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(An Autonomous Institution)

St. Joseph's Group of Institutions

OMR, Chennai - 119

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nirf NATIONAL INSTITUTIONAL RANKING FRAMEWORK

A+ NAAC

PROCEEDINGS OF THE NATIONAL CONFERENCE ON

ADVANCES IN ENGINEERING MATERIALS (NCAEM 2025)

21-03-2025 & 22-03-2025

Editors

Dr. P. Saravanan

Dr. K. Satheshkumar

Dr. G. Sasikumar

Sponsored by

Tamil Nadu State Council for Science and Technology (TNSCST)

Organized by

Department of Science

St. Joseph's College of Engineering

OMR, Chennai, Tamil Nadu, India.

PROCEEDINGS OF
THE NATIONAL CONFERENCE ON
ADVANCES IN ENGINEERING MATERIALS

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Preface

It is our great pleasure to welcome you to the **National Conference on Advances in Engineering Materials (NCAEM 2025)**. This esteemed conference serves as a platform for researchers, academicians, industry professionals, and students to exchange knowledge, present their latest findings, and discuss innovative ideas in the field of engineering materials.

Materials science and engineering continue to play a crucial role in the advancement of technology, shaping industries ranging from aerospace and automotive to biomedical and energy solutions. The rapid evolution of advanced materials, nanotechnology, sustainable materials, and smart composites has transformed the way we design and develop engineering solutions. NCAEM 2025 aims to highlight these advancements, providing a collaborative space for interdisciplinary discussions and research dissemination.

This year's conference features a diverse array of technical sessions, keynote speeches from distinguished experts, and thought-provoking discussions on emerging trends in material science. We are honored to host renowned researchers who will share their insights into the latest developments in materials engineering, including novel fabrication techniques, characterization methods, and applications in real-world scenarios.

We extend our sincere gratitude to all authors, reviewers, speakers, and participants for their valuable contributions, which make this conference a rich and intellectually stimulating experience. We also acknowledge the support of our organizing committee, sponsors, and partnering institutions, whose dedication and efforts have been instrumental in making NCAEM 2025 a success.

We hope that NCAEM 2025 will inspire new collaborations, spark innovative research ideas, and contribute to the continued progress of engineering materials. We look forward to engaging discussions and a productive conference experience for all.

Organizing Committee

NCAEM 2025

Forward Message

Dr. B. Babu Manoharan M.A., M.B.A., Ph.D.
Chairman - St. Joseph's Group of Institutions

It is with immense pride and joy that I extend a heartfelt welcome to all organizing members, resource persons, and distinguished guests of the TNSCST partially funded National Conference, organized by the Department of Science on 21 and 22 March 2025. This esteemed event brings together some of the brightest minds in the field of science and engineering, fostering collaboration, innovation, and the exchange of groundbreaking ideas.

I am honored to welcome our distinguished resource persons, including the Vice Chancellor from Tamil Nadu Open University (TNOU), the Professor and Research and Project Head from the University of Madras, the Senior Principal Scientist from CECRI Chennai Campus, the Vice President of TVS, and the esteemed professors from Anna University. Your presence and participation are invaluable to the success of this conference.

The support from the Tamil Nadu State Council for Science and Technology (TNSCST) highlights the significance of this conference in promoting research and development in the field of engineering materials. As we gather to share our latest findings, explore innovative solutions, and engage in insightful discussions, we contribute to the growth and advancement of our scientific community.

I would like to express my deepest gratitude to the department of science, organizing committee, sponsors, and participants for their unwavering dedication and commitment in making this event possible. Your collective efforts have ensured the success of this conference, and I am confident that the presentations, discussions, and networking opportunities will inspire new ideas and collaborations that will drive the future of science and technology.

I wish you all an enriching and rewarding experience at the conference.

Dr. B. Babu Manoharan, M.A., M.B.A., Ph.D.
Chairman

Mr. B. Shashi Sekar, M.Sc., Intl Business,
Managing Director, St. Joseph's Group of Institutions

It is with great honor and enthusiasm that I welcome you to the National Conference on Advances in Engineering Materials. As the Managing Director of St. Joseph's Group of Institutions, I am proud to host this significant event, which serves as a confluence of knowledge, innovation, and collaboration among researchers, academicians, industry professionals, and students.

The continuous development and enhancement of engineering materials are vital to the advancement of various industries, including aerospace, automotive, construction, and electronics. This conference provides an exceptional platform for sharing the latest research, exploring innovative solutions, and fostering collaborations that will drive the future of engineering materials.

I extend my heartfelt gratitude to the organizing committee, sponsors, and participants for their unwavering support and commitment in making this event a resounding success. I am confident that the presentations, discussions, and networking opportunities offered by this conference will ignite new ideas and partnerships, ultimately contributing to the growth and evolution of the engineering materials field.

Wishing you all great success for the conference.

Mr. B. Shashi Sekar, M.Sc.,
Managing Director

Mrs. S. Jessie Priya, M.Com.
Executive Director, St. Joseph's Group of Institutions

It is with immense pride and enthusiasm that I extend a warm welcome to all the organizing members, participants, and distinguished guests of the TNSCST partially funded National Conference, organized by the Department of Science. This prestigious event symbolizes the convergence of brilliant minds, innovative ideas, and collaborative efforts aimed at advancing the field of science and technology.

The support from the Tamil Nadu State Council for Science and Technology (TNSCST) underscores the significance of this conference in fostering research and development. As we gather to share our latest findings, discuss groundbreaking innovations, and explore new frontiers, we contribute to the growth and progress of our scientific community.

I would like to express my heartfelt gratitude to the organizing committee, sponsors, and participants for their unwavering dedication and commitment in making this conference a reality. Your collective efforts have ensured the success of this event, and I am confident that the presentations, discussions, and networking opportunities provided by this conference will inspire new ideas and collaborations that will drive the future of science and technology.

Wishing you a valuable and enriching experience at the conference.

Mrs. S. Jessie Priya, M.Com.
Executive Director

Dr. Vaddi Seshagiri Rao, M.E., M.B.A., Ph.D.
Principal, St. Joseph's College of Engineering.

It is with immense pleasure that I welcome you all to the National Conference on Advances in Engineering Materials, graciously supported by the Tamil Nadu State Council for Science and Technology (TNSCST). This esteemed event, scheduled for the 21st and 22nd of March 2025 at St. Joseph's College of Engineering, aims to unite distinguished researchers, academicians, industry experts, and students to discuss and explore pioneering advancements in engineering materials.

The swift progression of new materials and technologies has profoundly influenced various engineering disciplines, leading to groundbreaking solutions and applications. This conference serves as a vital platform for the exchange of ideas, knowledge, and research discoveries, promoting collaboration and inspiring future innovations in engineering materials.

I extend my sincere gratitude to TNSCST for their generous support and funding, which have made this conference possible. I also wish to acknowledge the organizing committee, speakers, and participants for their dedication and enthusiasm in ensuring the success of this event.

We are proud to receive an overwhelming response, with 50 oral presentations and 30 poster presentations from Ph.D. scholars, faculty, and students across institutions, including St. Joseph's College of Engineering. We sincerely appreciate their contributions to knowledge and academic excellence.

I am confident that this conference will offer valuable insights into cutting-edge research and foster meaningful connections within the engineering community.
I wish everyone a productive and inspiring conference experience.

Dr. Vaddi Seshagiri Rao, M.E., M.B.A., Ph.D.
Principal,

Program Schedule

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Partially Sponsored

NATIONAL CONFERENCE ON ADVANCES IN ENGINEERING MATERIALS (NCAEM 2025)

Conference Schedule

Day – 1: 21st March, 2025 – Friday

Venue: Laurel Hall, Placement Block

Session 1	**OPENING CEREMONY**	
08.00 - 08.30 am	Registration	
08.30 - 08.40 am	Lightning Kuthuvilakku Welcome Address	
08.40 - 08.50 am	Felicitation & Release of Conference Proceeding	
08.50 - 09.30 am	Inaugural Address **Prof. S. ARUMUGAM** Vice - Chancellor Tamil Nadu Open University, Saidapet, Chennai-15	PT-1
	SESSION CHAIR: Dr. S. Kiruba	
09.30 - 10.15 am	Keynote Speaker **Prof. S. BALAKUMAR** Director- Research schemes & Projects Professor-National Centre for Nanosciences & Nanotechnology University of Madras, Guindy Campus, Chennai-25	PT-2
	SESSION CHAIRS: Dr. A. Arulmozhi & Dr. N. Punitha	
10.15 - 10.45 am	Photo Session & Tea Break	
Session 2	**ORAL PRESENTATION**	**OP-1**
10.45 - 11.45 am	SESSION CHAIRS: Dr. J. Sivapriya, & Dr. S. Manikandan	1-12
11.45 - 12.45 pm	Lunch Break	
Session 3	**INVITED TALK**	
12.45 - 01.15 pm	**Dr. D KALPANA** Senior Principal Scientist Central Electrochemical Research Institute (CECRI) CSIR Madras Complex, Chennai-25	IT – 1
	SESSION CHAIRS: Dr. A. Mahalakshmi & Mr. S. Kaleel Mohamed Ibrahim	
Session 4	**ORAL PRESENTATION**	**OP-2**
01.15-02.15 pm	SESSION CHAIRS: Dr. V. Selvarani & Dr. P. Krishnan	13-25
02.15-02.30 pm	Tea Break	
	POSTER PRESENTATION	**PP-1**
02.30 - 03.00 pm	SESSION CHAIRS: Dr. S. Rama & Dr. G. Senthil Murugan	1-7

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Partially Sponsored

NATIONAL CONFERENCE ON ADVANCES IN ENGINEERING MATERIALS (NCAEM 2025)

Conference Schedule

Day – 2: 22nd March, 2025 – Saturday

Venue: Periwinkle Hall, Placement Block

Session 5	**PLENARY TALK**	
08.30 - 09.30 am	**Dr. S. ANANDAKUMAR** Professor (Associate) Anna University, CEG, Chennai-25	PT -3
	SESSION CHAIRS: Dr. G. Murugan & Dr. V. Swarnalatha	
09.30- 10.00 am	Tea Break	
Session 6	**INVITED TALK**	
10.00 -10.45 am	**Mr. NSR KANNA** Vice President Composites, Sundaram Brakes India Pvt Ltd	IT – 2
	SESSION CHAIRS: Dr. A. Uma Devi & Dr. N. R. Rajagopalan	
	ORAL PRESENTATIONS	OP -3
10.45 - 11.45 am	SESSION CHAIRS: Dr. J. Sharmila, Dr. S. Suresh & Dr. R. Sasikala	26-50
11.45 - 12.45 pm	Lunch Break	
Session 7	**INVITED TALK**	
12.45 - 01.15 pm	**Dr. P. MUTHU MAREESWARAN** Professor (Assistant) Anna University, CEG, Chennai-25	IT – 3
	SESSION CHAIRS: Ms. S. Savitha & Dr. B. Subash	
	POSTER PRESENTATION	PP-2
01.15-02.15 pm	SESSION CHAIRS: Dr. S. M. Prakash & Dr. A. Dhivya	8-28
02.15-02.30 pm	Tea Break	
Session 8	**VALEDICTORY FUNCTION**	
02.30 - 02.50 pm	Felicitations & Certificate Distribution	
02.50 - 03.00 pm	CONTRIBUTORY SESSION -Feedback	CS
	Dr. K. Dhanaraj & Dr. C. Chandrasatheesh	

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DEPARTMENT OF SCIENCE

cordially invites you to the inaugural function of

TNSCST *sponsored*

National Conference on Advances in Engineering Materials (NCAEM-2025)

On Friday, the 21st March 2025 at 08.30 am, Laurel Hall, St. Joseph's College of Engineering, OMR, Chennai.

Under the Chief Patronage of

Dr. B. Babu Manoharan, M.A., M.B.A., Ph.D.
Chairman, St. Joseph's Group of Institutions

Patronage of

Mr. B. Shashi Sekar, M.Sc. Intl Business,
Managing Director, St. Joseph's Group of Institutions

Mrs. S. Jessie Priya, M.Com.
Executive Director, St. Joseph's Group of Institutions

Chief guest

Prof. S. ARUMUGAM

Vice - Chancellor
Tamil Nadu Open University, Saidapet
Chennai - 600 015.

has kindly consent to grace the occasion and deliver inaugural address

Prof. S. BALAKUMAR

Director - Research Schemes & Projects
National Centre for Nanosciences & Nanotechnology
University of Madras, Guindy Campus
Chennai - 600 025.

has kindly consent to grace the occasion as guest of Honour

Presided by

Dr. Vaddi Seshagiri Rao, M.E., M.B.A., Ph.D.
Principal, St. Joseph's College of Engineering.

