechanisms:

3.1. Hantzsch Pyridine Synthesis (Hantzsch Method)

This method involves the condensation of β-ketoesters with ammonia (or primary amines) and an aldehyde. This reaction is a popular route for the synthesis of pyridine derivatives.

Reaction:

• Reactants: β-ketoester, ammonia (NH_3) or a primary amine, aldehyde (e.g., acetaldehyde).
• Product: Pyridine

Mechanism:

Step 1: The β-ketoester reacts with ammonia or a primary amine to form a Schiff base (imine) intermediate. β - ketoester + NH_3 → Schiff base

Step 2: The Schiff base then undergoes nucleophilic attack by the carbonyl group of the aldehyde (such as acetaldehyde), leading to the formation of a dihydropyridine intermediate.

Schiff base + Aldehyde → Dihydropyridine intermediate

Step 3: The dihydropyridine undergoes cyclization (formation of the pyridine ring) and dehydration to yield the final pyridine product. Dihydropyridine intermediate → Pyridine + H_2O

3.2. Chichibabin Pyridine Synthesis (Chichibabin Reaction)

The Chichibabin synthesis involves the direct synthesis of pyridine from aldehydes and ammonia or amines in the presence of a reducing agent like sodium metal.

Reaction:

• Reactants: Aldehyde (e.g., acetaldehyde), ammonia (NH_3) or a primary amine, sodium (Na).
• Product: Pyridine

Mechanism:

Step 1: The aldehyde reacts with ammonia or a primary amine to form a Schiff base (an imine).

Aldehyde + NH_3 → Schiff base

Step 2: The Schiff base is then subjected to a dehydrogenation step promoted by sodium (Na), which generates a dihydropyridine intermediate. The sodium donates electrons to the Schiff base, initiating the reduction process.

Step 3: The intermediate undergoes cyclization and elimination of hydrogen to form the pyridine ring structure.

Dihydropyridine intermediate → Pyridine + H_2

3.3. Skraup Pyridine Synthesis

The Skraup synthesis involves the reaction of aniline (phenylamine) with glycerol in the presence of sulfuric acid, and it produces pyridine through a series of complex reactions.

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Reaction:
Reactants: Aniline ($C_6H_5NH_2$), glycerol ($C_3H_8O_3$), concentrated sulfuric acid (H_2SO_4).
Product: Pyridine
Mechanism:
Step 1: Aniline reacts with glycerol in the presence of sulfuric acid to form an intermediate that undergoes electrophilic substitution.
Step 2: The sulfuric acid acts as a catalyst and dehydrating agent, promoting the formation of a pyridine ring through cyclization.
Step 3: Dehydration and further rearrangement of the intermediate result in the formation of pyridine.

3.4. Bönnemann Pyridine Synthesis

The Bönnemann synthesis is a method where pyridine is synthesized from 1,5-diketones using ammonia or primary amines, under basic conditions.

Reaction:
Reactants: 1,5-diketones, ammonia (NH_3) or primary amines, base (e.g., sodium acetate).
Product: Pyridine
Mechanism:
Step 1: The 1,5-diketone reacts with ammonia or a primary amine to form a Schiff base (imine).
Step 2: The intermediate undergoes nucleophilic attack by the nitrogen atom, leading to the formation of a dihydropyridine intermediate.
Step 3: The intermediate undergoes dehydration, resulting in the formation of the pyridine ring.

IV. APPLICATION

Pyridine and its derivatives are widely used in various fields due to their unique chemical properties. Here are some key applications of pyridine synthesis.

4.1. Pharmaceutical Industry:

Pyridine is a core structure in many drugs, including antihistamines (e.g., loratadine), tuberculosis drugs (e.g., isoniazid), and cardiovascular drugs.
Used in the synthesis of vitamin B3 (niacin) and vitamin B6 derivatives.

4.2. Agrochemicals

Pyridine-based compounds are used in pesticides, herbicides, and fungicides (e.g., paraquat and diquat). Essential in the production of plant growth regulators.

4.3. Chemical Solvents & Catalysts

Used as a solvent in chemical reactions, especially in dehydrohalogenation and acylation reactions. Acts as a base catalyst in organic synthesis.

4.4. Dye & Pigment Industry

Pyridine derivatives are used in the synthesis of dyes, pigments, and optical brighteners.

4.5. Polymer & Material Science:

Used in the production of advanced materials, including liquid crystal displays (LCDs) and conducting polymers.

4.6. Flavoring & Fragrance Industry:

Some pyridine derivatives contribute to the flavoring industry, though their strong odor requires careful handling.

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V. FUTURE SCOPE

The future scope of pyridine synthesis using green chemistry holds significant potential due to the increasing demand for more sustainable and environmentally-friendly methods in chemical production. The development of green chemistry methods for synthesizing pyridine will be influenced by advances in catalysis, alternative feedstocks, process optimization, and solvent-free reactions. Below are some key areas for future research and development:

5.1. Development of New Catalysts:

Biocatalysts: Enzyme-based catalysts, or biocatalysts, are of growing interest in green chemistry because of their selectivity and mild reaction conditions. Future work could focus on engineering enzymes to catalyze the formation of pyridine from simple, renewable precursors, potentially reducing the need for harsh chemicals or high temperatures.

Nanocatalysts: The use of nanomaterials (e.g., metal nanoparticles or carbon-based nanomaterials) as catalysts could improve the efficiency, selectivity, and recyclability of pyridine synthesis. Nanocatalysts can provide high surface area, which may enhance reaction rates and allow for reusability, reducing waste generation.

5.2. Use of Renewable Feedstocks:

Biomass-Derived Precursors: Pyridine synthesis could increasingly rely on renewable biomass sources instead of petroleum-based feedstocks. Research could focus on identifying and optimizing processes that convert bio-derived materials (such as glycerol, sugars, or lignocellulosic biomass) into pyridine or its precursors. This would reduce dependence on fossil fuels and lower the carbon footprint of production.

Green Ammonia Production: The conventional method of producing ammonia involves energy-intensive processes (e.g., Haber-Bosch process). Future research could focus on developing more sustainable, low-energy methods for ammonia production from renewable sources (such as water and nitrogen), which would make the ammonia-based pyridine synthesis greener.

5.3. Alternative Solvent Systems:

Supercritical Fluids: Supercritical CO_2 ($scCO_2$) is a promising green solvent for chemical reactions due to its low toxicity, recyclability, and ability to dissolve a wide range of organic compounds. Future developments in using $scCO_2$ as a reaction medium for pyridine synthesis could offer an alternative to traditional organic solvents, leading to reduced environmental impact.

Deep Eutectic Solvents (DES): DES, a new class of green solvents that are typically non-toxic, biodegradable, and cheap, are gaining attention in green chemistry. Researchers could explore their potential as solvents for pyridine synthesis, especially in catalytic reactions that require mild conditions.

5.4. Microwave and Ultrasound-Assisted Synthesis:

Microwave-Assisted Synthesis: As demonstrated in current methods, microwave- assisted reactions reduce energy consumption and improve reaction times. Future studies could focus on optimizing the conditions (e.g., power, temperature, time) and exploring new catalytic systems to further improve yields and reduce environmental impacts.

Ultrasound-Assisted Synthesis: Sonochemistry, or the use of ultrasound in reactions, can enhance reaction rates, improve mixing, and promote efficient energy transfer. Research could explore ultrasound as a green alternative to traditional heating for pyridine synthesis.

5.5. Solvent-Free and Solid-State Reactions:

Future research could focus on expanding solvent-free methods for pyridine synthesis. Solid-state reactions, in which all reactants and catalysts are in a solid phase, could significantly reduce the need for organic solvents and minimize waste generation.

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Mechanochemistry (the use of mechanical force to promote chemical reactions) offers an innovative approach to solvent-free pyridine synthesis. Solid reagents or mixtures could be activated under mechanical stress, potentially leading to cleaner processes with fewer by- products.

VI. CONCLUSION

The synthesis of pyridine and its derivatives through green chemistry principles represents a significant step toward sustainable and environmentally friendly chemical processes. Traditional methods for pyridine synthesis often involve hazardous reagents such as phosphorus oxychloride ($POCl_3$), thionyl chloride ($SOCl_2$), or molecular chlorine (Cl_2), which pose risks of toxicity, corrosiv eness, and waste generation. Additionally, conventional synthesis usually requires prolonged reaction times, high temperatures, and the use of harmful organic solvents, all of which contribute to environmental pollution and high energy consumption. Green chemistry offers innovative alternatives that not only minimize these hazards but also improve reaction efficiency, selectivity, and overall sustainability. Microwave- assisted synthesis, for example, has emerged as an effective green method for chlorination and other functionalization reactions of pyridine. Microwave irradiation provides rapid and uniform heating, significantly reducing reaction time from several hours to just a few minutes while lowering energy requirements. This method also enhances reaction selectivity, reducing the formation of unwanted byproducts and increasing overall yields. Furthermore, the use of mild chlorinating agents such as N-chlorosuccinimide (NCS) instead of hazardous chlorine gas aligns with the principles of green chemistry by reducing toxicity and waste. Another key advantage of green pyridine synthesis is the shift toward solvent-free or water-based reaction conditions. Many conventional reactions rely on toxic organic solvents such as benzene, chloroform, or dichloromethane, which contribute to environmental pollution and pose health risks. In contrast, green chemistry approaches emphasize the use of benign solvents such as water, ethanol, or ionic liquids, which are safer and biodegradable. In some cases, solvent-free synthesis eliminates the need for hazardous solvents altogether, further reducing the ecological footprint of pyridine production. Additionally, catalyst innovations play a crucial role in sustainable pyridine synthesis. Green catalysts, such as reusable metal catalysts, enzyme-based systems, or heterogeneous catalysts, not only improve reaction efficiency but also facilitate catalyst recovery and reuse, minimizing waste. These advancements contribute to the overall sustainability of pyridine chemistry by reducing the reliance on non-renewable resources and lowering the environmental impact of industrial-scale production. Overall, the application of green chemistry in pyridine synthesis demonstrates how modern scientific advancements can address environmental concerns while maintaining high efficiency and product quality.

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A Study on Electrophilic Aromatic Substitution of Acetanilide

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Abstract: *Acetanilide was the first aniline derivative serendipitously found to possess analgesic as well as antipyretic property. The literature review shows the study and preparation of acetanilide. The present work was planned to prepare acetanilide from different aldehydes. Acetanilide was prepared by reacting aniline, acetic anhydride and glacial acetic acid. The produced acetanilide is the substituted with different aromatic aldehydes.[1]*

Electrophilic Aromatic Substitution (EAS) of acetanilide involves the substitution of a hydrogen atom on the aromatic ring of acetanilide by an electrophile. In this process, the nucleophilic aromatic ring reacts with the electrophile, and one of its hydrogens is replaced by the incoming substituent. Acetanilide, with the formula C8H9NO, consists of a benzene ring attached to an amide group (-NHCOCH3).

The preparation of acetanilide from aniline via electrophilic aromatic substitution is a well-established method in organic chemistry. The process involves the activation of the aniline ring by the amino group, which makes it highly reactive toward electrophilic acetylation. Acetic anhydride is commonly used as the acetylating agent due to its higher reactivity compared to glacial acetic acid. Acetanilide remains a key intermediate in the chemical and pharmaceutical industries, underscoring the importance of this reaction in organic synthesis.[1].

Keywords: Acetanilide, Aldehyde Derivatives, Benzene, Amide group, Aniline

I. INTRODUCTION

Electrophilic Aromatic Substitution (EAS) is a crucial reaction mechanism in organic chemistry, enabling the modification of aromatic compounds by replacing one of their hydrogen atoms with an electrophilic species. The mechanism of EAS is essential for understanding the reactivity and functionalization of benzene rings, which serve as the core structure in many important organic molecules. Acetanilide, a derivative of aniline ($C_6H_5NH_2$), provides an interesting example of EAS due to the influence of the electron-donating amide group ($–NHCOCH_3$) on the aromatic ring, which significantly affects its reactivity.

Acetanilide is a white organic solid compound used primarily in organic synthesis. N-phenylacetamide, acetanilide and acetaniline are other names of this compound. It was used in the past to treat fever and headache and was known as Antifebrin by its brand name. [2]

In an electrophilic aromatic substitution, the first step involves the generation of an electrophile. Common electrophiles for EAS reactions include species like halogen ions (Cl_2, Br_2), nitronium ion (NO_2^+), sulfonium ion (SO_3H^+), or even alkyl groups (R^+). Once the electrophile is generated, it interacts with the electron-rich aromatic ring, where the amide group of acetanilide makes the ortho- and para-positions more reactive. The electrophile attacks one of these positions, forming a sigma complex, also known as an arenium ion or carbocation intermediate. This intermediate is a high-energy species in which the aromaticity of the ring is temporarily disrupted. The final step in the mechanism involves the loss of a proton (H^+), which restores the aromaticity of the ring, resulting in the formation of the substituted aromatic compound.

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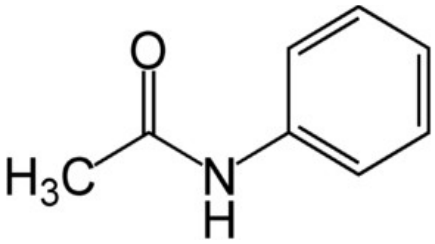
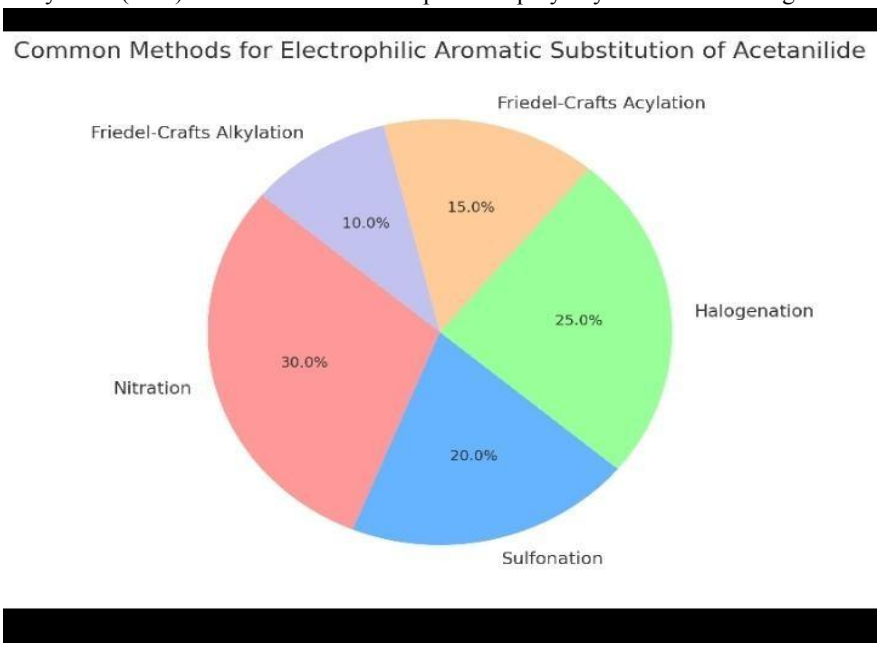


Fig.1. Structure of acetanilide [4]

Common methods for electrophilic aromatic substitution of acetanilide:

Electrophilic aromatic substitution (EAS) of acetanilide commonly occurs through the following reactions:

1. Nitration (30%) – Produces p-nitroacetanilide, useful in dye and pharmaceutical synthesis.
2. Sulfonation (20%) – Introduces a sulfonyl (-SO_3H) group, making the compound more water-soluble.
3. Halogenation (25%) – Selectively introduces halogens, crucial for agrochemicals and pharmaceuticals.
4. Friedel-Crafts Acylation (15%) – Adds an acyl group, modifying reactivity for further functionalization.
5. Friedel-Crafts Alkylation (10%) – Less common due to potential polyalkylation and rearrangements.



