

**NANO – CELLULOSE / MOF DERIVED CARBON DOPED $\text{Zn}(\text{NO}_3)_2$
COMPOSITES AS CATALYST FOR PHARMACEUTICAL POLLUTION REMEDY**

Submitted in partial fulfillment of the requirements for the award of Bachelor of
Technology degree in Chemical Engineering

by

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**Institute of Science and Technology
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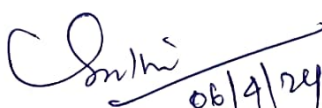
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **WILLIAM JOEL A (40190030)** who carried out the project entitled "Nano – Cellulose / MOF derived Carbon Doped Zn (NO₃)₂ Composites as Catalyst for Pharmaceutical Pollution Remedy" who carried out the project entitled under my supervision from November 2023 – April 2024


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I WILLIAM JOEL A (40190030) hereby declare that the Project Report entitled "Nano - Cellulose / MOF Derived Carbon Doped Zn (No₃)₂ Composites As Catalyst For Organic Pollution Remedy" is done by me under the guidance of Dr.S SATHISH M.E, Ph.D., at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of **BACHELOR OF TECHNOLOGY IN CHEMICAL ENGINEERING.**

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ABSTRACT

The growing environmental concerns linked to organic contaminants demand creative and effective catalysts for the removal of pollutants from the environment. In this project, $\text{Zn}(\text{NO}_3)_2$ is used to create carbon-doped nano-cellulose and metal-organic framework (MOF) precursors to create novel composites. These composites are then synthesized and characterized, and their catalytic potential for treating organic pollution is investigated.

$\text{Zn}(\text{NO}_3)_2$ is added as a dopant to increase catalytic activity, MOF serves as a porous template, and nano-cellulose is incorporated as a sustainable and environmentally acceptable substrate during the synthesis process. In order to clarify the structural, morphological, and chemical characteristics of the resultant composites, a variety of sophisticated analytical methods are employed, including X-ray diffraction (XRD), scanning electron microscopy (SEM), FESEM (Field Emission Scanning Electron Microscope) and Fourier-transform infrared spectroscopy (FTIR).

The outcomes of this research aim to contribute to the development of sustainable and effective catalysts for the remediation of organic pollutants, offering a promising avenue for addressing contemporary environmental challenges. The insights gained from this study may pave the way for the design and implementation of advanced materials with enhanced catalytic properties, thereby contributing to the sustainable management of environmental pollution.

TABLE OF CONTENTS

Chapter No.	CONTENTS	PAGE NO
1.	Introduction	
	1.1 Pharmaceutical pollution mitigation	1
	1.2 The need for innovation	3
	1.3 Scope of the Study	
2.	Literature Review	
	2.1 Overview of Organic Pollution in Water Bodies	5
	2.2 Current Challenges in Organic Pollution Remediation	6
	2.3 Metal-Organic Frameworks (MOFs) in Catalysis	11
	2.4 Nano-Cellulose-Based Materials for Environmental Applications	13
	2.5 Previous Research on Carbon Doped Zn (NO ₃) ₂ Composites	16
3.	AIM AND SCOPE	
	3.1 AIM	18
	3.2 SCOPE	18
	3.3 OBJECTIVE	18
4.	Materials and Methods	
	4.1 Preparation of Nano-Cellulose	20
	4.2 Synthesis of MOF Precursor	21
	4.3 Impregnation of MOF/Nano-cellulose	22

	4.4 Formulation of Zn (NO ₃) ₂ Solution	23
	4.5 Preparation of MOF	24
5.	Characterization Techniques	
	5.1 XRD	27
	5.2 FTIR	27
	5.3 FESEM	28
6.	Introduction to Ibuprofen	
	6.1 Characteristics of Ibuprofen	29
	6.2 Harmful effects of Ibuprofen in Pharmaceuticals	30
7.	Materials and Methods	
	7.1 Materials Required	32
	7.2 Preparation of Ibuprofen Stock solution	32
	7.3 Effect of dosage	33
	7.4 Effect on pH	34
	7.5 Effect on time	35
8.	Final Characterization	
	8.3 XRD	36
	8.4 FTIR	37
	8.5 FESEM	38
	8.6 BET	40
9.	Summary and Conclusion	
	9.1 Stock solution of ibuprofen	41
	9.2 Effect of dosage	42
	9.3 Effect of pH	44
	9.4 Effect of Time	45
	9.5 Effect of Temperature	46
	9.6 Absorption isotherm	47

	9.7 Adsorption Kinetics	49
	9.8 Thermodynamics	50
10.	Conclusion	52
	References	54

LIST OF TABLES

Table No.	Name of the Table	Page No.
8.1	XRD Peak List	37
8.2	FTIR Peak Picking	38

LIST OF FIGURES

Figure No.	Name of the Figure	Page No.
1.1	Conversion of MOF	4
3.1	Nano-Cellulose (Sugarcane Waste)	20
3.2	Mixing of ions	21
3.3	Preparation of biochar	22
3.4	Formulation of $Zn(NO_3)_2$	23
3.5	Preparation of MOF	24
5.1	XRD Graph	36
5.2	FTIR Graph	27
5.3	FESEM (Microstructural image of material)	28
6.1	Ibuprofen	29
8.1	XRD Graph	36
8.2	FTIR Graph	37
8.3	FESEM (Microstructural image of material)	39
9.1	Stock solution sample	41
9.2	Concentration removal graph	41
9.3	Dosage sample	42
9.4	Dosage graph	42
9.5	pH Sample	44
9.6	pH Graph	44
9.7	Effect of Time Graph	45
9.8	Temperature Graph	46
9.9	Temkin Graph	47
9.10	Langmuir	47
9.11	Freundlich	48
9.12	Pseudo First Order Graph	49
9.13	Pseudo Second Order	50
9.14	Thermodynamics Graph	51

CHAPTER 1

INTRODUCTION

1.1 Pharmaceutical Pollution Mitigation

In modern times, the rising levels of organic pollutants in waterways have become a pressing concern, posing significant threats to environmental sustainability and human health. The harmful effects of these pollutants, stemming from various sources like industry, agriculture, and domestic activities, have increased awareness of the urgent need for effective remediation strategies. The range of organic pollutants infiltrating aquatic ecosystems is broad and complex, including various compounds like synthetic dyes, agrochemicals, pharmaceutical residues, and volatile organic solvents. Each compound carries its own adverse effects, from acute toxicity to chronic hazards, complicating the environmental problem.

Industrial activities like textile manufacturing, chemical production, and food processing significantly contribute to the discharge of organic pollutants into water bodies. Synthetic dyes used in textiles are notorious for persisting in water and soil, threatening aquatic life and ecosystems. Similarly, agricultural pesticides and fertilizers contaminate surface and groundwater, harming aquatic biodiversity and human health. Moreover, pharmaceutical residues from human and animal excretion further compound the issue by entering water bodies through sewage and runoff, raising concerns about antibiotic resistance and endocrine disruption.

The degradation of organic pollutants relies on interactions between the catalyst and pollutants that activate chemical bonds, initiating breakdown pathways. Various materials like metal oxides, nanoparticles, zeolites, and carbon-based materials have been explored as catalysts to degrade organic pollutants. Metal-Organic Frameworks (MOFs) have garnered interest due to their tunable structure, high surface area, and catalytic potential. MOFs

provide well-defined, tailorable pores and opportunities to add active sites tailored to specific reactions, making them advantageous catalyst supports.

Nano-cellulose from renewable sources has emerged as a sustainable platform for advanced materials, given its high surface area, strength, biocompatibility, and biodegradability. By incorporating nano-cellulose into MOF-derived catalysts, synergies can enhance catalytic activity, stability, and selectivity for efficient organic pollutant degradation.

Synthesizing carbon-doped $\text{Zn}(\text{NO}_3)_2$ composites from nano-cellulose/MOF precursors is a promising approach for catalytic pollutant remediation. Carbon doping introduces active sites and enhances conductivity, promoting redox reactions and pollutant degradation. The $\text{Zn}(\text{NO}_3)_2$ provides metal centers to catalyze oxidative pathways, further improving the composite's performance. By utilizing nano-cellulose, MOFs, and carbon-doped metal oxides, highly efficient and sustainable catalysts can be developed for organic pollutant remediation.

The recalcitrant nature and resistance to degradation of organic pollutants exacerbate their persistence in the environment. Unlike inorganic pollutants which can undergo chemical changes or sedimentation, organic pollutants persist in water, posing long-term risks. Furthermore, some organic pollutants like PCBs and PBDEs bioaccumulate up the food chain, magnifying their impact on higher trophic levels including humans.

In response to the escalating threat of organic pollutants, scientists have developed innovative and sustainable remediation strategies to mitigate their adverse effects. Among available technologies, catalytic degradation has emerged as a promising approach due to its efficacy, versatility and potential for large-scale use. Heterogeneous catalysts in particular offer advantages like ease of separation, recyclability and compatibility with diverse pollutants.

This research article aims to synthesize and characterize nano-cellulose/metal-organic framework (MOF)-derived carbon-doped zinc nitrate composites for use as catalysts to remove organic pollutants from water. We will pyrolyze nano-cellulose/MOF precursors then impregnate the material with zinc nitrate to form the composites. Advanced techniques like X-ray diffraction, scanning electron microscopy, transmission electron microscopy, Fourier-transform infrared

spectroscopy, and Brunauer-Emmett-Teller analysis will comprehensively characterize the composites' structure, morphology, and surface properties. We will then evaluate the composites' catalytic performance in degrading model organic pollutants including dyes, pesticides, and pharmaceuticals using quantitative techniques like UV-vis spectroscopy, high-performance liquid chromatography, and chemical oxygen demand analysis. Mechanistic studies will provide insights into the catalytic degradation pathways to inform optimized catalyst design for removing organic pollutants from water. Through interdisciplinary collaboration and innovative approaches, this study aims to develop efficient and sustainable solutions to the critical environmental challenges posed by organic water pollutants, working towards a cleaner, healthier environment for future generations.

1.2 The need for innovation

The search for innovative and sustainable solutions to the problems associated with remediating organic waste has been fueled by the growing worries about environmental contamination and its detrimental effects on public health.

Ecosystems that are dependent on water and wastewater are constantly threatened by organic pollutants, which include a wide variety of toxins like pesticides, dyes, and pharmaceutical residues. The need to reduce these pollutants as soon as possible makes it imperative to create novel catalysts that can remove organic pollutants from a variety of environmental matrices in an efficient and sustainable manner.

Advanced and adaptable catalytic materials are required due to the complex nature of organic contaminants, which are typified by their persistence and resistance to traditional treatment techniques. The carbon-doped $\text{Zn}(\text{NO}_3)_2$ composite generated from nano cellulose and Metal-Organic Framework (MOF) is a viable option among the variety of possible catalysts for organic pollution cleanup. This introduction explores the compelling rationale behind the investigation of such composites and emphasises the need to solve the problems caused by organic contaminants in streams of water and wastewater.

Urgent intervention is required due to the worrisome levels of environmental contamination, which are mostly caused by industrial activity, agricultural runoff, and improper disposal of medications. Beyond just harming the environment, organic pollution also poses a health risk to people by contaminating sources of drinking water and upsetting aquatic ecosystems.

The problem of water contamination by organic pollutants is intricate and has far-reaching implications. The group consists of numerous substances starting from synthetics like plasticizers, polycyclic aromatic hydrocarbons (PAHs), diphenyl ethers (PBDEs), polybrominated biphenyl ethers (PBDEs) or pentachlorophenols (PCP)s; halogenated aromatics including polychlorinated dibenzodioxins(PCDDs), polychlorinated dibenzofurans(PCDFs); organochlorines such as chlorobenzenes(CBs), PCBs (polychlorinated benzene's); naturally occurring toxins such as microcystins (MCYST) or aflatoxins(AFTOXNs); personal care products e.g. thinners or fragrance enhancers; and other groups including drugs/pharmaceutical preparations besides others which should not have existed in water at all

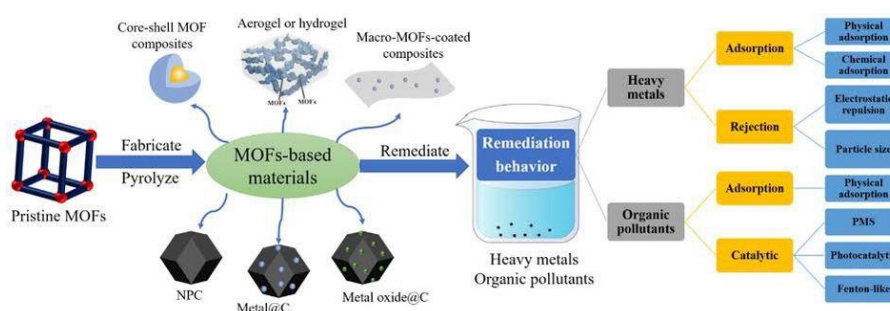


Fig 1.1 Conversion of MOF

CHAPTER – 2

LITERATURE REVIEW

OVERVIEW OF ORGANIC POLLUTION IN WATER BODIES

Waterways worldwide face an escalating threat from organic pollutants, posing significant risks to ecosystems and human health. These pollutants include a diverse array of compounds from industrial processes, agriculture, and domestic sources such as dyes, pesticides, pharmaceuticals, and hydrocarbons. Each carry distinct environmental and health risks.

The sources of organic pollution are wide-ranging, including industrial effluents, agricultural runoff, urban sewage, and improper waste disposal. Industrial activities discharge untreated or inadequately treated effluents containing manufacturing chemicals into waterways. Agricultural runoff carries pesticides, herbicides, and fertilizers into surface and groundwater, especially during rainfalls. Urban sewage introduces a mixture of organic pollutants into water bodies, often with inadequate treatment. Dumping waste into waterways or landfills also contributes to the organic pollution burden **(Carpenter, S. R., Caraco, N. F., Correll, D. L., Howarth, R. W., Sharpley, A. N., & Smith, V. H. 1998)**.

Once in waterways, organic pollutants persist and move to varying degrees depending on their properties and conditions. Persistent organic pollutants like PAHs and chlorinated compounds accumulate in sediments and biota, posing ecosystem risks. Through biomagnification up the food chain, these can impact human reproductive, immune, and neurological health.

The impacts on aquatic ecosystems are diverse, including acute and chronic toxicity to organisms, habitat degradation, disrupted ecosystems, and biodiversity losses. Exposure to high pollutant levels impairs growth, reproduction, and survival. Pollutants also interfere with biochemical processes, nutrient cycles, and habitat

quality. The cascading effects through food webs compromise ecosystem resilience **(Schwarzenbach, R. P., Gschwend, P. M., & Imboden, D. M. 2003).**

Additionally, organic pollution poses human health risks through contaminated drinking and recreational water and bioaccumulation in seafood. Integrated, concerted efforts are needed to address the sources, impacts, and risks to safeguard water quality, aquatic biodiversity, and sustainability **(US Environmental Protection Agency (EPA) (2019)).**

CURRENT CHALLENGES IN ORGANIC POLLUTION REMEDIATION

Traditional techniques for the remediation of natural pollution, encompassing bodily, chemical, and biological strategies, have long been employed to mitigate the negative outcomes of natural contaminants in water our bodies. but those conventional strategies frequently come across obstacles that hinder their effectiveness and sustainability, necessitating the exploration of revolutionary remediation strategies.

Physical strategies:

physical strategies for organic pollution remediation usually involve the physical removal or separation of pollutants from water matrices. techniques which include sedimentation, filtration, and membrane techniques are usually used to eliminate suspended solids, colloids, and dissolved organic compounds from water. at the same time as these methods can efficaciously lessen natural pollutant concentrations, they may now not be suitable for the entire elimination of contaminants or for addressing recalcitrant compounds. moreover, bodily methods may additionally require full-size power inputs and operational costs, mainly for membrane-primarily based tactics, which depend on stress-pushed separation mechanisms.

Chemical methods:

Chemical techniques for natural pollution remediation usually contain using chemical sellers to convert or degrade pollution into much less dangerous or inert by-products. Oxidation techniques, including ozonation and superior oxidation strategies (AOPs), are typically employed to degrade organic pollutants via the generation of surprisingly reactive hydroxyl radicals. whilst these methods can be effective for the degradation of a extensive variety of natural compounds, they regularly require significant strength inputs and may produce dangerous by-products, including chlorinated natural compounds or bromate ions, which pose extra environmental dangers. moreover, chemical oxidation approaches may exhibit limited selectivity and performance for positive recalcitrant pollutants, necessitating the improvement of tailor-made remedy techniques (Lee, C. S., Robinson, J., & Chong, M. F 2014)

Biological methods:

organic techniques for organic pollutants remediation depend upon the metabolic activities of microorganisms to degrade natural pollution into easier, less toxic compounds. techniques together with activated sludge methods, biofiltration, and built wetlands are commonly used for biological remedy of natural pollution in wastewater remedy flowers and herbal ecosystems. while biological strategies may be surprisingly powerful for the removal of biodegradable pollutants, they may be less suitable for recalcitrant compounds that resist microbial degradation. additionally, biological remedy strategies can also require longer retention times and large land areas in comparison to traditional bodily and chemical strategies, proscribing their applicability in sure settings (Wang, A., Quan, X., & Zhao, H. 2017).

Adsorption-based totally strategies:

Adsorption-based techniques contain the use of adsorbent substances to capture and do away with natural pollution from water matrices. Activated carbon, zeolites, and diverse nanoporous substances are usually used as adsorbents due to their high surface region and affinity for organic molecules. whilst adsorption can be an powerful method for doing away with natural pollutants, it may be afflicted by bad

selectivity, requiring frequent regeneration or alternative of adsorbents. furthermore, the adsorption capacity of adsorbents may be encouraged by way of elements inclusive of pH, temperature, and the presence of competing ions, which can affect standard treatment efficiency (Li, H., Li, Q., Wang, H., Di, Z., & Jiang, H. 2016).

Revolutionary and Sustainable Remediation techniques:

Given the constraints of traditional remediation strategies, there's a compelling want for the improvement of modern and sustainable methods to deal with the challenges posed by using natural pollution. emerging technology, inclusive of photocatalysis, electrochemical oxidation, and membrane-based totally methods, provide promising avenues for the efficient removal and degradation of natural pollutants with decreased power consumption and environmental impact. furthermore, the integration of superior substances, along with carbon nanomaterials, metal-natural frameworks (MOFs), and nano-cellulose-primarily based composites, into remediation structures holds capacity for reinforcing treatment efficiency and selectivity.

In conclusion, whilst conventional techniques for organic pollutants remediation were instrumental in mitigating the effects of organic contaminants in water bodies, they frequently encounter boundaries such as low efficiency, excessive operational prices, and the era of secondary pollution. consequently, the improvement of revolutionary and sustainable remediation techniques is imperative to deal with the challenges posed by way of organic pollution effectively. through leveraging rising technologies and advanced substances, we will increase value-powerful, electricity-efficient, and environmentally benign methods to guard water exceptional and guard aquatic ecosystems from the detrimental outcomes of natural contaminants **(Wang, J., Zheng, Y., & Liu, W. (2017).**

CATALYTIC DEGRADATION AS A PROMISING APPROACH:

Catalytic degradation has emerged as a promising method for the remediation of natural pollutants in water bodies, attributable to its ability for high efficiency, selectivity, and mild working situations. not like conventional treatment strategies, which often depend upon physical or chemical methods, catalytic degradation harnesses the power of catalytic materials to facilitate redox reactions that smash down natural pollution into much less dangerous or inert via-merchandise **(Chen, F., Liu, Y., & Wang, Z. 2019).**

One of the key blessings of catalytic degradation is its versatility in addressing a huge variety of organic pollutants found in water bodies. Heterogeneous catalysts, especially, have won substantial attention because of their capacity to catalyse reactions at the interface between the catalyst surface and the response medium. those catalysts may be tailored to goal unique pollution by means of adjusting their composition, morphology, and floor homes. moreover, heterogeneous catalysts offer numerous realistic benefits over homogeneous catalysts, which include smooth separation from response combinations, ability for reuse, and more advantageous balance beneath a ramification of operating situations **(Gogate, P. R., & Pandit, A. B 2004).**

The mechanism of catalytic degradation includes the activation of natural pollution by the catalytic cloth, followed via a series of redox reactions that lead to the cleavage of chemical bonds and the formation of easier, much less poisonous compounds. The catalytic cloth acts as a facilitator, supplying a floor for the adsorption and activation of reactant molecules, in addition to a pathway for the switch of electrons between reactants and merchandise. via accelerating the charge of those reactions, catalytic materials can drastically decorate the degradation performance of organic pollution, even at especially low concentrations.

One of the key advantages of catalytic degradation is its capacity to operate beneath slight situations, along with ambient temperature and pressure, reducing power consumption and environmental effect in comparison to traditional treatment strategies. this is especially crucial for the remediation of organic pollution in water our bodies, where stringent environmental policies and cost concerns regularly

restrict the feasibility of more strength-intensive remedy techniques. furthermore, catalytic degradation can be integrated into present water remedy systems or deployed as standalone devices, imparting flexibility and scalability for numerous applications (Yu, J., & Xu, X. 2014).

in addition to its environmental benefits, catalytic degradation gives financial advantages, along with ability value savings and sales technology thru the recuperation of precious by means of-products. for instance, positive catalytic techniques can convert natural pollution into intermediate compounds that can be in addition processed into useful chemicals or fuels, imparting a capability supply of sales or offsetting treatment charges. moreover, the recyclability of heterogeneous catalysts permits for multiple cycles of use, decreasing the need for common alternative and minimizing waste technology.

no matter its numerous advantages, catalytic degradation also gives certain demanding situations and barriers that must be addressed for sizable adoption in water remediation programs. those consist of the improvement of catalysts with progressed hobby, selectivity, and stability, in addition to the optimization of response conditions to maximise degradation efficiency whilst minimizing formation. additionally, the mixing of catalytic degradation into current water remedy infrastructure may also require adjustments or upgrades to accommodate the unique necessities of catalytic tactics.

In conclusion, catalytic degradation gives a promising method for the remediation of organic pollutants in water bodies, presenting high efficiency, selectivity, and moderate operating conditions. Heterogeneous catalysts, particularly, offer sensible advantages along with smooth separation, ability for reuse, and applicability to a huge variety of pollution. with the aid of harnessing the power of catalytic substances, we can boost up the degradation of natural pollutants and sell the remediation of infected water our bodies, contributing to environmental sustainability and human health.