Felicitated by

Dr. V. Vallinayagam, M.Sc., M.Phil., Ph.D.
Dean, Student Affairs

Dr. A. Chandra Sekar, M.E., Ph.D.
Dean, Research

Dr. G. Sreekumar, M.Sc., M.Tech., Ph.D.
Dean, Academics

Dr. N. ArunKumar, M.E., Ph.D.
Dean, Industry Collaboration and IQAC

PROGRAMME

INAUGURAL FUNCTION

Date: 21.03.2025 **Time: 08.30 am** **Venue: Laurel Hall**

08:30 am–08:35 am	Invocation & Lighting of Kuthuvilakku
08:35 am–08:40 am	Welcome address and Overview
08:40 am–08:45 am	Felicitations
08:45 am–08:50 am	Release of Conference Proceedings
08:50 am–09:30 am	Inaugural Address by Chief Guest
09:30 am–10:15 am	Special Address by Guest of Honor
10:15 am–10:20 am	Presidential Address
10:20 am–10:30 am	Vote of Thanks

VALEDICTORY FUNCTION

Date: 22.03.2025 **Time: 2.30 pm** **Venue: Hazel Hall**

02:30 pm–02:35 pm	Valedictory Address
02:35 pm–02:40 pm	Felicitations
02:40 pm–02:50 pm	Certificates Distribution
02:50 pm–02:55 pm	Feedback from Participants
02:55 pm–03:00 pm	Vote of Thanks

Resource Person

Two days TNSCST-sponsored National Conference on Advances In Engineering Materials (NCAEM 2025) Organized by Department of Chemistry, St. Joseph's College of Engineering (Autonomous), OMR, Chennai, Tamil Nadu, India

Resource Persons

Chief Guest

Dr. S. Arumugam
Vice-Chancellor,
Tamil Nadu Open University

Guest of Honour

Dr. S. Balakumar
Director, Research Scheme and Projects
University of Madras

Dr. D. Kalpana
Senior Principal Scientist
CECRI, CSIR Madras.

Dr. S. Anandakumar
Professor (Associate)
Anna University, Chennai

Dr. P. Muthu Mareeswaran
Professor (Assistant)
Anna university, Chennai

Mr. NSR Kanna
Vice President (Composites)
Sundaram Brake Linings Limited

INAUGURAL ADDRESS

Vice Chancellor's Inaugural Address
TNSCST Sponsored National Conference on Advances in Engineering Materials (NCAEM-2025) Department of Science, St. Joseph Engineering College, Chennai

Talk Title: Innovations in Engineering Materials: Paving the Path for a Sustainable and Technological Future

Esteemed Guests, Distinguished Academicians, Respected Faculty Members, Dear Students, and Research Scholars,

It is my immense pleasure and privilege to be here today at the TNSCST Sponsored National Conference on Advances in Engineering Materials (NCAEM-2025), organized by the Department of Science at St. Joseph Engineering College, Chennai. I extend my heartfelt appreciation to the organizers for bringing together such an illustrious gathering of experts, researchers, and scholars to deliberate on the advancements and

Engineering materials are at the core of technological evolution. The rapid advancement in materials science has led to groundbreaking developments in various sectors, including automobile, aerospace, electronics, construction, healthcare, and renewable energy. Today, we are witnessing a transformative shift where smart materials, biomaterials, nanotechnology, and eco-friendly composites are redefining industrial processes and consumer applications.

From self-healing materials that repair their own cracks to biodegradable polymers reducing environmental impact, the future of materials science is exciting and promising. These innovations are not just scientific milestones; they are catalysts for creating a more sustainable and resilient future.

The challenge of environmental degradation and climate change has made sustainability a global priority. Engineering materials have a vital role in addressing these challenges by developing energy-efficient materials, recyclable composites, and low-carbon alternatives. Green concrete, carbon fiber composites, bio-inspired materials, and hydrogen-based fuels are some of the promising solutions that are revolutionizing industries while ensuring environmental conservation.

India, with its strong research ecosystem, has the potential to be a leader in sustainable materials research. Our focus should be on developing cost-effective, durable, and eco-friendly materials that cater to both industrial and societal needs.

Several disruptive technologies are shaping the next era of materials engineering. Some of the most exciting innovations include:

- Nanomaterials – Enhancing the strength, durability, and efficiency of products in various industries.
- Shape-memory alloys – Finding applications in robotics, aerospace, and biomedical implants.
- Graphene and carbon nanotubes – Transforming electronics, energy storage, and wearable technology.
- 3D-printed materials – Enabling rapid prototyping and mass customization in manufacturing.

- Metamaterials – Controlling electromagnetic waves to create next-generation communication systems and stealth technology.

To harness these advancements, we must invest in interdisciplinary research, industry-academic collaborations, and skill development among young scientists and engineers.

The Importance of Research, Innovation, and Conferences like NCAEM-2025

A conference like NCAEM-2025 serves as a powerful platform for fostering collaboration, exchanging ideas, and inspiring future generations of researchers. The deliberations and discussions held here will contribute significantly to the field of materials science, addressing contemporary challenges and unlocking new opportunities.

I encourage all participants to actively engage in the sessions, explore potential collaborations, and challenge conventional wisdom to push the boundaries of what is possible in materials science.

I extend my sincere appreciation to St. Joseph Engineering College and the Department of Science for their commendable efforts in organizing this conference. I also thank the Tamil Nadu State Council for Science and Technology (TNSCST) for their unwavering support in promoting scientific research and technological innovation.

To all young researchers and students, I urge you to stay curious, remain dedicated, and keep innovating. Your contributions will not only shape the future of engineering materials but also play a pivotal role in building a sustainable and technologically advanced world.

With these thoughts, I formally inaugurate the National Conference on Advances in Engineering Materials (NCAEM-2025) and wish all participants a highly productive and intellectually enriching experience. May this conference serve as a beacon of knowledge and innovation for years to come.

Thank you, and I look forward to insightful discussions ahead.

Prof. S. Arumugam
Vice Chancellor
Tamil Nadu Open University (TNOU)

PLENARY TALK

Prof. S. ARUMUGAM
Vice - Chancellor
Tamil Nadu Open University, Saidapet, Chennai-15

ABSTRACT

INNOVATIONS IN ENGINEERING MATERIALS: PAVING THE PATH FOR A SUSTAINABLE AND TECHNOLOGICAL FUTURE

The **Vice Chancellor's Inaugural Address** at the **TNSCST Sponsored National Conference on Advances in Engineering Materials (NCAEM-2025)** highlights the pivotal role of engineering materials in shaping a sustainable and technologically advanced future. The address underscores recent breakthroughs in materials science, including **nanomaterials, graphene, shape-memory alloys, and 3D-printed composites**, and their impact on diverse industries such as aerospace, healthcare, and renewable energy.

Emphasizing sustainability, the speech discusses the development of **eco-friendly, energy-efficient, and recyclable materials** to combat environmental challenges. It also advocates for **interdisciplinary research, industry-academic collaboration, and skill development** to drive innovation in engineering materials. The address recognizes the significance of **conferences like NCAEM-2025** in fostering knowledge exchange, inspiring young researchers, and advancing materials science.

In conclusion, the Vice Chancellor encourages participants to embrace curiosity, push research frontiers, and contribute to transformative technological advancements, officially inaugurating the conference with a call for impactful discussions and collaborations.

Prof. S. BALAKUMAR
Director- Research schemes & Projects
Professor-National Centre for Nanosciences & Nanotechnology
University of Madras, Guindy Campus, Chennai-25
Email: balakumar@unom.ac.in, balasuga@yahoo.com

Advancing Sustainability Through Science and Technology

Sustainability stands at the forefront of global challenges, with science and technology serving as catalysts for achieving the Sustainable Development Goals (SDGs). The 2025 Sustainability Lecture explores the transformative role of scientific advancements in shaping a greener, more resilient future. This lecture focuses on key areas such as renewable energy, advanced materials, water conservation, biotechnology, and artificial intelligence, aligning with SDGs related to clean energy, climate action, and responsible resource management.

Nanotechnology plays a critical role in this transition, with bioactive ceramics and eco-friendly nanomaterials revolutionizing healthcare, environmental sustainability, and clean energy solutions. Moreover, AI-driven climate modeling, smart grids, and precision agriculture showcase the power of digital technologies in optimizing resources and mitigating climate change. Groundbreaking scientific discoveries, from plastic-eating bacteria to AI-enabled early disease detection, highlight the real-world impact of sustainability-driven research.

The lecture also underscores the vital role of student-led innovations, featuring projects such as solar backpacks, plastic roads, and AI-powered disaster prediction, which translate research into practical solutions. Additionally, it promotes interdisciplinary collaboration, strategic partnerships, and policy-driven approaches to accelerate global sustainability efforts.

By integrating science with sustainability, this lecture aims to inspire and empower the next generation of researchers and innovators to develop eco-friendly solutions. Ultimately, the 2025 Science City Sustainability goals catalyze scientific breakthroughs, driving impactful solutions toward a sustainable and resilient future.

Dr. D. KALPANA
Senior Principal Scientist
Central Electrochemical Research Institute (CECRI)
CSIR Madras Complex, Chennai-25

Innovations in Engineering Materials for the Energy Sector

The energy sector is transforming with the development of advanced engineering materials designed to improve efficiency, sustainability, and performance across various energy applications. Materials such as high-temperature alloys, nanostructured semiconductors, and high-performance ceramics are enhancing the durability and efficiency of power generation systems. In renewable energy, perovskite solar cells, silicon-based photovoltaics, and next-generation battery materials, including solid-state electrolytes and lithium-sulfur batteries, are driving advancements in energy storage and conversion. Additionally, hydrogen storage materials, such as metal hydrides and porous carbon-based materials, play a crucial role in the hydrogen economy. Smart materials and nanocomposites are also being integrated into wind and hydroelectric power systems to enhance reliability and performance. With the growing emphasis on sustainability, bio-based and recyclable materials are gaining attention for their potential to reduce environmental impact. The continuous innovation in engineering materials is shaping the future of clean, efficient, and resilient energy solutions for a sustainable world. A comprehensive and broad-spectrum picture of the state-of-the-art research and development in material science and engineering will be discussed.

DR. S. ANANDAKUMAR
Professor (Associate)
Department of Chemistry
Anna University, CEG, Chennai-25
Email: msrinivanand@gmail.com, srinivanand@annauniv.edu

FULLY BIO-BASED MEMBRANE WITH CALCINED EGGSHELL FOR ENHANCED INDUSTRIAL EFFLUENT TREATMENT

This research work concerns the stricter governmental regulations on industrial wastewater discharge demand with innovative solutions that address environmental and compliance challenges. Existing treatment methods often fall short due to high costs, energy consumption, and potential secondary pollution. Hence, our unique work introduces a novel, sustainable bio-based membrane infused with calcined eggshell (CES), a waste-derived filler, as a cost-effective, eco-friendly alternative for industrial effluent treatment. Incorporating CES into a biopolymer matrix resulted in a membrane with remarkable pollutant removal efficiencies, achieving up to 95% elimination of contaminants.

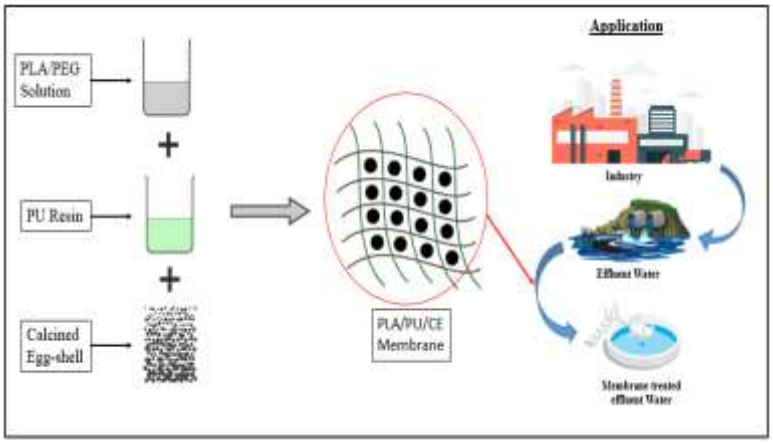

Fig.1 Overview of the work

Detailed characterization confirmed the membrane's structural integrity, while performance evaluations highlighted its mechanical strength and anti-fouling properties. By repurposing waste eggshells, this approach aligns with circular economy principles and provides a scalable solution that not only meets but exceeds current environmental compliance standards for wastewater management.