1. **Nitration of Acetanilide :**Nitration of acetanilide is a classic example of electrophilic aromatic substitution, where the acetamido group (-$NHCOCH_3$) directs the incoming nitro group primarily to the para position, with a lesser extent to the ortho position. The most common method employs a mixture of concentrated nitric acid and sulfuric acid, known as "mixed acid," to generate the nitronium ion (NO_2^+), the active electrophile in the reaction. Electrophilic aromatic substitution (EAS) reactions introduce electrophiles into the benzene ring of acetanilide, which is activated by the electron-donating –$NHCOCH_3$ group. The para position is typically favored due to steric hindrance at the ortho position.

2. Bromination of acetanilide :A common method for the bromination of acetanilide via electrophilic aromatic substitution involves dissolving acetanilide in glacial acetic acid and then adding a bromine solution in acetic acid. This reaction typically yields a mixture of ortho- and para-bromoacetanilide isomers, with the para isomer often being favored due to steric considerations.

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3. Sulphonation of acetanilide :A common method for the sulfonation of acetanilide involves the introduction of a sulfonic acid group ($-SO_3H$) onto the aromatic ring through an electrophilic aromatic substitution reaction. This process typically yields para-acetamidobenzenesulfonic acid as the major product due to steric and electronic effects.[7]

COMPARISON BETWEEN NITRATION OF ACETANILIDE , BROMINATION AND CHLORO-SULFONATION OF ACETANILIDE :

Reactions	Nitration of Acetanilide	Bromination of acetanilide	Chloro sulfonation of acetanilide
Reagents used	$HNO_3+H_2SO_4$	Br_2+Acetic acid	$Cl_2+H_2SO_4+SO_2CL_2$
Electrophile	NO_2^+(NITRONIUM ION)	Br^+(BROMONIUM ION)	SO_2CL^+(SULFOCHLORIDE ION)
Major product	p-nitroacetanilide	p-bromoacetanilide	p-chloro-sulfonyl-acetanilide
Minor product	o-nitroacetanilide	o-bromoacetanilide	o-chloro-sulfonyl-acetanilide
Reaction type	EAS	EAS	EAS
Otho/Para Directing	Para-directing due to the electron donating - $NHCOCH_3$ group	Para-directing due to the electron donating - $NHCOCH_3$ group	Para-directing due to the electron donating - $NHCOCH_3$ group
Deactivating or activating	Moderately activating(amide group)	Moderately activating(amide group)	Moderately activating(amide group)
Solvent used	Concentrated H_2SO_4	Acetic acid	H_2SO_4
Reaction condition	Cold condition (0-5°C) to prevent over nitration	Room temperature or slightly warm	Heated condition for better yield
Application	Used in dye and drug synthesis	Used in pharmaceuticals and agrochemicals	Used in sulfonamide drug synthesis

GENERAL MECHANISM OF ELECTROPHILIC AROMATIC SUBSTITUTION OF ACETANILIDE :

The Electrophilic Aromatic Substitution (EAS) of Acetanilide follows a general two-step mechanism:

1. Formation of the Arenium Ion (σ-Complex)

The benzene ring of acetanilide has an electron-donating amide ($-NHCOCH_3$) group, which activates the ring towards electrophilic attack. The incoming electrophile (E^+), such as NO_2^+ in nitration, attacks the ring at the para position (major product) due to resonance stabilization.

2. Restoration of Aromaticity

A base (like HSO_4^- in nitration) removes a proton from the carbon bearing the electrophile, restoring aromaticity and forming the final substituted product.[8],[9]

Mechanism of nitration of acetanilide :

The nitration of acetanilide is an electrophilic aromatic substitution reaction where a nitro group ($-NO_2$) is introduced into the aromatic ring of acetanilide. The acetamido group ($-NHCOCH_3$) is an electron-donating group that directs the nitration predominantly to the para position, yielding p-nitroacetanilide as the major product, with minor formation of o-nitroacetanilide.

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1. Generation of the Electrophile: A mixture of concentrated sulfuric acid (H_2SO_4) and nitric acid (HNO_3) is prepared. Sulfuric acid acts as a dehydrating agent, facilitating the formation of the nitronium ion (NO_2^+), the active electrophile in this reaction:

$$HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$$

2. Formation of the Sigma Complex (Arenium Ion): The nitronium ion attacks the electron-rich aromatic ring of acetanilide, primarily at the para position relative to the acetamido group. This forms a non-aromatic sigma complex (arenium ion).

3. Deprotonation and Restoration of Aromaticity: The sigma complex then loses a proton (H^+), and aromaticity is restored, resulting in the formation of p-nitroacetanilide.

Mechanism of chlorosulfonation of acetanilide

Chlorosulfonation of acetanilide involves the reaction of acetanilide with chlorosulfonic acid to produce p-acetamidobenzenesulfonyl chloride. The mechanism proceeds as follows:

1. Electrophilic Attack: Chlorosulfonic acid ($ClSO_3H$) acts as an electrophile. The sulfur atom, being highly electron-deficient, facilitates the generation of the electrophilic species.
2. Formation of σ-Complex: The electrophile attacks the aromatic ring of acetanilide, preferentially at the para position relative to the acetamido group due to both electronic and steric factors, forming a σ-complex.
3. Deprotonation: The σ-complex loses a proton, restoring aromaticity and yielding p-acetamidobenzenesulfonic acid.
4. Formation of Sulfonyl Chloride: Excess chlorosulfonic acid reacts with the sulfonic acid group, replacing the hydroxyl group with a chlorine atom, resulting in p-acetamidobenzenesulfonyl chloride.[16]

II. LITERATURE REVIEW

The preparation of acetanilide from aniline is a well-established and significant reaction in organic. chemistry, widely used in both laboratory and industrial settings. Acetanilide is produced by the acetylation of aniline, an aromatic amine, through electrophilic aromatic substitution (EAS). This reaction involves the introduction of an acetyl group (-COCH3) to the aniline molecule, producing acetanilide (C6H5NHCOCH3). The process is essential in the production of various chemicals, particularly in pharmaceuticals and dye industries.

The nitration of acetanilide is a fundamental reaction in organic chemistry, serving as a classic example of electrophilic aromatic substitution. This process involves introducing a nitro group ($-NO_2$) into the aromatic ring of acetanilide, resulting in the formation of nitroacetanilide isomers. Understanding this reaction is crucial due to its applications in synthesizing various compounds in pharmaceuticals, dyes, and agrochemicals.

In the nitration process, a nitronium ion (NO_2^+) acts as the electrophile, attacking the electron-rich aromatic ring of acetanilide. The reaction typically employs a mixture of concentrated nitric and sulfuric acids to generate the nitronium ion in situ. The acetamido group ($-NHCOCH_3$) present in acetanilide is an electron-donating group, which directs the incoming nitro group preferentially to the ortho and para positions on the benzene ring. However, due to steric hindrance at the ortho positions, the para-nitroacetanilide is often the major product.

Controlling reaction conditions is essential to achieve the desired product distribution and to prevent over-nitration. Maintaining low temperatures during the addition of the nitrating mixture helps minimize the formation of di-nitrated products. Additionally, the rate of addition and the concentration of reagents are carefully regulated to favor mono-nitration.

The significance of this reaction extends beyond academic interest; nitroacetanilide derivatives are valuable intermediates in the synthesis of various industrial products. For instance, they serve as precursors in the manufacture of dyes, pigments, and pharmaceuticals. Therefore, a comprehensive understanding of the nitration mechanism,

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regioselectivity, and factors influencing the reaction outcome is vital for chemists engaged in both research and industrial applications.[5]

A common approach to synthesizing chloro sulphonated acetanilide involves the stepwise introduction of chlorine and sulphonyl functional groups to the acetanilide core. Typically, chlorination is carried out using reagents such as thionyl chloride or phosphorus oxychloride, followed by sulphonation with sulfuric acid or chlorosulphonic acid Acetanilide is an organic compound commonly used as a precursor in the synthesis of various chemical compounds, including azo dyes and pharmaceuticals. It was historically used as an analgesic but has since been replaced due to safety concerns. The reaction for its synthesis from aniline is a classical example of an electrophilic aromatic substitution reaction, where an electrophile substitutes a hydrogen atom on the aromatic ring. [1]

The preparation of acetanilide from aniline is a well-established and significant reaction in organic. chemistry, widely used in both laboratory and industrial settings. Acetanilide is produced by the acetylation of aniline, an aromatic amine, through electrophilic aromatic substitution (EAS). This reaction involves the introduction of an acetyl group (-COCH3) to the aniline molecule, producing acetanilide (C6H5NHCOCH3). The process is essential in the production of various chemicals, particularly in pharmaceuticals and dye industries.

III. FUTURE SCOPE

The future scope of research into the electrophilic aromatic substitution reactions of acetanilide can focus on several aspects:

1. Green Chemistry Approaches: Developing eco-friendly solvents and reagents for EAS reactions to reduce environmental impact.
2. Substitution Pattern Modifications: Investigating how different substituents on the acetanilide molecules affect the regioselectivity of the substitution reaction.
3. Mechanistic Studies: Exploring the mechanism of EAS reactions in more detail to understand reaction pathways and intermediates.
4. Applications in Drug Synthesis: Electrophilic aromatic substitution reactions can be applied to the synthesis of pharmaceuticals and agrochemicals, where acetanilide derivatives play an
1. important role. [10], [11], [12]
5. Green Chemistry Innovations: The acetylation of aniline can be optimized by using greener reagents or solvents, reducing the use of toxic or harmful chemicals. Research into solvent-free reactions, or using alternative solvents like ionic liquids, could lead to more environmentally friendly methods of acetanilide preparation.
6. Catalysis and Efficiency: The use of catalysts in the acetylation reaction can enhance yield and selectivity. Developing more efficient catalysts or employing enzyme-based catalysts (biocatalysis) could improve the reaction's sustainability and efficiency.
7. Microreactor Technology: The use of microreactors in the synthesis of acetanilide is an emerging field. These reactors allow for precise control over reaction conditions, leading to more consistent products and potentially higher yields.
8. Optimization of Reaction Conditions: The reaction conditions (temperature, time, concentration, and solvent choice) are crucial for achieving high yields and purity of acetanilide. Future studies may focus on optimizing these parameters to reduce waste and increase efficiency.[13],[14],[15].

IV. CONCLUSION

The reaction involves the acetylation of aniline by acetic anhydride or glacial acetic acid, leading to the formation of acetanilide, an important organic intermediate. The acetanilide was isolated and purified through recrystallization, and the product exhibited a melting point of 169–170°C, which is consistent with the known value for pure acetanilide. The yield and purity of the product can be influenced by reaction conditions, but in general, this method provides a reliable and efficient way to synthesize acetanilide. [3]

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The reaction of acetanilide with chlorosulfonic acid results in the successful synthesis of chloro sulphonated acetanilide, where the introduction of both a chloro and sulfonic group enhances the reactivity of the molecule. The structure of the product is characterized by the electrophilic substitution of the acetanilide aromatic ring. This reaction provides a valuable intermediate that can be further utilized for the synthesis of various compounds in the chemical and pharmaceutical industries. The purity and yield of the product can be improved by careful control of reaction conditions, such as temperature and time, and through appropriate workup procedures like recrystallization. The electrophilic aromatic substitution reactions of acetanilide—specifically nitration, bromination, and sulfonation—demonstrate the significant influence of the acetamido group (-$NHCOCH_3$) on both the reactivity and regioselectivity of the aromatic ring.

In the nitration of acetanilide, the acetamido group, being an electron-donating substituent, activates the aromatic ring and directs the incoming nitro group to the ortho and para positions. However, due to steric hindrance at the ortho positions, the para-nitroacetanilide is predominantly formed. This selectivity is advantageous in synthetic applications where specific substitution patterns are desired. [6]

In sulfonation reactions, the acetamido group directs the sulfonic acid group (-SO_3H) to the ortho and para positions as well. However, the reaction conditions and the nature of the sulfonating agent can influence the product distribution. The para-substituted product is often favored due to similar steric considerations as observed in nitration and bromination.

In summary, the acetamido group in acetanilide plays a crucial role in directing electrophilic substitution reactions to the ortho and para positions, with para-substituted products often being predominant due to steric factors. Understanding these directing effects is essential for designing targeted synthetic pathways in organic chemistry.

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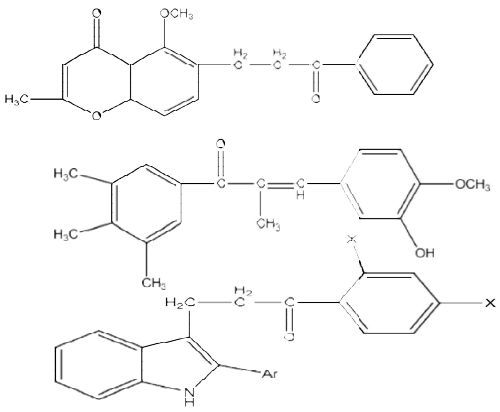
Chalcones and Their Biological Applications: A Review of Therapeutic Potential

Vishakha V. Pawar
D. G. Tatkare Mahavidyalaya, Mangaon, Raigad, Maharashtra

Abstract: *A class of naturally occurring flavonoids known as chalcones has attracted a lot of interest because of its wide range of pharmacological characteristics. Chalcones have a unique chemical structure made up of two aromatic rings joined by a three-carbon α,β-unsaturated carbonyl system. They are thought to be the biogenetic progenitors of flavonoids and isoflavonoids, which are plentiful in plants, and they form the core of many significant biological molecules. Chalcones and their derivatives have drawn a lot of interest in medicinal chemistry because of their structural diversity and bioactivity. Numerous biological activity, such as antioxidant, antibacterial, amoebicidal, antiulcer, antiviral, insecticidal, antiprotozoal, anticancer, cytotoxic, and immunosuppressive properties, are possessed by chalcones. This review provides a comprehensive analysis of the biological applications of chalcones, with a focus on their mechanisms of action and therapeutic implications. Furthermore, it discusses recent advancements in chalcone-based drug development and their potential for clinical translation. Understanding the pharmacological effects of chalcones could pave the way for the development of novel therapeutic agents, making them valuable in addressing various human health challenges.*

Keywords: Chalcones, medicinal chemistry, antioxidant, bioactivity, antimicrobial, anticancer

Graphical Abstract



Several chalcones with an indole moiety were created and their antibacterial and antifungal properties were examined.

The α- to methyl compound was found be the most active and tested for the chemotherapy of leukemias.

Heterocyclic substituted chalcones were introduced for the treatment of breast cancer, menopausal disorders and osteoporosis.