Metal-Organic Frameworks (MOFs) in Catalysis:

Metal-Organic Frameworks (MOFs) have emerged as a category of flexible substances with great capability in various fields, which includes catalysis, because of their particular structural residences, excessive surface location, and tunable pore systems. MOFs constitute a brand-new class of porous substances composed of steel ions or clusters coordinated with organic ligands to form crystalline frameworks. these frameworks usually showcase nicely described cavities and channels, resulting in excessive porosity and surface vicinity, which are relatively ideal houses for catalytic packages (Li, J. R., Sculley, J., & Zhou, H. C. 2012).

The structure of MOFs is characterized by way of steel nodes or clusters interconnected with the aid of organic linkers, forming prolonged networks with ordered structures. the choice of metallic ions and organic ligands lets in for the design and synthesis of MOFs with tailored homes, which include pore length, floor chemistry, and purposeful organizations, which can be finely tuned to optimize catalytic overall performance for unique reactions. The modular nature of MOFs enables specific manipulate over their composition and structure, making them rather versatile and adaptable as catalysts for a wide range of applications.

One of the key blessings of MOFs in catalysis is their excessive surface location, which arises from the inherent porosity of the crystalline frameworks. The large floor vicinity gives plentiful energetic websites for catalytic reactions, bearing in mind efficient adsorption and interaction of reactant molecules. moreover, the tunable pore structures of MOFs enable selective adsorption and diffusion of reactants and products, facilitating stronger catalytic pastime and selectivity.

Furthermore, MOFs provide the ability to encapsulate visitor molecules within their pores, imparting confined surroundings for catalytic reactions. This confinement effect can lead to accelerated balance and selectivity of catalysts, in addition to superior mass transfer and diffusion kinetics of reactants and merchandise. The encapsulation of reactant molecules in the pores of MOFs can also prevent undesirable aspect reactions and reduce catalyst deactivation, thereby enhancing the overall efficiency and performance of catalytic structures.

Every other noteworthy feature of MOFs is their flexibility in functionalization, whereby diverse practical compounds may be delivered onto the natural ligands or metallic nodes to modulate their catalytic homes. Functionalization lets in for the incorporation of unique catalytic sites, including metallic active web sites or organic useful agencies, tailored to the favored response mechanism. This versatility in functionalization enables the layout of MOF-based catalysts with more suitable activity, selectivity, and stability for various catalytic transformations.

In latest years, MOFs have been explored for a extensive variety of catalytic programs, which include heterogeneous catalysis, photocatalysis, electrocatalysis, and enzymatic catalysis. those programs span numerous industries and sectors, together with energy conversion and garage, environmental remediation, chemical synthesis, and biomedical packages. for instance, MOFs have proven promise as catalysts for organic differences, together with C-C bond formation, hydrogenation, oxidation, and move-coupling reactions, demonstrating excessive catalytic interest and selectivity.

Furthermore, the design and synthesis of MOF-based totally catalysts may be tailored to cope with unique challenges in catalysis, inclusive of improving reaction costs, selectivity, and balance, in addition to lowering environmental impact and aid consumption. by harnessing the specific houses of MOFs, researchers can increase revolutionary catalytic materials with better performance and capability for a extensive variety of industrial and environmental packages **(Cui, Y., Yue, Y., Qian, G., & Chen, B. 2012).**

Metal-organic Frameworks (MOFs) have emerged as promising catalysts because of their precise structural houses, excessive floor area, and tunable pore structures. MOFs offer severa advantages as catalysts, including high catalytic activity, selectivity, and the capability to encapsulate visitor molecules within their pores. moreover, the modular nature of MOFs permits for the layout and synthesis of tailored catalysts for particular applications, making them extraordinarily versatile and adaptable for a extensive variety of catalytic transformations. As research on this field keeps strengthening, MOFs are predicted to play a important role in addressing key challenges in catalysis and using innovation in various industries and sectors **(Dhakshinamoorthy, A., & Garcia, H. (2012).**

NANO-CELLULOSE-BASED MATERIALS FOR ENVIRONMENTAL APPLICATIONS

Nano-cellulose, derived from renewable biomass resources like timber pulp and agricultural residues, has garnered giant attention in recent years for its tremendous homes and various applications in environmental remediation. this versatile material, characterized by using its excessive floor vicinity, mechanical electricity, and biocompatibility, holds gigantic promise for addressing environmental challenges, mainly in pollutant remediation. here, we delve into the specific residences of nano-cellulose and explore its potential packages in pollutant adsorption, membrane filtration, and catalysis, focusing at the synergistic results accomplished with the aid of incorporating nano-cellulose into composite materials.

Properties of Nano-cellulose:

Nano-cellulose, which include cellulose nanocrystals (CNCs) or cellulose nanofibers (CNFs), possesses first rate physical and chemical houses thanks to its nanoscale dimensions and crystalline structure. With a excessive element ratio and massive precise floor region, nano-cellulose well-known shows terrific adsorption potential for numerous pollutants, such as heavy metals, organic dyes, and pharmaceutical compounds. furthermore, nano-cellulose demonstrates fantastic mechanical properties, together with excessive tensile energy and modulus, making it appropriate for the fabrication of strong membranes and composite materials. moreover, nano-cellulose is biocompatible, non-poisonous, and biodegradable, rendering it environmentally pleasant and secure for use in diverse packages **(Cui, Y., Yue, Y., Qian, G., & Chen, B 2012)**

Packages in Pollutant Adsorption:

Nano-cellulose-based substances have proven excellent capacity for pollutant adsorption due to their excessive surface region and purposeful groups able to form strong interactions with contaminants. by using enhancing the surface chemistry of nano-cellulose via chemical remedies or functionalization with specific organizations (e.g., carboxyl, amino, hydroxyl), the adsorption selectivity and performance may be tailor-made for specific pollution. Nano-cellulose composites, incorporating additional adsorbent materials or nanoparticles, can further beautify pollutant elimination performance through synergistic results. these composites may be utilized in diverse water treatment techniques, together with batch adsorption, non-stop waft structures, and point-of-use filtration devices, providing value-powerful and sustainable solutions for pollutant elimination from infected water assets.

Membrane Filtration applications:

Nano-cellulose-primarily based membranes preserve promise for membrane filtration applications because of their specific mixture of homes, together with high porosity, mechanical power, and tunable pore length distribution. by way of using nano-cellulose membranes, contaminants can be successfully removed from water streams through length exclusion, adsorption, and electrostatic interactions. furthermore, nano-cellulose membranes may be functionalized with surface coatings or nanoparticles to beautify their selectivity and fouling resistance. those membranes locate programs in numerous water remedy techniques, including microfiltration, ultrafiltration, and nanofiltration, for the elimination of pollution consisting of bacteria, viruses, organic rely, and microplastics. The improvement of nano-cellulose-based totally membranes represent a promising avenue for reaching sustainable and green water purification systems.

Catalytic programs:

In recent years, nano-cellulose has emerged as a promising guide cloth for catalytic packages because of its high floor region, mechanical robustness, and compatibility with heterogeneous catalysis. by means of immobilizing catalytic nanoparticles onto nano-cellulose substrates, novel catalysts can be evolved for various natural adjustments, including degradation of natural pollution, synthesis of excellent chemical substances, and conversion of biomass feedstocks **(Habibi, Y., Lucia, L. A., & Rojas, O. J 2010)**. The synergistic outcomes between nano-cellulose and catalytic nanoparticles result in stepped forward catalytic activity, selectivity, and balance. furthermore, the biodegradability of nano-cellulose makes it an environmentally sustainable option for catalytic applications, minimizing environmental impacts related to catalyst disposal **(Lu, P., & Hsieh, Y. L 2010)**. Nano-cellulose-based catalysts show promise for applications in wastewater remedy, inexperienced chemistry, and renewable strength technologies, imparting modern solutions for addressing environmental demanding situations **(Abdel-Mohsen, A. M., Amin, M. B., El-Newehy, M. H., & Al-Deyab, S. S. 2012)**.

Nano-cellulose, derived from renewable biomass resources, affords a flexible and sustainable fabric for environmental remediation applications. With its particular aggregate of properties, along with excessive floor area, mechanical electricity, and biocompatibility, nano-cellulose offers promising solutions for pollutant adsorption, membrane filtration, and catalysis. via incorporating nano-cellulose into composite substances, synergistic results may be accomplished, leading to greater overall performance and stability in environmental remediation techniques. persevered studies and improvement in nano-cellulose-primarily based substances keep the potential to revolutionize water treatment technology and make a contribution to a cleanser and greater sustainable surroundings **(Sehaqui, H., Salajková, M., Zhou, Q., & Berglund, L. A 2010)**.

PREVIOUS RESEARCH ON CARBON DOPED ZN (NO₃)₂ COMPOSITES:

Carbon doped Zn(NO₃)₂ composites have emerged as versatile materials with promising applications across various fields, including catalysis, energy storage, and sensing. These composites, formed through the incorporation of carbon into a Zn(NO₃)₂ matrix, exhibit unique properties that render them highly effective for catalytic applications, particularly in the remediation of organic pollutants from water bodies.

The synergistic effects between the carbon matrix and the active metal species, such as zinc ions, contribute to the enhanced catalytic activity of carbon doped Zn(NO₃)₂ composites. The carbon matrix serves as a support material, providing a high surface area and facilitating the dispersion of active metal species, thereby promoting catalytic reactions. Moreover, the presence of carbon species can modify the electronic and surface properties of the composite, leading to improved catalytic performance and selectivity **(Wang, X., Ma, W., & Gong, J. 2009)**.

Previous studies have demonstrated the efficacy of carbon doped Zn (No₃)₂ composites in various catalytic applications, including the degradation of organic pollutants, oxidation reactions, and hydrogen evolution. In the context of organic pollution remediation, carbon doped Zn (No₃)₂ composites have shown remarkable potential for the degradation of diverse organic contaminants present in water bodies. Through redox reactions facilitated by the active metal species, organic pollutants can be efficiently transformed into less harmful or inert by-products, thereby promoting the remediation of contaminated water bodies.

The catalytic performance of carbon doped Zn (No₃)₂ composites can be further optimized by tuning their composition and morphology. For instance, varying the carbon content, particle size, and surface area of the composites can influence their catalytic activity, selectivity, and stability. Additionally, the incorporation of dopants or modifying agents into the composite structure can enhance its performance for specific catalytic applications **(Wang, H., Zhang, X., & Li, Y 2011)**

In addition to organic pollution remediation, carbon doped Zn(NO₃)₂ composites have shown potential in other catalytic processes, such as oxidation reactions and hydrogen evolution. The unique properties of these composites, including their high surface area, porosity, and electronic conductivity, make them attractive candidates for various catalytic transformations. By harnessing the synergistic effects between carbon and metal species, carbon doped Zn (NO₃)₂ composites can facilitate efficient catalytic reactions with enhanced reaction rates and yields **(Zhang, X., Zhang, S., & Zhang, X 2015)**

Furthermore, the versatility and tunability of carbon doped Zn (NO₃)₂ composites make them promising candidates for future research and development in catalysis. By exploring novel synthesis methods, optimizing composite structures, and elucidating reaction mechanisms, researchers can further enhance the catalytic performance and applicability of these materials. Moreover, interdisciplinary collaborations between materials scientists, chemists, and environmental engineers can lead to the design of tailored carbon doped Zn (NO₃)₂ composites for specific catalytic applications, addressing the pressing challenges of organic pollution remediation and beyond **(Li, W., Ma, Z., & Yang, Y 2017)**

In conclusion, carbon doped Zn (NO₃)₂ composites represent a promising class of materials with diverse applications in catalysis, including the remediation of organic pollutants from water bodies. Through the synergistic effects between carbon and metal species, these composites exhibit enhanced catalytic activity, selectivity, and stability, making them valuable tools for environmental remediation and sustainable development.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

This study aims to synthesize and characterize nano-cellulose/IMOF (Inorganic Metal-Organic Framework) derived carbon-doped Zn (NO₃)₂ composites for application as catalysts in organic pollution remediation. The catalysts will be fabricated through a multi-step process involving the conversion of nano-cellulose and IMOF into carbon matrices doped with Zn (NO₃)₂. The resulting composites will be thoroughly characterized using various composite analytical techniques to understand their structural, morphological, and chemical properties. Subsequently, the catalytic performance of the composites will be evaluated in the remediation of organic pollutants, focusing on their efficiency, stability, and reusability. This research aims to contribute to the development of sustainable and effective catalyst materials for environmental remediation applications.

3.2 OBJECTIVE:

- To derive carbon doped Zn (NO₃)₂ composite catalyst for organic pollution remedy.
- To remove organic contaminants.
- To use various treatment techniques to treat organic pollutants to achieve maximum removal efficiency.

3.3 SCOPE

- Today there is a great focus on treating organic pollutants hence there is an urgent need to develop an economical treatment system for the treatment of organic pollutants, which can meet the strict quality standard.
- In recent days organic pollution remedies are focus on various economical and eco-friendly treatment.
- This feature contributes to the cost-effective.

CHAPTER 4

MATERIALS AND METHODS

3.1 MATERIALS:

The following list of materials were used for MOF synthesis.

CHEMICALS REQUIRED:

- Sodium hydroxide
- Distilled water
- Sugarcane waste
- Zinc Nitrate
- Ferric chloride
- Terephthalic acid
- Ethanol

EQUIPMENTS REQUIRED:

- Furnace
- Hot air oven
- Crucible
- Magnetic stirrer
- Beaker
- P.H paper
- Filter paper
- Stirring rod
- Glass pallet

3.2 PREPARATION OF NANO – CELLULOSE:



Fig 3.1 Nano Cellulose

Nano-cellulose is derived from cellulose rich source like wood pulp or agricultural waste through mechanical and chemical treatment to break down the cellulose fiber into nano scale dimension.

- Collect the sugarcane waste and grind the waste substance into smaller particles to remove non-cellulosic components like lignin.
- It is a chemical treatment where grinded sugarcane waste is immersed in a strong alkaline solution using sodium hydroxide (20g of NaOH in 1 litre of water)
- Heat the alkaline treated sugarcane waste while stirring to ensure uniform distribution of the alkaline solution (100 Degree Celsius)
- Thoroughly rinse the chemically treated sugarcane waste in 20 ml of diluted sulphuric acid (H_2SO_4) to remove the remains of chemical and impurities.
- Once again the sugarcane must be washed and after completing the washing, the sugarcane must be dried to remove excess water and obtain a dry cellulose rich material (Hot air oven can be used)

3.3 SYNTHESIS OF MOF PRECURSOR



Fig 3.2 Mixing metal ions.

MOF precursor is synthesized by mixing metal ions with organic ligands in a suitable solvent, this forms a crystalline MOF structure that will later be used to derive the catalyst.

- Dissolve zinc nitrate $\text{Zn}(\text{NO}_3)_2$ - 4.8 grams in solvent in 300ml of DMF + 200ml of Ethanol.
- Dissolve the organic ligand in a separate solvent (such as Terephthalic acid – 10 gram)
- Slowly add the metal solution to the organic ligand solution while stirring. This will allow the metal ion coordinate with the organic ligands and form the MOF precursor (Mixing metal solution and organic ligands).
- After mixing the metal solution and organic ligand, the MOF precursor solution may need to be left for a specific period of time to allow crystallization and aging.
- Filter the MOF crystals and wash them with a suitable solvent to remove any impurities or unreacted chemical.
- Dry the MOF precursor crystal to obtain a dry powder form that can be stored for further use

3.4 Impregnation of MOF or Nano – Cellulose

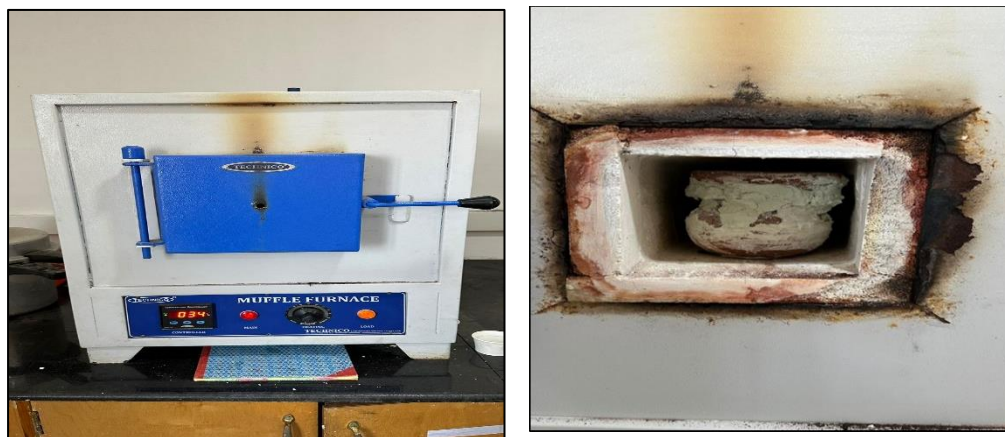


Fig 3.3 Preparation of Biochar

- To prepare biochar from dried sugar cane bits, a simple method involving a clay pot and a furnace can be employed. The process involves the following steps:
- Transfer the dried sugar cane bits into the clay pot. Ensure that the clay pot is clean and free from any contaminants.
- Seal the clay pot tightly using white cement. This step is crucial to prevent the escape of gases and to create an oxygen-limited environment inside the pot during the pyrolysis process.
- Place the sealed clay pot inside the furnace and heat it to a temperature of 500°C. It is recommended to maintain this temperature for approximately 3 hours to facilitate the pyrolysis of the sugar cane bits.
- During the pyrolysis process, the high temperature and absence of oxygen cause thermal decomposition of the sugar cane bits, leading to the formation of biochar. Biochar is a stable form of carbon with a high surface area and porous structure, making it suitable for various applications, including soil amendment, carbon sequestration, and environmental remediation.

3.5 Formulation of $\text{Zn}(\text{NO}_3)_2$ Solution:



Fig. 3.4: Formulation of $\text{Zn}(\text{NO}_3)_2$ Solution

The formulation of CoFe_2 involves a series of steps to put together a solution comprising zinc nitrate, ferric chloride, and terephthalic acid in a mixture of ethanol and distilled water. This answer serves as a precursor for $\text{Zn}(\text{NO}_3)_2$ synthesis and is ready as follows:

1. Choice of Precursors:

The number one precursor for the $\text{Zn}(\text{NO}_3)_2$ formulation encompasses zinc nitrate, ferric chloride, and terephthalic acid. These chemical substances are chosen based on their reactivity and compatibility with the desired synthesis method.

2. Preparation of Solution

To provoke the method manner, the required portions of zinc nitrate, ferric chloride, and terephthalic acid are measured and brought to an appropriate solvent combination comprising ethanol and distilled water. The solvent mixture helps the dissolution of the precursors and ensures homogeneity of the ensuing solution.

3. Stirring:

Once all of the precursors are brought to the solvent aggregate, the solution is subjected to stirring the use of a magnetic stirrer. Stirring is crucial to sell the dissolution of the precursors and to make sure uniform blending of the components. the solution is stirred for a length of approximately 3 hours to gain whole dissolution and homogenization.

4. Monitoring:

In the course of the stirring process, the answer is monitored for any adjustments in colour, viscosity, or readability, which might also imply the development of dissolution and mixing. ordinary monitoring enables make sure that the preferred homogeneity and consistency are completed within the final solution.

3.6 Preparation of MOF:



Fig 3.5: Preparation of MOF

The practise of Metal-organic Frameworks (MOFs) entails a series of steps geared toward incorporating biochar into an answer, observed via heating and drying procedures to attain the desired MOF powder. The technique is executed as follows:

- **Addition of Biochar to the solution:**

Step one inside the instruction of MOF entails adding biochar to the answer containing the essential precursor substances. Biochar, derived from sustainable biomass sources, is brought into the answer to function a template or scaffold for MOF formation. The addition of biochar is carefully managed to make sure right dispersion and incorporation in the answer.

- **Heating the answer in a Magnetic Stirrer:**

After the addition of biochar, the answer is heated in a magnetic stirrer to a temperature of 80°C. Heating the answer facilitates the infusion of biochar into the answer and promotes the formation of MOF structures. The stirring movement guarantees thorough mixing and distribution of biochar inside the solution, promoting uniform MOF boom.

- **Duration of Heating:**

The solution is maintained at a temperature of 80°C for a period of 6 hours. This extended heating period lets in enough time for the biochar to emerge as fully infused into the solution and for MOF formation to arise. The extended heating duration guarantees the improvement of well-defined MOF systems with stronger properties.

- **Transfer to a Hot Air Oven:**

Following the heating step, the semiliquid combination containing biochar and MOF precursors is transferred right into a hot air oven. the new air oven is ready to a temperature of 100°C to facilitate the evaporation of extra water from the combination. This step is vital for getting rid of moisture from the answer and selling the formation of MOF in powdered form.

- **Drying Method:**

The semiliquid combination is subjected to drying in the warm air oven for a length of 4 hours. for the duration of this time, the extra water gift within the mixture evaporates, leaving in the back of the preferred MOF in powdered form. The drying procedure is essential for accomplishing the preferred consistency and morphology of the MOF powder, ensuring its suitability for similarly characterization and application.

By means of following these sequential steps, biochar-infused MOF powder can be successfully prepared, ready for next characterization and utilization in diverse programs. The incorporation of biochar into the MOF synthesis system offers possibilities to beautify the residences and performance of the resulting MOF substances, contributing to the development of sustainable and environmentally pleasant technologies.