Mr. NSR Kanna
Vice President (Composites)
Sundaram Brake Linings Limited

Six Sigma Makes Money: Advanced Materials Beyond Steel

Six Sigma is a powerful methodology that enhances process efficiency and reduces defects, leading to substantial cost savings and increased profitability. While traditionally associated with manufacturing industries such as steel production, Six Sigma principles are equally valuable in advancing materials science. This paper explores the application of Six Sigma in the development and optimization of advanced materials beyond steel, including composites, ceramics, and high-performance polymers. By implementing Six Sigma tools such as DMAIC (Define, Measure, Analyze, Improve, Control) and statistical process control, industries can improve material properties, optimize production processes, and minimize waste. Case studies highlight successful applications in aerospace, automotive, and electronics, demonstrating how data-driven decision-making leads to superior material performance and financial gains. The findings emphasize that integrating Six Sigma into material science not only enhances quality but also drives economic benefits, making it a critical strategy for modern industries.

P. MUTHU MAREESWARAN
Professor (Assistant),
Department of Chemistry,
Anna University, CEG, Chennai-25

CARBON DIOXIDE SEQUESTRATION

Department of Chemistry, CEG, Anna University, Chennai – 600 025

Climate change refers to significant and lasting changes in the Earth's climate, particularly an increase in global temperatures, largely due to human activities. Here are the key aspects: **Greenhouse Gas Emissions**: The burning of fossil fuels (coal, oil, and natural gas) for energy and transportation releases large amounts of carbon dioxide (CO_2) and other greenhouse gases (GHGs) like methane (CH_4) and nitrous oxide (N_2O). **Deforestation**: Cutting down forests reduces the number of trees that can absorb CO_2 from the atmosphere. **Industrial Processes**: Certain industrial activities release GHGs and other pollutants. **Agriculture**: Practices such as livestock farming produce methane, while the use of synthetic fertilizers releases nitrous oxide. Global warming leads to higher average temperatures, resulting in heatwaves. Glaciers and polar ice caps are melting, contributing to rising sea levels. Thermal expansion of seawater and melting ice contribute to higher sea levels, threatening coastal communities. Increased frequency and intensity of hurricanes, droughts, floods, and other extreme weather events. Shifts in habitats and species behaviour, leading to biodiversity loss. Increased CO_2 levels lead to more acidic oceans, affecting marine life, particularly organisms with calcium carbonate shells or skeletons.

Carbon dioxide (CO_2) sequestration involves strategies and technologies aimed at reducing the amount of CO_2 released into the atmosphere and/or removing CO_2 from the atmosphere. Here are some key approaches: **Reducing Emissions:** Improving the efficiency of buildings, appliances, and industrial processes to use less energy.Transitioning to renewable energy sources such as solar, wind, hydro, and geothermal power to replace fossil fuels.Promoting electric vehicles, public transportation, biking, and walking to reduce emissions from the transportation sector.Implementing cleaner technologies and practices in manufacturing and other industrial activities. **Carbon Capture and Storage (CCS):** Capturing CO_2 emissions at their source (e.g., power plants, industrial facilities) before they are released into the atmosphere. Storing CO_2 underground in geological formations such as depleted oil and gas fields, deep saline aquifers, or using it in enhanced oil recovery (EOR). **Natural Carbon Sequestration:** Reforestation and Afforestation: Planting trees and restoring forests to absorb CO_2 from the atmosphere. Implementing agricultural practices

that enhance soil carbon storage, such as no-till farming, cover cropping, and agroforestry. Restoring wetlands, which are effective at capturing and storing carbon. **Technological Carbon Removal:** Technologies that capture CO_2 directly from the ambient air. Using biomass for energy and capturing the CO_2 emitted during the process, then storing it underground. Enhancing the ocean's ability to absorb CO_2 through methods like ocean fertilization or alkalinity enhancement. **Policy and Economic Instruments:** Implementing carbon taxes or cap-and-trade systems to incentivize reductions in CO_2 emissions. Providing financial support for renewable energy projects, energy efficiency improvements, and carbon capture technologies. Setting emissions standards and regulations to limit CO_2 emissions from various sectors.

Reference:

1. *Benzoguanamine based polyaminal carbon materials for CO_2 capture application*, M. Senthilkumaran, C. Saravanan, K. Aravinth, V. Sethuraman, P. Puthiyaraj, **P. Muthu Mareeswaran***, P. Ramasamy, *Carbon Capture Science and Tehcnology*, 2022, 2, 100021.

TABLE OF CONTENTS

ORAL PRESENTATION

ISBN: 9789348505026

Energy-Efficient Microwave-Assisted Green Synthesis of ZnO Nanoparticles for Biomedical Application

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Abstract

This study explores an environmentally friendly method for producing Zinc Oxide (ZnO) nanoparticles using microwaves. The leaves of the Lannea coromandelica plant were harnessed as a natural reducing agent to promote the formation of ZnO NPs. Cutting-edge techniques like UV-Vis spectroscopy (revealing a 314nm cutoff wavelength suitable for biomedical applications), FTIR, and XRD were employed to analyze the nanoparticles' optical, structural, and morphological properties. The characterization confirmed the successful synthesis of ZnO NPs with diverse shapes and sizes, averaging 21nm and exhibiting good crystallinity. Additionally, XRD analysis verified the hexagonal wurtzite crystal structure of the ZnO NPs .To investigate the potential of these nanoparticles in biomedicine, their antioxidant, antidiabetic, and anti-inflammatory properties were evaluated. Antioxidant tests demonstrated the ZnO NPs possessed significant activity, comparable to standard ascorbic acid. Furthermore, assays inhibiting α-amylase and α-glucosidase enzymes revealed the effectiveness of ZnO NPs in blood sugar control, mimicking the standard drug metformin. The anti-inflammatory activity of ZnO NPs was also found to be on par with the standard drug aspirin.

These findings highlight the potential of microwave-assisted green synthesis for producing ZnO NPs with promising applications in biomedicine. This research contributes to the advancement of sustainable nanotechnology by offering a greener and more efficient approach to synthesizing nanoparticles with significant therapeutic potential.

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Deposition of Bismuth Selenide thin film by Chemical Bath Deposition and it's structural and Optical studies

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Abstract

In this study, we have synthesized bismuth sulfide (Bi2S3) by a simple chemical method. semiconducting nanoparticle have been identified as a set of promising and versatile nanostructured building blocks for numberless applications owing to their attractive merits. chalcogenide nanoparticles have been widely explored in a variety of photonic and optoelectronic applications, the consideration of environmental compatibility and earth abundance of the materials motivated the expansion of environment-friendly materials. Bismuth sulphide. Bi2S3, is a direct band gap semiconductor, 1.3 eV, with orthorhombic structure. The deposited film were characterized by powder X-ray diffraction to confirm the structural property, The optical analysis by UV-Visible Spectrophotometer shows the deposited films have a bandgap about 1.8 eV. The micrographical analysis was carried out using Scanning Electron Microscopy. The results will be discussed in detail.

Keywords: thin film, semiconductors, optical property, SEM micrograph

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Photobiogenic Mediated Silver Nanoparticles Synthesis and Its Antimicrobial Activity

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Abstract

Silver nanopartilces was synthesized by photobiogenic method using Euphorbia hirta aqueous extract under the bright sunlight in 25 min at pH 7.5. Euphorbia hirta extract acts as a capping agent of silver nanoparticle synthesis. The synthesized Eh-AgNPs were characterized by UV-vis spectroscopy, HR-TEM, and zeta potential. The SPR peak of Eh-AgNPs was produced at 424nm. The Eh AgNPs was found to be spherical shape with average size of 12nm. The synthesized Eh-AgNPs was highly stabled in the liquid medium. The antibacterial activity of different concentration of Eh-AgNPs against both Gram positive and Gram negative pathogenic bacteria were analyzed by the well diffusion assay method. Eh-AgNPs inhibited the growth of both group of bacteria in the concentration manner. The maximum zone of inhibition15mm, 22mm, 19mm and 20mm were obtained at 100µg/ml concentration for Enterococcus faecalis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa respectively. The synthesized Eh-AgNPs has well antibacterial activity against both group of bacteria particularly it has maximum activity against pathogenic bacteria such as Pseudomonas aeruginosa, and Staphylococcus aureus.

Keywords: Silver nanoparticles, Euphorbia hirta, Sunlight irradiation, Green synthesis, Physicochemical characterization, Antibacterial activity.

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Synthesis and Properties Studies of Epoxy Derived Polymer Nanocomposite for Flame Retardancy via SET – LRP

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Abstract

Epoxy resins, widely recognized for their exceptional mechanical properties and adhesion capabilities, are extensively utilized in coatings, adhesives, and composite materials. However, their inherent flammability poses significant fire safety concerns. This work aims to investigate the flame retardancy of epoxy derived nanocomposites through the development and evaluation of novel flame-retardant formulations. The study explores the synergistic effects of various flame-retardant additives, including bromine-based compounds, metal hydrates, and nanomaterials, on the thermal stability and combustion behavior of epoxy derived systems. Herein, DGEBA has been polymerised with Glycidyl methacrylate via Single Electron Transfer – Living Radical Polymerisation and made into novel nano composites by reinforcing different nano particle additives like fused tetrabromobisphenol A – alumina trihydrate and tetrabromobisphenol A – antimony trioxide nano particles. Advanced characterization techniques, such as Thermo Gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC) and UL – 94 (Flame Retardancy Test for Plastics) are employed to assess the efficacy of this system. The results concludes that the DGEBA – GMA nanocomposite of Tetrabromobisphenol A – Antimony Trioxide nano particles possess high flame retardancy rate compared with other regular epoxy composites. The findings of this research contribute to the advancement of flame-retardant technologies, offering valuable insights for the design and implementation of safer and more resilient epoxy-based materials.

1. Casted nanocomposite before exposure to fire

2. Casted nanocomposite after exposure to fire

Temp: 300° C (approx) (Blue flame of Bunsen burner)

Specimen Size : 12.7mm X 3mm X 150mm (as per UL – 94 test method)

Keywords: Flame Retardants, inherent flammability.

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A Sustainable Future: Extracting CaO Nanoparticles from Crab Shell Waste

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Abstract

The focus of this study aimed to extract and analyze calcium oxide nanoparticles from crab shells. Crab shells are generated in large quantities at food processing facilities. Large amount of crab shell is usually thrown away by restaurants, homes, and seafood companies. Products that are thrown away may potentially pollute the environment. The calcium carbonate content of these thrown out crab shells were high. In order to generate this CaO nanoparticle, we crushed crab shells into tiny particles and then calcined them for over five hours at 900°C in a muffle furnace. This CaO nanoparticle's crystalline structure and grain size were assessed using X-ray diffraction. The chemical bonds and functional groups that are present in the nanoparticles have been studied further using FTIR analysis. The optical properties are evaluated using UV-visible spectrum, and the band gap was determined by using the Tauc's equation. CaO nanoparticles offer a wide range of applications, including their antibacterial properties, which make them highly effective in wound healing and sterilization. In agriculture, they serve as an efficient pest control agent, while in environmental applications, they are used to neutralize acidic waste and remove harmful contaminants.