I. INTRODUCTION

1,3-diaryl-2-propen-1-ones, another name for chalcones, are a significant class of naturally occurring substances that are members of the flavonoid family. They have a broad spectrum of pharmacological effects and are important intermediates in the production of flavones and flavonols. Because of their open-chain flavonoid backbone and structural simplicity, they are easily modified chemically, which increases their biological efficacy. They are very reactive and effective in biology because of the α,β-unsaturated carbonyl system that is part of their structure. The

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therapeutic potential of chalcones in a variety of diseases, including as cancer, bacterial and viral infections, and inflammatory disorders, has been thoroughly investigated due to their broad range of medical applications.[1]

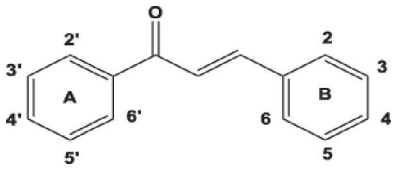
The therapeutic potential of chalcones spans several areas, including anti-inflammatory, antioxidant, anticancer, antimicrobial, antiviral, and antidiabetic effects. Research has shown that chalcones possess the ability to modulate various signaling pathways, inhibit key enzymes, and interact with cellular targets that play critical roles in disease mechanisms. In cancer research, for example, chalcones have been identified as potent inhibitors of tumor growth, promoting apoptosis (programmed cell death) and reducing metastasis in various cancer types.

Additionally, chalcones have demonstrated antimicrobial properties, offering promise in combating resistant bacterial and viral infections. Their antioxidant activities help protect cells from oxidative stress, potentially reducing the risk of degenerative diseases like Alzheimer's and cardiovascular disorders.

Given their diverse biological activities, chalcones are being explored in drug design and development, either as standalone compounds or as templates for synthetic modifications to improve efficacy and bioavailability. This review highlights the therapeutic potential of chalcones, summarizing current findings on their biological effects, mechanisms of action, and the promise they hold in advancing medical and pharmaceutical applications.[2]

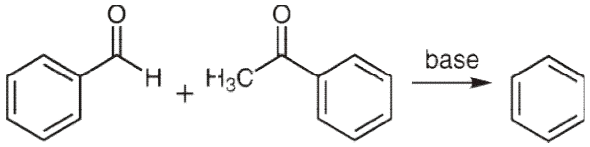
Chalcone Structure in General

Two aromatic rings (A and B) are joined by a three-carbon α,β-unsaturated carbonyl system to form chalcones. These rings' biological activity is influenced by the hydroxyl, methoxy, halogen, and other substituents that are present on them. Their therapeutic efficacy can be optimized through structural alterations, which makes them appealing scaffolds for drug design.



Chalcone Synthesis

The primary method of creating chalcones is the Claisen–Schmidt condensation reaction, which occurs when an aromatic aldehyde and an acetophenone are combined with an acid or basic catalyst (such as NaOH or KOH). Improved bioactivity is made possible by changes to the core structure.



Mechanisms of Action

There are several ways that chalcones influence biology, including:

Enzyme inhibition: Chalcones affect the activity of enzymes such tyrosinase, lipoxygenase, and cyclooxygenase (COX).

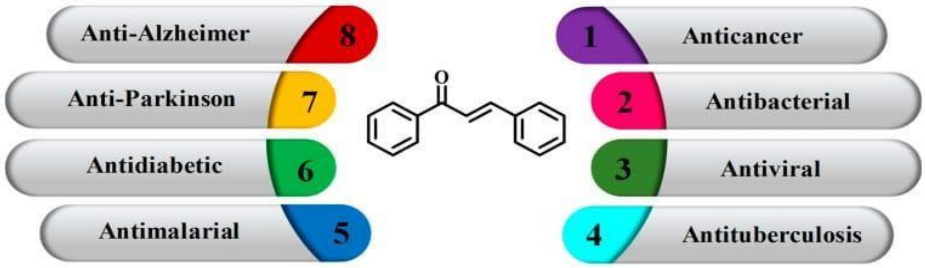
Numerous chalcones target mitochondrial pathways to cause cell cycle arrest and induce apoptosis in cancer cells.

Modulation of oxidative stress: Their antioxidant qualities aid in scavenging free radicals and minimizing oxidative damage.

Some chalcones exhibit antibacterial action through the breakdown of fungal and bacterial cell membranes.

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Biological Applications of Chalcones



Structure of chalcone and its bioactivities

Anti-Cancer Action

By focusing on several cellular pathways, chalcones have shown strong anticancer effects. They have the ability to restrict the growth of cancer cells, prevent angiogenesis, and trigger apoptosis. Certain chalcone derivatives interfere with microtubule dynamics, which are necessary for cell division, by acting as inhibitors of tubulin polymerization. Furthermore, they are intriguing candidates for cancer therapy due to their capacity to modify important signaling pathways like PI3K/Akt and NF-κB.[3]

Antimicrobial Characteristics

Chalcones have antibacterial, antifungal, and antiviral properties that are broad-spectrum. They work by interfering with the formation of nucleic acids, disrupting the membranes of microorganisms, and inhibiting enzyme function. Notably, chalcones have been studied as possible substitutes for traditional antibiotics, particularly in the fight against bacteria that are resistant to drugs.

Reduced Inflammation

By blocking important inflammatory mediators including the enzymes lipoxygenase (LOX) and cyclooxygenase (COX), a number of chalcone derivatives have strong anti-inflammatory effects. They also reduce inflammation- related conditions like arthritis and neuroinflammation by modifying transcription factors like NF-κB and pro- inflammatory cytokines.

Antioxidant Activity

Chalcones are known for their strong antioxidant properties, attributed to their ability to scavenge free radicals and enhance endogenous antioxidant defense systems. These properties contribute to their potential in preventing oxidative stress-related diseases, including cardiovascular disorders and neurodegenerative diseases like Alzheimer's and Parkinson's biological activity is influenced by the hydroxyl, methoxy, halogen, and other substituents that are present on them. Their therapeutic efficacy can be optimized through structural alterations, which makes them appealing scaffolds for drug design.

• Potential to Prevent Diabetes

Chalcones have been shown to have hypoglycemic effects, mainly via inhibiting important enzymes including dipeptidyl peptidase-4 (DPP-4) and α-glucosidase. Certain compounds are potential options for managing diabetes because they also improve glucose absorption and insulin sensitivity.

• Neuroprotective Impacts

By lowering oxidative stress, regulating neurotransmitter levels, and avoiding neuronal death, chalcones demonstrate neuroprotective qualities. Because of these effects, they may be used to treat neurological diseases such multiple

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sclerosis, Parkinson's disease, and Alzheimer's disease.4

Chalcone has also been shown to have several biological activities, including antiviral, prostaglandin binding, antiulcer, anti-parkinson, antimalarial, anti-tumor, and cardiovascular.

All things considered, chalcones are a broad class of bioactive substances with a variety of therapeutic applications. They are important for drug development because of their capacity to interact with a variety of biological targets. New therapeutic medicines made from chalcone scaffolds will be made possible by ongoing research that attempts to improve their pharmacokinetic characteristics and clinical usefulness.

II. METHODOLOGY

Chalcones are a class of compounds characterized by a distinctive structure comprising a benzene ring connected to a conjugated enone group. They are widely studied due to their biological activities, including antimicrobial, anticancer, anti- inflammatory, and antioxidant properties. Several synthetic methods have been developed for the preparation of chalcones, including:

1. Aldol Condensation (Base-Catalyzed)

• This is one of the most common and simple methods to synthesize chalcones.

• Mechanism: An aromatic aldehyde reacts with an α,β-unsaturated ketone (usually acetophenone) under basic conditions (e.g., sodium hydroxide or potassium hydroxide). The base deprotonates the α-position of the ketone, leading to the formation of an enolate ion, which attacks the carbonyl group of the aldehyde to form the chalcone.

• Advantages: Simple, cost-effective, and gives good yields.

2. Aldol Condensation (Acid-Catalyzed)

• In this method, the reaction proceeds under acidic conditions, using an acid like HCl, H2SO4, or p-toluenesulfonic acid.

• Mechanism: In the presence of acid, an α,β-unsaturated ketone undergoes condensation with an aldehyde to form a chalcone.

• Disadvantages: This method may require higher temperatures and longer reaction times.

3. Michael Addition

• The Michael addition is another synthetic route where an α,β-unsaturated carbonyl compound (such as an enone or enal) reacts with a nucleophile (typically an aromatic compound).

• Mechanism: A nucleophile, such as an aromatic compound (benzene or substituted benzene), attacks the β-carbon of an α,β-unsaturated carbonyl compound (such as methyl vinyl ketone or ethyl vinyl ketone), leading to the formation of chalcones.

• Advantages: This method is versatile and can be applied to a wide range of substrates.

4. Suzuki-Miyaura Coupling

• This is a palladium-catalyzed cross-coupling reaction used to synthesize chalcones.

• Mechanism: An aryl halide (such as aryl iodide or bromide) undergoes a palladium-catalyzed reaction with a boronic acid or boronate ester, leading to the formation of chalcones. This is particularly useful for introducing different aromatic rings into the chalcone structure.

• Advantages: It allows the introduction of different substituents on the aromatic rings and provides high yields.

5. Wittig Reaction

• The Wittig reaction involves the reaction of a phosphonium ylide with a carbonyl compound to form an alkene.

• Mechanism: A phosphonium salt reacts with a strong base to form a ylide, which then reacts with an aldehyde to produce a chalcone.

• Advantages: Provides good control over the geometry of the alkene (E or Z configuration).

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6. Vilsmeier-Haack Reaction

• This is a formylation reaction where an aromatic compound is treated with a reagent such as DMF (dimethylformamide) and POCl3 (phosphorus oxychloride) to generate an aromatic aldehyde, which can then undergo an aldol condensation to form the chalcone.

• Advantages: Useful for the synthesis of formylated chalcones.

7. Cyclization of 1,3-Dicarbonyl Compounds

• In this method, a 1,3-dicarbonyl compound (such as acetylacetone) can undergo cyclization, often in the presence of a base or acid, to form a chalcone structure.

• Advantages: This method offers a straightforward way of creating the chalcone skeleton.

8. Electrophilic Aromatic Substitution

• This method is less common but involves electrophilic substitution reactions on an aromatic ring to introduce a β-carbonyl group, leading to chalcone formation. The reaction can be carried out using a Lewis acid catalyst, such as AlCl3.

9. Condensation of α,β-Unsaturated Ketones with Aromatic Aldehydes

• This method typically involves the reaction of α,β-unsaturated ketones (such as acetophenone derivatives) with aromatic aldehydes under basic or neutral conditions. It is very similar to the aldol condensation but without the strong base.

• Example: Condensation of benzaldehyde with acetophenone derivatives to form chalcones.

III. LITERATURE REVIEW

Chalcones, a class of naturally occurring compounds with a characteristic α,β-unsaturated carbonyl system, have drawn significant attention in recent years for their broad spectrum of biological activities and therapeutic potential. These compounds are found in various plants and are considered precursors to flavonoids. Research has demonstrated that chalcones exhibit a variety of bioactivities, including anticancer, antimicrobial, anti-inflammatory, antioxidant, and antidiabetic effects. For instance, chalcones have shown potent anticancer properties by inducing apoptosis, arresting the cell cycle, and inhibiting metastasis in cancer cells. Studies have highlighted their ability to target critical signaling pathways involved in cancer progression, such as the PI3K/Akt/mTOR and MAPK pathways. Additionally, chalcones have been found effective against a range of pathogens, including bacteria, fungi, and viruses, contributing to their role as potential antimicrobial agents. Their anti-inflammatory and antioxidant properties also play a crucial role in mitigating chronic diseases associated with oxidative stress, such as cardiovascular and neurodegenerative disorders. Moreover, chalcones have demonstrated antidiabetic potential by improving insulin sensitivity and reducing blood glucose levels. The neuroprotective effects of chalcones are also notable, as they have been shown to reduce amyloid plaque formation and tau phosphorylation, both key features of Alzheimer's disease. Despite their promising therapeutic activities, chalcones face challenges such as poor bioavailability and metabolic instability, which hinder their clinical application. However, recent advancements in the synthesis of chalcone derivatives aim to overcome these limitations, offering hope for the development of new therapeutic agents. Continued research is necessary to optimize chalcones for clinical use and further explore their mechanisms of action. Conclusion:

A broad range of pharmacological activities, including antimalarial, anticancer, antiprotozoal (antileishmanial and antitrypanosomal), anti-inflammatory, antibacterial, antifilarial, antifungal, antimicrobial, anticonvulsant, and antioxidant properties, can be attributed to chalcones and their derivatives. As a result, scientists are paying more and more attention to chalcones and their derivatives to find novel, powerful pharmacological activity in them

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A Comprehensive Study on Synthesis of Imidazole Using Novel Techniques

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Abstract: *Imidazole is the heterocyclic 5-membered ring structure, out of which three are carbon and the Remaining two are nitrogen, arranged at 1 and 3 positions. It is the constituent of several natural Compounds like histamine, histidine, biotin, alkaloids and nucleic acid and a very important Class among the medicinal compounds. The unique structural feature of imidazole ring with desirable electron-rich characteristic is beneficial for imidazole derivatives to readily bind with a variety of enzymes and receptors in biological systems through diverse weak interactions, thereby exhibiting broad bioactivities. Thus, increasing research is being carried out on the synthesis of imidazoles and their derivatives, mainly because of the application of imidazoles in pharmaceutical and medicinal research. Keeping sustainability in mind, researchers are developing synthetic pathways for the synthesis of imidazoles and their derivatives by employing techniques involving green tools, thus leading to sustainable pathways. In this review, we aim to compile such synthetic methodologies involving green tools for the synthesis of imidazoles. The review will cover the synthetic reactions that involve green tools such as microwave irradiation and synthesis under green catalyst or a without catalyst. Imidazole-based compounds with antibacterial, anti-Inflammatory, antidiabetic, antiparasitic, antituberculosis, antifungal, antioxidant, antitumor, Antimalarial, anticancer, antidepressant and many others make up the therapeutic arsenal and New bioactive compounds proposed in the most diverse works. Large number of imidazole derivatives have been are Being developed for different therapeutic actions, therefore this article aims to review the work Reported on the synthesis of imidazole derivatives using microwave reactions as a modern Method for synthesis.*

Keywords: Imidazole, Synthesis, Microwave Techniques, Green Chemistry, Drug Discovery, Microwave Techniques, Green Chemistry.