CHAPTER 5

INITIAL CHARACTERIZATION

XRD (X-Ray diffraction)

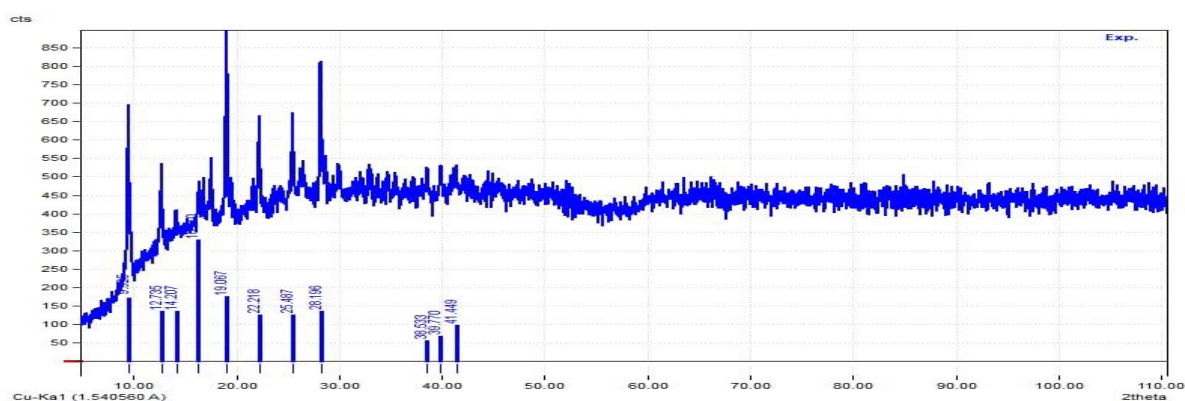


Fig 4.1 XRD Graph

FTIR (Fourier Transform Infrared Spectroscopy)

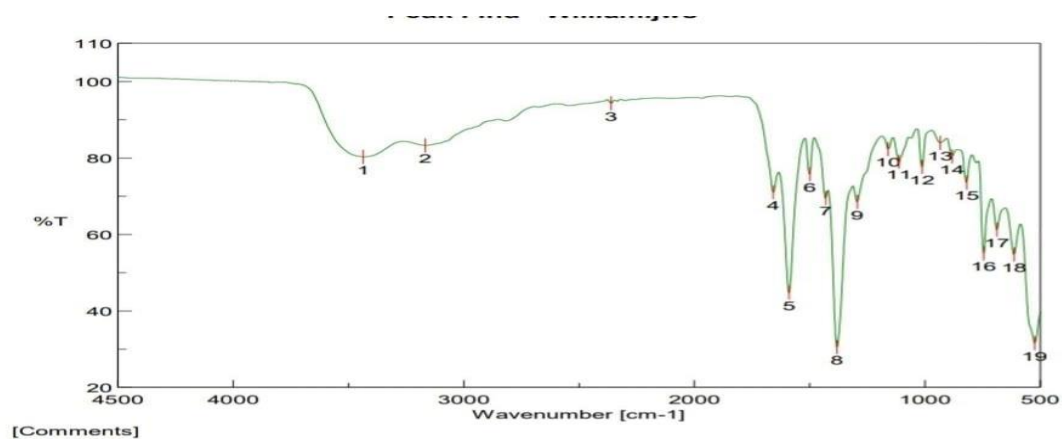
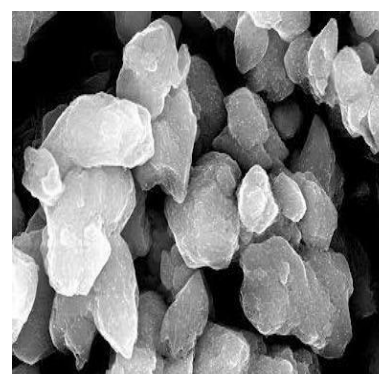
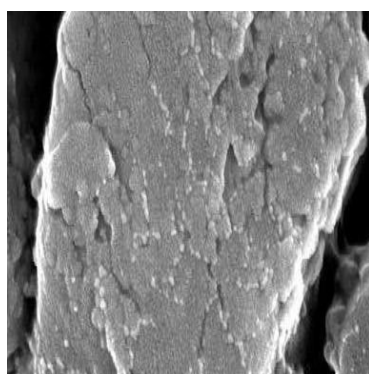
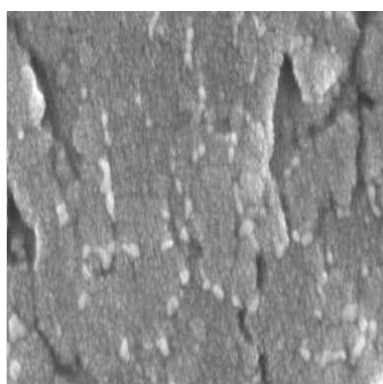


Fig 4.2 FTIR Graph

FESEM (Field Emission Scanning Electron Microscope)



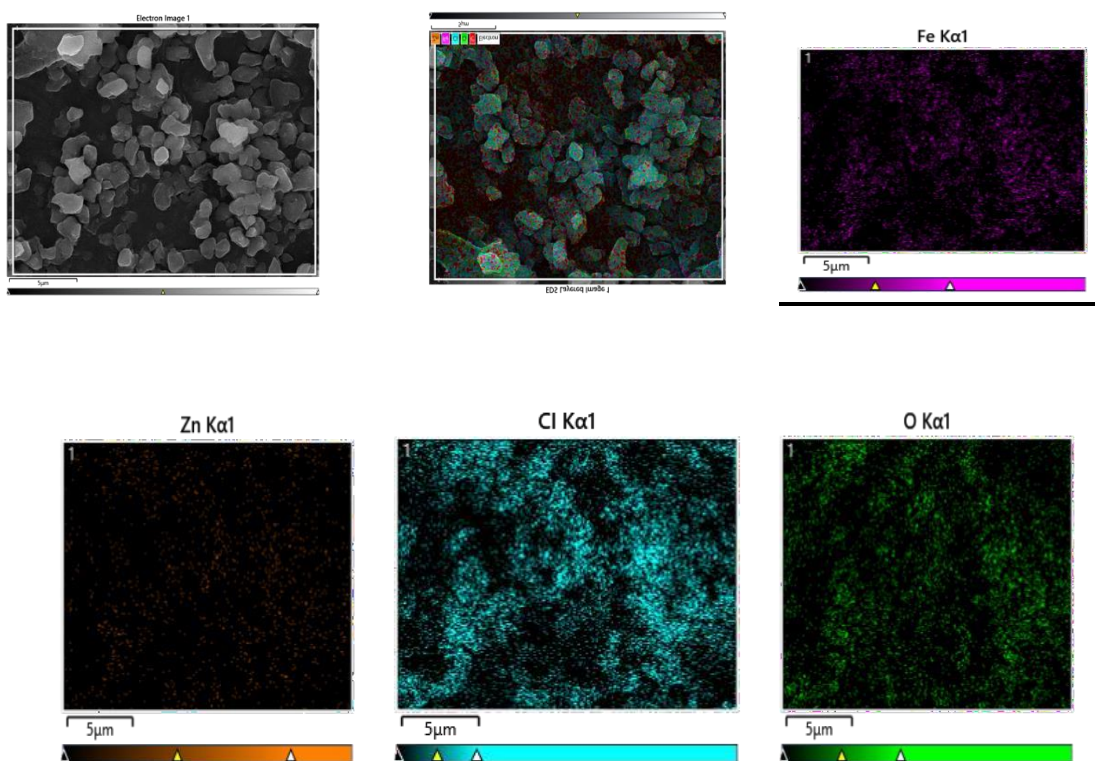


Fig 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11 FESEM (Microstructure image of the material)

CHAPTER 6

INTRODUCTION TO IBU PROFEN



Fig 5.1 Ibuprofen

Ibuprofen, a nonsteroidal anti-inflammatory drug (NSAID) belonging to the propionic acid derivatives class, is widely used for pain relief and fever reduction. Since its discovery in the 1960s, ibuprofen has become a key component in managing various conditions, from minor aches and pains to inflammatory disorders.

CHARACTERISTICS OF Ibu Profen:

Mechanism of Action: Ibuprofen primarily works by inhibiting the enzyme cyclooxygenase (COX), reducing the production of prostaglandins that are crucial in inflammation, pain, and fever. By blocking prostaglandin synthesis, ibuprofen effectively alleviates pain and inflammation.

Analgesic Properties: Ibuprofen is highly effective in providing relief from mild to moderate pain, making it suitable for managing headaches, toothaches, menstrual cramps, muscle aches, and acute pain.

Anti-Inflammatory Effects: As an NSAID, ibuprofen exhibits potent anti-inflammatory properties, commonly used to alleviate inflammation associated with arthritis, tendonitis, bursitis, and other inflammatory disorders.

Antipyretic Action: Ibuprofen is also classified as an antipyretic, reducing fever by acting on the hypothalamus, which regulates body temperature. Lowering fever with ibuprofen helps improve comfort and aids in recovery during febrile illnesses.

Rapid Onset of Action: Ibuprofen is known for its quick onset of action, often providing noticeable relief within 30 minutes to an hour after ingestion, depending on the formulation and individual response.

Duration of Action: The effects of ibuprofen typically last between 4 to 6 hours, requiring multiple doses per day for sustained pain relief or fever reduction. Extended-release formulations are available for longer-lasting effects, allowing for less frequent dosing.

HARMFUL EFFECTS OF IBUPROFEN IN PHARMACEUTICALS:

Ibuprofen, a commonly used and effective medication for pain relief and inflammation management, can have potential harmful effects if used inappropriately or excessively. It is important for healthcare professionals and patients to understand these risks in order to ensure the safe and responsible use of this medication.

Gastrointestinal Complications: One of the well-known adverse effects of ibuprofen is its ability to cause gastrointestinal (GI) complications, such as gastritis, ulcers, and gastrointestinal bleeding. When ibuprofen is used for a prolonged period or in high doses, it can irritate the stomach lining, leading to inflammation and the formation of ulcers. In severe cases, GI bleeding can occur, which can be life-threatening if not addressed promptly.

Cardiovascular Risks: The long-term use of ibuprofen, especially at high doses, has been associated with an increased risk of cardiovascular events like heart attacks and strokes. This risk is particularly concerning for individuals with pre-

existing cardiovascular conditions or those who have factors such as advanced age, hypertension, diabetes, or smoking that put them at a higher risk.

Kidney Damage: Ibuprofen, like other NSAIDs, can impair kidney function, especially when used chronically or in high doses. Prolonged use of ibuprofen can lead to kidney damage, which is characterized by reduced kidney function, fluid retention, and electrolyte imbalances. Patients with pre-existing kidney conditions, such as chronic kidney disease, are particularly susceptible to this risk.

Allergic Reactions: Some individuals may develop allergic reactions to ibuprofen, which can range from mild skin rashes to severe anaphylaxis. Symptoms of an allergic reaction may include itching, hives, facial swelling, difficulty breathing, and rapid heartbeat. If any signs of an allergic reaction to ibuprofen are experienced, immediate medical attention should be sought.

Increased Bleeding Risk: Ibuprofen, like other NSAIDs, has the potential to inhibit platelet aggregation and prolong bleeding time, increasing the risk of bleeding, especially in individuals undergoing surgery or those with bleeding disorders. Healthcare providers should be informed of ibuprofen use before surgical procedures to reduce the risk of excessive bleeding.

Central Nervous System Effects: While taking ibuprofen, some individuals may experience central nervous system (CNS) side effects such as headache, dizziness, drowsiness, and confusion. These effects are usually mild and temporary but may require caution, particularly when driving or operating heavy machinery.

Gastrointestinal Distress: Apart from ulceration and bleeding, ibuprofen can also lead to gastrointestinal symptoms like nausea, vomiting, indigestion, and abdominal pain. These symptoms may be more severe in individuals with a history of GI problems or those who take ibuprofen on an empty stomach.

CHAPTER – 7

METHOD AND METHODOLOGY OF IBUPROFEN

7.1 Materials Required:

1. IB profen - 100% pure
2. Distilled water
3. Mixing flask
4. Beaker
5. MOF sample
6. PH meter
7. Heated magnetic stirrer

7.2 Preparation of IB Profen Stock Solution:

Synthesis Process: To guarantee that IB dissolves in distilled water, a number of careful procedures are involved in the synthesis of the IB stock solution. Below is a thorough description of the protocol:

- **Weighing IB Profen:** Using an analytical balance, weigh one gramme of IB Profen precisely to start. To guarantee that the stock solution has the appropriate concentration, measurement accuracy is essential.
- **Dissolution in distilled water:** Pour the precisely measured IB Profen powder into a dry, clean mixing flask for dissolution in distilled water. Then fill the mixing flask with one litre of distilled water and IB Profen powder. Using distilled water guarantees that there are no contaminants present that could impede the breakdown process.
- **Rest Period:** After the solution has completely dissolved, let it sit for a little while. Any undissolved particles can sink to the bottom of the flask during this resting period. Molecular interactions stabilise during this period, which adds to the solution's homogeneity.

7.3 EFFECT OF DOSGAE:

Experimental Procedure: A number of careful processes must be taken to prepare samples with different MOF sample dosages and evaluate their catalytic performance in order to investigate dosage effects.

- **Beaker Preparation:** To make it easier to prepare samples with various MOF sample doses, start by obtaining four dry, clean beakers. The integrity of the experimental setting is guaranteed by the choice of premium beakers.
- **Stock Solution Dispensing:** Transfer 20 millilitres of the previously made IB Profen stock solution into each beaker. Add 800 cc of distilled water to the stock solution in order to obtain homogeneity. The right concentration for ensuing catalytic reactions is guaranteed by this dilution.
- **Addition of MOF Samples:** To investigate the effects of varying MOF sample doses on catalytic activity, new samples are added to each beaker. To each beaker, add 0.2 g of the MOF sample, 0.4 g to the second, 0.6 g to the third, and 1 g to the fourth. A thorough assessment of the effects of dosage-dependent changes on catalytic performance is made possible by the different dosages.
- **Mixing and Rest Period:** Make sure the MOF samples are properly dispersed throughout the solution by giving each beaker a good shake after adding them. After that, give the solutions a five-minute break. This relaxation time promotes molecular equilibration and interactions, which strengthens the catalytic system's stability.
- **Sample Collection:** Using an appropriate tester or sampling instrument, take samples from each beaker after the rest period. Place the samples into the containers intended for UV analysis with care. Maintaining sample identity and proper labelling is crucial to preserving data integrity during the analysis process.
- **UV Analysis:** To assess catalytic activity, do UV analysis on each sample that has been collected. The degradation efficiency of organic pollutants in the presence of Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites can be understood using UV analysis. To identify patterns in catalytic performance that are depending on dosage, record and examine the UV spectra.

7.4 EFFECT ON pH:

Experimental Setup: An organised experimental protocol is used as follows to examine the pH sensitivity of Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites:

Container Preparation: For the experimental configuration, five containers have been chosen. These receptacles offer distinct settings for assessing the impact of pH on catalytic efficiency. To avoid contamination and guarantee precise experimental outcomes, every container is meticulously cleaned.

Stock Solution Dispensing: A precise 100 ml portion of the previously prepared IB Profen stock solution is placed into each of the five containers. This guarantees that the catalytic processes have a constant beginning point and makes comparisons across various pH levels easier.

Initial pH Measurement: Using a pH metre that has been calibrated, the initial pH of each container is determined prior to the addition of the MOF solution. Throughout the course of the experiment, any pH variations brought about by the catalytic processes will be evaluated using this initial pH reading as a baseline.

Addition of MOF Solution: One gramme of the MOF solution is added to each container after the initial pH measurement. In the experimental setup, the MOF solution—which is produced from Nano-Cellulose/MOF—acts as the catalyst. When it is added, the solution begins to undergo catalytic reactions, which could change the pH of the containers.

Rest Period: The containers are kept intact for a full day following the addition of the MOF solution. The MOF composite catalyses reactions that occur during this resting period, which may have an impact on the pH of the fluids as organic contaminants degrade.

Final pH Measurement: Using a pH metre, the final pH of each container is determined after the 24-hour resting period. Any pH fluctuations that resulted from the catalytic reactions can be understood by looking at this final pH reading. The pH sensitivity of the Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites can be evaluated by comparing the initial and final pH values.

EFFECT ON TIME:

Cellulose/MOF Derived Carbon Doped Zn(NO₃)₂ composites: Beaker Selection:

The vessel used to carry out the catalytic reactions is a 500 ml beaker. The beaker accommodates the required volume of reactants and makes stirring easier. It also offers a suitable environment for tracking the development of the reaction over time.

Making the Reaction Mixture: Put 180 ml of distilled water and 20 ml of the previously produced IB Profen stock solution in the chosen beaker. The intended concentration of the reactants for the catalytic reactions is guaranteed by this dilution. The catalytic process is then started by adding 1 g of the MOF sample to the mixture.

Stirring: A magnetic stirrer is used to stir the reaction mixture in the beaker. Stirring encourages the MOF sample to disperse evenly throughout the solution, which facilitates the catalyst's and the organic pollutants' effective interaction.

Time: A total of two hours are given to the catalytic process to continue. This time range was chosen in order to record the catalytic activity's temporal evolution and evaluate the composites' long-term effectiveness.

Sample Collection: Throughout the course of the two-hour reaction period, samples are taken from the reaction mixture at regular intervals. To be more precise, 10 millilitres of the reaction mixture are taken out every ten minutes, giving researchers plenty of data points to examine how the catalytic reactions change over time.

UV Analysis: To determine how much the Nano-Cellulose/MOF Derived Carbon Doped Zn(NO₃)₂ composites have contributed to the breakdown of organic pollutants, the collected samples are exposed to UV analysis. The evaluation of time-dependent catalytic activity is made possible by UV analysis, which provides information on the effectiveness of the catalytic reactions at various times.

CHAPTER – 8

FINAL CHARACTERIZATION

XRD (X-Ray diffraction):

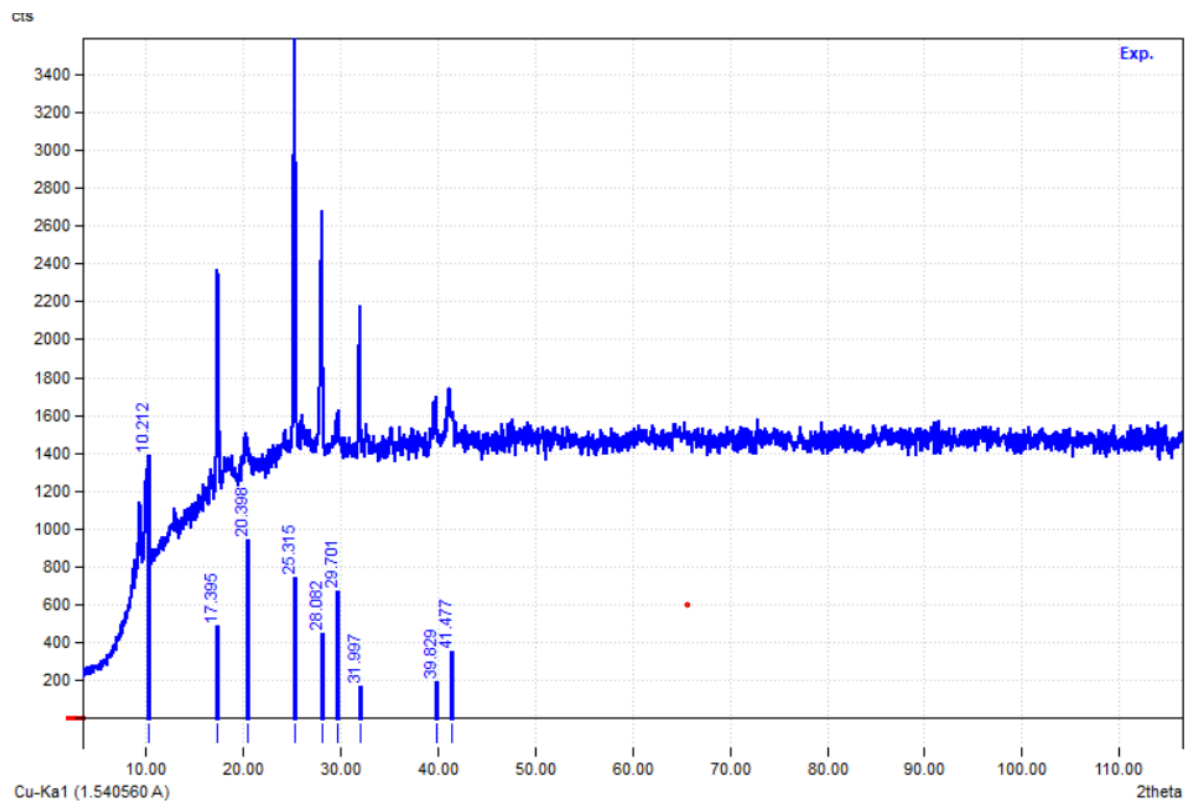


Fig 8.1 XRD Graph

PEAK LIST

No.	2theta [°]	d [Å]	I/I0 (peak height)	Counts (peak area)	FWHM
1	10.21	8.6551	220.86	1383.24	2.1028
2	17.40	5.0938	585.74	478.47	0.2743
3	20.40	4.3502	190.78	932.59	1.6413
4	25.31	3.5153	1000.00	732.92	0.2461
5	28.08	3.1749	601.90	442.50	0.2468
6	29.70	3.0054	107.65	664.54	2.0727
7	32.00	2.7948	376.28	161.57	0.1442
8	39.83	2.2614	85.95	187.12	0.7310
9	41.48	2.1753	81.75	349.74	1.2486

FTIR (Fourier Transform Infrared Spectros copy)

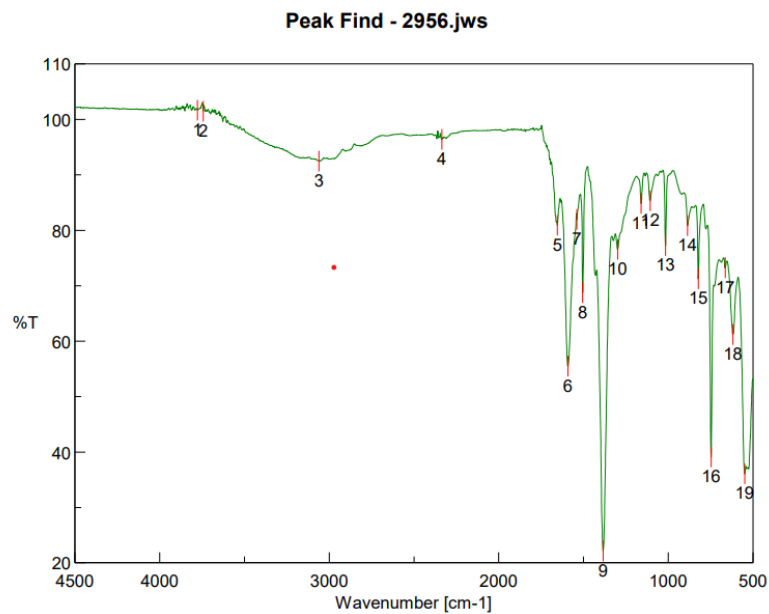


Fig 8.2 FTIR Graph

RESULT OF PEAK PICKING:

No.	Position	Intensity	No.	Position	Intensity
1	3776.9	101.649	2	3743.15	101.484
3	3060.48	92.4336	4	2335.37	96.3906
5	1654.62	80.8681	6	1591.95	55.4553
7	1538.92	81.9312	8	1505.17	68.7368
9	1384.64	22.0995	10	1298.82	76.5336
11	1159.97	84.8186	12	1106.94	85.2923
13	1016.3	77.2057	14	886.131	80.8009
15	822.491	71.234	16	747.281	39.0898
17	664.357	73.2246	18	618.074	61.1465
19	548.649	36.0535			

FESEM (Field Emission Scanning Electron Microscope)

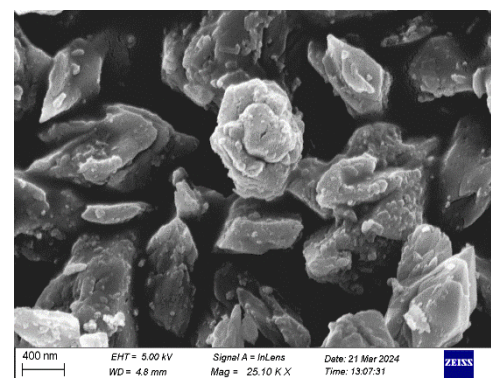
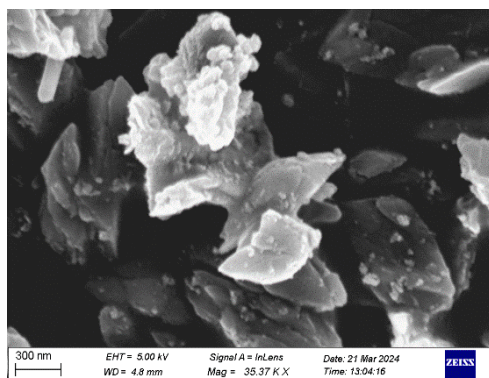
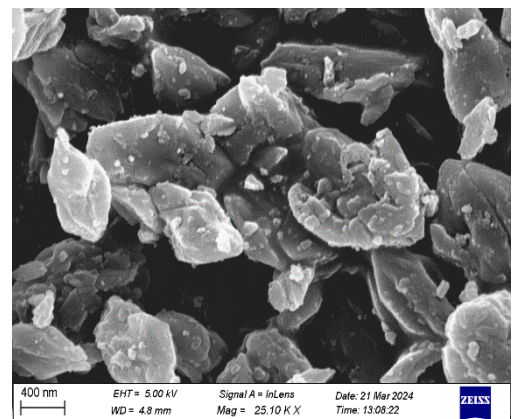
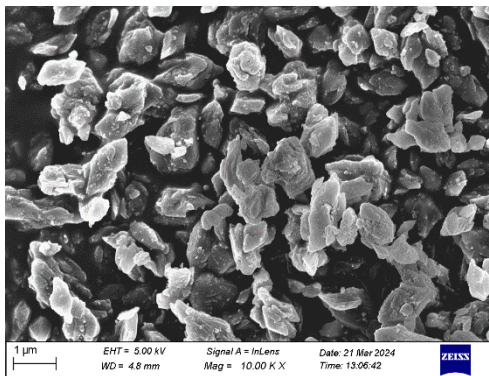
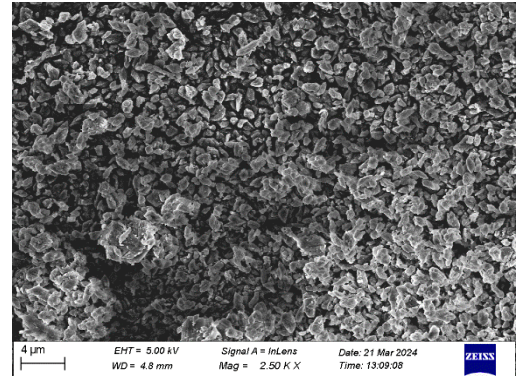
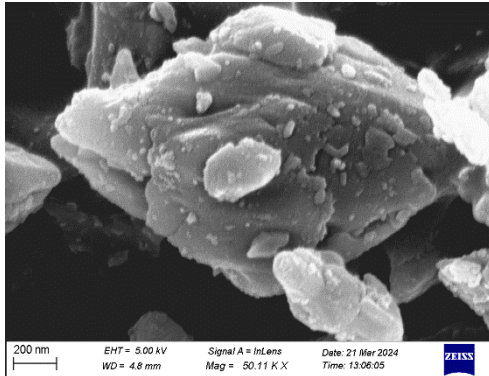


Fig 8.3, 8.4, 8.5, 8.6, 8.7, 8.8 FESEM (Microstructural image of material)

Brunauer-Emmett-Teller (BET) surface area analysis:

- 1.Slope:** The slope of the BET plot is related to the monolayer capacity of the adsorbent and is used to calculate the specific surface area
- 2. Intercept:** The intercept of the BET plot is related to the volume of the adsorbate gas and is also used in the calculation of the specific surface area
- 3. Correlation Coefficient (r):** This value indicates how well the experimental data fits the BET model. A value close to suggests a good fit.
- 4. Constant:** This constant is used in the BET equation and is determined experimentally.
- 5.Surface Area:** This is the specific surface area of the material, expressed in square meters per gram (m^2/g). It represents the total surface area available for adsorption per unit mass of the material.

Analysis		Report	
Operator:	Quantachrome	Date: 2024/03/22	Operator: Quantachrome
Sample ID:	William	Filename:	2-30.qps
Sample Desc:	Powder sample	Comment:	Degassed
Sample weight:	0.0436 g	Sample Volume:	0.02638 cc
Outgas Time:	6.0 hrs	Outgas Temp:	160.0 C
Analysis gas:	Nitrogen	Bath Temp:	77.3 K
Press. Tolerance:	0.100/0.100 (ads/des)	Equil time:	35/35 sec (ads/des)
Analysis Time:	152.3 min	Equil timeout:	70/70 sec (ads/des)
Cell ID:	3	End of run:	2024/03/22 15:48:52
		Instrument:	Nova Station A

Adsorbate model Nitrogen		Data Reduction Parameters	
		Temperature	77.350K
Molec. Wt.:	28.013	Cross Section:	16.200 Å
		Liquid Density:	0.808 g/cc
Relative Pressure		Volume @ STP	1 / [W((Po/P) - 1)]
P/Po		cc/g	1/g
1.60567e-01		2.6219	5.8373e+01
2.09464e-01		2.8203	7.5171e+01
2.58114e-01		2.9945	9.2961e+01

BET summary

Slope =	354.573 1/g
Intercept =	1.260e+00 1/g
Correlation coefficient, r =	0.999838
C constant =	282.328
Surface Area =	9.787 m ² /g

CHAPTER – 9

RESULTS AND CONCLUSION

CONCENTRATION TABLE:



04

Fig 8.1 Stock Solution Sample

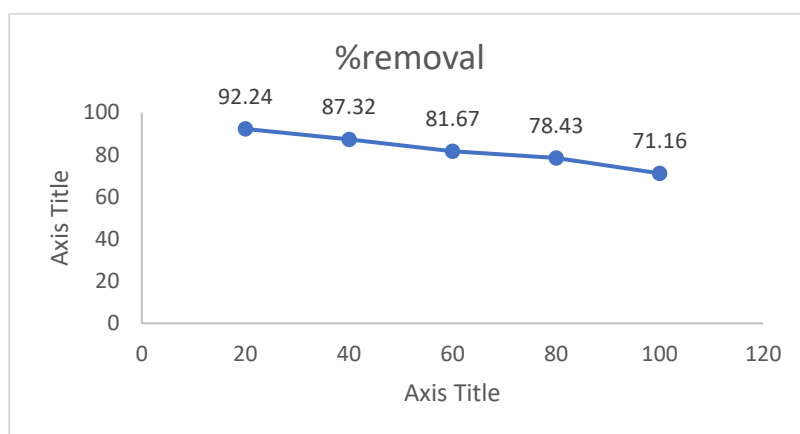


Fig 8.2 Concentration Removal Graph

Effect of dosage



Fig 8.3 Dosage Sample

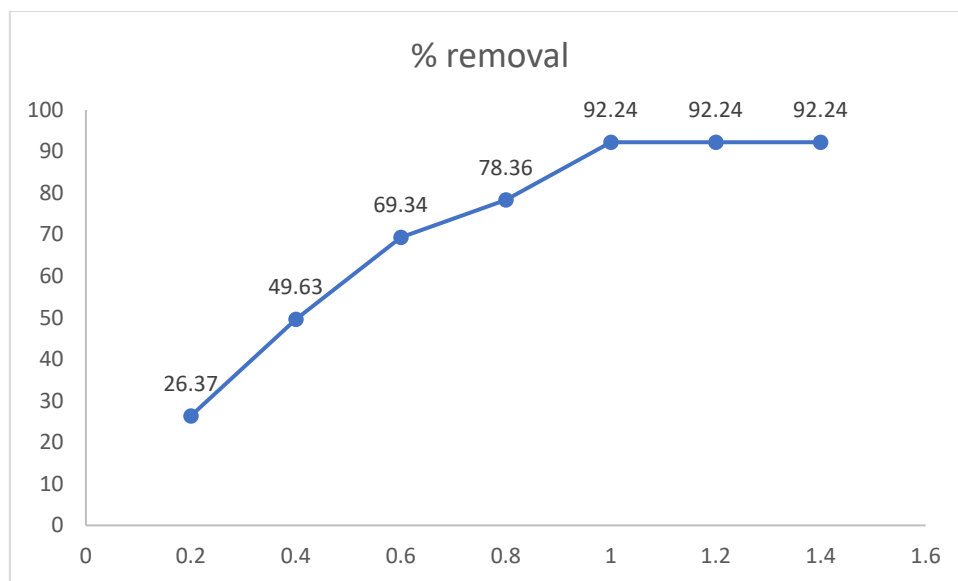


Fig 8.4 Dosage Graph

Effect of pH



Fig 8.5 pH Sample

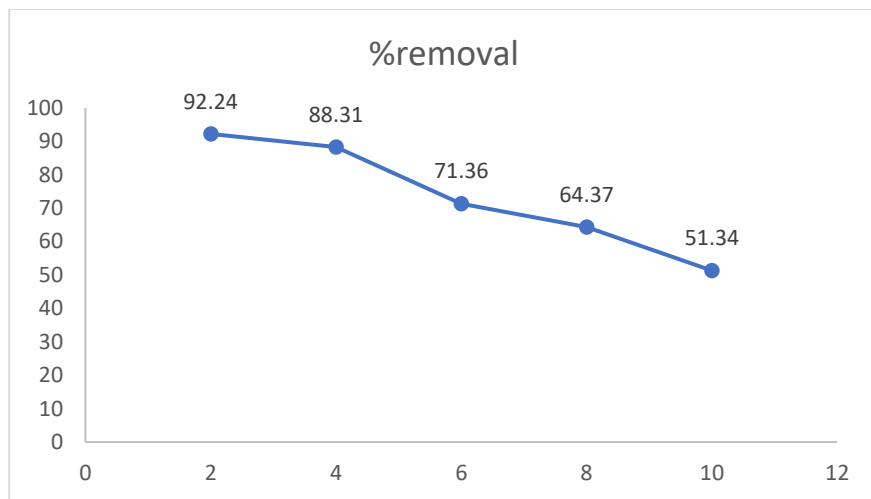


Fig 8.6 pH Graph

Effect of time:

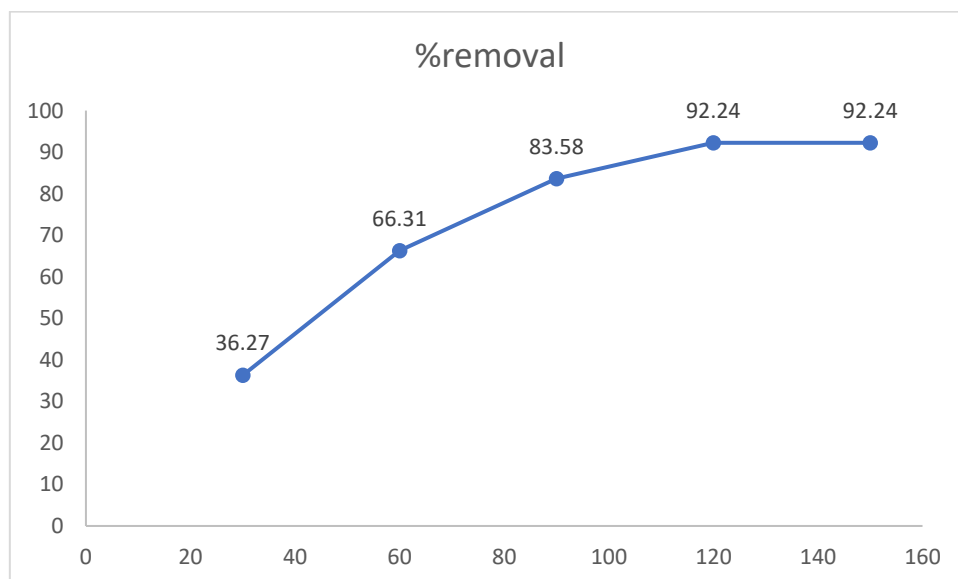


Fig 8.7

Effect of Temperature:

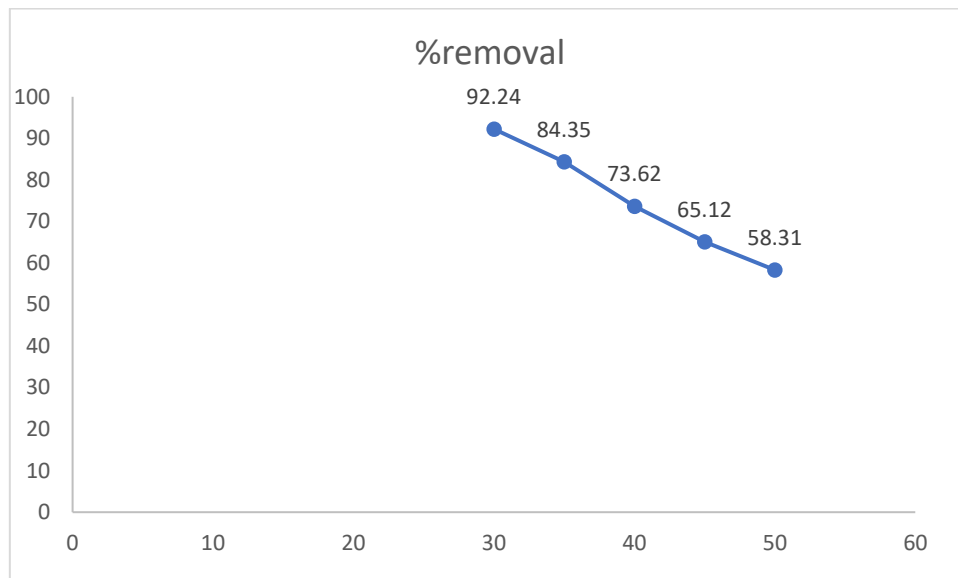


Fig 8.8

Isotherm

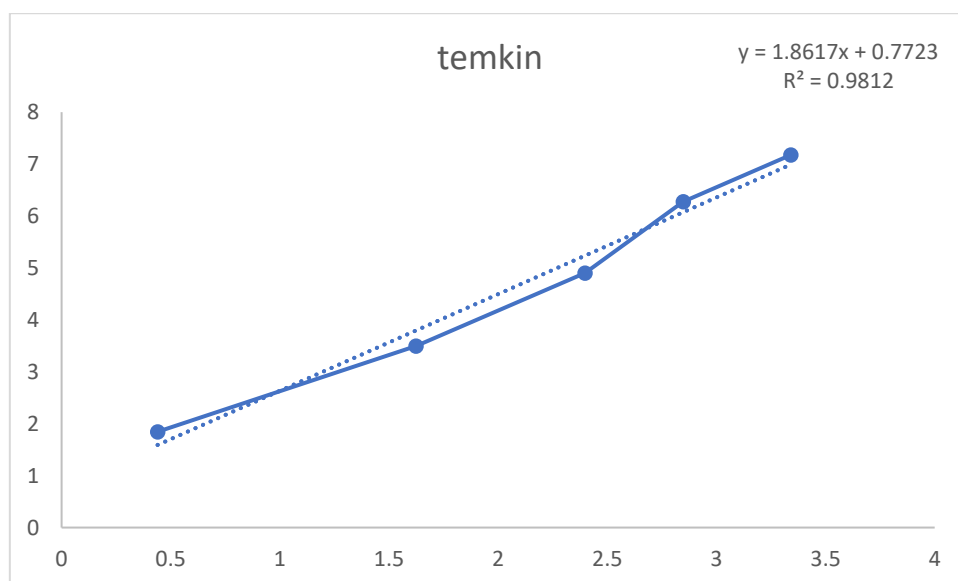


Fig 8.9

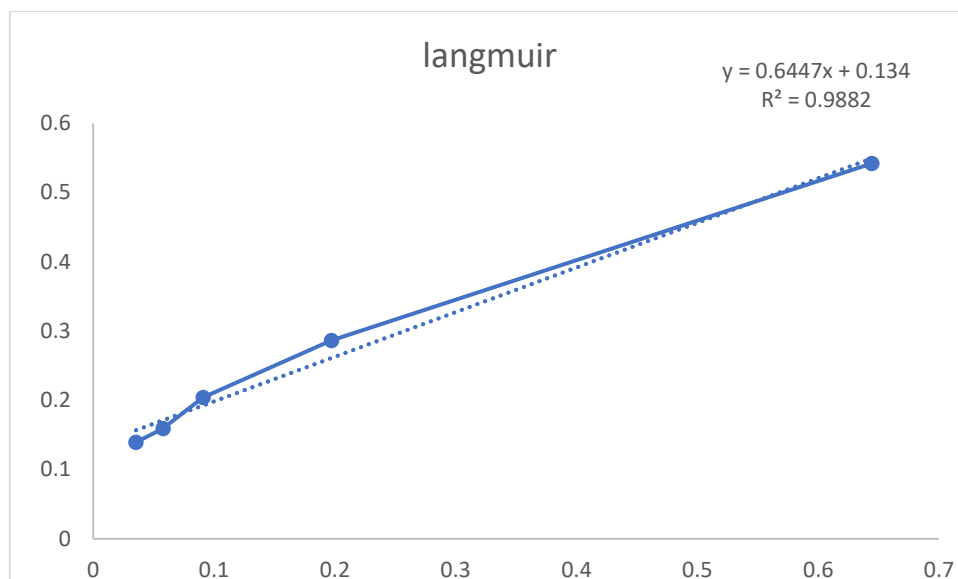


Fig 8.10

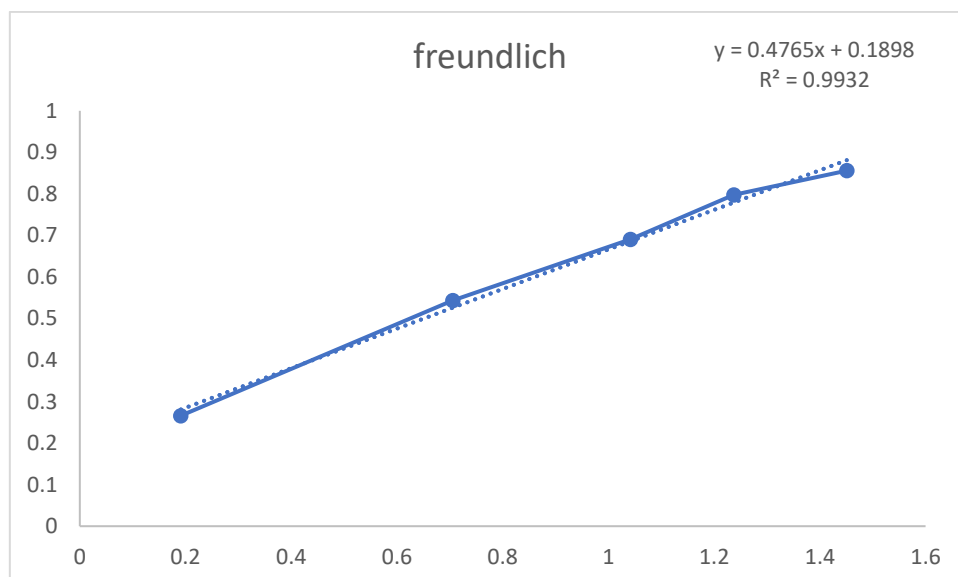


Fig 8.11

Kinetics

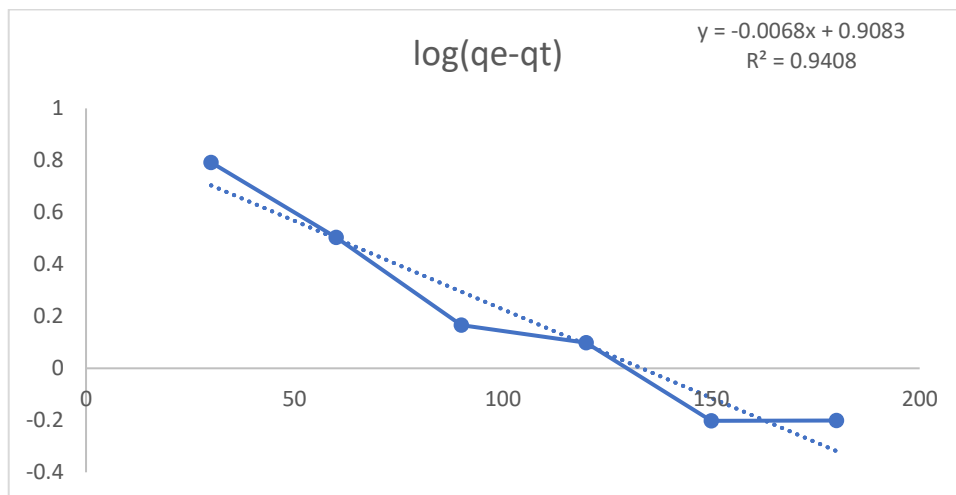


Fig 8.12

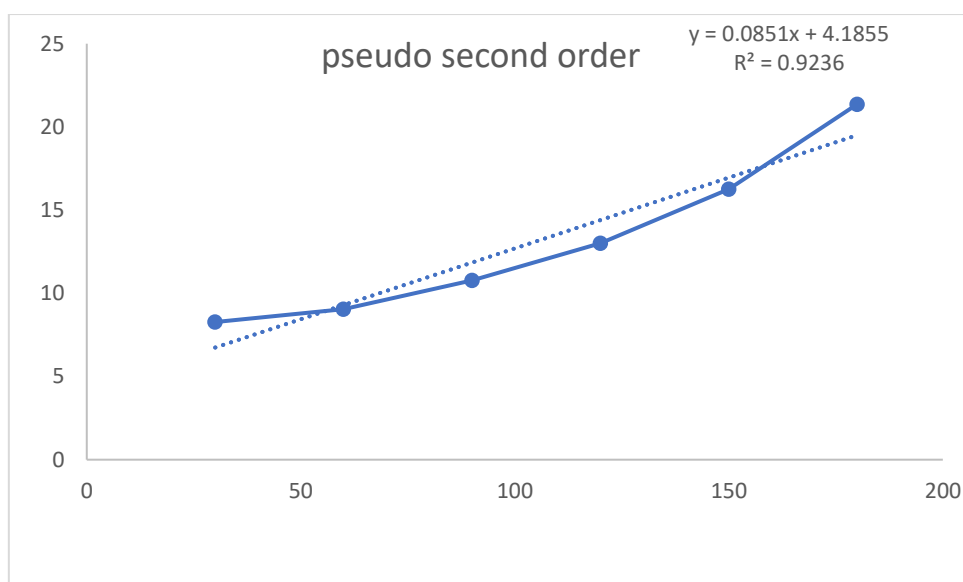


Fig 8.12

Thermodynamics

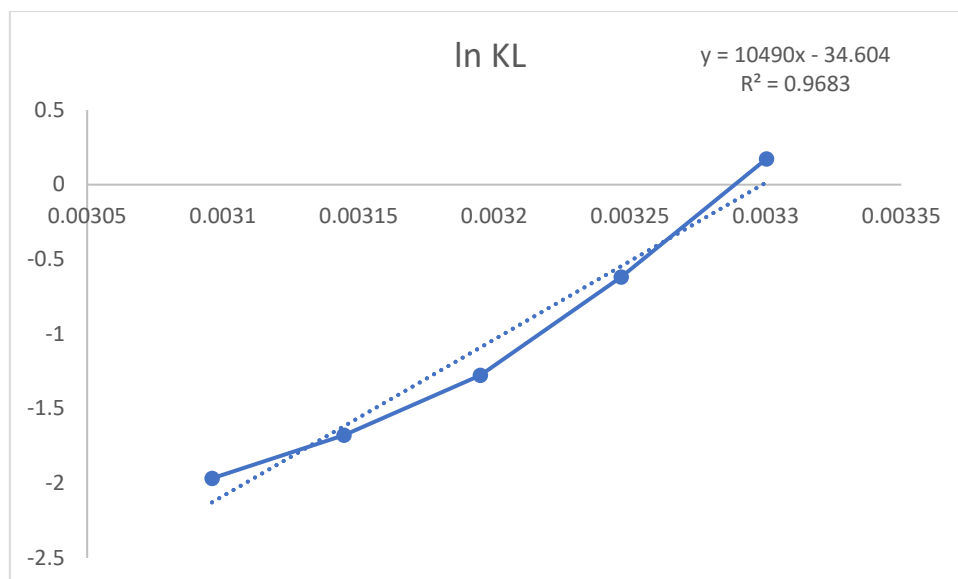


Fig 8.13

CHAPTER 10

CONCLUSION

The global challenge of organic pollution necessitates innovative and sustainable solutions to safeguard the environment and public health. In response to this pressing issue, our project embarked on an exploration of Nano-Cellulose/MOF Derived Carbon Doped Zn(NO₃)₂ composites as catalysts for organic pollution remediation. Through systematic experimentation and analysis, we endeavored to elucidate the catalytic performance, mechanisms, and potential applications of these novel composites in addressing organic pollution.

Our journey commenced with the synthesis of Nano-Cellulose/MOF Derived Carbon Doped Zn(NO₃)₂ composites, a multifaceted process involving meticulous preparation

and characterization techniques. By harnessing the synergistic properties of cellulose nanomaterials and metal-organic frameworks (MOFs), we engineered composites with tailored structural and chemical properties conducive to catalytic applications. The incorporation of zinc ions and carbon doping further enhanced the catalytic activity and stability of the composites, setting the stage for comprehensive catalytic evaluations.

In investigating the catalytic efficacy of the composites, we delved into various aspects, including dosage, pH sensitivity, and time-dependent activity. Through controlled experiments, we systematically evaluated the influence of these parameters on the catalytic performance of Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites. Our findings unveiled the intricate interplay between catalyst composition, environmental conditions, and reaction kinetics, shedding light on the underlying mechanisms governing organic pollutant degradation.

The effect of dosage emerged as a critical determinant of catalytic efficiency, with varying MOF sample dosages exerting distinct impacts on pollutant degradation rates. By meticulously adjusting the dosage, we discerned optimal conditions for maximizing catalytic activity while minimizing resource consumption—a pivotal step towards practical application in real-world pollution remediation scenarios. Moreover, our exploration of pH sensitivity elucidated the responsive nature of the composites to changes in environmental pH, highlighting their adaptability and versatility across different pollution contexts.

The investigation of time-dependent catalytic activity provided further insights into the kinetics and dynamics of catalytic reactions mediated by Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites. Through systematic monitoring of reaction progress over time, we observed the evolution of catalytic activity and identified critical time intervals where maximal pollutant degradation occurred. This temporal understanding of catalytic behavior lays the groundwork for optimizing reaction conditions and designing efficient pollutant remediation strategies with enhanced efficacy and sustainability.

Our project culminates in a comprehensive understanding of the catalytic potential of Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites for organic pollution remediation. From synthesis to characterization to catalytic evaluation, each phase of our research journey has contributed valuable insights and knowledge towards addressing one of the most pressing environmental challenges of our time. As we reflect on our findings, it becomes evident that Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites hold immense promise as catalysts for organic pollution remediation, offering a pathway towards a cleaner, healthier, and more sustainable future.

Looking ahead, further research avenues beckon, inviting exploration into advanced synthesis techniques, comprehensive mechanistic studies, and field-scale applications of Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites. By leveraging interdisciplinary approaches and collaborative efforts, we can harness the full potential of these innovative catalysts to combat organic pollution and safeguard the integrity of our environment for generations to come.

CHAPTER 10

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**NANO – CELLULOSE / MOF DERIVED CARBON DOPED Zn (NO₃)₂
COMPOSITES AS CATALYST FOR ORGANIC POLLUTION REMEDY**

Submitted in partial fulfillment of the requirements for the award of Bachelor of

Technology degree in Chemical Engineering

by

WILLIAM JOEL A (40190030)



DEPARTMENT OF CHEMICAL ENGINEERING

SCHOOL OF BIO AND CHEMICAL

SATHYABAMA

Institute of Science and Technology

(DEEMED TO BE UNIVERSITY)

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **WILLIAM JOEL A (40190030) NANO – CELLULOSE / MOF DERIVED CARBON DOPED Zn (NO₃)₂ COMPOSITES AS CATALYST FOR ORGANIC POLLUTION REMEDY** who carried out the project entitled under my supervision from

Internal Guide

Dr. S SATHISH Ph.D.,

2

Head of the Department

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Submitted for Viva Voce Examination held on 06/04/2024

Internal Examiner

External Examiner

DECLARATION

I **WILLIAM JOEL A (40190030)** hereby declare that the Project Report entitled
“**NANO – CELLULOSE / MOF DERIVED CARBON DOPED Zn (NO₃)₂**
COMPOSITES AS CATALYST FOR ORGANIC POLLUTION REMEDY” is done by
me under the guidance of **Dr.S SATHISH Ph.D.**, at Sathyabama Institute of Science
and Technology is submitted in partial fulfillment of the requirements for the award of
BACHELOR OF TECHNOLOGY IN CHEMICAL ENGINEERING.

DATE: 06/04/2023

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATE

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ABSTRACT

The growing environmental concerns linked to organic contaminants demand creative and effective catalysts for the removal of pollutants from the environment. In this project, $\text{Zn}(\text{NO}_3)_2$ is used to carbon-dope nano-cellulose and metal-organic framework (MOF) precursors to create novel composites. These composites are then synthesized and characterized, and their catalytic potential for treating organic pollution is investigated.

$\text{Zn}(\text{NO}_3)_2$ is added as a dopant to increase catalytic activity, MOF serves as a porous template, and nano-cellulose is incorporated as a sustainable and environmentally acceptable substrate during the synthesis process. In order to clarify the structural, morphological, and chemical characteristics of the resultant composites, a variety of sophisticated analytical methods are employed, including X-ray diffraction (XRD), scanning electron microscopy (SEM), FESEM (Field Emission Scanning Electron Microscope) and Fourier-transform infrared spectroscopy (FTIR).

The outcomes of this research aim to contribute to the development of sustainable and effective catalysts for the remediation of organic pollutants, offering a promising avenue for addressing contemporary environmental challenges. The insights gained from this study may pave the way for the design and implementation of advanced materials with enhanced catalytic properties, thereby contributing to the sustainable management of environmental pollution.

TABLE OF CONTENTS

S.NO	CONTENTS	PAGE NO
1.	Introduction	
	1.1 Pharmaceutical pollution mitigation	
	1.2 The need for innovation	
	1.3 Scope of the Study	
2.	Literature Review	
	2.1 Overview of Organic Pollution in Water Bodies	
	2.2 Current Challenges in Organic Pollution Remediation	
	2.3 Metal-Organic Frameworks (MOFs) in Catalysis	
	2.4 Nano-Cellulose-Based Materials for Environmental Applications	
	2.5 Previous Research on Carbon Doped Zn (NO ₃) ₂ Composites	
3.	AIM AND SCOPE	
	3.1.1 AIM	
	3.1.2 SCOPE	
	3.1.3 OBJECTIVE	
4.	Materials and Methods	
	4.1 Preparation of Nano-Cellulose	
	4.2 Synthesis of MOF Precursor	
	4.3 Impregnation of MOF/Nano-cellulose	
	4.4 Formulation of CoFe ₂ Solution	
	4.5 Preparation of MOF	
5.	Characterization Techniques	
	5.1 XRD	
	5.2 FTIR	
	5.3 FESEM	

6. Introduction to Ibuprofen
 - 6.1 Characteristics of Ibuprofen
 - 6.2 Harmful effects of Ibuprofen in Pharmaceuticals
7. Materials and Methods
8. Final Characterization
 - 8.1 XRD
 - 8.2 FTIR
 - 8.3 FESEM
 - 8.4 BET
9. Summary and Conclusion
10. References

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CHAPTER 1

INTRODUCTION

1.1 Pharmaceutical Pollution Mitigation

In modern times, the rising levels of organic pollutants in waterways have become a pressing concern, posing significant threats to environmental sustainability and human health. The harmful effects of these pollutants, stemming from various sources like industry, agriculture, and domestic activities, have increased awareness of the urgent need for effective remediation strategies. The range of organic pollutants infiltrating aquatic ecosystems is broad and complex, including various compounds like synthetic dyes, agrochemicals, pharmaceutical residues, and volatile organic solvents. Each compound carries its own adverse effects, from acute toxicity to chronic hazards, complicating the environmental problem.

Industrial activities like textile manufacturing, chemical production, and food processing significantly contribute to the discharge of organic pollutants into water bodies. Synthetic dyes used in textiles are notorious for persisting in water and soil, threatening aquatic life and ecosystems. Similarly, agricultural pesticides and fertilizers contaminate surface and groundwater, harming aquatic biodiversity and human health. Moreover, pharmaceutical residues from human and animal excretion further compound the issue by entering water bodies through sewage and runoff, raising concerns about antibiotic resistance and endocrine disruption.

The degradation of organic pollutants relies on interactions between the catalyst and pollutants that activate chemical bonds, initiating breakdown pathways. Various materials like metal oxides, nanoparticles, zeolites, and carbon-based materials have been explored as catalysts to degrade organic pollutants. Metal-Organic Frameworks (MOFs) have garnered interest due to their tunable structure, high surface area, and catalytic potential. MOFs provide well-defined, tailorable pores and

opportunities to add active sites tailored to specific reactions, making them advantageous catalyst supports.

Nano-cellulose from renewable sources has emerged as a sustainable platform for advanced materials, given its high surface area, strength, biocompatibility, and biodegradability. By incorporating nano-cellulose into MOF-derived catalysts, synergies can enhance catalytic activity, stability, and selectivity for efficient organic pollutant degradation.

Synthesizing carbon-doped Zn (NO₃)₂ composites from nano-cellulose/MOF precursors is a promising approach for catalytic pollutant remediation. Carbon doping introduces active sites and enhances conductivity, promoting redox reactions and pollutant degradation. The Zn(NO₃)₂ provides metal centers to catalyze oxidative pathways, further improving the composite's performance. By utilizing nano-cellulose, MOFs, and carbon-doped metal oxides, highly efficient and sustainable catalysts can be developed for organic pollutant remediation.

The recalcitrant nature and resistance to degradation of organic pollutants exacerbate their persistence in the environment. Unlike inorganic pollutants which can undergo chemical changes or sedimentation, organic pollutants persist in water, posing long-term risks. Furthermore, some organic pollutants like PCBs and PBDEs bioaccumulate up the food chain, magnifying their impact on higher trophic levels including humans.

In response to the escalating threat of organic pollutants, scientists have developed innovative and sustainable remediation strategies to mitigate their adverse effects. Among available technologies, catalytic degradation has emerged as a promising approach due to its efficacy, versatility and potential for large-scale use. Heterogeneous catalysts in particular offer advantages like ease of separation, recyclability and compatibility with diverse pollutants.

This research article aims to synthesize and characterize nano-cellulose/metal-organic framework (MOF)-derived carbon-doped zinc nitrate composites for use as catalysts to remove organic pollutants from water. We will pyrolyze nano-cellulose/MOF precursors then impregnate the material with zinc nitrate to form the composites. Advanced techniques like X-ray diffraction, scanning electron microscopy, transmission electron microscopy, Fourier-transform infrared

spectroscopy, and Brunauer-Emmett-Teller analysis will comprehensively characterize the composites' structure, morphology, and surface properties. We will then evaluate the composites' catalytic performance in degrading model organic pollutants including dyes, pesticides, and pharmaceuticals using quantitative techniques like UV-vis spectroscopy, high-performance liquid chromatography, and chemical oxygen demand analysis. Mechanistic studies will provide insights into the catalytic degradation pathways to inform optimized catalyst design for removing organic pollutants from water. Through interdisciplinary collaboration and innovative approaches, this study aims to develop efficient and sustainable solutions to the critical environmental challenges posed by organic water pollutants, working towards a cleaner, healthier environment for future generations.

1.2 The need for innovation

The search for innovative and sustainable solutions to the problems associated with remediating organic waste has been fueled by the growing worries about environmental contamination and its detrimental effects on public health.

Ecosystems that are dependent on water and wastewater are constantly threatened by organic pollutants, which include a wide variety of toxins like pesticides, dyes, and pharmaceutical residues. The need to reduce these pollutants as soon as possible makes it imperative to create novel catalysts that can remove organic pollutants from a variety of environmental matrices in an efficient and sustainable manner.

Advanced and adaptable catalytic materials are required due to the complex nature of organic contaminants, which are typified by their persistence and resistance to traditional treatment techniques. The carbon-doped CoFe_2O_4 composite generated from nano cellulose and Metal-Organic Framework (MOF) is a viable option among the variety of possible catalysts for organic pollution cleanup. This introduction explores the compelling rationale behind the investigation of such composites and emphasises the need to solve the problems caused by organic contaminants in streams of water and wastewater.

Urgent intervention is required due to the worrisome levels of environmental contamination, which are mostly caused by industrial activity, agricultural runoff, and improper disposal of medications. Beyond just harming the environment, organic pollution also poses a health risk to people by contaminating sources of drinking water and upsetting aquatic ecosystems.

The problem of water contamination by organic pollutants is intricate and has far-reaching implications. The group consists of numerous substances starting from synthetics like plasticizers, polycyclic aromatic hydrocarbons (PAHs), diphenyl ethers (PBDEs), polybrominated biphenyl ethers (PBDEs) or pentachlorophenols (PCPs); halogenated aromatics including polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs); organochlorines such as chlorobenzenes (CBs), PCBs (polychlorinated benzene's); naturally occurring toxins such as microcystins (MCYST) or aflatoxins (AFTOXNs); personal care products e.g. thinners or fragrance enhancers; and other groups including drugs/pharmaceutical preparations besides others which should not have existed in water at all



Fig 1. 1 Conversion of MOF

CHAPTER – 2

LITERATURE REVIEW

OVERVIEW OF ORGANIC POLLUTION IN WATER BODIES

Waterways worldwide face an escalating threat from organic pollutants, posing significant risks to ecosystems and human health. These pollutants include a diverse array of compounds from industrial processes, agriculture, and domestic sources such as dyes, pesticides, pharmaceuticals, and hydrocarbons. Each carry distinct environmental and health risks.

The sources of organic pollution are wide-ranging, including industrial effluents, agricultural runoff, urban sewage, and improper waste disposal. Industrial activities discharge untreated or inadequately treated effluents containing manufacturing chemicals into waterways. Agricultural runoff carries pesticides, herbicides, and fertilizers into surface and groundwater, especially during rainfalls. Urban sewage introduces a mixture of organic pollutants into water bodies, often with inadequate treatment. Dumping waste into waterways or landfills also contributes to the organic pollution burden **(Carpenter, S. R., Caraco, N. F., Correll, D. L., Howarth, R. W., Sharpley, A. N., & Smith, V. H. 1998).**

Once in waterways, organic pollutants persist and move to varying degrees depending on their properties and conditions. Persistent organic pollutants like PAHs and chlorinated compounds accumulate in sediments and biota, posing ecosystem risks. Through biomagnification up the food chain, these can impact human reproductive, immune, and neurological health.

The impacts on aquatic ecosystems are diverse, including acute and chronic toxicity to organisms, habitat degradation, disrupted ecosystems, and biodiversity losses. Exposure to high pollutant levels impairs growth, reproduction, and survival. Pollutants also interfere with biochemical processes, nutrient cycles, and habitat

quality. The cascading effects through food webs compromise ecosystem resilience (Schwarzenbach, R. P., Gschwend, P. M., & Imboden, D. M. 2003).

Additionally, organic pollution poses human health risks through contaminated drinking and recreational water and bioaccumulation in seafood. Integrated, concerted efforts are needed to address the sources, impacts, and risks to safeguard water quality, aquatic biodiversity, and sustainability (US Environmental Protection Agency (EPA) (2019)).

CURRENT CHALLENGES IN ORGANIC POLLUTION REMEDIATION

Traditional techniques for the remediation of natural pollution, encompassing bodily, chemical, and biological strategies, have long been employed to mitigate the negative outcomes of natural contaminants in water our bodies. but those conventional strategies frequently come across obstacles that hinder their effectiveness and sustainability, necessitating the exploration of revolutionary remediation strategies.

Physical strategies:

physical strategies for organic pollution remediation usually involve the physical removal or separation of pollutants from water matrices. techniques which include sedimentation, filtration, and membrane techniques are usually used to eliminate suspended solids, colloids, and dissolved organic compounds from water. at the same time as these methods can efficaciously lessen natural pollutant concentrations, they may now not be suitable for the entire elimination of contaminants or for addressing recalcitrant compounds. moreover, bodily methods may additionally require full-size power inputs and operational costs, mainly for membrane-primarily based tactics, which depend on stress-pushed separation mechanisms.

Chemical methods:

Chemical techniques for natural pollution remediation usually contain using chemical sellers to convert or degrade pollution into much less dangerous or inert by-products. Oxidation techniques, including ozonation and superior oxidation strategies (AOPs), are typically employed to degrade organic pollutants via the generation of surprisingly reactive hydroxyl radicals. whilst these methods can be effective for the degradation of a extensive variety of natural compounds, they regularly require significant strength inputs and may produce dangerous by-products, including chlorinated natural compounds or bromate ions, which pose extra environmental dangers. moreover, chemical oxidation approaches may exhibit limited selectivity and performance for positive recalcitrant pollutants, necessitating the improvement of tailor-made remedy techniques (Lee, C. S., Robinson, J., & Chong, M. F 2014)

Biological methods:

organic techniques for organic pollutants remediation depend upon the metabolic activities of microorganisms to degrade natural pollution into easier, less toxic compounds. techniques together with activated sludge methods, biofiltration, and built wetlands are commonly used for biological remedy of natural pollution in wastewater remedy flowers and herbal ecosystems. while biological strategies may be surprisingly powerful for the removal of biodegradable pollutants, they may be less suitable for recalcitrant compounds that resist microbial degradation. additionally, biological remedy strategies can also require longer retention times and large land areas in comparison to traditional bodily and chemical strategies, proscribing their applicability in sure settings (Wang, A., Quan, X., & Zhao, H. 2017).

Adsorption-based totally strategies:

Adsorption-based techniques contain the use of adsorbent substances to capture and do away with natural pollution from water matrices. Activated carbon, zeolites, and diverse nanoporous substances are usually used as adsorbents due to their high surface region and affinity for organic molecules. whilst adsorption can be an powerful method for doing away with natural pollutants, it may be afflicted by bad

selectivity, requiring frequent regeneration or alternative of adsorbents. furthermore, the adsorption capacity of adsorbents may be encouraged by way of elements inclusive of pH, temperature, and the presence of competing ions, which can affect standard treatment efficiency (Li, H., Li, Q., Wang, H., Di, Z., & Jiang, H. 2016).