Keywords: Environmental Sustainability, Crab Shell, CaO, Biomass conversion, XRD, FTIR

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Eggshells as a Green Resource: Sustainable CaO Nanoparticles for the Future

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Abstract

In this study, we have converted chicken egg shells a frequently thrown-away waste product into a beneficial and useful material. The majority of egg shells generated in the poultry and food industries are usually discarded. On the other hand, egg shells have one of the greatest quantities of calcium in the world. Eggshells are a waste product that is high in calcium carbonate (CaCO3) and can be easily reduced to calcium oxide, a valuable inorganic substance with a range of biological uses. By using waste materials as a precursor for the synthesis of NPs, the entire process becomes more affordable, environmentally friendly, and sustainable. Being the most prevalent mineral in the human body, calcium is vital. The calcium oxide nanoparticles in this work are synthesized from chicken egg shells. Egg shells (ES) were calcined at 900° C for five hours in order to synthesis calcium oxide nanoparticles. We used Fourier-transform infrared (FTIR) spectroscopy, ultraviolet-visible spectroscopy (UV-Vis), and X-ray diffraction (XRD) to analyze the synthesized calcium oxide (CaO) nanoparticles. These findings suggest that calcium oxide nanoparticles possess a wide range of uses in the food, agricultural, and medical sectors.

Keywords: Environmental Sustainability, Egg Shell, CaO, Biomass conversion, XRD, FTIR

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Microstructural Evolution and Mechanical Properties of Laser Metal Deposited (LMD) Ti-6Al-4V Alloy

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Abstract

Laser Metal Deposition (LMD) is an advanced additive manufacturing technique that enables precise fabrication and repair of high-performance metallic components. Ti-6Al-4V, a widely used titanium alloy in aerospace, biomedical, and automotive industries, exhibits excellent strength-to-weight ratio and corrosion resistance. However, process-induced microstructural heterogeneities significantly influence its mechanical properties. This paper investigates the microstructural evolution and mechanical behavior of LMD-processed Ti-6Al-4V alloy to establish process-property correlations. The research involved depositing Ti-6Al-4V powder onto a Ti-6Al-4V substrate using a high-power laser source under controlled process parameters, including laser power, scanning speed, and powder feed rate. Phase transformation and elemental distribution were analyzed via X-ray diffraction (XRD) and energy-dispersive spectroscopy (EDS). Mechanical properties were evaluated through microhardness testing and tensile testing to determine strength, ductility, and fracture characteristics. Results indicate that the as-deposited microstructure primarily consists of acicular α and retained β phases, with columnar β grains oriented along the thermal gradient. The observed microstructural gradient along the deposition layers influences mechanical anisotropy. Post-deposition heat treatment was found to refine the microstructure, promoting homogeneous α/β phase distribution and improved mechanical properties. The hardness values exhibited significant variation across different deposition zones, correlating with grain morphology and residual stress distribution. Tensile test results revealed a trade-off between strength and ductility, with as-deposited specimens showing higher tensile strength but lower elongation compared to heat-treated counterparts.

Keywords: Laser Metal Deposition; Ti-6Al-4V Alloy; Microstructural Evolution; Mechanical Properties; Phase Transformation; Additive Manufacturing

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Review on Green Synthesis of Copper Nanoparticles and Their Diverse Applications

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Abstract

The green synthesis of copper nanoparticles (CuNPs) has gained significant attention due to its eco-friendly, cost-effective, and sustainable nature. Copper nanoparticles exhibit unique physicochemical properties, including high catalytic activity, electrical conductivity, and antimicrobial effects, making them highly versatile for biomedical, environmental, and industrial applications. This review provides a comprehensive analysis of green synthesis approaches for CuNPs using plant extracts, microbial sources, and biopolymers. The underlying mechanisms, factors influencing nanoparticle size and morphology, and key characterization techniques are discussed. Furthermore, the applications of CuNPs in antimicrobial activity, drug delivery, photocatalysis, agriculture, and environmental remediation are explored. Finally, challenges and future prospects in enhancing the stability, biocompatibility, and scalability of green synthesis methods are highlighted.

Keywords: Copper nanoparticles, green synthesis, plant extracts, antimicrobial activity, photocatalysis, biocompatibility.

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Samarium Doped Zinc Oxide Nanoparticle for Photo Catalytic Activity

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Abstract

Samarium-doped zinc oxide (Sm-ZnO) nanoparticles have gained significant attention due to their enhanced optical, electrical, and photocatalytic properties. In this study, Sm-doped ZnO nanoparticles were synthesized using the sol-gel method, ensuring uniform dopant dispersion and controlled particle size. X-ray diffraction (XRD) analysis confirmed the hexagonal wurtzite structure of ZnO, with slight lattice distortions due to Sm incorporation. UV-Vis spectroscopy revealed a redshift in the bandgap energy, indicating improved optical absorption. Photoluminescence (PL) analysis demonstrated reduced recombination rates, enhancing photocatalytic efficiency. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) images showed well-defined nanoparticles with an average size in the range of 20–50 nm. Energy-dispersive X-ray spectroscopy (EDS) confirmed the presence of samarium in the ZnO matrix. The photocatalytic activity of Sm-ZnO was evaluated using methylene blue degradation under UV-light irradiation, showing a significant improvement compared to pure ZnO. These results suggest that Sm-doped ZnO nanoparticles hold great potential for applications in optoelectronics, environmental remediation, and solar energy harvesting.

Keywords: Samarium doping, Zinc oxide nanoparticles, Sol-gel synthesis, Photocatalysis, Optical properties.

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NO_2 to Energy conversion

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Abstract

The disposal of NO_2 is a very tedious task since it is a harmful gas. In this paper, we proposed a new method to dispose NO_2 into energy. We adsorb NO_2 gas from the incineration using BaO-Al_2O_3. The NO2 is pumped into 0.1M NaOH at high pressure and the mixed solution is pumped into the cathode rod in the battery setup. Now, NO_2 is converted into HNO_3 and dissociates into $NO_3^+$and H_3O^+ ions. The sodium in the anode releases Na^+ ion and an electron. The released electron travels through the anode to the cathode and produces electricity. This method is a cost-effective method and it is also eco-friendly.

Keywords: Incineration, NO_2, Anode, Cathode

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Advancing Carbon Capture and Storage (CCS) Technologies for Sustainable Decarbonization in the Petroleum Sector

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Abstract

The petroleum industry is a major contributor to global CO_2 emissions, necessitating urgent decarbonization strategies to mitigate climate change. Decarbonisation in the petroleum industry is an urgent global priority as it reduces greenhouse gases and addresses the pressing challenge of climate change. Carbon Capture and Storage (CCS) is a promising technology that enables the industry to significantly reduce its carbon footprint by capturing CO_2 from extraction, refining, and combustion processes. CCS involves three key stages: capture, transport, and long-term storage in deep geological formations such as depleted oil and gas reservoirs or saline aquifers. By integrating CCS with existing infrastructure, the petroleum sector can lower emissions from refining, hydrogen production, and power generation while enabling enhanced oil recovery (EOR). Despite its potential, CCS faces challenges such as high costs, energy consumption, and the need for supportive policies and investments. Advancements in capture efficiency, reduced operational costs, and coupling CCS with renewable energy can enhance its feasibility. This research paper examines the transformative potential of CCS technologies in the petroleum sector, providing a comprehensive analysis of their technical, economic, and policy dimensions to accelerate the transition toward net-zero emissions.

Keywords: CCS, decarbonization, petroleum industry, net-zero emissions, climate change.

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Biosynthesis of Silver Oxide Nanoparticles with Enterobacter aerogenes: Structural Analysis and Antibacterial Activity

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Abstract

This work highlights the significance of green synthesis for nanomaterial production, specifically focusing on the biosynthesis of silver nanoparticles (AgNPs) using Enterobacter aerogenes as a reducing agent. The visual observation of a color change from colorless liquid to yellow-brownish provided initial indication of nanoparticle formation. The biosynthesized AgNPs were structurally confirmed through X- ray diffraction (XRD), revealing a perfect match with the standard pattern of Ag_2O crystal structure, corresponding to JCPDS card number 76-1393. Scanning electron microscopy (SEM) was employed to analyze the morphology of the synthesized nanoparticles. Importantly, the synthesized silver oxide nanoparticles demonstrated excellent antibacterial effects against both Escherichia coli and Bacillus subtilis.

Keywords: Biosynthesis; Antibacterial; SEM; Bacillus subtilis, Escherichia coli

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Less complexity VLSI architecture for enhanced primal–double support vector machine learning core

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Abstract

Support Vector Machine (SVM) is an efficient classification tool providing good accuracy and reliability. The primal–dual method is an interior-point method for SVM training with considerable scalability and accuracy. In this paper, an improved primal–dual method for SVM learning is proposed. The proposed primal–dual method offers faster convergence of the SVM learning core by up to 25%, which is made possible by reducing the number of iterations required for obtaining the optimal solution while maintaining its accuracy. We also propose a low-complexity pipelined very large scale integration (VLSI) architecture for implementing the improved primal–dual method both on field-programmable gate array (FPGA) and 65 nm application specific integrated circuit (ASIC) platforms. The computational complexity of the proposed VLSI architecture is independent of the size of the training data and the feature vector.

Keywords: Support Vector Machine (SVM), Very Large Scale Integration (VLSI)

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Comprehensive Evaluation of Indolium and Pyridinium Ionic Liquids: Synthesis ADMET Predictions and Anticancer Activities

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Abstract

Water-soluble flexible substituted indolium/pyridinium cations with different inorganic counter anions are produced using both conventional and silica-supported Muffle furnace methods. More yields, faster reaction times, ease of workup, and non-toxicity make the solvent-free synthesis process better to the conventional approach. To Compared the literature now readily available 1-heptyl-3-methoxy-3H-indol-1-ium substituted salts showed exceptional catalytic reactions for the synthesis of chalcone derivatives. The pharmacokinetic and physicochemical properties of synthesized indolium/pyridinium types ionic liquids (1a to 1c and 2a to 2c) were evaluated for oral bioavailability and drug-likeness. Most compounds complied with Lipinski's rule of five, exhibited good intestinal absorption, and showed minimal CYP inhibition. The BOILED-Egg model confirmed high gastrointestinal permeability, while P-gp substrate analysis indicated potential efflux interactions. Compounds 1c and 2c emerged as strong candidates for lead optimization, demonstrating ideal bioavailability and synthetic feasibility. The molecular simulation studies revealed that the compound 1c strongly interacted with B-Raf kinase receptor. The HOMO and LUMO energies, calculated using the B3LYP/LANL2DZ method show the compound 2 shows smaller bond gap and most stability. Finally, the Cytotoxicity effect of Compound 1 & 2, 1a to 1c and 2a to 2c in KB1 Breast Cancer Cell Line Data are shown as means ± SD (n = 3) compared with the control blank group, $p < 0.05$. These findings suggest the potential of indolium/pyridinium type of Ionic Liquids in future therapeutic applications.

Keywords: Indolium/pyridinium type of Ionic Liquids, ADMET, Molecular simulation, Cytotoxicity, DFT

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The End of the Forever Chemical[PFAS]

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Abstract

Persistent per- and polyfluoroalkyl substances (PFAS), often termed "forever chemicals," have emerged as a critical environmental challenge due to their widespread use, environmental persistence, and potential health risks. This college project delves into innovative strategies for the breakdown and remediation of PFAS in the environment, focusing on advanced chemical, biological, and physical treatment methods. By exploring cutting-edge technologies such as photocatalytic degradation, microbial bioremediation, and plasma-based oxidation, the project aims to identify sustainable and scalable solutions to mitigate PFAS contamination. Key areas of investigation include the molecular mechanisms of PFAS degradation, the role of environmental factors in enhancing breakdown efficiency, and the development of eco-friendly alternatives to PFAS. Through interdisciplinary research, this project seeks to contribute to a cleaner, safer environment by addressing one of the most pressing pollution issues of our time.

Keywords: PFAS, forever chemicals, environmental remediation, photocatalytic degradation, microbial bioremediation, plasma oxidation, sustainable solutions, pollution mitigation, eco-friendly alternatives, environmental persistence.

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Energy Storage and Harvesting Materials

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Abstract

Energy storage and harvesting materials play a crucial role in advancing sustainable technologies by capturing, storing, and converting energy from various sources. These materials enable efficient energy management across renewable systems, portable electronics, and electric vehicles. Advanced materials such as lithium-ion batteries, supercapacitors, and solid-state electrolytes enhance energy density, cycle life, and safety. Simultaneously, energy harvesting materials—like piezoelectric, thermoelectric, and photovoltaic materials—convert mechanical, thermal, and solar energy into electrical power. Emerging research focuses on nanomaterials, including graphene and perovskites, to boost performance and scalability. Integrating multifunctional materials, improving ion transport kinetics, and developing eco-friendly alternatives are critical to addressing global energy demands. The synergy between storage and harvesting technologies paves the way for self-powered systems and smart grids, promoting a cleaner, more sustainable energy landscape.