I. INTRODUCTION

Imidazole, a five-membered heterocyclic compound containing two nitrogen atoms, has gained significant attention due to its diverse biological and chemical properties. This compound is a key structural component of various bioactive molecules such as histamine, purines, and several alkaloids, making it an essential building block in medicinal chemistry, pharmaceuticals, and biochemistry [1]. The compound's unique properties also find applications in the production of agrochemicals, materials science, and catalysis [2]. Traditional methods for synthesizing imidazole often rely on reactions involving diamines and aldehydes or amidines, typically requiring harsh conditions such as elevated temperatures, long reaction times, and the use of toxic reagents [3]. While these methods have proven effective, their environmental impact and safety concerns have prompted the scientific community to explore alternative, more sustainable synthetic strategies. Furthermore, issues such as low yields, undesired side reactions, and the production of hazardous waste associated with conventional methods have driven the search for greener, more efficient approaches [4]. In response to these challenges, several novel techniques have emerged in the synthesis of imidazole, focusing on improving reaction efficiency, reducing environmental harm, and offering more sustainable alternatives to traditional methods. One of the most promising advances is the use of microwave-assisted synthesis, which enables faster reactions with higher yields by utilizing microwave radiation to accelerate the heating process [5]. This technique offers several advantages over conventional heating methods, including reduced reaction times, better control over temperature, and enhanced reaction selectivity. Another key advancement involves the principles of green chemistry, which emphasize the use of non-toxic reagents, renewable raw materials, and solvent-free reactions [6]. Green methods

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for imidazole synthesis, such as those employing ionic liquids and supercritical fluids, have been developed to replace conventional solvents that are often harmful to both the environment and human health [7]. These alternatives not only reduce the environmental footprint of the synthesis process but also improve reaction efficiency and selectivity, making them viable options for large-scale industrial applications. Furthermore, the incorporation of catalysis has become a pivotal approach in imidazole synthesis. Both metal-catalyzed and enzyme-catalyzed reactions offer significant benefits by promoting selective reactions and reducing the need for harsh conditions [8]. Transition metal catalysts, in particular, have shown remarkable success in facilitating imidazole formation under milder conditions, thus reducing energy consumption and the production of unwanted byproducts.This comprehensive study aims to evaluate and compare these innovative techniques for imidazole synthesis, considering factors such as reaction time, yield, energy efficiency, and environmental impact [9]. By reviewing the latest advancements in the field, this work provides an in-depth understanding of the current state of imidazole synthesis and offers insights into potential future developments that could further optimize the process. The goal of this research is not only to highlight the progress made in the field but also to emphasize the importance of developing greener, more sustainable synthetic methods. As global efforts to mitigate environmental degradation intensify, adopting environmentally friendly approaches to chemical synthesis will become increasingly crucial for both academic and industrial sectors [10].

Imidazole is a heterocyclic organic compound that plays a significant role in various chemical and biological processes. Its structure, consisting of a five-membered ring with two nitrogen atoms, makes it a critical building block in many bioactive molecules. Imidazole is found in several natural products and is a key component in the structure of histamine, alkaloids, and certain vitamins .[11] Furthermore, it has been widely studied for its applications in pharmaceuticals, including antimicrobial, anticancer, and anti-inflammatory agents, as well as in industrial catalysis and material science [12]. Historically, imidazole has been synthesized via classical methods such as the condensation of diamines with aldehydes or amidines, often requiring high temperatures and long reaction times. While these methods have been effective, they have drawbacks, including low yields, the use of toxic reagents, and the generation of significant amounts of waste [13]. As a result, researchers have shifted toward more sustainable and efficient techniques for synthesizing imidazole. These new methods aim to minimize energy consumption, improve reaction selectivity, and reduce the environmental impact of the process.

1.1. METHODS USE FOR IMIDAZOLE SYNTHESIS

1.1.1. Microwave-Assisted Synthesis: One of the most promising advancements in imidazole synthesis is the use of microwave-assisted synthesis, which utilizes microwave irradiation to heat reactants more uniformly and efficiently. This technique has gained popularity due to its ability to accelerate reactions, reduce reaction times, and enhance product yields [14]. Microwave-assisted synthesis has been applied in the preparation of imidazole derivatives, offering advantages such as faster heating, better control over temperature, and high reproducibility. Additionally, microwave synthesis reduces the need for solvents, making it a greener alternative to traditional methods. In a study by microwave-assisted synthesis of imidazole derivatives was achieved with high efficiency, allowing for faster production and improved yields compared to conventional heating methods. This technique has demonstrated its potential in both laboratory-scale and industrial-scale reactions, contributing to the shift towards more sustainable synthetic practices [15].

1.1.2 Green Chemistry Approaches: The principles of green chemistry have been pivotal in the development of novel, environmentally friendly techniques for imidazole synthesis. Green chemistry focuses on the use of renewable, non-toxic reagents, reduction of energy consumption, and the minimization of hazardous waste [16]. For imidazole synthesis, green chemistry strategies have included the use of ionic liquids as solvents and reagents in reactions, which offer several advantages, such as negligible vapor pressure, recyclability, and a high degree of tunability [17].

In a key study it was demonstrated the use of ionic liquids as an effective solvent for the synthesis of imidazole, yielding products with excellent purity and high selectivity [18]. This approach avoids the use of toxic organic solvents and presents an environmentally benign alternative. Furthermore, supercritical fluids have also been explored as reaction media for imidazole synthesis. These fluids, typically carbon dioxide at high pressures and temperatures, offer

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unique solvation properties that can improve reaction rates and selectivity, while minimizing the environmental impact [19].

1.1.3 Catalytic Methods: Another significant advancement in imidazole synthesis is the use of catalysis to promote reactions under milder conditions. Both metal-catalyzed and enzyme-catalyzed methods have been developed to enhance the selectivity and efficiency of imidazole formation, while reducing the need for harsh reagents and high temperatures. Transition metal catalysts, such as those based on copper, iron, and palladium, have been successfully employed to catalyze the formation of imidazole derivatives with high yields and reduced side reactions [20]. For example, a study explored the use of copper catalysts in the synthesis of imidazole, demonstrating a significant reduction in reaction time and an increase in product yield when compared to traditional methods [21]. Similarly, enzyme-catalyzed methods have also shown promise, particularly in the selective formation of imidazole derivatives under mild conditions [22]. The use of biocatalysts in imidazole synthesis not only offers high selectivity but also contributes to greener and more sustainable chemical processes.

1.1.4 Solvent-Free and Sustainable Method: Recent developments have focused on solvent-free reactions, which eliminate the need for organic solvents that are often toxic and harmful to the environment. Solvent-free imidazole synthesis typically involves direct solid-phase reactions or reactions in the presence of solid supports, which offer the advantage of simplicity, high yield, and minimal waste generation [23]. Additionally, advances in biomass-derived solvents have paved the way for more sustainable and eco-friendly approaches. Solvents such as ethanol, derived from renewable resources, have been employed in imidazole synthesis, replacing petroleum-based solvents. These approaches not only reduce the carbon footprint but also promote the use of green and sustainable raw materials [24].

II. LITERATURE REVIEW

2.1 Synthesis and Functionalization of Imidazole:

The synthesis of substituted imidazole 1 using heterogeneous catalysis has been widely exploited. These functionalized structures are useful building blocks for the synthesis of molecules of biological and pharmaceutical interest.

2.1.1. Mono-Substituted Derivatives

One-pot reactions using iodobenzene 11 and imidazole 1 in the presence of K3PO4 as the base, CuI as the catalyst and DMF as the solvent at 35–40 °C for 40 h, give the corresponding N-arylimidazoles 12 in quantitative yields.

A copper-catalyzed process has been developed for the N-arylation reaction under very mild conditions in the absence of additional ligand. This protocol could not only tolerate an array of thermally sensitive functional groups, but also achieve high chemoselectivity.

Exploring the bifunctionalization of 1,2-disubstituted acetylenes 13 by ruthenium carbonyl to form cis-enediol diacetates 14, followed by reaction with ammonium carbonate as a source of nitrogen and methanol for the C-2 carbon, permitted us to obtain monosubstituted imidazoles 15, as shown below. A one-step, oxidative bisfunctionalization of alkynes to generate cis- enediol diacetates catalyzed by ruthenium carbonyl (triruthenium dodecacarbonyl) is presented. The reaction was performed using the alkyne, (diacetoxyiodo)benzene, Ru3(CO)12 as the catalyst, and toluene as the solvent at 100 °C to give the cis- enediol diacetates in up to 82% yields. This method overcomes the shortcomings of existing methods, such as tedious reaction steps, substrate limitations, and the use of toxic reagents. Furthermore, the reaction of module cis-enediol diacetates with ammonium carbonate [(NH4)2CO3] in an alcohol solvent gave imidazole derivatives in 37–84% yields, thus providing a simple and mild new method for the synthesis of imidazole compounds.

2.1.2. Disubstituted Derivatives

The work below shows the development of an efficient methodology for the synthesis of novel 2-aryl-4-benzoyl-imidazoles 16 by structural modification of 2-aryl-imidazole-4-carboxylic amide (AICA) 17 and 4-substituted methoxylbenzoyl-aryl-thiazoles (SMART) 18, presenting antiproliferative activity. A series of 2-aryl-4-benzoyl-imidazoles (ABI) was synthesized as a result of structural modifications based on the previous set of 2-aryl-imidazole-

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4-carboxylic amide (AICA) derivatives and 4-substituted methoxylbenzoyl-aryl-thiazoles (SMART). The average IC50 of the most active compound (5da) was 15.7 nM. ABI analogues have substantially improved aqueous solubility (48.9 μg/mL for 5ga vs 0.909 μg/mL for SMART-1, 0.137 μg/mL for paclitaxel, and 1.04 μg/mL for combretastatin A4). Mechanism of action studies indicate that the anticancer activity of ABI analogues is through inhibition of tubulin polymerization by interacting with the colchicine binding site. Unlike paclitaxel and colchicine, the ABI compounds were equally potent against multidrug resistant cancer cells and the sensitive parental melanoma cancer cells. In vivo results indicated that 5cb was more effective than DTIC in inhibiting melanoma xenograph tumor growth. Our results suggest that the novel ABI compounds may be developed to effectively treat drug-resistant tumors.

2.1.3. Trisubstituted Derivatives

On the other hand, 2,4,5-trisubstituted imidazoles 36 could be obtained by using 2,3-dioxo-3-substituted propanoates 37 as precursors after condensation using ammonium acetate and various aromatic aldehydes 38 in EtOH and AcOH as catalysts at room temperature.

A one-pot synthesis of the trisubstituted imidazole derivatives from α-acetoxy-α-chloro-β-keto-esters, aldehydes, and ammonium acetate has been developed. A one-pot synthesis of the trisubstituted imidazole derivatives from α-acetoxy-α- chloro-β-keto-esters, aldehydes, and ammonium acetate has been developed. The employment of privileged scaffolds in medicinal chemistry supplies scientists with a solid start in the search for new and improved therapeutic molecules. One of these scaffolds is the imidazole ring, from which several derivatives have shown a wide array of biological activities. A series of 2,4,5-triphenyl imidazole derivatives were synthesized, characterized, and evaluated in vitro as antioxidant molecules using 1,1-diphenyl-2-picrylhydrazyl (DPPH.) and 2-2′ -azino-bis-(3-ethylbenzothiazoline-6-sulfonate) (ABTS.+) assays, acetylcholinesterase (AChE) and xanthine oxidase (XO) inhibitors as well as antiproliferative agents. Additional in silico studies such as docking and determination of their absorption, distribution, metabolism, and excretion (ADME) properties were calculated.

2.1.4. Tetrasubstituted Derivatives

Using various aldehydes 55, benzyl 56, ammonium acetate and prop-2-ynylamine 57 in the presence of CuFe2O4NPs as a catalyst in H2O:EtOH under reflux for approximately 50 min, it was possible to obtain several tetrasubstituted imidazole derivatives 58 in a multicomponent synthesis. It was possible to reuse the catalyst for six reactions without losing its efficiency. In the presence of SO 2−/Y O as a catalyst, the multicomponent condensation of benzyl 56, aminoethylpiperazine 59, various aldehydes 60 and ammonium acetate in ethanol at 80 °C for 10 h was carried out to form tetrasubstituted 1,2,4,5-imidazole derivative 61. The catalyst was reused up to five times with no significant loss in catalytic efficiency. Alternatively, the synthesis of 1,2,4,5-tetrasubstituted imidazole derivatives 62 could be achieved through the condensation of benzyl 56, aldehydes 63 and anilines 64 in the presence of ammonium acetate under the solvent-free catalysis of Fe3O4@SiO2/bipyridinium nanocomposite (Fe3O4@SiO2/BNC).

III. APPLICATIONS

This application will explore the use of innovative and environmentally friendly techniques for the synthesis of imidazole. The focus will be on approaches that offer improved yields, shorter reaction times, reduced environmental impact, and broader scalability.

3.1. Microwave-Assisted Synthesis

Microwave-assisted synthesis (MAS) is a modern and efficient technique that uses microwave radiation to accelerate chemical reactions. The technique enhances the reaction rate by directly transferring energy to the reaction mixture, which leads to rapid and uniform heating.

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3.2. Green Synthesis Using Ionic Liquids (ILs)

Ionic liquids (ILs) are salts that are in liquid form at ambient temperature. Due to their unique properties, such as non-volatility, high thermal stability, and the ability to dissolve a wide variety of organic compounds, they have found significant use as solvents in organic synthesis.

3.3. Electrochemical Synthesis

Electrochemical synthesis is a cutting-edge method that uses electrical energy to drive chemical reactions. This method is gaining traction for its environmentally friendly nature and ability to selectively generate chemical products without the need for toxic reagents.

3.4. Biocatalytic Synthesis

Biocatalysis involves the use of natural catalysts, such as enzymes, to facilitate chemical reactions. This technique is considered a "green" alternative to traditional synthetic methods because it operates under mild conditions and exhibits high specificity.

3.5. Sonogashira Coupling for Imidazole Derivatives

The Sonogashira coupling reaction is widely used to form carbon-carbon bonds and can be adapted to synthesize imidazole derivatives by coupling terminal alkynes with guanidine derivatives in the presence of a palladium catalyst.
These novel methods not only enhance the efficiency of imidazole synthesis but also open up new possibilities for the development of more selective, environmentally friendly, and cost-effective processes in both research and industrial applications.

IV. REACTION AND MECHANISM

The synthesis of imidazole, a nitrogen-containing heterocyclic compound, can be achieved through several innovative and environmentally friendly techniques. Below is an overview of the reaction mechanisms for the synthesis of imidazole using various novel approaches, including microwave-assisted synthesis, green synthesis using ionic liquids, electrochemical synthesis, biocatalysis, and Sonogashira coupling.

4.1. Microwave-Assisted Synthesis of Imidazole Reaction Mechanism:

Reaction: The synthesis of imidazole typically involves the reaction of guanidine or guanidine derivatives with α,β-unsaturated aldehydes or ketones under microwave irradiation. The microwave energy accelerates the cyclization process, resulting in the formation of the imidazole ring structure.

General Reaction:

α , β -unsaturated aldehyde/ketone+guanidine→Microwave IrradiationImidazole

Mechanism:

Under microwave radiation, the reactants are heated rapidly, which reduces the reaction time. Microwaves selectively heat the polar molecules, enhancing the rate of the reaction. The reaction between the α,β-unsaturated aldehyde and guanidine undergoes a cyclization step where the guanidine acts as a nucleophile, attacking the electrophilic carbon of the α,β- unsaturated carbonyl group. The resulting intermediate undergoes intramolecular cyclization, forming an imidazole ring. The microwave energy enhances the reaction speed and efficiency, yielding imidazole derivatives.

4.2. Green Synthesis Using Ionic Liquids (ILs) Reaction Mechanism:

Reaction: The synthesis of imidazole using ionic liquids typically involves the reaction of guanidine derivatives with α,β- unsaturated aldehydes in the presence of an ionic liquid (IL) such as 1-butyl-3-methylimidazolium chloride (BMIM- Cl).

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General Reaction:

α , β -unsaturated aldehyde+guanidine→BMIM-ClImidazole

Mechanism:

Ionic liquids serve as both solvent and catalytic medium. The IL interacts with the reactants, stabilizing the intermediate reaction states and promoting the formation of the imidazole ring.

The guanidine acts as a nucleophile, attacking the electrophilic carbonyl group of the α,β-unsaturated aldehyde, forming an intermediate that undergoes cyclization to form the imidazole structure. The reaction takes place in the ionic liquid phase, which allows for efficient heat transfer, faster reaction rates, and minimal side reactions. The ionic liquid can also be recycled, making this method environmentally friendly.