Revolutionary and Sustainable Remediation techniques:

Given the constraints of traditional remediation strategies, there's a compelling want for the improvement of modern and sustainable methods to deal with the challenges posed by using natural pollution. emerging technology, inclusive of photocatalysis, electrochemical oxidation, and membrane-based totally methods, provide promising avenues for the efficient removal and degradation of natural pollutants with decreased power consumption and environmental impact. furthermore, the integration of superior substances, along with carbon nanomaterials, metal-natural frameworks (MOFs), and nano-cellulose-primarily based composites, into remediation structures holds capacity for reinforcing treatment efficiency and selectivity.

In conclusion, whilst conventional techniques for organic pollutants remediation were instrumental in mitigating the effects of organic contaminants in water bodies, they frequently encounter boundaries such as low efficiency, excessive operational prices, and the era of secondary pollution. consequently, the improvement of revolutionary and sustainable remediation techniques is imperative to deal with the challenges posed by way of organic pollution effectively. through leveraging rising technologies and advanced substances, we will increase value-powerful, electricity-efficient, and environmentally benign methods to guard water exceptional and guard aquatic ecosystems from the detrimental outcomes of natural contaminants **(Wang, J., Zheng, Y., & Liu, W. (2017).**

CATALYTIC DEGRADATION AS A PROMISING APPROACH:

Catalytic degradation has emerged as a promising method for the remediation of natural pollutants in water bodies, attributable to its ability for high efficiency, selectivity, and mild working situations. not like conventional treatment strategies, which often depend upon physical or chemical methods, catalytic degradation harnesses the power of catalytic materials to facilitate redox reactions that smash down natural pollution into much less dangerous or inert via-merchandise **(Chen, F., Liu, Y., & Wang, Z. 2019).**

One of the key blessings of catalytic degradation is its versatility in addressing a huge variety of organic pollutants found in water bodies. Heterogeneous catalysts, especially, have won substantial attention because of their capacity to catalyse reactions at the interface between the catalyst surface and the response medium. those catalysts may be tailored to goal unique pollution by means of adjusting their composition, morphology, and floor homes. moreover, heterogeneous catalysts offer numerous realistic benefits over homogeneous catalysts, which include smooth separation from response combinations, ability for reuse, and more advantageous balance beneath a ramification of operating situations **(Gogate, P. R., & Pandit, A. B 2004).**

The mechanism of catalytic degradation includes the activation of natural pollution by the catalytic cloth, followed via a series of redox reactions that lead to the cleavage of chemical bonds and the formation of easier, much less poisonous compounds. The catalytic cloth acts as a facilitator, supplying a floor for the adsorption and activation of reactant molecules, in addition to a pathway for the switch of electrons between reactants and merchandise. via accelerating the charge of those reactions, catalytic materials can drastically decorate the degradation performance of organic pollution, even at especially low concentrations.

One of the key advantages of catalytic degradation is its capacity to operate beneath slight situations, along with ambient temperature and pressure, reducing power consumption and environmental effect in comparison to traditional treatment strategies. this is especially crucial for the remediation of organic pollution in water our bodies, where stringent environmental policies and cost concerns regularly

restrict the feasibility of more strength-intensive remedy techniques. furthermore, catalytic degradation can be integrated into present water remedy systems or deployed as standalone devices, imparting flexibility and scalability for numerous applications (Yu, J., & Xu, X. 2014).

in addition to its environmental benefits, catalytic degradation gives financial advantages, along with ability value savings and sales technology thru the recuperation of precious by means of-products. for instance, positive catalytic techniques can convert natural pollution into intermediate compounds that can be in addition processed into useful chemicals or fuels, imparting a capability supply of sales or offsetting treatment charges. moreover, the recyclability of heterogeneous catalysts permits for multiple cycles of use, decreasing the need for common alternative and minimizing waste technology.

no matter its numerous advantages, catalytic degradation also gives certain demanding situations and barriers that must be addressed for sizable adoption in water remediation programs. those consist of the improvement of catalysts with progressed hobby, selectivity, and stability, in addition to the optimization of response conditions to maximise degradation efficiency whilst minimizing formation. additionally, the mixing of catalytic degradation into current water remedy infrastructure may also require adjustments or upgrades to accommodate the unique necessities of catalytic tactics.

In conclusion, catalytic degradation gives ³⁷ a promising method for the remediation of organic pollutants in water bodies, presenting high efficiency, selectivity, and moderate operating conditions. Heterogeneous catalysts, particularly, offer sensible advantages along with smooth separation, ability for reuse, and applicability to a huge variety of pollution. with the aid of harnessing the power of catalytic substances, we can boost up the degradation of natural pollutants and sell the remediation of infected water our bodies, contributing ²³ to environmental sustainability and human health.

Metal-Organic Frameworks (MOFs) in Catalysis:

⁷ Metal-Organic Frameworks (MOFs) have emerged as a category of flexible substances with great capability in various fields, which includes catalysis, because of their particular structural residences, excessive surface location, and tunable pore systems. MOFs constitute a brand-new class of porous substances composed of steel ions or clusters coordinated with organic ligands to form crystalline frameworks. these frameworks usually showcase nicely described cavities and channels, resulting in excessive porosity and surface vicinity, which are relatively ideal houses for catalytic packages (¹⁰ Li, J. R., Sculley, J., & Zhou, H. C. 2012).

The structure of MOFs is characterized by way of steel nodes or clusters interconnected with the aid of organic linkers, forming prolonged networks with ordered structures. the choice of metallic ions and organic ligands lets in for the design and synthesis of MOFs with tailored homes, which include pore length, floor chemistry, and purposeful organizations, which can be finely tuned to optimize catalytic overall performance for unique reactions. The modular nature of MOFs enables specific manipulate over their composition and structure, making them rather versatile and adaptable as catalysts for a wide range of applications. ³²

One of the key blessings of MOFs in catalysis is their excessive surface location, which arises from the inherent porosity of the crystalline frameworks. The large floor vicinity gives plentiful energetic websites for catalytic reactions, bearing in mind efficient adsorption and interaction of reactant molecules. moreover, the tunable pore structures of MOFs enable selective adsorption and diffusion of reactants and products, facilitating stronger catalytic pastime and selectivity.

Furthermore, MOFs provide the ability to encapsulate visitor molecules within their pores, imparting confined surroundings for catalytic reactions. This confinement effect can lead to accelerated balance and selectivity of catalysts, in addition to superior mass transfer and diffusion kinetics of reactants and merchandise. ⁷ The encapsulation of reactant molecules in the pores of MOFs can also prevent undesirable aspect reactions and reduce catalyst deactivation, thereby enhancing the overall efficiency and performance of catalytic structures.

Every other noteworthy feature of MOFs is their flexibility in functionalization, whereby diverse practical companies may be delivered onto the natural ligands or metallic nodes to modulate their catalytic homes. Functionalization lets in for the incorporation of unique catalytic sites, including metallic active web sites or organic useful agencies, tailored to the favored response mechanism. This versatility in functionalization enables the layout of MOF-based catalysts with more suitable activity, selectivity, and stability for various catalytic transformations.

¹⁰ In latest years, MOFs have been explored for a extensive variety of catalytic programs, which include heterogeneous catalysis, photocatalysis, electrocatalysis, and enzymatic catalysis. those programs span numerous industries and sectors, together with energy conversion and garage, environmental remediation, chemical synthesis, and biomedical packages. for instance, MOFs have proven promise as catalysts for organic differences, together with C-C bond formation, hydrogenation, oxidation, and move-coupling reactions, demonstrating excessive catalytic interest and selectivity.

Furthermore, the design and synthesis of MOF-based totally catalysts may be tailored to cope with unique challenges in catalysis, inclusive of improving reaction costs, selectivity, and balance, in addition to lowering environmental impact and aid consumption. by harnessing the specific houses of MOFs, researchers can increase revolutionary catalytic materials with better performance⁴ and capability for a extensive variety of industrial and environmental packages (Cui, Y., Yue, Y., Qian, G., & Chen, B. 2012).

Metal-natural Frameworks (MOFs) have emerged as promising catalysts because of their precise structural houses, excessive floor area, and tunable pore structures. MOFs offer severa advantages as catalysts, including high catalytic activity, selectivity, and the capability to encapsulate visitor molecules within their pores. moreover, the modular nature of MOFs permits for the layout and synthesis of tailored catalysts for particular applications, making them extraordinarily versatile and adaptable for a extensive variety of catalytic transformations. As research on this field keeps strengthening, MOFs are predicted to play a important role in addressing key challenges in catalysis and using innovation in various industries and sectors (Dhakshinamoorthy, A., & Garcia, H. (2012).

NANO-CELLULOSE-BASED MATERIALS FOR ENVIRONMENTAL APPLICATIONS

Nano-cellulose, derived from renewable biomass resources like timber pulp and agricultural residues, has garnered giant attention in recent years for its tremendous homes and various applications in environmental remediation. this versatile material, characterized by using its excessive floor vicinity, mechanical electricity, and biocompatibility, holds gigantic promise for addressing environmental challenges, mainly in pollutant remediation. here, we delve into the specific residences of nano-cellulose and explore its potential packages in pollutant adsorption, membrane filtration, and catalysis, focusing at the synergistic results accomplished with the aid of incorporating nano-cellulose into composite materials.

Properties of Nano-cellulose:

Nano-cellulose, which include cellulose nanocrystals (CNCs) or cellulose nanofibers (CNFs), possesses first rate physical and chemical houses thanks to its nanoscale dimensions and crystalline structure. With a excessive element ratio and massive precise floor region, nano-cellulose well-known shows terrific adsorption potential for numerous pollutants, such as heavy metals, organic dyes, and pharmaceutical compounds. furthermore, nano-cellulose demonstrates fantastic mechanical properties, together with excessive tensile energy and modulus, making it appropriate for the fabrication of strong membranes and composite materials. moreover, nano-cellulose is biocompatible, non-poisonous, and biodegradable, rendering it environmentally pleasant and secure for use in diverse packages (Cui, Y., Yue, Y., Qian, G., & Chen, B 2012)

Packages in Pollutant Adsorption:

Nano-cellulose-based substances have proven excellent capacity for pollutant adsorption due to their excessive surface region and purposeful groups able to form strong interactions with contaminants. by using enhancing the surface chemistry of nano-cellulose via chemical remedies or functionalization with specific organizations (e.g., carboxyl, amino, hydroxyl), the adsorption selectivity and performance may be tailor-made for specific pollution. Nano-cellulose composites, incorporating additional adsorbent materials or nanoparticles, can further beautify pollutant elimination performance through synergistic results. these composites may be utilized in diverse water treatment techniques, together with batch adsorption, non-stop waft structures, and point-of-use filtration devices, providing value-powerful and sustainable solutions for pollutant elimination from infected water assets.

Membrane Filtration applications:

Nano-cellulose-primarily based membranes preserve promise for membrane filtration applications because of their specific mixture of homes, together with high porosity, mechanical power, and tunable pore length distribution. by way of using nano-cellulose membranes, contaminants can be successfully removed from water streams through length exclusion, adsorption, and electrostatic interactions. furthermore, nano-cellulose membranes may be functionalized with surface coatings or nanoparticles to beautify their selectivity and fouling resistance. those membranes locate programs in numerous water remedy techniques, including microfiltration, ultrafiltration, and nanofiltration, for the elimination of pollution consisting of bacteria, viruses, organic rely, and microplastics. The improvement of nano-cellulose-based totally membranes represent a promising avenue for reaching sustainable and green water purification systems.

Catalytic programs:

In recent years, nano-cellulose has emerged as a promising guide cloth for catalytic packages because of its high floor region, mechanical robustness, and compatibility with heterogeneous catalysis. by means of immobilizing catalytic nanoparticles onto nano-cellulose substrates, novel catalysts can be evolved for various natural adjustments, including degradation of natural pollution, synthesis of excellent chemical substances, and conversion of biomass feedstocks (Habibi, Y., Lucia, L. A., & Rojas, O. J 2010). The synergistic outcomes between nano-cellulose and catalytic nanoparticles result in stepped forward catalytic activity, selectivity, and balance. furthermore, the biodegradability of nano-cellulose makes it an environmentally sustainable option for catalytic applications, minimizing environmental impacts related to catalyst disposal (Lu, P., & Hsieh, Y. L 2010). Nano-cellulose-based catalysts show promise for applications in wastewater remedy, inexperienced chemistry, and renewable strength technologies, imparting modern solutions for addressing environmental demanding situations (Abdel-Mohsen, A. M., Amin, M. B., El-Newehy, M. H., & Al-Deyab, S. S. 2012).

Nano-cellulose, derived from renewable biomass resources, affords a flexible and sustainable fabric for environmental remediation applications. With its particular aggregate of properties, along with excessive floor area, mechanical electricity, and biocompatibility, nano-cellulose offers promising solutions for pollutant adsorption, membrane filtration, and catalysis. via incorporating nano-cellulose into composite substances, synergistic results may be accomplished, leading to greater overall performance and stability in environmental remediation techniques. persevered studies and improvement in nano-cellulose-primarily based substances keep the potential to revolutionize water treatment technology and make a contribution to a cleanser and greater sustainable surroundings (Sehaqui, H., Salajková, M., Zhou, Q., & Berglund, L. A 2010).

PREVIOUS RESEARCH ON CARBON DOPED ZN (NO₃)₂ COMPOSITES:

Carbon doped Zn(NO₃)₂ composites have emerged as versatile materials with promising applications across various fields, including catalysis, energy storage, and sensing. These composites, formed through the incorporation of carbon into a Zn(NO₃)₂ matrix, exhibit unique properties that render them highly effective for catalytic applications, particularly in the remediation of organic pollutants from water bodies.

The synergistic effects between the carbon matrix and the active metal species, such as zinc ions, contribute to the enhanced catalytic activity of carbon doped Zn(NO₃)₂ composites. The carbon matrix serves as a support material, providing a high surface area and facilitating the dispersion of active metal species, thereby promoting catalytic reactions. Moreover, the presence of carbon species can modify the electronic and surface properties of the composite, leading to improved catalytic performance and selectivity (Wang, X., Ma, W., & Gong, J. 2009).

Previous studies have demonstrated the efficacy of carbon doped Zn (NO₃)₂ composites in various catalytic applications, including the degradation of organic pollutants, oxidation reactions, and hydrogen evolution. In the context of organic pollution remediation, carbon doped Zn (NO₃)₂ composites have shown remarkable potential for the degradation of diverse organic contaminants present in water bodies. Through redox reactions facilitated by the active metal species, organic pollutants can be efficiently transformed into less harmful or inert by-products, thereby promoting the remediation of contaminated water bodies.

The catalytic performance of carbon doped Zn (NO₃)₂ composites can be further optimized by tuning their composition and morphology. For instance, varying the carbon content, particle size, and surface area of the composites can influence their catalytic activity, selectivity, and stability. Additionally, the incorporation of dopants or modifying agents into the composite structure can enhance its performance for specific catalytic applications (Wang, H., Zhang, X., & Li, Y 2011)

In addition to organic pollution remediation, carbon doped Zn(NO₃)₂ composites have shown potential in other catalytic processes, such as oxidation reactions and hydrogen evolution. The unique properties of these composites, including their high surface area, porosity, and electronic conductivity, make them attractive candidates for various catalytic transformations. By harnessing the synergistic effects between carbon and metal species, carbon doped Zn (NO₃)₂ composites can facilitate efficient catalytic reactions with enhanced reaction rates and yields **(Zhang, X., Zhang, S., & Zhang, X 2015)**

Furthermore, the versatility and tunability of carbon doped Zn (NO₃)₂ composites make them promising candidates for future research and development in catalysis. By exploring novel synthesis methods, optimizing composite structures, and elucidating reaction mechanisms, researchers can further enhance the catalytic performance and applicability of these materials. Moreover, interdisciplinary collaborations between materials scientists, chemists, and environmental engineers can lead to the design of tailored carbon doped Zn (NO₃)₂ composites for specific catalytic applications, addressing the pressing challenges of organic pollution remediation and beyond **(Li, W., Ma, Z., & Yang, Y 2017)**

In conclusion, carbon doped Zn (NO₃)₂ composites ¹¹represent a promising class of materials with diverse applications in catalysis, including the remediation of organic pollutants from water bodies. Through the synergistic effects between carbon and metal species, these composites exhibit enhanced catalytic activity, selectivity, and stability, making them valuable tools for environmental remediation and sustainable development.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

This study aims to synthesize and characterize nano-cellulose/IMOF (Inorganic Metal-Organic Framework) derived carbon-doped Zn (NO₃)₂ composites for application as catalysts in organic pollution remediation. The catalysts will be fabricated through a multi-step process involving the conversion of nano-cellulose and IMOF into carbon matrices doped with Zn (NO₃)₂. The resulting composites will be thoroughly characterized using various composite analytical techniques to understand their structural, morphological, and chemical properties. Subsequently, the catalytic performance of the composites will be evaluated in the remediation of organic pollutants, focusing on their efficiency, stability, and reusability. This research aims to contribute to the development of sustainable and effective catalyst materials for environmental remediation applications.

3.2 OBJECTIVE:

- To derive carbon doped Zn (NO₃)₂ composite catalyst for organic pollution remedy.
- To remove organic contaminants.
- To use various treatment techniques to treat organic pollutants to achieve maximum removal efficiency.

3.3 SCOPE

- Today there is a great focus on treating organic pollutants hence there is an urgent need to develop an economical treatment system for the treatment of organic pollutants, which can meet the strict quality standard.
- In recent days organic pollution remedies are focus on various economical and eco-friendly treatment.
- This feature contributes to the cost-effective.

MATERIALS AND METHODS**3.1 MATERIALS:**

The following list of materials were used for MOF synthesis.

CHEMICALS REQUIRED:

- Sodium hydroxide
- Distilled water
- Sugarcane waste
- Zinc Nitrate
- Ferric chloride
- Terephthalic acid
- Ethanol

EQUIPMENTS REQUIRED:

- Furnace
- Hot air oven
- Crucible
- Magnetic stirrer
- Beaker
- P.H paper
- Filter paper
- Stirring rod
- Glass pallet

3.2 PREPARATION OF NANO – CELLULOSE:



Fig 3.1 Nano Cellulose

Nano-cellulose is derived from cellulose rich source like wood pulp or agricultural waste through mechanical and chemical treatment to break down the cellulose fiber into nano scale dimension.

- Collect the sugarcane waste and grind the waste substance into smaller particles to remove non-cellulosic components like lignin.
- It is a chemical treatment where grinded sugarcane waste is immersed in a strong alkaline solution using sodium hydroxide (20g of NaOH in 1 litre of water)
- Heat the alkaline treated sugarcane waste while stirring to ensure uniform distribution of the alkaline solution (100 Degree Celsius)
- Thoroughly rinse the chemically treated sugarcane waste in 20 ml of diluted sulphuric acid (H_2SO_4) to remove the remains of chemical and impurities.
- Once again the sugarcane must be washed and after completing the washing, the sugarcane must be dried to remove excess water and obtain a dry cellulose rich material (Hot air oven can be used)

3.3 SYNTHESIS OF MOF PRECURSOR



Fig 3.2 Mixing metal ions.

MOF precursor is synthesized by mixing metal ions with organic ligands in a suitable solvent, this forms a crystalline MOF structure that will later be used to derive the catalyst.

- Dissolve zinc nitrate $\text{Zn}(\text{NO}_3)_2$ - 4.8 grams in solvent in 300ml of DMF + 200ml of Ethanol.
- Dissolve the organic ligand in a separate solvent (such as Terephthalic acid – 10 gram)
- Slowly add the metal solution to the organic ligand solution while stirring. This will allow the metal ion coordinate with the organic ligands and form the MOF precursor (Mixing metal solution and organic ligands).
- After mixing the metal solution and organic ligand, the MOF precursor solution may need to be left for a specific period of time to allow crystallization and aging.
- Filter the MOF crystals and wash them with a suitable solvent to remove any impurities or unreacted chemical.
- Dry the MOF precursor crystal to obtain a dry powder form that can be stored for further use

3.4 Impregnation of MOF or Nano – Cellulose

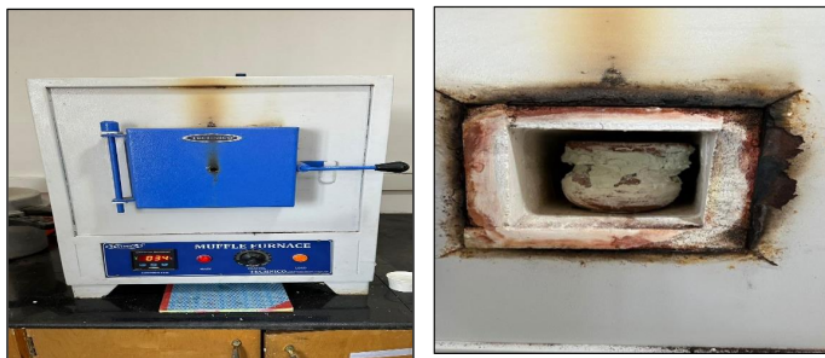


Fig 3.3 Preparation of Biochar

- To prepare biochar from dried sugar cane bits, a simple method involving a clay pot and a furnace can be employed. The process involves the following steps:
- Transfer the dried sugar cane bits into the clay pot. Ensure that the clay pot is clean and free from any contaminants.
- Seal the clay pot tightly using white cement. This step is crucial to prevent the escape of gases and to create an oxygen-limited environment inside the pot during the pyrolysis process.
- Place the sealed clay pot inside the furnace and heat it to a temperature of 500°C. It is recommended to maintain this temperature for approximately 3 hours to facilitate the pyrolysis of the sugar cane bits.
- During the pyrolysis process, the high temperature and absence of oxygen cause thermal decomposition of the sugar cane bits, leading to the formation of biochar. Biochar is a stable form of carbon with a high surface area and porous structure, making it suitable for various applications, including soil amendment, carbon sequestration, and environmental remediation.

3.5 Formulation of CoFe2 Solution:



Fig. 3.4: Formulation of CoFe2 Solution

The formulation of CoFe₂ involves a series of steps to put together a solution comprising zinc nitrate, ferric chloride, and terephthalic acid in a mixture of ethanol and distilled water. This answer serves as a precursor for CoFe₂ synthesis and is ready as follows:

1. Choice of Precursors:

The number one precursor for the CoFe₂ formulation encompasses zinc nitrate, ferric chloride, and terephthalic acid. these chemical substances are chosen based on their reactivity and compatibility with the desired synthesis method.