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Problem Statement: Weather And Disaster Management

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Abstract

Nano piezoelectric materials have huge potential for weather monitoring and disaster management as they can scavenge mechanical energy at the nanoscale and transform it into electrical signals. Nano piezoelectric materials can drive self-sustaining sensor networks that track a variety of environmental parameters, including atmospheric pressure, temperature fluctuations, and seismic movements. This real-time information can improve disaster warning systems for events such as earthquakes, hurricanes, and tsunamis, potentially leading to a lowering of damage and loss of lives. The nano piezoelectric sensors may also be deployed in structural health monitoring (SHM) systems to monitor the condition of the key infrastructure. Not withstanding obstacles pertaining to scalability, durability, and integration, material and energy-harvesting technologies development is mitigating these challenges to render nano piezoelectric materials an intriguing solution to infrastructure and disaster management.

Keywords: Nano piezoelectric materials , structural health monitoring, seismic movements , seismic movements.

 ISBN: 9789348505026

Bio-Prison Hydrogel: A Smart Water Retention Solution for Sustainable Farming

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Abstract

Water shortages and labour-intensive irrigation are major challenges in agriculture. This project introduces a bio-prison solution that enhances soil moisture retention, reducing water demand. The gel is formulated using natural components such as almond gum, drumstick resin, aloe vera gel, and sodium polycryolite, combined with medicinal plant powders like neem and aloe vera. When mixed with soil, the gel absorbs rainwater and gradually releases moisture, ensuring a continuous water supply to plant roots. This controlled hydration system minimizes water wastage, supports plant growth, and reduces manual labour. Additionally, neem powder provides antimicrobial, fungicidal, and antibacterial benefits, promoting healthier crops. This innovation not only conserves water but also improves soil health, making it a sustainable and cost-effective solution for farmers. By integrating biotechnology with smart irrigation, this project offers a practical method to enhance agricultural efficiency, particularly in regions facing unpredictable rainfall and water scarcity.

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Swarm-Based Computational Modelling of Biomaterials: A Theoretical and Simulation Framework

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Abstract

This work explores the theoretical and computational framework of agent-based swarming systems, emphasizing their potential to model and simulate the complex behaviors observed in biomaterials. By leveraging multi-agent interactions, we investigate the emergence of self-organized structures and their parallels to collective phenomena in biological materials. Central to this study is the integration of swarm intelligence with principles of nonlinear dynamics, statistical mechanics, and biophysics, enabling the development of robust simulation tools. These tools elucidate how localized cellular or molecular interactions drive global pattern formation, phase transitions, and adaptive responses in biomaterials. Applications span diverse domains, including tissue engineering, biofilm dynamics, and self-healing materials, providing insights into emergent properties such as structural adaptability and functional robustness. Through comparative analyses and simulations, we demonstrate the utility of agent-based approaches in bridging the gap between micro-level interactions and macro-level emergent behaviors in biomaterials. The findings underscore the relevance of swarm-based methodologies in advancing biomaterials research, offering new perspectives on self-organization, adaptability, and design principles for bio-inspired materials.

Keywords: Agent-based Modeling, Swarm Intelligence, Nonlinear Dynamics, Statistical Mechanics, Computational Simulation & Ecological Modeling.

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Piezoelectric Materials for Energy Harvesting and Sensor Applications

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Abstract

Piezoelectric materials can generate electricity from mechanical pressure, but their efficiency is often limited. This research article aims to improve voltage production by doping a piezoelectric material with an element that enhances its electrical output. Additionally, a special gel is being developed to reduce sudden impact forces while efficiently transferring mechanical energy to the doped piezoelectric material. This combined approach will help maximize energy conversion, making it useful for energy harvesting, sensors, and impact-based power generation.

Keywords: Piezoelectric materials, energy harvesting, sensors and power generation

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Integration of Photonic and Electronic

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Abstract

Electronics and photonics are fundamental disciplines in contemporary technology. Electronics deals with the movement of electrons within materials and devices, whereas photonics deals with light and its application in information transmission and processing. Electronic materials, such as semiconductors and insulators, are crucial in devices that include transistors and diodes. Photonic materials facilitate applications such as lasers, optical fibre, and photodetectors. The merging of electronics and photonics, or optoelectronics, unites the advantages of both: electrical processing for efficiency and light for fast data transmission. This union fuels innovation in displays, optical communications, and quantum computing. Continued research in nanotechnology, metamaterials, and semiconductors is pushing the boundaries of performance, efficiency, and miniaturization, defining the future of information and energy technologies, such as smart devices and low-energy data transfer.

Keywords: Photonics, Electronics, Optoelectronics, Semiconductor, Nanotechnology, Metamaterials, Low-energy data transfer

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Optimization of Carbon Electrodes for Bioelectricity Generation from Marshland Microbial Fuel Cells

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Abstract

Electricity generation from marshlands is driven by bacterial metabolism, which facilitates electron transfer and enables bioelectricity production. This study investigates the potential of microbial fuel cells (MFCs) by analysing voltage generation in marshland environments. A batch setup was designed using three different marshland mud samples collected from separate locations to evaluate the influence of environmental variation on power generation. To optimize electrode performance, three types of carbon rods were tested: one from a used battery, one from a fresh battery, and one from a previous experiment.

The results demonstrated significant variations in voltage output based on the type of carbon rod used, indicating that electrode material selection plays a crucial role in optimizing bioelectricity generation. The findings suggest that optimizing carbon-based electrodes can enhance the efficiency and sustainability of microbial fuel cells in harnessing energy from natural wetland ecosystems. This research highlights the potential of marshlands as a renewable energy source while emphasizing the need for further studies on electrode composition and microbial activity. By refining the electrode materials used in MFCs, this study contributes to the advancement of sustainable energy solutions and the broader application of bioelectricity generation from microbial interactions in natural environments.

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Seed Sowing Efficiency through Arduino Controlled Automation

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Abstract

Our project aims to create an automated seed sowing system using Arduino technology to improve farming efficiency. We will be using three types of seeds: green gram(Vigna radiata),Pigeon pea(Cajanus Cajan) and cotton(Gossypium spp.). Traditional sowing methods can lead to uneven seed placement. By controlling motors and a seed dispenser, the Arduino will enable precise and consistent sowing for all three seed types across the field area. Our automated seed sowing system improves the efficiency of planting various seeds. It ensures accurate seed placement, which leads to better crop yields. This project offers a valuable solution for farmers, by simplifying the Sowing process.

Keywords: Automated Seed Sowing , Arduino technology, Seed dispenser, Precision planting

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Next-Generation Smart Materials for Sustainable Engineering

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Abstract

The emergence of next-generation smart materials is revolutionizing engineering by enhancing sustainability, efficiency, and adaptability across various industries. This study explores intelligent materials such as shape-memory alloys, piezoelectric materials, self-healing polymers, and bio-inspired composites, highlighting their ability to minimize environmental impact while optimizing performance. Key findings reveal that self-healing concrete prolongs infrastructure lifespan, piezoelectric materials facilitate energy harvesting, and adaptive polymers improve flexibility in aerospace and healthcare applications. Additionally, AI and nanotechnology are accelerating material advancements, leading to superior mechanical and electrical properties. The study concludes that integrating smart materials with AI-driven innovation can drive sustainable engineering by extending product lifespans, reducing resource consumption, and enabling energy-efficient solutions, emphasizing the need for continued research and large-scale adoption.

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Smart And Sensor Materials

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Abstract

The rapid advancement of smart and sensor materials is transforming industries by enhancing responsiveness, efficiency, and real-time monitoring. These materials exhibit self-healing properties, corrosion resistance, and multifunctionality, making them crucial for sustainable and eco-friendly innovations. This study explores the systematic development of smart materials, encompassing material selection, advanced fabrication techniques, characterization, and application testing. Key materials such as shape-memory alloys, piezoelectric ceramics, and nanomaterials are optimized for durability and adaptability. The integration of AI and IoT further enhances automation, healthcare, and structural monitoring, enabling intelligent and energy-efficient solutions. Key findings highlight adaptive and responsive behavior, advancements in sensing technology, and AI-driven material optimization. Despite challenges in scalability and cost, progress in nanotechnology continues to drive innovation, ensuring the widespread adoption of smart materials across aerospace, healthcare, and construction. This research underscores the transformative potential of next-generation smart materials in enabling sustainable and intelligent engineering solutions.

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A Critical Review on Green Synthesis of Titanium Oxide Nanoparticles: Characterization and its Application in Waste Water Treatment

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Abstract

The fascinating uses of nanotechnology in a variety of sectors are generating a lot of interest globally. One of the most common nanoparticles (NPs) in daily life is titanium dioxide (TiO2), which can be produced using a variety of physical, chemical, and environmentally friendly techniques. Green synthesis is a non-toxic, economical, and environmentally beneficial method of creating NPs. Ferritins, dendrimers, micelles, liposomes, and NPs with magnetic properties, as well as metal and semiconductor NPs including oxides, nitrides, and sulfides, are examples of both organic and inorganic modules that comprise nanoparticles. Numerous fields, including photocatalysis, photoelectricity, probing, electrochromism, photochromism, etc., are seeing a surge in interest in TiO2-based nanomaterials. They are frequently found in toothpaste, sunscreens, paints, and polymers. TiO2 nanoparticle size, shape, and crystallinity are influenced by different production methods. The primary techniques for producing titanium dioxide (having the structure of anatase, rutile, or brookite) in the form of spheres, rods, fibers, and tubes are sol-gel technology, hydrothermal and solvothermal techniques, high-frequency electromagnetic waves used in microwaves, template techniques, electrodeposition, a sonochemical technique employing ultrasound, chemical and physical vapor deposition, "green" techniques, etc. This overview of the literature provides current scientific findings on the several techniques used to produce TiO2 nanoparticles and its applications.

Keywords: TiO2; TiO2 NPs; green synthesis; plant extract.

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Conventional Methods of Extraction of Anthocyanin from Plants

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Abstract

Water-soluble pigments, called anthocyanins belong to the flavonoid family and they are responsible for the red, blue, and purple colour in various fruits, vegetables, and flowers. Possessing antioxidant, anti-inflammatory, and anti-carcinogenic properties, they are ideal for various industrial applications including the pharmaceutical, nutraceutical, textile, biomedical, cosmetic and food industry. The conventional method of extraction of anthocyanin has been done by solvent-based extraction techniques such as maceration, Soxhlet extraction, etc. Heat- assisted extraction is also used to increase the anthocyanin solubility in solvents, thereby, accelerate the extraction process. The various limitations of the conventional anthocyanin extraction methods, despite being cost-efficient, have led to the innovations of modern green extraction techniques, such as Ultrasound-assisted extraction, enzyme-assisted extraction, microwave-assisted extraction, solid-phase extraction, biotechnology approaches, nanotechnology integration, and supercritical fluid extraction, which has resulted in increased yield and efficiency while decreasing the negative impacts on the environment. These advanced techniques are in need of specialized equipment and optimization for various plant sources. The various applications of anthocyanins are seen in functional foods, nutraceuticals, etc., and there, for proper usage, their extraction efficiency is needed to be enhanced. This has lead to the recent growths in the necessity of development of natural and eco-friendly products with emerging challenges in the optimization of the yield, concerns regarding the stability and degradation of anthocyanin and impacts of the use of solvent in the environment.