4.3. Electrochemical Synthesis of Imidazole Reaction Mechanism:

Reaction: The electrochemical synthesis of imidazole involves applying an electric current to a solution of nitroaromatic compounds (or similar substrates) and guanidine derivatives.

General Reaction:

Nitroaromatic compound+guanidine→ElectrolysisImidazole

Mechanism:

In an electrochemical cell, an electric current is passed through the reaction mixture, inducing reduction of the nitroaromatic compound at the cathode. This reduction forms an intermediate that is highly reactive. The guanidine acts as a nucleophile, attacking the intermediate, leading to a cyclization step that forms the imidazole ring. The reaction occurs under mild conditions, with the electrochemical process allowing precise control over the reaction, ensuring high selectivity and yield without the need for toxic reagents.

4.4. Biocatalytic Synthesis of Imidazole Reaction Mechanism:

Reaction: In biocatalytic methods, enzymes such as laccases or cytochrome P450 are used to catalyze the formation of imidazole from amine-based compounds and unsaturated substrates.

General Reaction:

Amine or alkyne-based substrate+guanidine→Enzyme CatalysisImidazole

Mechanism:

Enzymes selectively facilitate the nucleophilic attack of guanidine on the electrophilic site of the substrate (either amines or alkynes). The enzyme stabilizes the transition state and directs the cyclization reaction to form the imidazole ring in a highly selective and efficient manner. The use of enzymes ensures that the reaction proceeds under mild conditions, without harsh reagents or extreme temperatures. This approach is environmentally friendly as the enzymes are biodegradable, and the reaction can proceed in aqueous solvents.

Example: The laccase-catalyzed synthesis of imidazole derivatives from amine-functionalized alkynes demonstrates high regioselectivity and yields, with the enzyme providing a sustainable and efficient catalytic route.

4.5. Sonogashira Coupling for Imidazole Derivatives Reaction Mechanism:

Reaction: In the Sonogashira coupling, a terminal alkyne and guanidine derivative are coupled in the presence of a palladium catalyst, leading to the formation of imidazole derivatives.

General Reaction:

Terminal alkyne+guanidine derivative→Pd catalyst, BaseImidazole

Mechanism:

The palladium catalyst promotes the formation of an alkyne-activated intermediate by facilitating the oxidative addition of the alkyne to the palladium center. This intermediate undergoes nucleophilic attack by the guanidine at the carbon atom, leading to a cyclization that forms the imidazole ring. The reaction occurs under mild conditions and provides a versatile route to functionalize the imidazole ring with various substituents.

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V. FUTURE SCOPE

The future scope of imidazole synthesis using green chemistry holds great promise, especially as there is a growing focus on sustainability, environmental concerns, and the reduction of harmful chemical processes. Imidazole, a five-membered heterocyclic compound, is widely used in pharmaceuticals, agrochemicals, and material science. However, traditional methods of imidazole synthesis often involve toxic reagents, solvents, and energy-intensive procedures.

4.1 Sustainable Reagents and Green Solvents: Ionic Liquids (ILs)

These have gained attention as potential "green" solvents due to their low vapor pressure, non-flammability, and recyclability. Using ILs in imidazole synthesis could provide a safer and more sustainable alternative to conventional solvents, offering better solubility, fewer byproducts, and often higher yields.Supercritical Fluids: Supercritical carbon dioxide (CO2), for instance, can act as a "green" solvent that's environmentally benign, easy to recycle, and can be tuned to optimize the solubility of reactants. This technology might be explored in future imidazole syntheses, particularly to avoid hazardous solvents or the use of high temperatures.Water as a Solvent: Water is considered the ultimate green solvent. Developing water-based reaction systems for the synthesis of imidazole could be highly beneficial. Aqueous systems often require fewer precautions, are safer, and tend to be more energy-efficient. Designing water-compatible catalysts and reagents will be key in advancing this direction.

4.2 Microwave and Ultrasound-Assisted Synthesis: Microwave-assisted Synthesis:

Using microwave irradiation in synthetic processes can reduce reaction time, improve yield, and often lower energy consumption. This technique has already been explored for the synthesis of imidazole and its derivatives. In green chemistry, microwave-assisted reactions are viewed as eco-friendly alternatives because they enable faster reactions with less energy input.Ultrasound-assisted Synthesis: Similarly, ultrasound can assist in accelerating reactions, enhancing mass transfer, and minimizing the use of harmful chemicals. For imidazole synthesis, this method could facilitate greener, more efficient pathways by reducing the need for high temperature or excessive reagents.

4.3 Green Process Intensification: Flow Chemistry:

Continuous flow processes are gaining traction in green chemistry because they offer controlled reaction conditions, high throughput, and minimal waste. Integrating flow reactors into imidazole synthesis could improve process efficiency, especially when coupled with renewable energy sources or catalytic systems that optimize selectivity and yield.Microreactors: These are small-scale reactors that can precisely control temperature, pressure, and reaction time. For imidazole synthesis, microreactors could reduce the need for large amounts of reagents, minimize energy use, and allow for a more fine-tuned control of reaction parameters. Their compact size also means a lower environmental footprint.

4.4 Carbon Capture and Utilization (CCU): Using CO2 as a Feedstock:

In the context of green chemistry, CO2 is often seen as a potential resource. Imidazole derivatives are of interest for capturing CO2, so researchers might explore synthesizing imidazole derivatives that could sequester CO2 in a green way. For example, imidazole can act as a catalyst in the fixation of CO2, opening up the potential for dual-purpose processes in which imidazole synthesis itself contributes to carbon capture.

4.5 Advanced Catalytic Methods: Biocatalysis and Enzyme Engineering:

Advances in biocatalysis could lead to more specific and efficient pathways for imidazole synthesis. Engineered enzymes or natural biocatalysts could promote selective formation of imidazole rings under mild conditions, avoiding toxic reagents and byproducts. Directed evolution of enzymes or discovering new biocatalysts could be key in optimizing this process.Green Catalysts: Catalysts that are more environmentally benign, such as earth-abundant metal catalysts (e.g., iron or copper-based catalysts), could replace more toxic and rare metals traditionally used in imidazole synthesis. These catalysts might also allow for faster, more efficient reactions that minimize energy input and waste.

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VI. CONLUSION

In conclusion, the synthesis of imidazole using green chemistry represents a promising and sustainable approach to meet the increasing demand for this versatile compound across various industries, including pharmaceuticals, agrochemicals, and materials science. Traditional methods of imidazole synthesis often rely on toxic reagents, hazardous solvents, and energy- intensive processes, which pose environmental and safety concerns. Green chemistry offers alternative strategies that emphasize sustainability, waste reduction, and resource efficiency.The future of imidazole synthesis can be significantly improved by employing green chemistry principles such as the use of renewable feedstocks, solvent-free reactions, and environmentally benign catalysts. Advancements in areas like catalysis (e.g., biocatalysis, heterogeneous catalysts), energy- efficient processes (e.g., microwave, ultrasound, or electrochemical methods), and process intensification (e.g., continuous flow or microreactors) will likely lead to more sustainable and cost-effective pathways for imidazole production. Additionally, the integration of green solvents, such as ionic liquids or supercritical CO2, as well as the potential for using water as a solvent, offers exciting possibilities for reducing environmental impact.Ultimately, the synthesis of imidazole through green chemistry not only aligns with the broader goals of reducing toxicity, conserving energy, and minimizing waste, but also facilitates the development of safer and more efficient processes for industrial applications.

As green chemistry techniques continue to evolve, the synthesis of imidazole and its derivatives is likely to become increasingly sustainable, offering significant benefits to both industry and the environment. To further elaborate, the synthesis of imidazole via green chemistry holds significant potential for transforming traditional chemical processes into more sustainable, efficient, and eco-friendly alternatives. By leveraging innovative methods such as solvent-free reactions, renewable feedstocks, and greener catalytic systems, it is possible to reduce the environmental impact typically associated with imidazole production. These advancements not only contribute to cleaner manufacturing but also align with global trends toward sustainability and eco-conscious production. As research progresses in these areas—particularly in catalysis, renewable energy sources, and waste minimization—the synthesis of imidazole could play a pivotal role in advancing green chemistry.

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A Study on Extraction, Evaluation and Antibacterial Activity of Trachyspermum Ammi L.

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Abstract: *Essential oil is a complex mixture of volatile compounds and can be extracted from various parts of plants. It has been used for thousands of years for medicinal and health purposes. Because of their detoxifying, antibacterial, antiviral and calming properties, it is used as a natural, safe and cost-effective therapy for a number of health concerns. Ajwain seed is very valuable for its oil contents. It is a high value medicinally important seed. It contains 53-65% Thymol as a photochemical. Thymol is reported to exhibit diverse biological activities like antibacterial, antioxidant, antiseptic, antifungal, anti- inflammatory and anticancer etc. It is also reported to show potent inhibitory activity against E. coli and Staphylococcus aureus. Resistance to antibacterial agents has become a serious problem for global health. The current study evaluated the antimicrobial activities of essential oil and respective fractions of Trachyspermum Ammi (L) Sprague. Seeds of the essential oil were extracted and fractionated using column chromatography. All fractions were then analyzed by gas chromatography/mass spectrometry. Antifungal and antibacterial activities of the oil and its fractions were assessed using micro dilution method. Compounds γ-terpinene (48.07%), ρcymene (33.73%), and Thymol (17.41%) were determined as major constituents. The effect of fraction II was better than total essential oil, fraction I, and standard Thymol. The greater effect of fraction II compared to standard Thymol showed the synergistic effects of the ingredients in this fraction. As this fraction and also total oil were effective on the studied microorganism, the combination of these products with current antimicrobial agents could be used.*

Keywords: Medicinal and health purpose, Antibacterial Activity of Trachyspermum Ammi Antioxidant, Anti- inflammatory, Anticancer.

I. INTRODUCTION

The idea of using medicinal plants to treat human being and livestock is not new and in many developing countries their use is still in vogue. Despite the fact that in developed countries modern development in allopathic medicine is at climax, there is a renewed interest in using medicinal plants to treat humans, pets and livestock. Medicinal plants are being used for therapeutic purposes in several ways. In modern medicine, many drugs are used that are mainly derived from plants, e.g. digitalis, morphine, atropine, cinchona and vinblastine [1-3]. The interest in plant products has considerably increased all over the world due to the fact that many herbal medicines are free from side effects TrachyspermumAmmi L belongs to (Apiaceous family) is a traditional medicinal plant with therapeutic properties. Ammi L seeds are used to treat a variety of gastrointestinal ailments in traditional Indian medicine system. A hot and dry fomentation of the seeds is applied to the chest to treat asthma, and a paste of powdered seeds is used externally to relieve colic pains.Aqueous extract of the seeds of the Ajwain plant is a common therapy for diarrhoea. Seeds have also been linked to the prevention of stomach cancers, aches, and piles. There are a variety of Ajwainayurvedic formulations available to treat worm infections.

Essential oil of Ajwain:

Spices have remarkable therapeutic value. It is used to increase the flavour as well as aroma. There are some other names of Ajwain in history such as omum, owa, Ethiopian cumin, carom and bishops weed. Carom seeds are belonging to the Apiaceous family. The botanical name of carom seeds is Trachyspermum Ammi. Essential oil which is extracted from carom seeds have volatile nature and have physio-chemical and organoleptic properties. Trachyspermum Ammi is

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a native of Egypt and it is cultivated in Pakistan, India, Iran, Iraq, and Afghanistan. T. Ammi is a medicinally important seed as the seeds of 7. Ammi contain excellent aphrodisiac properties and its roots are diuretic in nature. The T. Ammi seeds consisted of 2-4.4 % brown colored oil which is known as ajwain oil in which (40-50) % thymol is present. Thymol can easily be crystalized from the essential oils of ajwain and the remainder contains beta pinene, carvacrol, dipentene, beta terpinenes, and rho-cymene. Ajwain seeds are most commonly used as a household remedy for diarrhea, asthma, colic and dyspepsia and it also have antifungal, antibacterial, hypocholesterolemic, anthelminthic, antioxidant and bronchodilator effects.

Composition of Ajwain oil

The principle active components of essential oil of T. Ammi are phenols, carvacrol and mainly thymol. Both phenolic compounds carvacrol and thymol are responsible for antitussive and antiseptic properties. Thymol has antiseptic activity and carvacrol contains antifungal properties. Ajwain is rich source of thymol, y-terpinene and p-cymene and carvacrol. Major components which are present in the ajwain essential oil are a-pinene, athujene, ßmyrcene, B-pinene, B- phellendrene, o cymene, y-terpinene, limonene, 4-terpineol, dodecane, cis limonene oxide, ßfenchyl alcohol, tetra decane, thymol, ethylene methacrylate, heptadecane, diethyl phthalate.

Literature Review

Antimicrobial Activity

T. ammi's antimicrobial properties include preventing food from rotting due to microbes, doing in vitro tests to determine its effectiveness, and using it as an antibacterial. Carvacol and thymol were identified as the active ingredients believed to be in charge of ajwain's antibacterial properties. Thymol functions as a plant-based, fourth-generation herbal antibiotic formulation by eliminating bacteria that are resistant to even common third-generation antibiotics and multidrug-resistant microbial infections. Ten fungi (Acrophialophora fusispora, Curvularia lunata, Fusarium chlamydosporum, F. poae, Myrothecium roridum, Papulaspora sp., Alternaria grisea, A. tenuissima, Drechslera tetramera, and Rhizoctonia solani) were investigated for the antifungal activity of T. ammi seeds' volatile compounds. and discovered to suppress all test fungal growt by72–90%. Thymol and carvacol are examples of phenolic compounds that are known to have bacteriostatic or bactericidal properties, depending on the concentration, which was reported to suppress all test fungal growth by 72– 90%. Depending on the concentration, phenolic substances like thymol and carvacol can be either bacteriostatic or bactericidal agents.

Anti-inflammator Activity

Allergic rhinitis (AR) is an immune inflammatory-related disorder that affects the nasal mucosa. Free radicals play a crucial role in the expansion of allergic reaction and the researcher used the antioxidant therapy to treat the disease. Trachyspermum ammi L. (Ajwain oil) is popular traditional medicine. It has been proved their potential effect on various diseases. Ajwain oil showed anti-tumor, antioxidant, antidiabetic, anti-inflammatory, and anti-bacterial properties. Yet, the anti-allergic effect of Ajwain oil is still not explored. In this experimental study, an ovalbumin (OVX)-induced AR model was used to scrutinize the anti-allergic, antioxidant and anti-inflammatory effects of Ajwain oil.

Antilithiasis and diuretic activiy

Additionally investigated are T. ammi's antilithiasis and diuretic effects in vivo on preventing rat-induced oxalate urolithiasis. In an additional investigation on a potential diuretic effect, T. ammi was not successful in raising 24-hour urine production. The findings showed that there was no experimental support for the traditional usage of T. ammi to treat kidney stones. Additionally investigated are T. ammi's antilithiasis and diuretic effects in vivo on preventing rat-induced oxalate urolithiasis. In an additional investigation on a potential diuretic effect, T. ammi was not successful in raising 24-hour urine production. The findings showed that there was no experimental support for the traditional usage of T. ammi to treat kidney stones.