2. Preparation of Solution

To provoke the method manner, the required portions of zinc nitrate, ferric chloride, and terephthalic acid are measured and brought to a appropriate solvent combination comprising ethanol and distilled water. The solvent mixture helps the dissolution of the precursors and ensures homogeneity of the ensuing solution.

3. Stirring:

Once all of the precursors are brought to the solvent aggregate, the solution is subjected to stirring the use of a magnetic stirrer. Stirring is crucial to sell the dissolution of the precursors and to make sure uniform blending of the components. the solution is stirred for a length of approximately 3 hours to gain whole dissolution and homogenization.

4. Monitoring:

In the course of the stirring process, the answer is monitored for any adjustments in colour, viscosity, or readability, which might also imply the development of dissolution and mixing. ordinary monitoring enables make sure that the preferred homogeneity and consistency are completed within the final solution.

5. Completion:

After the stirring length of 3 hours, the answer is taken into consideration equipped for in addition processing or synthesis steps. The finishing touch of the method system indicates a hit training of the CoFe₂ precursor answer, which may be used for subsequent synthesis steps to acquire the favoured CoFe₂ cloth.

Usual, the components of CoFe₂ entails the proper addition and combining of zinc nitrate, ferric chloride, and terephthalic acid in a solvent mixture, followed by means of stirring to obtain entire dissolution and homogenization. This prepared answer serves as a critical precursor for the synthesis of CoFe₂ and represents a essential step in the normal synthesis process.

3.6 Preparation of MOF:



Fig 3.5: Preparation of MOF

The practise of Metal-organic Frameworks (MOFs) entails a series of steps geared toward incorporating biochar into an answer, observed via heating and drying procedures to attain the desired MOF powder. The technique is executed as follows:

- **Addition of Biochar to the solution:**

Step one inside the instruction of MOF entails adding biochar to the answer containing the essential precursor substances. Biochar, derived from sustainable biomass sources, is brought into the answer to function a template or scaffold for MOF formation. The addition of biochar is carefully managed to make sure right dispersion and incorporation in the answer.

- **Heating the answer in a Magnetic Stirrer:**

After the addition of biochar, the answer is heated in a magnetic stirrer to a temperature of 80°C. Heating the answer facilitates the infusion of biochar into the answer and promotes the formation of MOF structures. The stirring movement guarantees thorough mixing and distribution of biochar inside the solution, promoting uniform MOF boom.

- **Duration of Heating:**

The solution is maintained at a temperature of 80°C for a period of 6 hours. This extended heating period lets in enough time for the biochar to emerge as fully infused into the solution and for MOF formation to arise. The extended heating duration guarantees the improvement of well-defined MOF systems with stronger properties.

- **Transfer to a Hot Air Oven:**

Following the heating step, the semiliquid combination containing biochar and MOF precursors is transferred right into a hot air oven. the new air oven is ready to a temperature of 100°C to facilitate the evaporation of extra water from the combination. This step is vital for getting rid of moisture from the answer and selling the formation of MOF in powdered form.

- **Drying Method:**

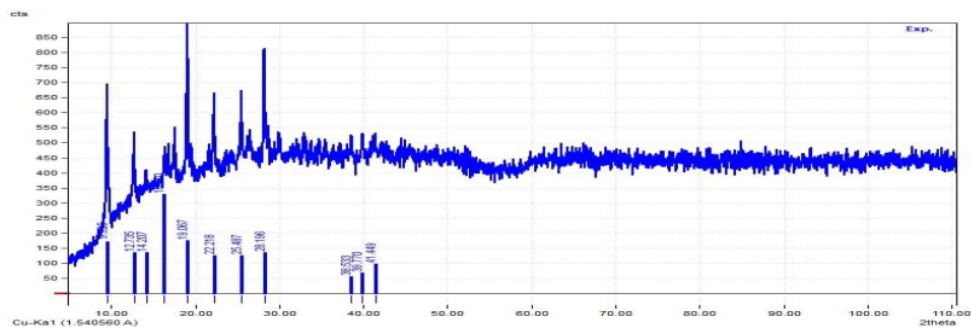
The semiliquid combination is subjected to drying in the warm air oven for a length of 4 hours. for the duration of this time, the extra water gift within the mixture evaporates, leaving in the back of the preferred MOF in powdered form. The drying procedure is essential for accomplishing the preferred consistency and morphology of the MOF powder, ensuring its suitability for similarly characterization and application.

By means of following these sequential steps, biochar-infused MOF powder can be successfully prepared, ready for next characterization and utilization in diverse programs. The incorporation of biochar into the MOF synthesis system offers possibilities to beautify the residences and performance of the resulting MOF substances, contributing to the development of sustainable and environmentally pleasant technologies.

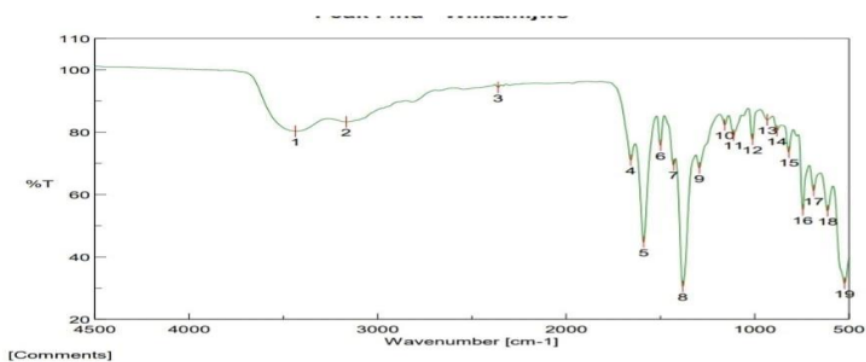
CHAPTER 4

INITIAL CHARACTERIZATION

XRD (X-Ray diffraction)



FTIR (Fourier Transform Infrared Spectroscopy)



FESEM (Field Emission Scanning Electron Microscope)

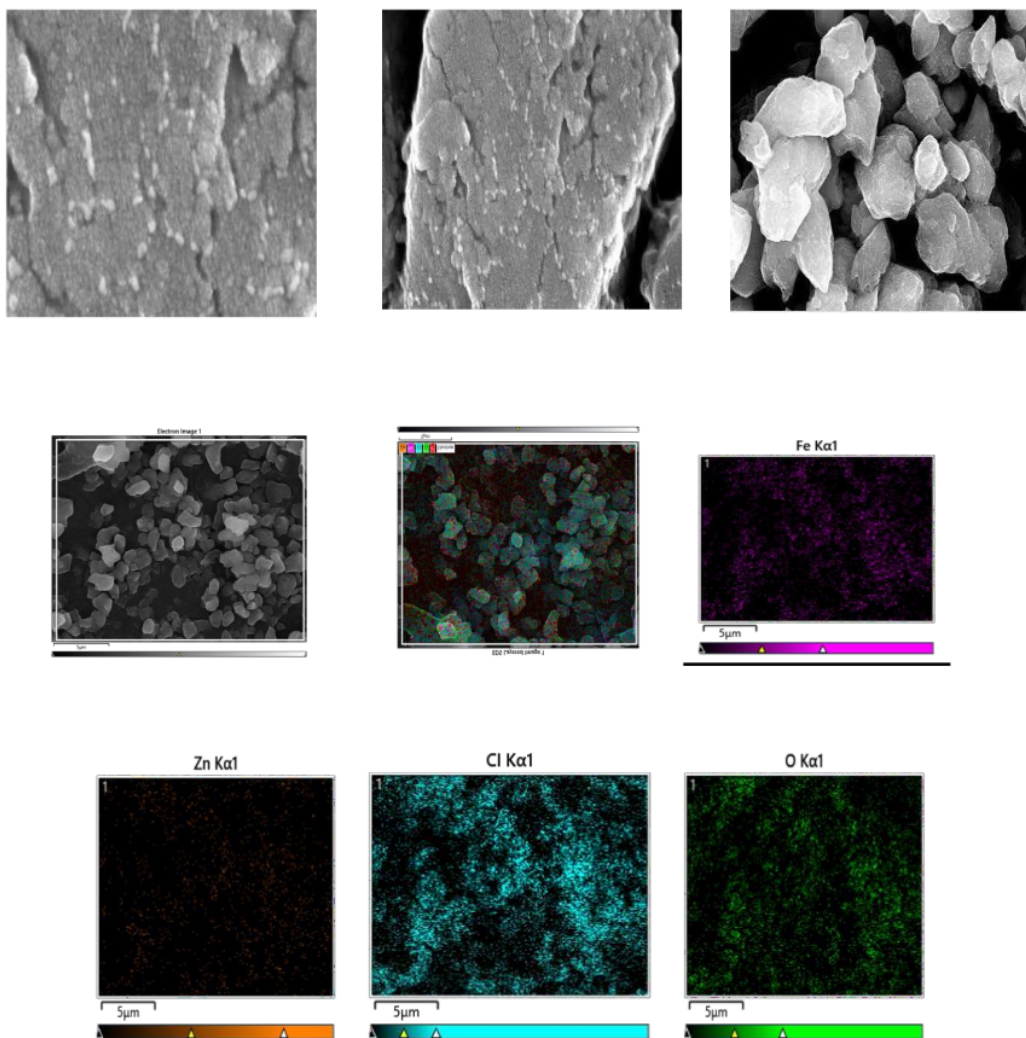


Fig 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11 FESEM (Microstructure image of the material)

CHAPTER 5

INTRODUCTION TO IBU PROFEN



Fig 5.1 Ibuprofen

22

Ibuprofen, a nonsteroidal anti-inflammatory drug (NSAID) belonging to the propionic acid derivatives class, is widely used for pain relief and fever reduction. Since its discovery in the 1960s, ibuprofen has become a key component in managing various conditions, from minor aches and pains to inflammatory disorders.

CHARACTERISTICS OF Ibu Profen:

Mechanism of Action: Ibuprofen primarily works by inhibiting the enzyme cyclooxygenase (COX), reducing the production of prostaglandins that are crucial in inflammation, pain, and fever. By blocking prostaglandin synthesis, ibuprofen effectively alleviates pain and inflammation.

Analgesic Properties: Ibuprofen is highly effective in providing relief from mild to moderate pain, making it suitable for managing headaches, toothaches, menstrual cramps, muscle aches, and acute pain.

Anti-Inflammatory Effects: As an NSAID, ibuprofen exhibits potent anti-inflammatory properties, commonly used to alleviate inflammation associated with arthritis, tendonitis, bursitis, and other inflammatory disorders.

Antipyretic Action: Ibuprofen is also classified as an antipyretic, reducing fever by acting on the hypothalamus, which regulates body temperature. Lowering fever with ibuprofen helps improve comfort and aids in recovery during febrile illnesses.

Rapid Onset of Action: Ibuprofen is known for its quick onset of action, often providing noticeable relief within 30 minutes to an hour after ingestion, depending on the formulation and individual response.

Duration of Action: The effects of ibuprofen typically last between 4 to 6 hours, requiring multiple doses per day for sustained pain relief or fever reduction. Extended-release formulations are available for longer-lasting effects, allowing for less frequent dosing.

HARMFUL EFFECTS OF IBUPROFEN IN PHARMACEUTICALS:

Ibuprofen, a commonly used and effective medication for pain relief and inflammation management, can have potential harmful effects if used inappropriately or excessively. It is important for healthcare professionals and patients to understand these risks in order to ensure the safe and responsible use of this medication.

Gastrointestinal Complications: One of the well-known adverse effects of ibuprofen is its ability to cause gastrointestinal (GI) complications, such as gastritis, ulcers, and gastrointestinal bleeding. When ibuprofen is used for a prolonged period or in high doses, it can irritate the stomach lining, leading to inflammation and the formation of ulcers. In severe cases, GI bleeding can occur, which can be life-threatening if not addressed promptly.

Cardiovascular Risks: The long-term use of ibuprofen, especially at high doses, has been associated with an increased risk of cardiovascular events like heart attacks and strokes. This risk is particularly concerning for individuals with pre-existing cardiovascular conditions or those who have factors such as advanced age, hypertension, diabetes, or smoking that put them at a higher risk.

Kidney Damage: Ibuprofen, like other NSAIDs, can impair kidney function, especially when used chronically or in high doses. Prolonged use of ibuprofen can lead to kidney damage, which is characterized by reduced kidney function, fluid retention, and electrolyte imbalances. Patients with pre-existing kidney conditions, such as chronic kidney disease, are particularly susceptible to this risk.

Allergic Reactions: Some individuals may develop allergic reactions to ibuprofen, which can range from mild skin rashes to severe anaphylaxis. Symptoms of an allergic reaction may include itching, hives, facial swelling, difficulty breathing, and rapid heartbeat. If any signs of an allergic reaction to ibuprofen are experienced, immediate medical attention should be sought.

Increased Bleeding Risk: Ibuprofen, like other NSAIDs, has the potential to inhibit platelet aggregation and prolong bleeding time, increasing the risk of bleeding, especially in individuals undergoing surgery or those with bleeding disorders. Healthcare providers should be informed of ibuprofen use before surgical procedures to reduce the risk of excessive bleeding.

Central Nervous System Effects: While taking ibuprofen, some individuals may experience central nervous system (CNS) side effects such as headache, dizziness, drowsiness, and confusion. These effects are usually mild and temporary but may require caution, particularly when driving or operating heavy machinery.

Gastrointestinal Distress: Apart from ulceration and bleeding, ibuprofen can also lead to gastrointestinal symptoms like nausea, vomiting, indigestion, and abdominal pain. These symptoms may be more severe in individuals with a history of GI problems or those who take ibuprofen on an empty stomach.

CHAPTER – 6

METHOD AND METHODOLOGY OF IBUPROFEN

Materials Required:

1. IB profen - 100% pure
2. Distilled water
3. Mixing flask
4. Beaker
5. MOF sample
6. PH meter
7. Heated magnetic stirrer

Preparation of IB Profen Stock Solution:

Synthesis Process: To guarantee that IB dissolves in distilled water, a number of careful procedures are involved in the synthesis of the IB stock solution. Below is a thorough description of the protocol:

- **Weighing IB Profen:** Using an analytical balance, weigh one gramme of IB Profen precisely to start. To guarantee that the stock solution has the appropriate concentration, measurement accuracy is essential.
- **Dissolution in distilled water:** Pour the precisely measured IB Profen powder into a dry, clean mixing flask for dissolution in distilled water. Then fill the mixing flask with one litre of distilled water and IB Profen powder. Using distilled water guarantees that there are no contaminants present that could impede the breakdown process.
- **Rest Period:** After the solution has completely dissolved, let it sit for a little while. Any undissolved particles can sink to the bottom of the flask during this resting period. Molecular interactions stabilise during this period, which adds to the solution's homogeneity.

EFFECT OF DOSGAE:

- **Experimental Procedure:** A number of careful processes must be taken to prepare samples with different MOF sample dosages and evaluate their catalytic performance in order to investigate dosage effects. Below is a description of the experimental protocol:

Beaker Preparation: To make it easier to prepare samples with various MOF sample doses, start by obtaining four dry, clean beakers. The integrity of the experimental setting is guaranteed by the choice of premium beakers.

Stock Solution Dispensing: Transfer 20 millilitres of the previously made IB Profen stock solution into each beaker. Add 800 cc of distilled water to the stock solution in order to obtain homogeneity. The right concentration for ensuing catalytic reactions is guaranteed by this dilution.

- **Addition of MOF Samples:** To investigate the effects of varying MOF sample doses on catalytic activity, new samples are added to each beaker. To each beaker, add 0.2 g of the MOF sample, 0.4 g to the second, 0.6 g to the third, and 1 g to the fourth. A thorough assessment of the effects of dosage-dependent changes on catalytic performance is made possible by the different dosages.
- **Mixing and Rest Period:** Make sure the MOF samples are properly dispersed throughout the solution by giving each beaker a good shake after adding them. After that, give the solutions a five-minute break. This relaxation time promotes molecular equilibration and interactions, which strengthens the catalytic system's stability.
- **Sample Collection:** Using an appropriate tester or sampling instrument, take samples from each beaker after the rest period. Place the samples into the containers intended for UV analysis with care. Maintaining sample identity and proper labelling is crucial to preserving data integrity during the analysis process.
- **UV Analysis:** To assess catalytic activity, do UV analysis on each sample that has been collected. The degradation efficiency of organic pollutants in the presence of Nano-Cellulose/MOF Derived Carbon Doped Zn (NO₃)₂ composites can be understood using UV analysis. To identify patterns in catalytic performance that are depending on dosage, record and examine the UV spectra.

EFFECT ON pH:

Experimental Setup: An organised experimental protocol is used as follows to examine the pH sensitivity of Nano-Cellulose/MOF Derived Carbon Doped Zn(NO₃)₂ composites:

Container Preparation: For the experimental configuration, five containers have been chosen. These receptacles offer distinct settings for assessing the impact of pH on catalytic efficiency. To avoid contamination and guarantee precise experimental outcomes, every container is meticulously cleaned.

Stock Solution Dispensing: A precise 100 ml portion of the previously prepared IB Profen stock solution is placed into each of the five containers. This guarantees that the catalytic processes have a constant beginning point and makes comparisons across various pH levels easier.

Initial pH Measurement: Using a pH metre that has been calibrated, the initial pH of each container is determined prior to the addition of the MOF solution. Throughout the course of the experiment, any pH variations brought about by the catalytic processes will be evaluated using this initial pH reading as a baseline.

Addition of MOF Solution: One gramme of the MOF solution is added to each container after the initial pH measurement. In the experimental setup, the MOF solution—which is produced from Nano-Cellulose/MOF—acts as the catalyst. When it is added, the solution begins to undergo catalytic reactions, which could change the pH of the containers.

Rest Period: The containers are kept in tact for a full day following the addition of the MOF solution. The MOF composite catalyses reactions that occur during this resting period, which may have an impact on the pH of the fluids as organic contaminants degrade.

Final pH Measurement: Using a pH metre, the final pH of each container is determined after the 24-hour resting period. Any pH fluctuations that resulted from the catalytic reactions can be understood by looking at this final pH reading. The pH sensitivity of the Nano-Cellulose/MOF Derived Carbon Doped Zn(NO₃)₂ composites can be evaluated by comparing the initial and final pH values.

EFFECT ON TIME:

Cellulose/MOF Derived Carbon Doped Zn (NO₃)₂ composites: Beaker

Selection: The vessel used to carry out the catalytic reactions is a 500 ml beaker. The beaker accommodates the required volume of reactants and makes stirring easier. It also offers a suitable environment for tracking the development of the reaction over time.

Making the Reaction Mixture: Put 180 ml of distilled water and 20 ml of the previously produced IB Profen stock solution in the chosen beaker. The intended concentration of the reactants for the catalytic reactions is guaranteed by this dilution. The catalytic process is then started by adding 1 g of the MOF sample to the mixture.

Stirring: A magnetic stirrer is used to stir the reaction mixture in the beaker. Stirring encourages the MOF sample to disperse evenly throughout the solution, which facilitates the catalyst's and the organic pollutants' effective interaction.

Time: A total of two hours are given to the catalytic process to continue. This time range was chosen in order to record the catalytic activity's temporal evolution and evaluate the composites' long-term effectiveness.

Sample Collection: Throughout the course of the two-hour reaction period, samples are taken from the reaction mixture at regular intervals. To be more precise, 10 millilitres of the reaction mixture are taken out every ten minutes, giving researchers plenty of data points to examine how the catalytic reactions change over time.

UV Analysis: To determine how much the Nano-Cellulose/MOF Derived Carbon Doped Zn (NO₃)₂ composites have contributed to the breakdown of organic pollutants, the collected samples are exposed to UV analysis. The evaluation of time-dependent catalytic activity is made possible by UV analysis, which provides information on the effectiveness of the catalytic reactions at various times.