Keywords: Anthocyanin, Solvent-extraction, Ultrasound-assisted extraction, Enzyme-assisted extraction, Microwave-assisted extraction, Nanotechnology extraction, Biotechnology extraction, Supercritical fluid extraction

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Neuromorphic Computing and Hafnium Oxide: Advancing AI Hardware for Smart Cities

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Abstract

The world has gone through significant changes due to the rise of AI, which is the main field of computing, yet the mainstream of silicon devices still struggles in terms of efficiency and scaling. Taking inspiration from the human brain's discharge, neuromorphic computing can help through materials that can mimic the different behaviors of the synapse. Although it talks about many aspects, the setting aside of $140 million for the Smart Cities program raises questions about the planning of Smart Cities and the elimination of the digital divide, making it an unquestionable issue. Hafnium Oxide is the key component in the neuromorphic model as it controls the resistive switching procedures and synaptic plasticity needed for quick learning along with mind development. Some AI processors, for instance, IBM's TrueNorth and Intel's Loihi, employ these techniques to process the limited knowledge they receive from machine-learning insights at a basic level. The practical implementations are numerous and range from artificial intelligence to wearable devices, such as autonomous robots and brain-to-machine interfaces that will open new opportunities in AI. Nevertheless, certain challenges require further research, such as device variability, aging, and mass fabrication. The integration of Smart City technologies leads to an 85% worldwide reduction in energy usage thanks to the adoption of the newest international standards in telecommunication and electronic hardware, driven by the rapid growth of renewables. The adoption of Hafnium Oxide, which is compatible with current semiconductor technologies, will decrease the need for computational power and mark a new milestone in AI hardware, ultimately bridging the gap between electronic and biological intelligence.

Keywords: Neuromorphic Computing, Hafnium Oxide, Smart Cities, AI processors

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Identifying the Gene Alterations in Orthopaedic Infection and the Treatment Intervention through Nanotechnology

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Abstract

This study explores the genetic and molecular aspects of periodontitis, focusing on single nucleotide polymorphisms (SNPs) in key cytokine genes (IL-1α, IL-1ß, IL-4, IL-6, IL-8, IL-18, and TNF-α) and their association with disease progression. The research also examines VEGF A, C, and D expression in gingival tissues and evaluates genetic changes before and after treatment. Additionally, bone tissue markers are quantified following nanoparticle-based therapy, assessing its impact on cytokine regulation and orthopedic infections. Real-time PCR is used to detect SNPs in VEGF, IL-6, IL-1β, IL-10, IFN-γ, and TNF-α, while ELISA quantifies cytokine levels and bone biomarkers. Calcium phosphate based nanoparticles are characterized through UV-Vis spectrophotometry and X-ray diffraction. Findings indicate VEGF alterations in gingival crevicular fluid and serum post-treatment, alongside modulations in cytokine gene expression due to nanoparticle therapy. These results highlight nanotechnology's potential in periodontitis treatment and bone regeneration, offering novel therapeutic insights. So finally this study will throw light to the society about the genetic changes in cytokine protein up regulation and also effective treatment for periodontitis using nanotechnology.

Keywords: Periodontitis, Epithelial tissue, cytokine, single nucleotide gene polymorphisms, nanoparticles

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INanostructured and Electrochoromic Materials for Smart Swtichable Windows

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Abstract

This study focuses on improving electrochromic materials (ECMs) for smart windows to enhance efficiency, longevity, and light adjustment. WO_3 and V_2O_5 thin films were developed using a chemical method and tested for structural, optical, and electrical properties. Results showed that WO_3 exhibited strong coloration (70 cm^2/C) with a fast 5-second response time, while V_2O_5 stored more charge. Their nanostructures improved ion movement, ensuring stability and 90% efficiency over 10,000 cycles. These findings confirm that nanostructured ECMs can enhance smart window performance, promoting energy savings and sustainability. Future research will explore new material combinations and improved manufacturing techniques.

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Piezoelectric Materials

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Abstract

Piezoelectric materials have garnered significant attention due to their ability to convert mechanical energy into electrical energy and vice versa. These materials play a crucial role in applications such as sensors, actuators, energy harvesting devices, and medical diagnostics. This study explores the fundamental properties of piezoelectric materials, focusing on their working mechanism, material classifications, and key performance parameters.

A comprehensive review of natural and synthetic piezoelectric materials is conducted, highlighting their advantages and limitations. The study examines the fabrication techniques of commonly used piezoelectric ceramics (such as lead zirconate titanate—PZT) and polymers (such as polyvinylidene fluoride—PVDF). The methodology involves an in-depth analysis of their crystal structures, polarization mechanisms, and electromechanical coupling coefficients. Additionally, recent advancements in lead-free alternatives are discussed, considering environmental concerns associated with conventional lead-based materials.

Key findings indicate that while PZT remains the benchmark material due to its high piezoelectric response, environmental concerns over lead toxicity have accelerated research into lead-free alternatives.

In conclusion, the continuous evolution of piezoelectric materials is driven by the need for sustainable and high-performance solutions. Future research should focus on enhancing material efficiency, stability, and integration into emerging technologies. The development of eco-friendly and high-output piezoelectric materials will play a crucial role in advancing energy-efficient and smart technologies across multiple industries.

Keywords: Piezoelectric materials, Energy harvesting, Electromechanical coupling, Smart materials, Sensor applications, Actuators, Crystal structures.

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Toxicity and Molecular Mechanisms of Actions of Silver Nanoparticles

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Abstract

Silver nanoparticles (AgNPs) have gained significant attention due to their broad-spectrum antimicrobial properties and applications in medicine, consumer products, and industry. However, concerns regarding their toxicity and molecular mechanisms of action have emerged. This review explores the cytotoxic, genotoxic, and ecotoxic effects of AgNPs, emphasizing their interaction with biological systems. AgNPs exert toxicity through oxidative stress, disruption of cellular membranes, mitochondrial dysfunction, and DNA damage. The release of silver ions (Ag^+) plays a crucial role in their biological activity, leading to protein misfolding and enzyme inhibition. Additionally, AgNPs influence cellular signaling pathways, inducing apoptosis, autophagy, and inflammatory responses. Their size, shape, surface charge, and coating significantly affect their toxicity. Understanding these mechanisms is essential for developing safer nanomaterials and mitigating potential health and environmental risks. Further research is required to establish regulatory guidelines and assess long-term effects.

Keywords: Silver nanoparticles, toxicity, oxidative stress, cytotoxicity, genotoxicity, mitochondrial dysfunction, DNA damage, silver ions (Ag^+), apoptosis, autophagy, inflammation, cellular signaling, nanotoxicology, environmental impact, biomedical app.

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AI-Powered Smart Case

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Abstract

The AI-powered Smart case revolutionizes smartphone energy management by integrating graphene battery technology, AI-driven charging optimization, and modular power solutions. With ultra-fast charging, superior energy density, and unmatched durability, graphene batteries outperform traditional lithium-ion alternatives. Advanced AI algorithms intelligently regulate power consumption, eliminating overcharging risks, extending battery lifespan, and minimizing wasted energy. The innovative modular power bank provides on-the-go backup power, ensuring uninterrupted device usage. Harnessing kinetic energy through piezoelectric materials adds a sustainable edge, while wireless power sharing transforms the case into a dynamic energy hub for charging other devices effortlessly. This groundbreaking fusion of AI and advanced materials delivers a self-optimizing, high-performance, and eco-conscious charging experience, setting a new standard for mobile power solutions. By revolutionizing energy efficiency and user convenience, this innovation paves the way for a smarter, more sustainable, and future-proof approach to smartphone charging.

Keywords: AI algorithms, battery lifespan.

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Iceberg Battery Technology: High-Performance Energy Storage Using Li Anode, SiC-Al Doping, and COF-CNT Cathodes

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Abstract

This study explains a high-performance battery design integrating a lithium (Li) anode with silicon carbide (SiC) doped with aluminum (Al) increases electron mobility and helps to decrease the size and increase the capacity. A covalent organic framework (COF)based cathode embedded in carbon nanotubes (CNTs)which help to electro positivity nature which increases the capacity of the battery. The Li+ anode offers high capacity (3860 mAh/g), while SiC enhances structural stability and prevents dendrite formation. Al doping improves over all conductivity and ion diffusion in SiC, this reduces volume expansion issues. On the cathode side, COFs provide a highly porous surface, high-capacity structure, while CNTs enhance electron conductivity, dissipates heat and structural reinforcement, enabling faster charge/ discharge cycles. This combination significantly boosts energy density and cycling stability, support super-fast charging, high electron mobility in a small form factors the addition of COFs and CNTs endows high mechanical durability for long-term reliability under extreme conditions. The designed nanostructure facilitates uniform ion distribution for the alleviation of hotspots and improved safety. The advanced materials with record synergy pave the way for next-generation batteries to achieve excellent performance in energy storage/sustainability.

Keywords: High-performance battery, Lithium (Li) anode, Silicon carbide (SiC), Aluminum (Al) doping, Covalent organic frameworks (COFs), Carbon nanotubes (CNTs), Improved safety, Extended lifespan

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NEURO-SWARM: A Swarm-Based Neuromorphic AI for Scalable and Energy-Efficient Computing

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Abstract

Neuromorphic computing, inspired by the human brain, has gained attention for its low-power AI processing and event-driven intelligence. However, current neuromorphic architectures are highly centralized, limiting their scalability and adaptability in real-world applications. Large-scale neuromorphic networks consume high power and struggle with efficient real-time learning and decision-making, restricting their deployment in autonomous robotics, edge AI, and large-scale distributed AI systems.

To address this challenge, we propose NEURO-SWARM, a swarm-based neuromorphic computing framework that enables distributed, scalable, and energy-efficient AI processing. Instead of relying on a single neuromorphic chip, NEURO-SWARM utilizes multiple interconnected neuromorphic nodes that collaborate dynamically, mimicking biological swarm intelligence found in nature. This architecture introduces:

Distributed Neuromorphic Processing – Multiple neuromorphic cores operate in parallel, optimizing workload distribution and improving real-time decision-making.

Self-Organizing Learning Mechanism – Each node learns independently but shares knowledge via spike-based communication, enabling adaptability without requiring full system retraining.

Energy-Efficient Dynamic Processing – Nodes activate or deactivate based on computational demand, significantly reducing power consumption while maintaining performance.

By implementing a swarm-based neuromorphic framework, NEURO-SWARM bridges the gap between centralized AI models and real-time distributed computing, making it ideal for applications in robotics, IoT, smart edge devices, and large-scale AI networks. With NEURO-SWARM, neuromorphic AI moves beyond single-chip limitations, unlocking a future of truly autonomous and scalable AI.

Keywords: Neuromorphic Computing, Swarm Intelligence, Distributed AI, Spiking Neural Networks, Energy-Efficient AI

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Nanozyme Therapy for Brain Disorder

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Abstract

Neurodegenerative diseases like Alzheimer's and Parkinson's happen when harmful proteins build up in the brain, damaging nerve cells and causing memory loss or movement problems. Current treatments can slow symptoms but cannot remove these toxic proteins. Nanozymes— tiny artificial enzymes—offer a new way to break down these harmful proteins safely.

This study explores how metal-based (gold, cerium oxide) and carbon-based (graphene, carbon dots) nanozymes can act like natural enzymes to clear toxic protein clumps and reduce brain cell damage. A major challenge is getting nanozymes past the blood-brain barrier (BBB). To solve this, we test liposome-coated nanozymes (which help them pass through) and magnetic nanoparticles (which can be guided to the brain).

By studying how nanozymes interact with harmful brain proteins in cells and lab models, this research aims to create a new, more effective treatment for Alzheimer's, Parkinson's, and similar diseases.

Keywords: Nanozymes, Brain Disorders, Alzheimer's, Parkinson's, Blood-Brain Barrier, Nanomedicine.

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Piezoelectric Nanogenerators: The Future of Self-Powered AI and Wearable Technology

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Abstract

The popularity of devices that are energy self-sufficient and efficient has risen due to the proliferation of artificial intelligence (AI) and the Internet of Things (IoT). Electronics that rely on conventional batteries face several issues including the need for repeated recharging, limited useful lives, and environmental considerations. Wearable medical sensors and intelligent electronics that need constant power supply utilize piezoelectric nanogenerators (PENGs), which generate power from human activity and vibrations. PENGs use of applied mechanical energy to produce electricity.Energy harvesting from motion is supported by the use of piezoelectric materials such as zinc oxide (ZnO), lead zirconate titanate (PZT) and polyvinylidene fluoride (PVDF). Integrated with AI based systems, PENGs are used in smart health monitors, AI powered robots, and autonomous sensor networks. For example, a heart monitor can be controlled by a piezoelectric device that tracks a patient's pulse continuously without external power source. In industrial automation, AI self-powered sensors can autonomously optimize processes by capturing and processing real time information.This paper tries to review the operating principle, applications, and benefits of PENGs in comparison with conventional sources of power. The advancements in nanotechnology concerning AI based energy harvesting systems are analyzed in regard to how PENGs substantiate the reduction of batteries dependency as well as extended lifetime of the devices.