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Antifilarial activity

It has been studied how well the methanolic extract of Trachyspermum ammi's (Apiaceae) fruits inhibits Setaria digitata worms in vitro. The active fraction and the crude extract shown noteworthy effectiveness against the adult S. digitata in both the MTT [3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide] reduction assay and worm motility tests. When tested for in vivo antifilarial efficacy against the human filarial worm B. malayi in Mastomys coucha, the isolated active principle phenolic monoterpene demonstrated macrofilaricidal action and female worm sterility against B. malayi. The crude extract of T. ammi shown macrofilaricidal properties. After two incubation periods of 24 and 48 hours, the isolated active principle 2-isopropyl-5-methyl phenol had IC50 values of 0.024 and 0.002 mg/ml, respectively. In a Mastomys coucha, the in vivo efficacy of the active principle 2-isopropyl-5-methyl phenol was assessed against the B. malayi parasite. model. Adults in the 50 mg/kg group experienced a mean percentage mortality of 58.93%, which was substantially($P<0.0001$) higher than that of the control group (19.05%). Using a Mastomys coucha model, the in vivo impact of the active principle 2-isopropyl-5-methyl phenol was assessed against the B. malayi parasite. Adults in the 50 mg/kg group experienced a mean percentage mortality of 58.93%, which was substantially ($P<0.0001$) higher than that of the control group (19.05%).

Antihypertensive, antispasmodic and broncho- dilating activity

T. ammi's intravenous antihypertensive impact in vivo, as well as its antispasmodic and bronchodilating properties in vitro, shown that calcium channel blockage has been discovered to mediate the spasmolytic actions of plant materials; it is thought that this mechanism supports the traditional use of T. ammi in treating hypertensive conditions and hyperactive disease states of the gut, including diarrhoea and colic.

Future Scope

Medicinally, it has been proven to possess various pharmacological activities like antifungal, antioxidant, antimicrobial, ant nociceptive, cytotoxic, hypolipidemic, antihypertensive, antispasmodic, Broncho-dilating actions, antilithiasis, diuretic, abortifacient, antitussive, nematicidal, anthelmintic and Not only does organic production help reduce public health risks, mounting evidence shows that food grown organically are rich in nutrients, such as Vitamin C, iron, magnesium, and phosphorus, with less exposure to nitrates and pesticide residues in organically grown fruits, vegetables, and grains when compared to conventionally grown products.

II. CONCLUSION

Solvent extraction is an effective method for extracting the essential oil from ajwain seeds. Theextraction of again has been successfully accomplished, resulting in the production of essential oils and beneficial compounds. This process holds significant potential for various industries, including pharmaceuticals, food, and cosmetics. The extracted oil possessessignificant antimicrobial and antioxidant activities. Trachyspermumammi has long been regarded as a valuable medicinal plant. It's been utilized for stomach problems in the past, and it's also used as a flavoring agent. It has a wide spectrum of phytoconstituents that are responsible for a variety of biological properties. Hence the antibacterial activity of T. ammi seeds provides a scientific foundation for their usage as a traditional remedy. T. ammi is a substantial natural antibacterial agent, according to our findings, and can be suggested for the treatment of a variety of microbiological illnesses

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Innovative Applications of Nanoparticles in Cancer Diagnosis and Treatment

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Abstract: *Numerous nanoparticles have been created and evaluated during the last few decades, sparking a great deal of interest in their possible applications as therapeutic and diagnostic tools. Iron oxide nanoparticles are the sole formulation of nanoparticles that has been used in clinical practice to date, despite the fact that they have been suggested as potential diagnostic tools. This is mostly because it is difficult to consistently produce monodispersed nanoparticles and get appropriate pharmacokinetic characteristics. Concerns exist over their possible toxicity, biodegradation, and remove as well. Currently, therapeutic applications account for the majority of nanoparticle formulations utilized in clinical settings. The goal of these therapeutic nanoparticles is to minimize accumulation in healthy tissues and organs while more effectively delivering (chemo-)therapeutic medicines to specific locations. The "enhanced permeability and retention" (EPR) effect forms a substantial part of their foundation. Furthermore, because nanoparticles can combine therapeutic and diagnostic properties in a single formulation, they exhibit significant promise for theranostic applications. They are extremely useful for customizing therapies based on nanomedicine because of this feature. In this study, we address the function of EPR in the development of nanotheranostic formulations, examine the application of therapeutic and diagnostic nanoparticles, and provide an overview of popular non-invasive imaging methods. We also look at the practical possibilities of image-guided drug administration and nanotheranostics for more individualized and effective (chemo-)therapeutic treatments.*

Keywords: Nanoparticles; Diagnostic agents; Pharmacokinetics; Drug delivery;(Chemo-) therapeutic interventions; Targeted drug delivery.

I. INTRODUCTION

Currently, one of the most important areas of medical research is in vivo molecular imaging. Early disease detection, precise disease staging, image-guided therapeutic interventions, and individualized treatment plans are all greatly aided by this quickly developing field. Moreover, it gives crucial information regarding the effectiveness of medicines, enabling clinicians to change treatment programs based on real- time data. Despite its potential, molecular imaging significantly relies on the employment of specific imaging probes that are designed to observe and characterize biological processes at the cellular and molecular level (1-5). These probes are vital resources for learning more about the pathophysiology of illnesses and how treatments affect those illnesses.

The development of nanotechnology, which has made it easier to create a variety of nanoparticle formulations for medicinal and diagnostic uses, has been one of the most revolutionary advances in recent years. The main purpose of diagnostic nanoparticles is to provide high-resolution imaging capabilities, which enable the visualization of illnesses and enhance our understanding of the fundamental (patho-

)physiological concepts that underlie a variety of diseases. By targeting particular biomarkers or illness- related cellular structures, these nanoparticles can be designed to improve disease progression detection and comprehension. The intrinsic properties of nanoparticles—such as their small size, surface area, and ability to be functionalized with targeting ligands—hold immense potential for integrating both diagnostic and therapeutic functions into a single nanoparticle formulation. This integration enables the development of theranostic nanoparticles, which combine both diagnostic and therapeutic capabilities within a single platform. Such theranostic nanoparticles have the unique ability

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to monitor the biodistribution and accumulation of therapeutic agents at target sites, visualize and quantify the release of drugs from nanoparticles, and longitudinally assess the therapeutic efficacy of treatment regimens.

In clinical settings, theranostic nanoparticles offer the ability to personalize treatment approaches. They enable the preselection of patients based on their molecular profiles, ensuring that only those who are most likely to benefit from a particular therapeutic approach are chosen. Furthermore, by providing continuous feedback on treatment efficacy, theranostic nanoparticles allow for real-time monitoring of therapeutic outcomes, enabling clinicians to adjust treatment strategies accordingly. This personalization of treatment holds great promise in the field of nanomedicine, as it can significantly improve the overall success rates of therapies, reduce unnecessary side effects, and optimize patient care (7-15).

This review article will delve into the current landscape of nanoparticle formulations used for both diagnostic and therapeutic applications, offering a detailed analysis of their functions and clinical relevance. Additionally, it will provide an overview of various non-invasive imaging modalities that can be used in conjunction with these nanoparticles to enhance disease diagnosis and treatment. The article will also explore the role of nanoparticles as molecular imaging probes and contrast agents, which can amplify the sensitivity and specificity of disease detection. Lastly, the review will address the potential for nanoparticles to play a transformative role in clinical practice, particularly in the context of facilitating personalized therapy interventions by improving treatment accuracy, efficacy, and safety.

II. LITERATURE REVIEW

Nanoparticles for imaging the MPS

Numerous nanoparticle formulations have been designed and evaluated over the last years, including e.g. liposomes, polymers, micelles, proteins, antibodies, gold nanoparticles, ultrasmall superparamagnetic iron oxide nanoparticles, and nanotubes, which possess intrinsic properties that influence their biodistribution, elimination, and target site accumulation The majority of these nanoparticles are used for therapeutic purposes (6,16,50,51). Currently, several therapeutic nanoparticles are applied in clinical practice. Doxil (PEGylated, doxorubicin-loaded liposomes, Janssen, Horsham, PA), Abraxane (paclitaxel-containing albumin nanoparticles, Celgene, Summit, NJ), and AmBisome (liposomal amphotericin B, Gilead, Foster City, CA) are some prominent examples of clinically approved therapeutic nanoparticles; many other nanomedicine formulations are currently being tested in preclinical and clinical trials (52-54). In contrast to the therapeutic application of nanoparticles, diagnostic applications are still lagging behind (6,8). Although nanoparticles are frequently proposed as diagnostic agents, there is still only one nanoparticle formulation, namely iron oxide nanoparticles, that was used in clinical practice (ferucarbotran, Resovist, Bayer Schering Pharma, Germany). However, even ferucarbotran was recently taken off the market. Instead, ferumoxytol (Feraheme, AMAG Pharmaceuticals Inc., USA), which is an FDA approved therapeutic iron oxide nanoparticle formulation for treating anemia, is now used offlabel by many radiologists (55). Despite enormous progress in the synthesis of novel diagnostic nanoparticle formulations, there are several limiting factors that impede the clinical translation of diagnostic nanoparticles. The major difference between nanodiagnostics and nanotherapeutics is their intended pharmacological behavior. While nanotherapeutics should possess pharmacological activity, nanodiagnostics should not generate (patho-) physiological effects. Furthermore, nanotherapeutics should be characterized by a long blood circulation time, as their main purpose is to achieve a selective accumulation of drugs in tissues characterized by enhanced permeability and retention (EPR), such as tumors. In this regard, therapeutic nanoparticle formulations are advantageous over standard low- molecular-weight drugs, as their renal excretion is reduced, causing prolonged circulation times and decreased volume of distribution. This leads to less accumulation in healthy tissue and thus less side effects, and improves the ability of drug molecules to accumulate at the pathological site, and thereby increase their therapeutic efficacy (6,8-11). For nanodiagnostics, short circulation times and fast biodegradation and elimination without pharmacological and toxicological activity are preferred. In addition, with respect to their application as molecular imaging probes, diagnostic nanoparticles should possess a good and efficient delivery to the target site and should exhibit highly specific binding and internalization capabilities. Their non-specific accumulation in healthy tissue should be low and short. Furthermore, a high sensitivity of the imaging method to detect the molecularly targeted diagnostic nanoparticles is

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required (the intrinsic properties of nanoparticles often do not correspond with the pharmacokinetic and pharmacodynamic demands. If not taken up by the mononuclear phagocyte system (MPS) (formerly known as RES), due to their size, ranging from a few nanometers to 1000 nm, the biodistribution tends to be restricted to the compartment in which they were administered. For diagnostic agents targeting extravascular structures, it is essential that they rapidly extravasate out of blood vessels and penetrate and distribute within the interstitial space. The unbound fraction also has to leave these compartments rapidly in order to keep the unspecific background signal low. However, although nanoparticles accumulate in the interstitial space, their penetration into the tissue is slow and their intratumoral distribution is significantly smaller than for low-molecular-weight diagnostics (6,8,11). It should be noted, that for therapeutic nanoparticles, it is often sufficient that the nanoparticles reach the interstitial space and here release their drug load, while tumor cell-targeted diagnostic probes need to pass the entire interstitial space to ultimately reach and bind to the tumor cell. Those demands for diagnostic nanoparticle formulations are often not adequately addressed (6).

Nanoparticles for imaging tumor vascularization and angiogenesis

The use of nanoparticles in monitoring tumor vascularization and angiogenesis—two important markers of tumor aggressiveness and malignancy—is growing. While targeted nanoparticles bind to activated endothelial cells and enable the evaluation of tumor vascular changes and treatment effects during therapies such as anti-angiogenic treatments and radiotherapy, non-targeted nanoparticles aid in determining the enhanced permeability and retention (EPR) effect.

The use of imaging agents based on nanoparticles to track tumor angiogenesis and treatment outcomes is highlighted in a number of publications. For example, when employed for ultrasound imaging, microbubbles that were targeted to the integrins VEGFR2 and αvβ3 demonstrated specific binding to the blood arteries of angiogenic tumors. The monitoring of anti-angiogenic therapy in human colon cancer xenografts was made possible by these microbubbles. Similar to this, MR imaging using paramagnetic liposomes coated with RGD peptides revealed clear tumor accumulation patterns, especially in the tumor rims. Another study employed MRI to distinguish between tumors with high and low αvβ3 integrin expression using USPIO nanoparticles coupled with RGD peptides.

By evaluating polymeric drug carriers modified with RGD- and NGR-based peptides using optical imaging, a theranostic strategy was shown. Active targeting boosted tumor accumulation, but it also resulted in higher liver uptake and shorter blood half-lives.

Last but not least, patients with malignant melanoma underwent PET and optical imaging using hybrid silica nanoparticles (C dots) functionalized with RGD peptides in a first-in-human clinical trial. Nanoparticles show potential for clinical translation in cancer diagnosis and treatment monitoring because they provide a flexible method for visualizing tumor angiogenesis and assessing anti-angiogenic medicines.

Nanoparticles for imaging EPR and targeted drug delivery

As mentioned earlier, most nanoparticle formulations are based on the Enhanced Permeability and Retention (EPR) effect and are made for tumor medication targeting. Because solid tumors usually have abnormally leaking blood arteries, nanoparticles, which can be anywhere from a few tens to hundreds of nanometers in size, can enter the tumor from the bloodstream. Abnormal angiogenesis and the overproduction of vascular permeability-enhancing substances like VEGF are the causes of the enhanced permeability of the tumor vasculature. An incomplete endothelium layer with strongly fenestrated (porous) walls—often with fenestrations greater than 300 nm—is the result of an imbalance between the formation of new blood vessels and their maturity. The absence of functional lymphatic drainage in solid tumors contributes to the EPR effect in addition to the increased permeability of tumor blood vessels. This limits the evacuation of nanoparticles from the tumor site and is caused by aberrant lymphangiogenesis and lymphatic artery compression. Consequently, nanoparticles stay in the tumor tissue for a long time. Here are a few instances of targeted medicine delivery using nanoparticles.

pHPMA-copolymers were used as a medication delivery mechanism in a study by Lammers et al. Gemcitabine and doxorubicin were used to functionalize these copolymers for therapeutic applications, and gadolinium and 131I for imaging. Using γ-scintigraphy and MRI, the biodistribution of these copolymers was assessed. According to the study, longer circulation durations and increased tumor accumulation were observed with bigger copolymers. These findings showed that HPMA-copolymers can be used as flexible, multipurpose drug carriers that enhance low-molecular-weight drug delivery and increase anticancer activity.

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86Re-labeled Doxil (PEGylated liposomal doxorubicin) was administered to naked rats with head and neck squamous cell cancer (HNSCC) in a different study by Soundararajan et al. SPECT-CT and γ- scintigraphy were used to track tumor accumulation, and the results indicated that 186Re-Doxil had significant tumor uptake, low liver accumulation, and long blood retention. The effectiveness of 186Re- Doxil in conjunction with radiofrequency ablation therapy was assessed in a follow-up research. The combination showed improved tumor growth inhibition, increased drug accumulation at the tumor site, and enhanced treatment efficiency. In a different investigation, Koukourakis et al. visualized and measured EPR-mediated passive medication targeting to tumors in sarcoma patients using radiolabeled stealth liposomal doxorubicin. By guaranteeing targeted drug accumulation, these results demonstrate the potential of image-guided nanoparticles for efficient drug delivery to tumors, enhancing therapeutic results.