CHAPTER – 7

FINAL CHARACTERIZATION

XRD (X-Ray diffraction):

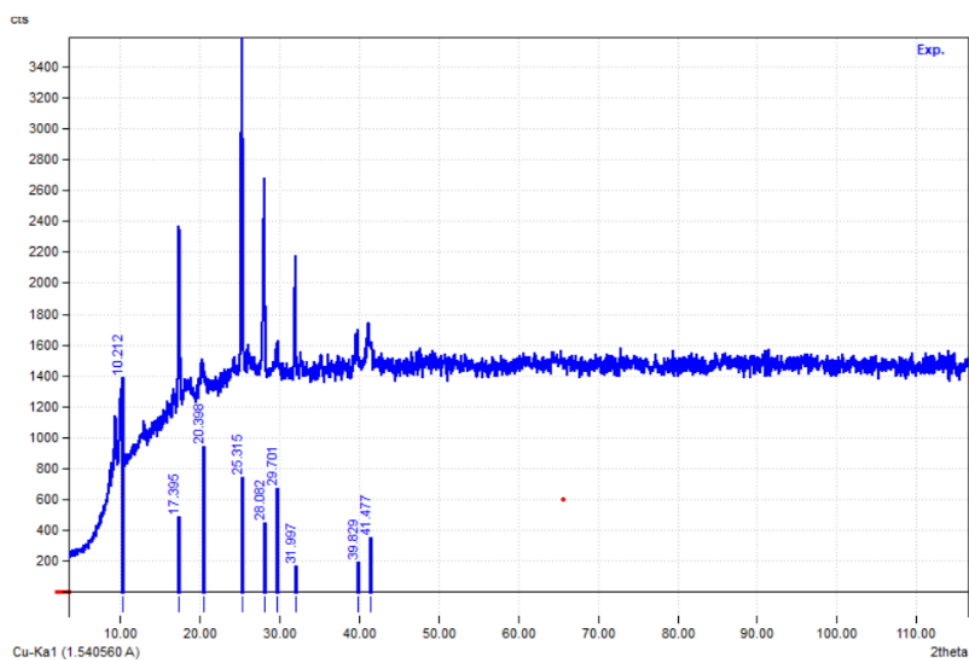


Fig 6.1 XRD Graph

PEAK LIST

No.	2theta [°]	d [Å]	I/I0 (peak height)	Counts (peak area)	FWHM
1	10.21	8.6551	220.86	1383.24	2.1028
2	17.40	5.0938	585.74	478.47	0.2743
3	20.40	4.3502	190.78	932.59	1.6413
4	25.31	3.5153	1000.00	732.92	0.2461
5	28.08	3.1749	601.90	442.50	0.2468
6	29.70	3.0054	107.65	664.54	2.0727
7	32.00	2.7948	376.28	161.57	0.1442
8	39.83	2.2614	85.95	187.12	0.7310
9	41.48	2.1753	81.75	349.74	1.2486

FTIR (Fourier Transform Infrared Spectros copy)

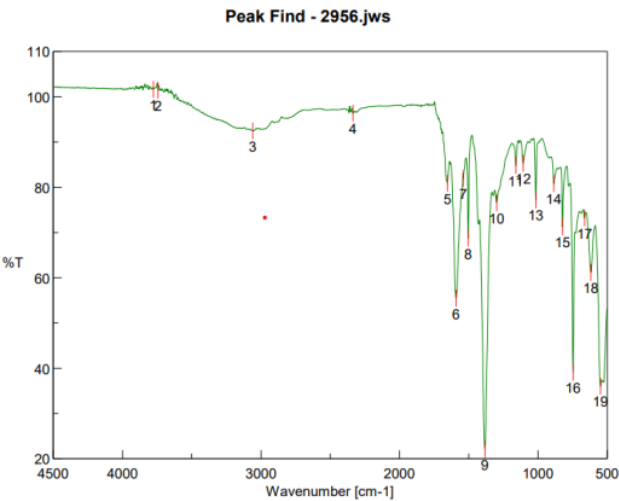
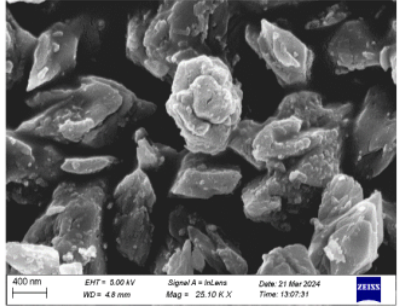
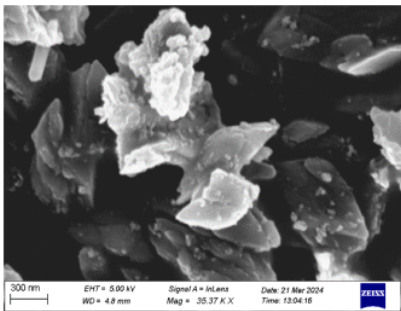
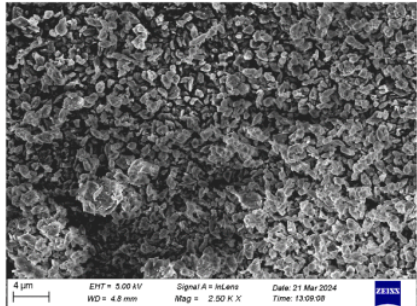
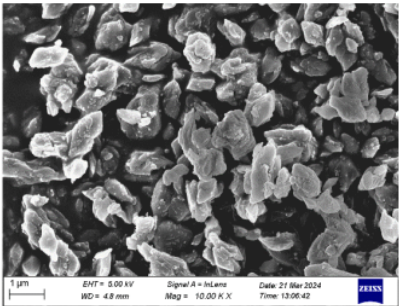


Fig 6.2 FTIR Graph

RESULT OF PEAK PICKING:

No.	Position	Intensity	No.	Position	Intensity
1	3776.9	101.649	2	3743.15	101.484
3	3060.48	92.4336	4	2335.37	96.3906
5	1654.62	80.8681	6	1591.95	55.4553
7	1538.92	81.9312	8	1505.17	68.7368
9	1384.64	22.0995	10	1298.82	76.5336
11	1159.97	84.8186	12	1106.94	85.2923
13	1016.3	77.2057	14	886.131	80.8009
15	822.491	71.234	16	747.281	39.0898
17	664.357	73.2246	18	618.074	61.1465
19	548.649	36.0535			

FESEM (Field Emission Scanning Electron Microscope)



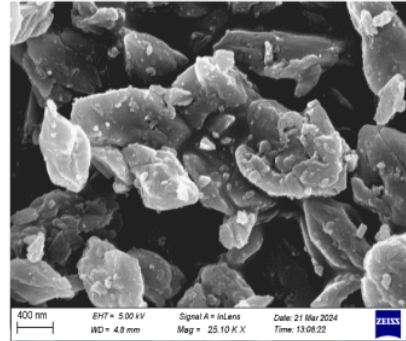
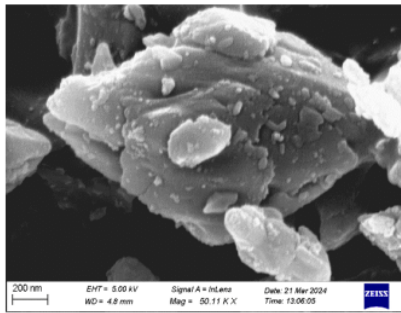


Fig 6.3, 6.4, 6.5, 6.6, 6.7, 6.8 FESEM (Microstructural image of material)

24

Brunauer-Emmett-Teller (BET) surface area analysis:

- 1.Slope:** The slope of the BET plot is related to the monolayer capacity of the adsorbent and is used to calculate the specific surface area
- 2. Intercept:** The intercept of the BET plot is related to the volume of the adsorbate gas and is also used in the calculation of the specific surface area
- 3. Correlation Coefficient (r):** This value indicates how well the experimental data fits the BET model. A value close to suggests a good fit.
- 4. Constant:** This constant is used in the BET equation and is determined experimentally.
- 5.Surface Area:** This is the specific surface area of the material, expressed in square meters per gram (m²/g). It represents the total surface area available for adsorption per unit mass of the material.

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marcbangalore@hotmail.com
Quantachrome NovaWin ©1994-2018, Quantachrome Instruments v11.05

Analysis Report
Operator: Quantachrome Date:2024/03/22 Operator: Quantachrome Date:2024/03/22
Sample ID: William Filename: 2-30.qps
Sample Desc: Powder sample Comment: Degassed
Sample weight: 0.0436 g Sample Volume: 0.02638 cc Sample Density:1.653 g/cc
Outgas Time: 6.0 hrs OutgasTemp: 160.0 C
Analysis gas: Nitrogen Bath Temp: 77.3 K
Press. Tolerance:0.100/0.100 (ads/des) Equil time: 35/35 sec (ads/des) Equil timeout: 70/70 sec (ads/des)
Analysis Time: 152.3 min End of run: 2024/03/22 15:48:52 Instrument: Nova Station A
Cell ID: 3

Adsorbate modelNitrogen Data Reduction Parameters
Temperature 77.350K

Relative Pressure P/Po	Volume @ STP cc/g	1 / [W((Po/P) - 1)] 1/g
1.60567e-01	2.6219	5.8373e+01
2.09464e-01	2.8203	7.5171e+01
2.58114e-01	2.9945	9.2961e+01

BET summary
Slope = 354.573 1/g
Intercept = 1.260e+00 1/g
Correlation coefficient, r = 0.999838
C constant= 282.328

Surface Area = 9.787 m²/g

CHAPTER – 8

RESULTS AND CONCLUSION

CONCENTRATION TABLE:



Fig 8.1 Stock Solution Sample

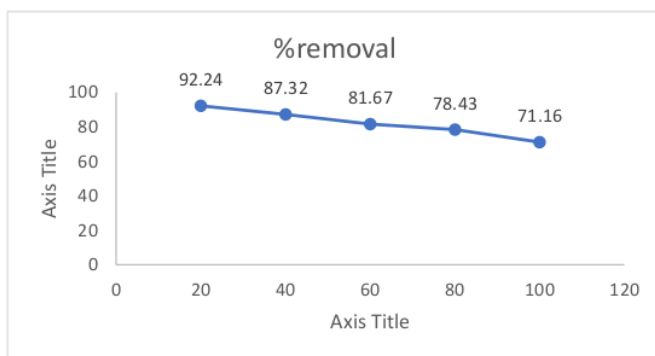


Fig 8.2 Concentration Removal Graph

Effect of dosage



Fig 8.3 Dosage Sample

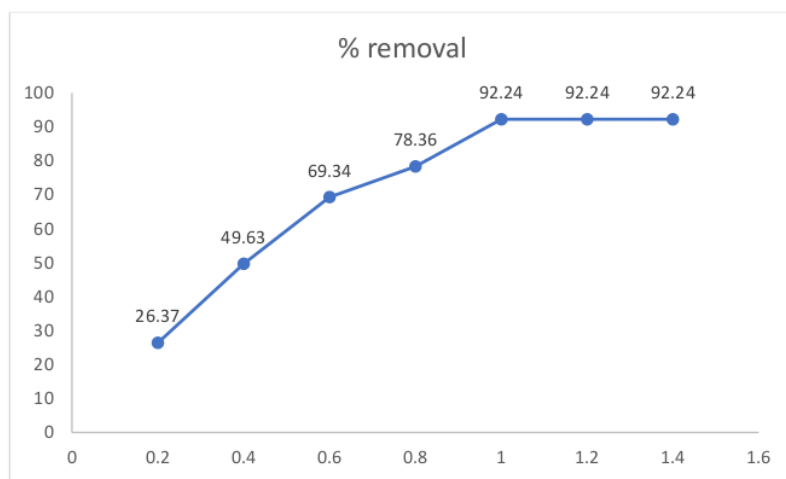


Fig 8.4 Dosage Graph

Effect of pH



Fig 8.5 pH Sample

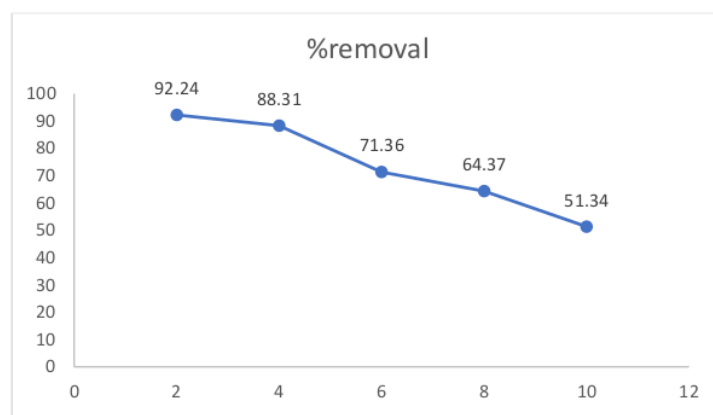


Fig 8.6 pH Graph

Effect of time:

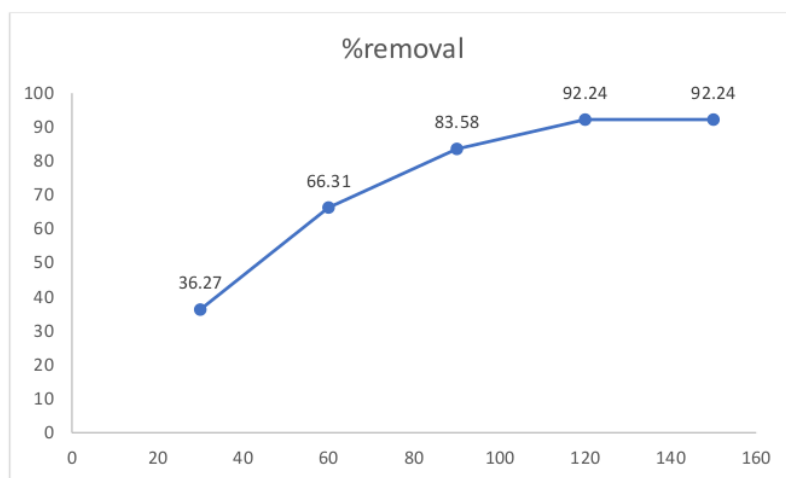


Fig 8.7

Effect of Temperature:

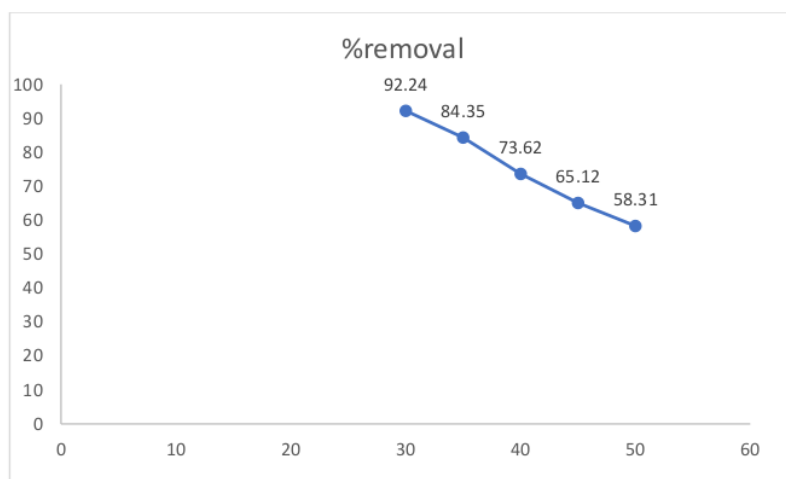


Fig 8.8

Isotherm



Fig 8.9

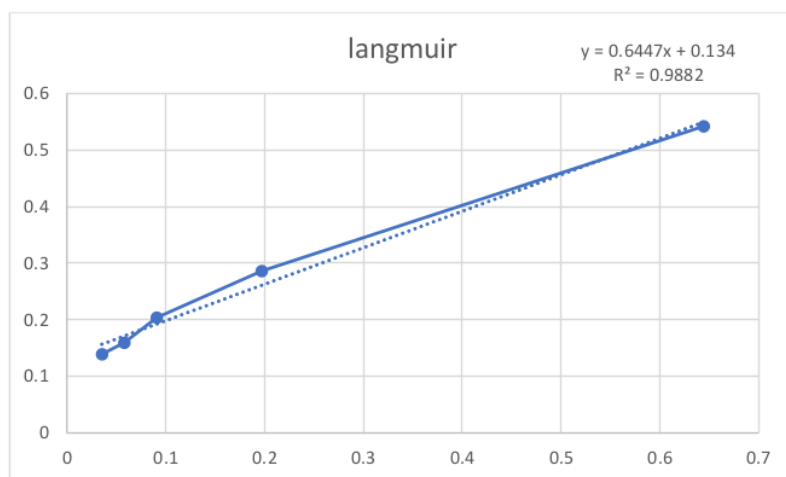


Fig 8.10

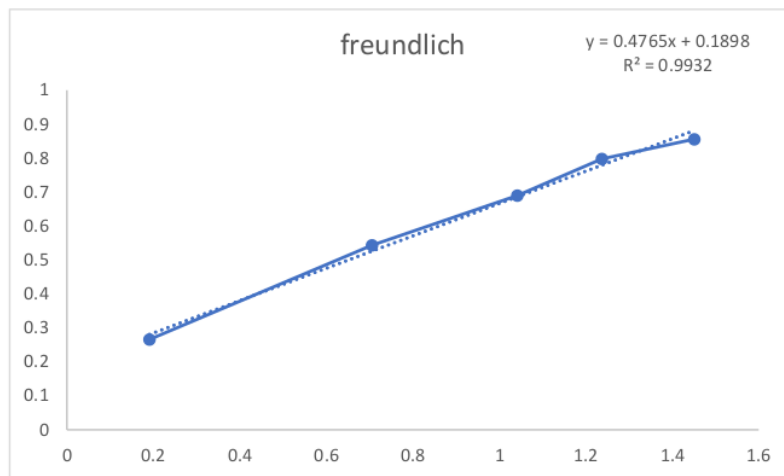


Fig 8.11
Kinetics

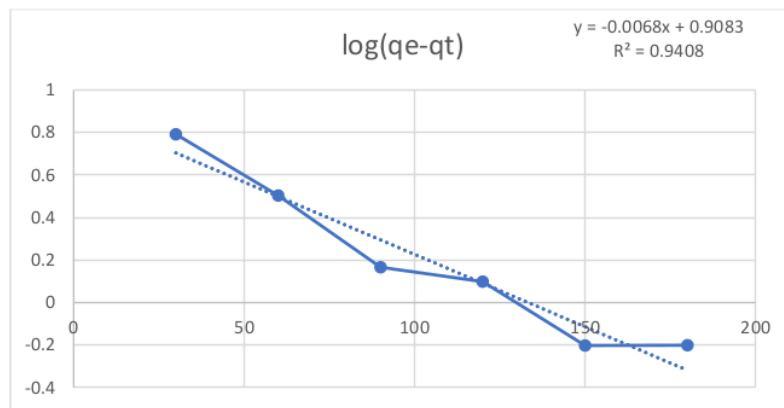


Fig 8.12

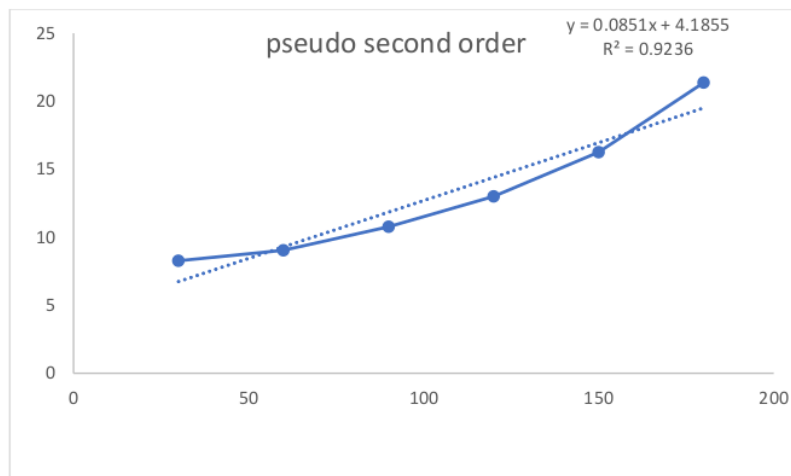


Fig 8.12

Thermodynamics

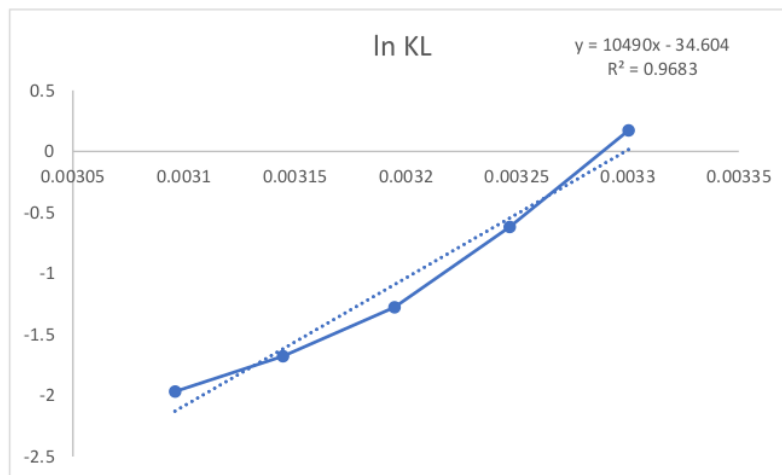


Fig 8.13

CHAPTER 9

CONCLUSION

The global challenge of organic pollution necessitates innovative and sustainable solutions to safeguard the environment and public health. In response to this pressing issue, our project embarked on an exploration of Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites as catalysts for organic pollution remediation. Through systematic experimentation and analysis, we endeavored to elucidate the catalytic performance, mechanisms, and potential applications of these novel composites in addressing organic pollution.

Our journey commenced with the synthesis of Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites, a multifaceted process involving meticulous preparation and characterization techniques. By harnessing the synergistic properties of cellulose nanomaterials and metal-organic frameworks (MOFs), we engineered composites with tailored structural and chemical properties conducive to catalytic applications. The incorporation of zinc ions and carbon doping further enhanced the catalytic activity and stability of the composites, setting the stage for comprehensive catalytic evaluations.

In investigating the catalytic efficacy of the composites, we delved into various aspects, including dosage, pH sensitivity, and time-dependent activity. Through controlled experiments, we systematically evaluated the influence of these parameters on the catalytic performance of Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites. Our findings unveiled the intricate interplay between catalyst composition, environmental conditions, and reaction kinetics, shedding light on the underlying mechanisms governing organic pollutant degradation.

The effect of dosage emerged as a critical determinant of catalytic efficiency, with varying MOF sample dosages exerting distinct impacts on pollutant degradation rates. By meticulously adjusting the dosage, we discerned optimal conditions for maximizing catalytic activity while minimizing resource consumption—a pivotal step

towards practical application in real-world pollution remediation scenarios. Moreover, our exploration of pH sensitivity elucidated the responsive nature of the composites to changes in environmental pH, highlighting their adaptability and versatility across different pollution contexts.

The investigation of time-dependent catalytic activity provided further insights into the kinetics and dynamics of catalytic reactions mediated by Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites. Through systematic monitoring of reaction progress over time, we observed the evolution of catalytic activity and identified critical time intervals where maximal pollutant degradation occurred. This temporal understanding of catalytic behavior lays the groundwork for optimizing reaction conditions and designing efficient pollutant remediation strategies with enhanced efficacy and sustainability.

Our project culminates in a comprehensive understanding of the catalytic potential of Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites for organic pollution remediation. From synthesis to characterization to catalytic evaluation, each phase of our research journey has contributed valuable insights and knowledge towards addressing one of the most pressing environmental challenges of our time. As we reflect on our findings, it becomes evident that Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites hold immense promise as catalysts for organic pollution remediation, offering a pathway towards a cleaner, healthier, and more sustainable future.

Looking ahead, further research avenues beckon, inviting exploration into advanced synthesis techniques, comprehensive mechanistic studies, and field-scale applications of Nano-Cellulose/MOF Derived Carbon Doped $\text{Zn}(\text{NO}_3)_2$ composites. By leveraging interdisciplinary approaches and collaborative efforts, we can harness the full potential of these innovative catalysts to combat organic pollution and safeguard the integrity of our environment for generations to come.

CHAPTER 10

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PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26

PAGE 27

PAGE 28

PAGE 29

PAGE 30

PAGE 31

PAGE 32

PAGE 33

PAGE 34

PAGE 35

PAGE 36

PAGE 37

PAGE 38

PAGE 39

PAGE 40

PAGE 41

PAGE 42

PAGE 43

PAGE 44

PAGE 45

PAGE 46