Keywords: Piezoelectric Nanogenerators, Energy Harvesting, AI Devices, Wearable Devices, Smart Sensors, Sustainable Electronics, Self-Powered Systems, IoT, Nanotechnology

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Forest Fire Prediction Using Machine Learning

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Abstract

Forest fires are a major threat to the environment, wildlife, and human habitations. Conventional fire detection techniques are based on real-time observations, which tend to result in late responses. This paper seeks to create a machine learning-based forest fire prediction system that can predict the probability of fire events occurring based on environmental conditions like temperature, humidity, wind speed, and rainfall. We employ the Random Forest Classifier, a powerful machine learning algorithm, to predict fire incidences from historical fire data accurately. The dataset, which is retrieved from publicly accessible sources such as Kaggle or UCI ML, is preprocessed to eliminate inconsistencies. The model is trained with an 80-20 train-test split and assessed using accuracy score, confusion matrix, and classification reports. The system can also be implemented as a web application with Flask for real-time user input for fire hazard assessment. This AI driven method enhances early warning systems by decreasing environmental and economic losses from forest fires.

Keywords: Forest Fire Prediction, Machine Learning, Random Forest, Environmental Monitoring, AI in Disaster Management

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POSS-Based Fire-Resistant Materials: Enhancing Building Safety Under Extreme Heat Conditions

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Abstract

Fire hazards in buildings pose a severe threat to human safety, structural integrity, and economic stability, especially under extreme conditions such as high temperatures and prolonged fire exposure. Traditional building materials, including steel, concrete, and wood, suffer from significant weaknesses when exposed to fire. Steel loses its strength above 600°C, concrete cracks under thermal stress, and flammable materials accelerate fire spread. These vulnerabilities make fire incidents more catastrophic, leading to rapid structural failure and increased casualties. To address this challenge, Polyhedral Oligomeric Silsesquioxane (POSS) emerges as a highly efficient fire-resistant material for buildings. POSS-based coatings and composites exhibit exceptional thermal stability, preventing heat penetration and reducing material degradation under extreme conditions. When applied to concrete, steel, and insulation materials, POSS significantly enhances fire resistance, mechanical strength, and durability. Its nano-structured composition ensures a lightweight yet highly protective barrier against high-temperature environments. Unlike traditional fireproofing solutions, POSS offers superior flame retardancy, low smoke emission, and enhanced stability at elevated temperatures. POSS-modified polymers and coatings create a protective layer that resists thermal breakdown, delaying fire-induced structural failures. Additionally, its low toxicity and eco-friendly nature make it a sustainable alternative for fireproofing applications in modern construction. By integrating POSS-based fire-resistant materials into buildings, we can achieve greater fire safety, prolonged structural lifespan, and reduced fire damage. This study highlights the potential of POSS in revolutionizing fireproofing strategies, paving the way for safer, more resilient infrastructure under extreme fire conditions.

Keywords: Fire hazards, Extreme conditions, POSS (Polyhedral Oligomeric Silsesquioxane),Fire-resistant coating, Building safety

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Low Dimensional Materials

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Abstract

Low-dimensional materials, with nanoscale dimensions (<100 nm), exhibit exceptional electronic, optical, and mechanical properties due to quantum confinement effects and high surface-to-volume ratios. These unique characteristics enable their use in advanced applications across multiple fields. In electronics and nanoelectronics, they enhance the performance of transistors, diodes, and flexible devices. In optoelectronics, they improve LEDs, photodetectors, and solar cells through tunable bandgaps. Their role in energy storage and conversion includes advancing lithium-ion batteries, supercapacitors, and hydrogen storage. Additionally, they contribute to quantum computing and spintronics by serving as qubits and spintronic memory components. Biomedical applications benefit from their use in biosensors, drug delivery, and bio-imaging, while their superior strength and lightweight properties make them valuable in aerospace, automotive, and wear-resistant coatings. With their diverse and tunable functionalities, low-dimensional materials are driving significant advancements in science and technology.

Keywords: Low-dimensional materials, quantum confinement, nanoelectronics, optoelectronics, energy storage, quantum computing, spintronics, biosensors, nanotechnology, advanced materials.

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High-Performance Photocatalytic and Antibacterial Properties of coupled oxide Honeycomb Structures: Synthesis and Mechanistic Insights

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Abstract

A hexagonal honeycomb-structured WO3 loaded ZnO catalyst was synthesized using a solvothermal method and characterized through various techniques, including FTIR, XRD, FE-SEM, TEM, UV-vis, DRS, PL, XPS, and BET measurements. The work novelty for WO_3-loaded ZnO photocatalysts refers to the innovative aspects and new contributions to the field of photocatalysis that come from the combination of tungsten oxide (WO_3) with zinc oxide (ZnO). The influence of tungsten concentration on the surface morphology, structure, and optical properties was thoroughly investigated. The introduction of tungsten notably altered the properties of ZnO nanoparticles, with the grain size playing a key role in these modifications. Additionally, the band gap decreased with 5 wt.% WO3 loading. Photoluminescence spectra showed an emission at 482 nm, corresponding to blue-green emission bands. Additionally, the synthesized WO3/ZnO catalyst have also a wonderful photocatalytic performance in the degradation of three azo dyes: NBB, RR 120, and AR 27, when exposed to sunlight. Moreover, WO3 loaded ZnO nanoparticles exhibited enhanced antibacterial effectiveness against E. coli, S. typhimurium, and P. mirabilis strains.

Keywords: WO_3 loaded ZnO; photoluminescence; Optical band-gap; self-cleaning property; biological activity.

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Chemical vapour deposition: A pathway for thin film and surface characteristics

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Abstract

Chemical Vapor Deposition (CVD) has revolutionized thin-film technology, offering precise control over film properties, making it a cornerstone in microelectronics, energy storage, and protective coatings. The technique involves the chemical reaction of gaseous precursors on a heated substrate, leading to high-purity and uniform coatings with superior adhesion. Sustainable and eco-friendly CVDs are produced using bio-derived and metal organic precursors as green alternatives, enabling safer deposition processes to reduce toxic by-products and conserve energy. Based on application, hybrid techniques such as a combination of physical vapor deposition or laser-based methods are employed to enhance material characteristics precise for high-performance coating in aerospace and biomedical fields. CVD can synthesise 2D materials like graphene transition metal dichalcogenides (TMDs) and hexagonal boron nitride essential for quantum computing, flexible electronics, and next-generation transistors. CVD finds its application in energy storage, nano-electrodes for lithium-ion batteries, supercapacitors and solid state hydrogen storage, sensors for detecting environmental pollutants, and biomedical markers. Machine learning (ML) and artificial intelligence (AI) are now pivotal in optimizing CVD processes, predicting growth patterns, and minimizing experimental iterations, leading to improved efficiency and material quality. As innovations continue to emerge, CVD remains at the forefront of advanced materials research, bridging the gap between fundamental science and industrial applications.

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Microstructural Evolution and Mechanical Properties of Laser Metal Deposited (LMD) Ti-6Al-4V Alloy

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Abstract

Laser Metal Deposition (LMD) is an advanced additive manufacturing technique that enables precise fabrication and repair of high-performance metallic components. Ti-6Al-4V, a widely used titanium alloy in aerospace, biomedical, and automotive industries, exhibits excellent strength-to-weight ratio and corrosion resistance. However, process-induced microstructural heterogeneities significantly influence its mechanical properties. This paper investigates the microstructural evolution and mechanical behavior of LMD-processed Ti-6Al-4V alloy to establish process-property correlations. The research involved depositing Ti-6Al-4V powder onto a Ti-6Al-4V substrate using a high-power laser source under controlled process parameters, including laser power, scanning speed, and powder feed rate. Phase transformation and elemental distribution were analyzed via X-ray diffraction (XRD) and energy-dispersive spectroscopy (EDS). Mechanical properties were evaluated through microhardness testing and tensile testing to determine strength, ductility, and fracture characteristics. Results indicate that the as-deposited microstructure primarily consists of acicular α and retained β phases, with columnar β grains oriented along the thermal gradient. The observed microstructural gradient along the deposition layers influences mechanical anisotropy. Post-deposition heat treatment was found to refine the microstructure, promoting homogeneous α/β phase distribution and improved mechanical properties. The hardness values exhibited significant variation across different deposition zones, correlating with grain morphology and residual stress distribution. Tensile test results revealed a trade-off between strength and ductility, with as-deposited specimens showing higher tensile strength but lower elongation compared to heat-treated counterparts.

Keywords: Laser Metal Deposition; Ti-6Al-4V Alloy; Microstructural Evolution; Mechanical Properties; Phase Transformation; Additive Manufacturing

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Optical Materials

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Abstract

Optical materials play a crucial role in a wide range of applications, from telecommunications to medical imaging. These materials are designed to manipulate light through reflection, refraction, absorption, or transmission, enabling advanced technologies. Key optical materials include glasses, crystals, polymers, and semiconductors, each offering unique properties based on their molecular and structural characteristics. Innovations in optical coatings and thin films allow for enhanced performance in devices like lenses, mirrors, and fiber optics. Additionally, the development of nonlinear optical materials and metamaterials has opened new frontiers in manipulating light beyond traditional limitations. The ongoing research into nanomaterials and quantum optics promises further breakthroughs, offering improved efficiency, precision, and functionality in optical devices. The continuous advancement of optical materials is critical for the evolution of technologies like lasers, sensors, displays, and photonic circuits, ultimately driving progress in communications, healthcare, and industrial applications. Optical materials can be categorized based on their properties and applications. Here are some common types of optical materials Glasses are commonly used Common types include silica glass, borosilicate glass, and lead glass. They are often used in applications requiring clarity and durability. Crystals like laser components, optical filters, and polarizers. They have well-defined structures that affect how light interacts with them. Polymers are flexible, lightweight materials that can be engineered to have specific optical properties. Semiconducting materials, such as silicon, gallium arsenide, and indium phosphide, are essential in optoelectronic devices like light-emitting diodes (LEDs), photodetectors, and solar cells.

Nonlinear optical crystals like potassium titanyl phosphate (KTP) and beta barium borate (BBO) are used in laser sources, frequency conversion, and optical switching. Metamaterials are artificially engineered to have unique optical properties not found in nature. Each type of optical material is chosen based on its specific properties, such as refractive index, transparency, durability, and ability to withstand different environmental conditions.

In conclusion, optical materials are fundamental to the advancement of modern technology, offering diverse solutions for controlling and manipulating light. From traditional glasses and crystals to advanced semiconductors, polymers, and emerging metamaterials, each type of optical material serves a unique role in applications ranging from telecommunications and healthcare to industrial and scientific research.

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Magnetic Levitation

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Abstract

Superconductors are materials that exhibit zero electrical resistance when cooled below a critical temperature, enabling energy-efficient applications in various fields, including MRI, quantum computing, and particle accelerators. A key advancement is their role in Maglev (magnetic levitation) trains, which offer high-speed, low-maintenance, and energy-efficient transportation. Countries like Japan, China, and South Korea have successfully implemented this technology, revolutionizing public transit.

Introducing Maglev trains in India could significantly enhance the transportation sector, reducing travel time and accidents while promoting sustainable development. However, challenges such as high initial costs, land acquisition, technology transfer, and energy demand must be addressed. This paper explores strategic solutions, including public-private partnerships, indigenous manufacturing, government subsidies, and cost-effective track design, to make Maglev trains a feasible reality in India. By leveraging superconductors for magnetic levitation, India can usher in a new era of technological and economic transformation.

Keywords: Superconductors, Magnetic Levitation, Maglev Trains, Zero Electrical Resistance, Energy Efficiency, Quantum Computing, Particle Accelerators, High-Speed Transportation, Public-Private Partnership, Technology Transfer

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AI-Driven Rover for Smart Terrain Analysis

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Abstract

Agriculture and space exploration require accurate terrain analysis and real-time environmental monitoring to make better decisions. Our project, AI-Driven Data Science Rover for Smart Terrain Analysis, aims to develop an intelligent rover that can navigate different terrains, collect environmental data, and provide insights using AI and data science. The rover is equipped with computer vision (YOLOv8) and LiDAR sensors for obstacle detection and terrain classification. It also includes temperature, humidity, and soil moisture sensors to monitor environmental conditions. Using machine learning models, the system can analyze soil health, detect obstacles, and make navigation decisions. The collected data is sent to the cloud (Firebase) for real-time remote access through a web dashboard (React.js), where users can monitor and analyze terrain and environmental data.