Tuning the properties of diagnostic and therapeutic nanoparticles

The key characteristics of nanoparticle formulations include their size and charge, core and surface properties, shape and flexibility, as well as multivalency and controlled synthesis. These properties directly influence the nanoparticle's distribution, targeting potential, and toxicity in the body. Additionally, they have a significant impact on the drug loading capacity, release, and stability of the nanoparticles.

One of the most thoroughly explored aspects of nanoparticle pharmacokinetics and biodistribution is the effect of particle size on its in vivo behavior. It is generally accepted that nanoparticles with sizes ranging from 10 to 100 nm are optimal for drug delivery systems. These formulations can effectively exploit the EPR effect in tumors while avoiding premature elimination by the spleen. Moreover, smaller particles tend to accumulate more easily and penetrate tissues better. Therefore, the size of nanoparticles, along with their surface composition, plays a critical role in ensuring effective accumulation at the target site. Additionally, the dispersion and size variation of nanoparticles are crucial for their in vivo behavior. Polydisperse nanoparticles tend to have varied retention times and biodistribution. Hence, controlled synthesis that produces nanoparticles with uniform size, shape, charge, and functional group density is essential for achieving consistent distribution. Only monodisperse nanoparticles can be expected to exhibit similar biological half-life, biodistribution, and target affinity.

Another important feature of nanoparticles is their multivalency. Nanoparticles possess a high surface area-to-volume ratio, allowing for significant loading capacity for various imaging probes, targeting ligands, and therapeutic agents. For instance, a carbon nanotube with the same volume as a large protein (100-150 kDa) offers a surface area 15 times larger than that of the protein, facilitating the attachment of numerous targeting ligands to the nanoparticle and enhancing target binding. Additionally, the shape of nanoparticles significantly affects their in vivo behavior and biological function, particularly their internalization into cells. For example, a study comparing PEGylated rod-shaped gold nanoparticles with PEGylated spherical nanoparticles showed that the gold nanorods were less taken up by the liver and macrophages, exhibited longer circulation times, and accumulated more in tumors than their spherical counterparts. The modification of nanoparticle surfaces and charge can either enhance or reduce their circulation times. Research has shown that polystyrene microparticles with primary amine groups on their surface underwent more phagocytosis compared to those with sulfate, hydroxyl, or carboxyl groups. As a result, it is well understood that positively charged nanoparticles tend to have a higher rate of nonspecific internalization and a shorter blood circulation time than neutral or negatively charged formulations.

There are several strategies for modifying nanoparticle surfaces to influence their in vivo behavior and alter their biodistribution. One common modification is the use of polyethylene glycol (PEG), which forms a hydrophilic layer on the nanoparticle surface, protecting it from immune system recognition and reducing uptake by macrophages in the mononuclear phagocyte system (MPS). This process, known as the "stealth effect," enhances the nanoparticle's circulation half-life and promotes accumulation at target tissues. Another popular surface coating is dextran, which is commonly used for nanoparticles such as SPIO (superparamagnetic iron oxide) and USPIO (ultra-small superparamagnetic iron oxide) for MRI imaging of the MPS.

In addition to surface modifications, nanoparticle formulations have been developed to respond to various intrinsic stimuli in the tumor microenvironment, such as low pH or overexpressed enzymes, as well as to externally applied stimuli like ultrasound, magnetic fields, hyperthermia, or light. These stimuli- responsive formulations trigger site-specific drug release. For example, temperature-sensitive liposomes containing both chemotherapeutic agents and MRI

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contrast agents enable the monitoring of drug release triggered by temperature changes by tracking changes in relaxation times. Many of these trigger- responsive MRI contrast agents exploit the chemical exchange saturation transfer (CEST) effect, a novel class of MR contrast agents. CEST agents are characterized by exchangeable protons (such as -NH, -OH) that resonate at distinct frequencies. When these protons are selectively saturated with an MR pulse, they exchange with protons in bulk water, causing a reduction in the water peak's signal intensity, which can be measured.

For instance, in a study by Langereis et al., a combined temperature-sensitive liposomal 1H CEST and 19F MR contrast agent system was evaluated as a carrier for MR-guided drug delivery alongside high- intensity focused ultrasound (HIFU)-induced hyperthermia. Both the CEST agent and 19F MR probe were loaded into the aqueous core of the liposomes. At temperatures below the liposome's bilayer melting point, the CEST effect allowed localization of the liposomes, while the 19F signal was suppressed. Upon heating above the liposomal bilayer melting point, the CEST and 19F probes were released from the liposome, and the 19F signal increased, allowing for real-time tracking of local drug release. These stimuli-sensitive nanoparticle formulations may offer valuable feedback on the effectiveness of temperature-triggered drug release, particularly when used in combination with treatments like radiofrequency ablation or MR-guided HIFU-induced hyperthermia.

Theranostics and therapy individualization

The concept of theranostics incorporates two distinct approaches, which encompass all steps of a patient's healthcare management The "biomarker" or "companion diagnostics" approach offers the opportunity to assist treatment selection, response prediction, and treatment monitoring, while the "image guidance" approach allows planning, pre-operative guidance, and follow up of the therapeutic action, including e.g. local drug delivery. Companion diagnostics are diagnostic clinical tests on specific biomarkers or biological targets that aim to identify patients that are (more) likely to benefit from a specific treatment by elucidating the efficacy and/or safety of a specific drug for a targeted patient group. Furthermore, companion diagnostics can provide information about the target receptor density. Companion diagnostics can be categorized into two main groups, comprising assays that have been developed after a therapeutic drug has come to the market and assays that are developed in conjunction, as companion to a specific therapeutic agent. The co-development of companion diagnostics offers the potential to significantly alter the drug development process and commercialization of potential drug candidates by yielding safer drugs with enhanced therapeutic efficacy in a faster and more cost-efficient manner. An example of a companion diagnostic imaging agent is etarfolatide (Folcepri, Endocyte Inc., West Lafayette, IN). It consists of a small-molecule high-affinity ligand for the folate receptor linked to technetium-99m for SPECT imaging. Etarfolatide is used in platinum-resistant ovarian cancer or non-small cell lung cancer to stratify patients for treatment with the folate receptor-targeted chemotherapeutic drug vintafolide (Vynfinit, Endocyte Inc., West Lafayette, IN) (90). The combination of diagnostic and therapeutic properties into a single nano- or microparticle formulation for theranostic purposes holds significant potential for image-guided drug delivery and personalized therapies (Fig. 4) (91-93). Theranostic nanoparticles enable monitoring of their biodistribution and target site accumulation, the visualization and quantification of their local activation and sometimes even drug release, and the non-invasive and longitudinal assessment of their therapeutic efficacy (11-12,91,94-96). In this context, Lammers, Koczera et al. for instance investigated the potential of poly(n-butyl-cyanoacrylate) (PBCA)-based microbubbles, that contained USPIO nanoparticles in their shell to simultaneously induce and monitor blood-brain barrier permeation (97). Transcranial ultrasound-mediated microbubble destruction led to USPIO release and the permeation of the blood-brain barrier was subsequently visualized and quantified by MRI. Such theranostic strategies are considered to be useful for monitoring and assessing efficient and safe drug delivery across biological barriers. The application of theranostic nanoparticles may facilitate patient preselection based on noninvasive imaging, providing insights on drug delivery, drug release and drug efficacy, and predicting, which patients are likely to respond to nanomedicine treatments. In addition, preselected and nanomedicine-treated patients can be longitudinally monitored to visualize their responsiveness to the administered nanomedicine formualtion. Patients showing insufficient therapeutic response can be assigned to alternative therapies, to facilitate and refine individualized treatment interventions (8,11,90,98). Therefore, theranostic nanoparticles hold significant potential for enabling personalized medicine and patient

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individualization by optimizing treatment strategies and drug delivery, and by longitudinally monitoring therapy efficacy

III. CONCLUSION

Nanoparticle formulations have versatile applications and can serve both as diagnostic and therapeutic tools in cancer treatment. From a diagnostic standpoint, there is a growing demand for agents capable of accurately characterizing the enhanced permeability and retention (EPR) effect. Theranostic nanoparticles, which combine both therapeutic and diagnostic functions, can be used to visualize and assess the biodistribution and accumulation of nanoparticles at the target site, monitor drug release, track long-term drug efficacy, and predict potential treatment outcomes. This dual capability allows for the pre-selection of patients for the most appropriate (nano-)chemotherapeutic treatments, aligning with the principles of personalized medicine and improving patient-specific treatment approaches.

Moreover, nanoparticles can be utilized to study tumor angiogenesis, with very small nanoparticles (less than 5 nm) also serving as molecular diagnostics for targets outside the vasculature. However, while therapeutic nanoparticle formulations are typically designed for slow renal clearance and extended blood circulation times to enhance tumor accumulation and therapeutic effect, diagnostic nanoparticles require short circulation times to reduce nonspecific background and facilitate the development of clinically relevant imaging techniques. In this regard, the advantage of using nanoparticulate diagnostic agents over traditional low-molecular-weight drugs must always be carefully evaluated.

For further clinical translation of nanoparticle formulations for both diagnostic and therapeutic uses, particularly in oncology and personalized medicine, it is essential to address key regulatory challenges.

These include ensuring controlled nanoparticle synthesis, achieving consistency and reproducibility across batches, and scaling up production methods. Variations in nanoparticle size, charge, and shape from batch to batch can significantly affect blood circulation time, biodistribution, and elimination, making standardization a critical factor for success.

Ultimately, accelerating the clinical application of nanoparticles for diagnostic and therapeutic purposes, as well as advancing the development of clinically relevant nanodiagnostics, will require greater interdisciplinary collaboration and knowledge sharing among scientists across various fields.

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Solvent and Catalyst Free Acylation of Anilines with Acetic Acid

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Abstract: An efficient and green microwave assisted protocol to prepare amide fromamine via acylation without using catalyst provides quantitative yields in short reaction times. Synthesis of Acetanilide under microwave irradiation was described, in which Aniline was directly reacted with glacial acetic acid without any catalytic agents. The reaction took place in 40−50 min in the frequency range of 160 MHz, with almost quantitative yields. By applying green synthesis method, we avoid use of any hazardous or toxic materials. Quantitative yields are produced in a short amount of time by an effective and environmentally friendly microwave assisted approach that produces amide from amine via acylation without the need for a catalyst. Aniline and glacial acetic acid were directly combined during the synthesis of acetanilide under microwave irradiation, without the use of anycatalytic agent.The reaction occurs in the frequencybond of 160 MHz in 40 - 50 min. with almost quantitative yields. We don't employ any harmful or toxic components by using the Green synthesis techniques.

Keywords: Acylation,microwaveirradiation,amide,amine,aniline,acetanilide,greensynthesis.

I. INTRODUCTION

Green Chemistry is the new branch of chemistry which involves pulling together tools, techniques and technologies. It is helpful to chemists and chemical engineers in research, development and production for development of more eco-friendly and efficient products, which may also have significant financial benefits. It is now going to become an essential tool in the field of synthetic chemistry. [3,8] The development of Green Chemistry redefines the role of a solvent. "An ideal solvent facilitates the mass transfer but does not dissolve". In addition, a desirable Green Solvent should be natural, nontoxic, cheap and readily available with additional benefits of aiding the reaction, separation or catalyst recycling. Of various principles of Green Chemistry, the important one is maximizing the Atom Economy which evaluates the efficiency of chemical transformation [9].Amide compounds have attracted much attention because of their extensive application in the pharmacological industry. They have been generally used as protective routes for synthetic routes. An Amide functional group is contained in many bioactive compounds or drugs, an Amide modification is an important optimization methodology for new chemical entities in medicinal Chemistry. Furthermore, peptide bonds, a special kind of Amide bond in life sciences, constitute the back bone of proteins. In the chemical industry, the structure of Amides is involved in many important materials [10]

The formation of Amide bond is generally developed in these ways: the traditional synthetic procedures of the acetamido group compounds are carried out by primary amino compounds with acyl halides, acid anhydrides, esters or acids in different conditions. However all these procedures have usage limitations: the acyl halides and acid anhydrides were hygroscopic and many active acylation agents would be exothermic and produce unwanted acid during the reaction process, so they should be treated carefully under well-cooled and anhydrous conditions in the presence of acid-tricing agents [2]. The esters and acids were low chemically active acylation agents, so they would take longer time for the reaction process with low yields. Some chemical active agents such as N,N'- dicyclohexylcarbodiimide (DCC), N-(3-dimethylaminopropyl)-N-ethylcarbodiimide (EDC), and these should be added to catalyze the reactions because they are harmful and hazardous to body and environment. [13]

Amide bond formations are one of the most important transformations carried out in pharmaceutical synthesis, accounting for 65% of all preliminary screening reactions in industrial medicinal chemistry laboratories as recently reported. Amides also represent very important family of intermediates widely employed in the preparation of fine

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chemicals, cosmetics and food additives.[14] However, the majority of the current employed protocols to form Amides involve the use of stoichiometric activated, toxic and corrosive agents such as acid anhydrides or acyl chlorides with poor atom economy that generate considerable waste. Furthermore, an excess of these reagents is normally needed to achieve optimum amide yields and the reaction is water sensitive with the efficient removal of water being a critical factor in the systems [1].

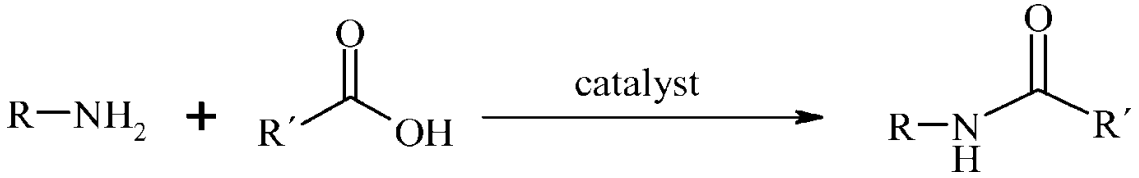
The development of cleaner syntheses is key to reducing the environmental impact of amide formations. In this regard, the direct reaction of Amines with carboxylic acids remains the most attractive approach. These types of reactions are best carried out without catalysis where possible, however, reaction conditions remain harsh in order to accomplish direct Amide formation [1,7]

The acylation of amines is one of the most frequently used transformations in organic synthesis as it provides an efficient and inexpensive means for protecting hydroxyl and amino groups in a multistep synthesis process. For the amide formation mostly acetyl chloride and acetic anhydride are routinely used in the presence of an acidic or base catalyst. However, both of these reagents are corrosive and are not always ideal to use. Moreover, the acidic condition in Lewis acid acylation of amines leads to the cleavage of sensitive functional groups such as acetals and TBDMS ethers. Sc(OTf)3, TMSOTf and clays such as K-10, KSF were reported for acylation of amines with acetic anhydride. Tetrabutylammonium salt, cyanide anion and Cp2Sm(thf)2 are also used in the acylation of amines with an esters. [18]The protection of amino groups by the formation of amides, especially acetamides, is one of the most fundamental and widely used procedures in organic syntheses.[5]

During recent years, microwave irradiations have been widely used in organic syntheses because of its reduction in reaction time and its good yields. Its application in N-acylation amides were also developed, but anhydrides were used to form the amide bonds in anhydrous conditions, and the diversity of amines was not sufficient to elucidate the influential factor of the reaction.[1] Microwave irradiation of organic reactions has rapidly gained in popularity as it accelerates a variety of synthetic transformations via time and energy saving protocol. Microwave assisted organic syntheses are suited to the increased demands in industry, particularly because of short reaction time, selectivity, solvent free technique and also for the expanded reaction range. Acetic acid can alone act as an acetylating agent under microwave irradiation, but this method is applicable with only primary amines. [1,2]

A range of greener catalytic methodologies have been reported for the preparation of amides. These include the N-acylation of amines with organic acids, the use of solid supported reagents (e.g. polymer-bound acylating agents), arylboronic or boronic acid derivatives and the use of microwave irradiation. Many different catalysts have been reported for the acylation of amines including transition metal salts, immobilised ionic liquids on mesoporous materials, and solid acid catalysts[1].

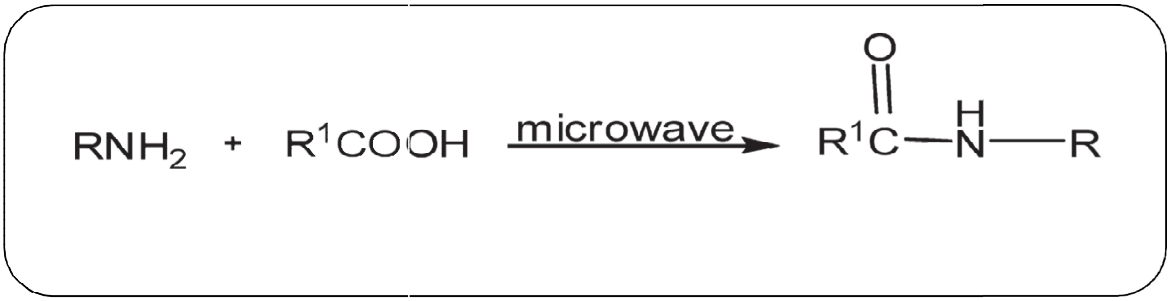
There are many reactions reported using different catalysts. One of the reactions of amides via N-acylation of primary and secondary amines under microwave irradiation was reported using starbon acid catalyst and acetic acid as the acetylating agent. In this reaction typical N-acylation of amine was carried out by adding 2mmol of aniline with 2mmol acetic acid and 0.1g of catalyst in a tube using microwave irradiation at 300 watt for 1-10 minutes at 120-130℃. The yield obtained was quantitative (>98%) with the starbon acid catalyst, which was not seen with any other acid catalyst despite of increasing the time and frequency of the reaction[1,3].



There is also an article on formation of an amide bond using acid without other solvents under microwave irradiation. In this reaction, firstly the benzyl amine and acetic acid were put together in a microwave reaction chamber, and an N-acetylated compound was obtained. In this reaction, acetic acid was used as acylation agent and solvent. Compared with the traditional amide synthetic procedure, this method was mild and convenient with a short time (a few minutes instead of several hours) and high yields (more than 90%). Most of the primary amines react with acetic acid and gave higher

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yields, between 90 and 95%. Instead of acetic acid, benzoic acid was used as an acylation reagent and also gave similarly high yields. In this reaction 200mg of aniline was added to 2ml of acetic acid or benzoic acid 800mg under microwave irradiation at 200 watt, 50℃ for 6-8 minutes. The reaction mixture was poured into a mixture of acetic ether and cyclohexane (1:50), then stored for some time in a refrigerator. The white crystal was obtained which was washed and dried out. The yield obtained was 98%. [2]



Acylation of amines with acetic acid using LaY and HY as catalysts are also reported. Recently, Gd(OTf)3 and iodine, ZnO, bromodimethyl- sulfoniumbromide, lanthanide, tosylates, CoCl2.6H2O, ZrOCl2.8H2O have been reported to promote the acylation of amines with acetic anhydride or acetyl chloride.[16] Acylation with acetic anhydride without catalyst has also been reported. The use of acetic acid rather than acetic anhydride or acetyl chloride is both economically and environmentally advantageous, because substances used in chemical synthesis may either be incorporated into final product or into by product as a waste material. Acylation reaction of amines was also carried out by using acid catalyst known as Zeolites. In this reaction 2mmol of aniline was mixed with 2ml of acetic acid and 200 mg of zeolite catalyst was used under microwave irradiation at 600 watts for 30-40 minutes at 117℃. The yield obtained was 73% [5].

$$R\text{-}NH_2 + CH_3COOH \xrightarrow[mi\ rowave\ i\ radiation]{zeolite} R\text{-}NHCOCH_3$$

Acylation reaction of amine is also carried out via catalyst using Zn dust. In this reaction 3.3g of aniline was mixed with 10ml of acetic acid with a0.16g of catalyst. The reaction was heated on a burner for 45 minutes and the yield obtained was 70-80%. In this reaction metal Zn is used as a catalyst which is toxic to the health and environment. [3,19]

$$R\text{-}NH_2 + CH_3CHOOH \xrightarrow{Zn\ dust} R\text{-}NHCOCH_3$$

Although a variety of methods are available for this purpose, acetylation of amines is routinely carried out with acetic anhydride or acetyl chloride in presence of base catalysts. The reaction is generally carried out in the presence of tertiary amines such as triethylamine or pyridine. The use of catalysts such as LiCl, I2, montmorillonite-K 10 or KSF, KF-Al2O3 and AlPO4 have also been reported. Pyridine(tetrahydroborate)zinc complex has also been used for acylation of amines with ethyl acetate. In this reaction 0.093g of aniline in THF and ethyl acetate was prepared which was mixed with the zinc complex of 0.697g and was refluxed for 2.5 hours, the yield obtained was 97%.[4]

$$RR'NH \xrightarrow[THF,reflux]{(Py)Zn(BH4)2} RR'NCOCH_3$$

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II. LITERATURE REVIEW

Acetanilide, derived from aniline through an acetyla-tion reaction, is a white, odorless, crystalline solid with a characteristic amide functional group; its key chemical proper-ties include: de H_2C-COOH/Zn

Structure and Formation:

* Chemical Formula: C6H5NHC(O)CH3
* Formation: Aniline reacts with acetic anhydride (or glacial acetic acid) in the presence of a catalyst like zinc dust to produce acetanilide.
* Functional Group: Amide group (C(O)NH)

Physical Properties:

* Appearance: White, flaky crystals
* Melting Point: Approximately 113-115°C
* Solubility: Slightly soluble in water, more soluble in organic solvents like ethanol

Chemical Properties:

* Weak Base: Due to the resonance within the amide group, acetanilide exhibits weak basic properties
•Acylation: Can undergo further acylation reactions to form diacetanilide
* Halogenation: Can be halogenated on the aromatic ring under appropriate conditions
* Nitration: Can be nitrated on the aromatic ring to produce nitro-substituted acetanilide derivatives

Analysis Methods:

Melting Point Determination:

A simple method to confirm the purity of acetanilide, as a pure sample will melt at a specific temperature range Thin Layer Chromatography (TLC):

Used to identify and compare the presence of acetanilide in a mixture by analyzing its retention factor (Rf) value[24] Infrared Spectroscopy (IR):

Characteristic amide bond stretching vibrations can be observed in the IR spectrum, confirming the presence of the amide group Nuclear Magnetic Resonance (NMR) Spectroscopy:

Provides detailed information about the structure of acetanilide by analyzing the chemical shifts of different hydrogen atoms

Historical Use:

Acetanilide was once used as a pain reliever (under the trade name "Antifebrin") but was later found to be toxic and largely replaced by safer alternatives like acetaminophen.

Synthetic Intermediate:

Today, acetanilide is primarily used as a starting material for synthesizing other organic compounds, including dyes and pharmaceuticals.

Key chemical properties of acetanilide:

* Appearance: White, crystalline powder or flakes
* Molecular formula: C6H5NHCOCH3
* Solubility: Slightly soluble in water, readily soluble in organic solvents like ethanol, ether, chloroform

Pharmacological properties

Acetanilide (N-phenylacetamide) has analgesic and antipyretic properties, and is metabolized into paracetamol (acetaminophen) in the body. It was used as a pain reliever and fever reducer in the late 19th century, but was eventually replaced by acetaminophen because of its toxic side effects.[17]

* Analgesic: Acetanilide relieves mild to moderate pain
* Antipyretic: Acetanilide reduces fever
* Anti-inflammatory: Acetanilide has a limited anti-inflammatory effect

Mechanism of action

* Acetanilide is metabolized in the liver to form paracetamol

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• Paracetamol inhibits the production of prostaglandins, which are lipid compounds that cause inflammation and pain

Side effects

•Acetanilide can cause cyanosis, liver damage, and kidney damage

* Acetanilide can interfere with hemoglobin's ability to carry oxygen
* Acetanilide was introduced in 1886 as an antipyretic and analgesic drug
* Acetanilide was a popular alternative to opium and morphine
* Acetanilide was removed from the market in the 1980s

Applications

Acetanilide has many applic-ations, including as a phar-maceutical, dye, and stabilizer. HN-C-CH Acetanilide Pharmaceutical Application:

* Analgesic: Acetanilide reduces pain and fever
* Antipyretic: Acetanilide reduces fever
* Anti-inflammatory: Acetanilide can be used as an inflammatory agent
* Antimicrobial: Acetanilide derivatives have antimicrobial properties
* Antibiotic: Acetanilide is a building block of penicillin, an antibiotic that treats gram-positive bacteria
* Sulfa drug: Acetanilide is used to synthesize sulfa drugs, which treat bacterial infections.

Dye

* Fabric dye: Acetanilide is used to dye cellulose fabrics
* Textile dye: Acetanilide is used to manufacture colored dyes for textiles Stabilizer
* Hydrogen peroxide stabilizer: Acetanilide prevents hydrogen peroxide from decomposing
* Cellulose ester varnish stabilizer: Acetanilide stabilizes the structure of cellulose ester varnishes .
* Rubber accelerator: Acetanilide is used to speed up the synthesis of rubber
* Plasticizer: Acetanilide is used as a plasticizer in the polymer industry
* Photographic developer: Acetanilide was used as an experimental photographic developer in the 19th century
* Fragrance: Acetanilide can be used in fragrances

(released at high initial velocity into zone of very high rapid air mation). 2.5-10 m/s (500-2000 f/min.) Within each range the appropriate value depends on Lower end of Future Scope

Acetanilide (not acetimide) is the typical derivative obtained from aniline. Here are some potential scopes for acetanilide:

Industrial Applications

1. Dyes and Pigments: Acetanilide is used as an intermediate in the production of dyes, pigments, and pharmaceuticals.
2. Pharmaceuticals: Acetanilide is a precursor to paracetamol (acetaminophen), a widely used analgesic and antipyretic.
3. Agricultural Chemicals: Acetanilide is used in the synthesis of pesticides, herbicides, and fungicides.

Research and Development

1. Organic Synthesis: Acetanilide can be used as a starting material for the synthesis of complex organic compounds, such as heterocycles and natural products.
2. Materials Science: Acetanilide can be used to synthesize polymers, such as polyamides and polyimides, with potential applications in textiles, adhesives, and composites.
3. Biotechnology: Acetanilide can be used as a building block for the synthesis of biomolecules, such as peptides and nucleotides.

Emerging Trends

1. Green Chemistry: Acetanilide can be synthesized using environmentally friendly methods, such as enzymatic catalysis and solvent- free reactions.[21]
2. Nanotechnology: Acetanilide can be used to synthesize nanoparticles with potential applications in medicine, electronics, and energy storage.
3. Sustainable Energy: Acetanilide can be used as a precursor to synthesize materials for energy storage and conversion, such as batteries and fuel cells.[23]

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Pain Management

1. Analgesic properties: Acetanilide has been shown to exhibit analgesic properties, making it a potential candidate for pain management.[22]
2. Development of new analgesics: Researchers may explore modifying acetanilide's structure to create new, more effective analgesics.

Anti-Inflammatory and Antioxidant Properties

1. Inflammation reduction: Acetanilide hasbeen found to possess anti-inflammatory properties, which could be beneficial in treating conditions like arthritis.
2. Antioxidant activity: Its antioxidantproperties may help protect against oxidative stress-related diseases, such as cancer and neurodegenerative disorders.

Antimicrobial and Antibacterial Applications

1. Antibacterial agents: Acetanilide hasdemonstrated antibacterial activity, making it a potential candidate for developing new antibacterial agents.
2. Antimicrobial coatings: Researchers mayexplore using acetanilide-based coatings to prevent microbial growth on medical devices.

Neuroprotective and Neuro regenerative Properties

1. Neuroprotection: Acetanilide may have neuroprotective effects, which could be beneficial in treating neurodegenerative diseases like Alzheimer's and Parkinson's.
2. Neuroregeneration: Its potential neuroregenerative properties may aid in the development of new treatments for nerve damage and neurodegenerative disorders.

Cancer Research

1. Anticancer properties: Acetanilide has been found to exhibit anticancer properties, making it a potential candidate for cancer treatment.
2. Cancer prevention: Researchers may explore using acetanilide as a preventive measure against certain types of cancer.

Future Research Directions

1. Clinical trials: Conducting clinical trials to evaluate the efficacy and safety of acetanilide-based treatments.
2. Mechanism of action: Elucidating the mechanisms by which acetanilide exerts its biological effects.
3. Structure-activity relationships: Investigating the relationships between acetanilide's structure and its biological activity to design more effective analogs.

III. CONCLUSION

The use of acetic acid in the acylation reaction instead of corrosive acetyl chloride or acetic anhydride provides many advantages from both economic and environmental In conclusion, our efficient, atom economic and an environmentally friendly protocol allowed the preparation of a wide range of intermediates for pharmaceuticals (acetanilide). We have developed an efficient, rapid, safe, high yielding and eco- friendly method for Acylation of amines without using catalyst under microwave irradiation. The present method is applicable to primary amines and anilines. Magnesium sulphate heptahydrate-glacial acetic acid system has proved to be a mild, cheap, simple, and benign catalyst for the synthesis of acetanilide from aniline. Lewis acid catalysis nucleophilic acyl substitution reaction by increasing the electrophilicity of the carbonyl group. The method may serve as a sustainable, inexpensive and green route for the acetylation of the primary amines. The method of acetylation reported above is well suited for stu-dents at the undergraduate level since it avoids the use of any catalyst or reducing agent. Since the reaction is carried out in water, it avoids the use of acetic acid as a solvent. The product is obtained immediately on the addition of acetic anhydride and thus eliminates the unnecessary step of refluxing for long peri-ods under anhydrous conditions. This procedure also avoids the use of corrosive chemicals like acetyl chloride. In short, it is a very safe and convenient green procedure for the acetylation of aniline, which gives acetanilide in excellent yields and is easy for students to carry out.

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To Studythe Presence of Adulterants in Different Spices by Chemical Methods

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Abstract:*The adulteration of spices is a widespread issue that compromises both the quality and safety of food products. This research investigates the chemical methods used to detect and analyze the adulteration of commonly used spices, including chilli powder, turmeric powder, andcoriander powder are mainly used in cooking. Differentsamples of spices areselected for the study to determine the adulteration levels and the qualitative difference between them and identify common adulterants such as salts, artificial colorants, and non-edible substances. The findings highlight the significant prevalence of spice adulteration,different spices underscoring the need for more stringent regulatory measures. Additionally, the study provides a detailed analysis of the detection, their sensitivity, and their applicability in ensuring food safety. This research aims to raise awareness about spice adulteration and promote the development of effective methods for its detection, ensuring consumer protection and enhancing food quality control.*

Keywords: Adulterants, spices, artificial colorants, non edible substances

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