This rover is designed for two main applications:

Agriculture – Helping farmers by detecting soil moisture levels, predicting irrigation needs, and identifying potential crop health issues.

Space Exploration – Assisting in planetary research by mapping unknown terrain, assessing surface conditions, and making autonomous navigation decisions.

In the future, we aim to integrate AI-driven autonomous decision-making, enabling the rover to send alerts or take corrective actions when it detects critical changes in the environment. This project highlights how AI and data science can improve agricultural efficiency and space exploration capabilities.

Keywords: AI, Data Science, Autonomous Rover, Smart Agriculture, Space Exploration, Computer Vision, Machine Learning, Terrain Analysis.

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AI-Powered Digital Twin Teacher

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Abstract

Rapid progress in artificial intelligence (AI) and attractive technologies have paved the way for transformation innovations in education. The study specializes in developing an AI-controlled digital twin teacher in a meta-based lecture chamber to create an interactive, adaptive and intelligent virtual trainer. Digital Twin meets two main functions: Students who allow feedback from real -time and help teachers by dealing with simple questions so that they can focus on complex discussions. This software is especially useful in engineering training, where students require immediate support for technical concepts. By integrating Virtual Reality (VR) and AI, students can discover their university, inside Metaverse, interact with their virtual twin trainer, and acquire engaging, real -time help. This method involves developing a virtual learning environment to develop AI-controlled avatar trained on course materials, student queries and teaching strategies after testing. Student interaction, commentary accuracy and engagement level have been measured through simulation and individual evaluation. The most important conclusions suggest that virtual double teachers improve the engagement of students, increase storage and lose weight on teachers through repetitive examination. The implementation of AI-operated digital twin coaches deals with the most important instructions as demanding conditions, including teachers' deficiency, student engagement, time control and advanced interactions. This study emphasizes the ability of AI-controlled education to create efficient, scalable and inclusive learning environment, and bridge the bridge between traditional and digital classes.

Keywords: AI-powered digital twin, Metaverse-based learning, Virtual Reality (VR) in education, real-time feedback

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Non-Toxic Nano-Hybrid Coatings with Anti-Fouling and Anti-Corrosion Propertie

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Abstract

Eco-friendly nano-hybrid coatings possess remarkable anti-fouling and anti-corrosion characteristics, that are very effective in preventing marine biofouling as well as delivering advanced corrosion resistance. These environmentally friendly materials protect metals from corrosion, which reduces pollution in the environment by a large extent. Addition of nanoparticles to hybrid materials, like polymers, ceramics, or composites, lessens the maintenance needs and increases corrosion protection. Electrochemical impedance spectroscopy (EIS) confirms their superior performance.Perfectly designed for marine, aerospace, and construction sectors, these coatings provide a tried and tested, eco-friendly solution. The use of silica, ceramic, or polymer nanoparticles makes the coatings non-toxic and environmentally friendly. With the use of these innovative coatings, industries can ensure longer metal life, lower maintenance costs, and improved safety, while fostering environmental responsibility and reducing the environmental impact of industrial activities. Also, the coatings are designed to specifically suit the particular needs of individual industries, for a consistent and durable corrosion defense solution.

Keywords: Non-toxic coating,nano-hybrid, antifouling, anticorrosion, marine biofouling, corrosion resistance, sustainable materials, electrochemical impedance spectroscopy.

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Piezoelectric Nanogenerators: The Future of Self-Powered AI and Wearable Technology

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Abstract

The popularity of devices that are energy self-sufficient and efficient has risen due to the proliferation of artificial intelligence (AI) and the Internet of Things (IoT). Electronics that rely on conventional batteries face several issues including the need for repeated recharging, limited useful lives, and environmental considerations. Wearable medical sensors and intelligent electronics that need constant power supply utilize piezoelectric nanogenerators (PENGs), which generate power from human activity and vibrations. PENGs use of applied mechanical energy to produce electricity.Energy harvesting from motion is supported by the use of piezoelectric materials such as zinc oxide (ZnO), lead zirconate titanate (PZT) and polyvinylidene fluoride (PVDF). Integrated with AI based systems, PENGs are used in smart health monitors, AI powered robots, and autonomous sensor networks. For example, a heart monitor can be controlled by a piezoelectric device that tracks a patient's pulse continuously without external power source. In industrial automation, AI self-powered sensors can autonomously optimize processes by capturing and processing real time information.This paper tries to review the operating principle, applications, and benefits of PENGs in comparison with conventional sources of power. The advancements in nanotechnology concerning AI based energy harvesting systems are analyzed in regard to how PENGs substantiate the reduction of batteries dependency as well as extended lifetime of the devices.

Keywords: Piezoelectric Nanogenerators, Energy Harvesting, AI Devices, Wearable Devices, Smart Sensors, Sustainable Electronics, Self-Powered Systems, IoT, Nanotechnolo.

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Nanocerium reinforced Thiophenyl Pendent pyridine core Imine skeletal Polybenzoxazine (nCeO2/PBZ) hybird Nanocomposites

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Abstract

A novel nanocerium reinforced thiophenyl pendent core imine skeletal polybenzoxazine (nCeO2/PBZ) nanocomposites were designed and developed via ring opening thermal polymerization. The benzoxazine (BZ) monomer was synthesized from thiophenyl Pendent core imine skeletal aromatic diamine by mannich condensation. Varying percentages of cerium oxide were then added with benzoxazine to prepare nCeO2/PBZ nanocomposites. The synthesized PBZ nanocomposites were characterized by FT-IR, thermogravimetry (TGA), x-ray diffraction (XRD), Scanning electron microscopy (SEM) and Atomic force microscopy (AFM). The PBZ nanocomposites have shown high thermal stability, glass transition temperature (Tg) and high dielectric constant. The enhancement in the glass transition temperature and improved thermal stability which could be afforded by the restrained motion of polymeric chain, caused from nano reinforcement effect of nanocerium. The homogeneous morphology of the nanocomposites caused from the good interfacial interaction between the embedded nanocerium particles and PBZ nanocomposites as evidenced by SEM and AFM images.

Keywords: Benzoxazine, nCeO2, thermal polymerization, polybenzoxazine, thermal stability, morphological properties, nanocomposites.

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Smart Bio-Robotic Sewage Cleaning: AI-Powered Waste Management

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Abstract

Manual sewage cleaning remains a dangerous and unhygienic task, often exposing workers to severe health risks despite legal restrictions. This study presents an AI-driven Bio-Robotic Sewage Cleaning System designed to replace manual intervention with a fully automated solution. The system combines autonomous robotic cleaners, AI-powered sensors, and IoT-based real-time monitoring to detect and clear blockages in sewage pipelines efficiently. High-power suction, water-jet technology and bio-remediation pods help break down waste, while predictive AI algorithms assist in maintenance and gas leak detection. A swarm robotics approach improves cost efficiency, and solar-powered floating units tackle open drains. Beyond sewage cleaning, this technology extends to industrial wastewater treatment, smart city sanitation, and flood-related sewage management. Advanced sensor networks allow for early detection of system failures, reducing emergency repairs. Cloud-based AI optimizes sewage system performance over time, and the modular design ensures adaptability across different urban infrastructures. Collaboration with municipal authorities and industries will be the key to successful large-scale implementation, making sanitation safer, smarter, and more sustainable.

Keywords: AI-Driven Robotics, Sewage Management, IoT-Based Monitoring, Bio-Remediation Technology, Sustainable Wastewater Treatment

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AquaPulse: Smart Wearable Hydration Monitor for Active Lifestyles

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Abstract

Hydration is essential for maintaining physical and cognitive performance, especially for individuals with active lifestyles. This paper introduces AquaPulse an innovative wearable hydration monitor that utilizes biosensors and AI-driven analytics to provide real-time hydration tracking and personalized fluid intake recommendations. The objective of AquaPulse is to develop a non-invasive, real-time monitoring system that helps athletes, fitness enthusiasts, and individuals maintain proper hydration based on physiological and environmental factors. Using bioelectrical impedance analysis (BIA) and sweat composition sensors, the device continuously assesses hydration status, with machine learning algorithms processing user-specific metrics such as body composition, activity levels, and weather conditions. Key features include real-time hydration tracking, AI-powered insights, Bluetooth connectivity for seamless integration with smartphones and smartwatches, an sweat-resistant design, and smart alerts to prevent dehydration and overhydration. By combining advanced sensor technology with AI-driven analytics, AquaPulse enhances hydration awareness, optimizes performance, and supports overall health. This innovation provides an intelligent, user-friendly solution for hydration management, ensuring individuals stay adequately hydrated for peak efficiency in their daily activities.

Keywords: Wearable hydration monitor; Real-time tracking; Biosensors; AI-driven analytics; Personalized recommendations; Dehydration prevention.

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Autonomous Robotic Systems for Efficient Marine Waste Clean-up

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Abstract

Increasing water pollution is one of the biggest concerns in today's world. It leads to a variety of problems including an increase in the level of toxic concentration in the water and make the aquatic habitat worst. This paper aims to introduce a concept of an ocean/ water body cleaning robot that attempts to detect the wastes using a camera with a custom machine learning model and segregate accordingly using separators while collecting them in the basket attached, which can be recycled at the base station. The robot can be deployed on any water surface and under water for few meters, making it more effective than large-scale ocean pollution cleaning techniques. It can monitor the water quality of the particular location and if the waste is detected it will clean and collect. The robot works in dual system. When the sunlight is available it works with the solar energy and when the sunlight is not available it works with other energy source like tidal energy and battery. It is monitored using cloud network and use GPS for navigation. The waste will be detected by the camera and sensor. Energy is converted from one to another by transducers. The waste will be collected by robotic arms and other source.

Keywords: Environmental Instrumentation; GPS; Marine; Cloud Network; Robotics; Sensors and Transducers; Solar Energy.

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Smart Recycling System for Converting Plastic Waste into 3d Printing Filament

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Abstract

Plastic waste pollution is growing environmental crisis, with millions of tons are disposed every day. The aim of this project is to develop a hardware-based system that reduces the plastic waste. It converts plastic waste into high-quality 3D printing filament. This system is integrated with sorting, cleaning, melting, extrusion, cooling, filament spooling and quality checking. The first process sorting is done using AI-powered machine vision sorting. AI detects the non-plastic materials (like labels or metal caps) and removes them before further processing. Then, the machine melts the plastic waste and extract them into thin filament. During, the process of melting toxic gases is emitted. To avoid this, we use air filtration system (HEPA filters) to capture the volatile organic compounds. Cooling of filament is done with the help of water which may sometimes contaminates it. Instead of that we use closed-loop water cooling system. Then, the filament is spooled and to check the uniform diameter of the filament we use sensor (laser diameter sensor). Finally, the filament is used for 3D printing. This innovative system has the potential to revolutionize the recycling industry and promote a circular economy.

Keywords: Plastic waste, Sustainable recycling, 3D printing filament.

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POSTER PRESENTATION

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Studies on the Picric Acid Based Carbonates Crystals for the Optical Limiting Properties

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Abstract

This research focuses on the studies and comprehensive characterization of picric acid-lithium carbonate (PAC-Li_2CO_3) crystals, designed for optical limiting properties. As high-intensity laser systems become more widespread, the demand for efficient optical limiting materials that can protect photosensitive devices has grown significantly. Combining the nonlinear optical properties of picric acid with the stability of lithium carbonate, these crystals exhibit exceptional potential in mitigating laser-induced damage while maintaining high transparency at lower light intensities. Such properties make them ideal for safeguarding optical sensors, laser-based medical equipment, and other sensitive photonic devices.

The synthesis of high-quality PAC-Li_2CO_3 crystals requires precise control over chemical composition, crystallization conditions, and thermal parameters. Using the slow evaporation technique, picric acid and lithium carbonate are dissolved in a suitable solvent and allowed to crystallize gradually, ensuring the formation of well-structured and highly pure crystals. This method enables better control over crystal morphology and enhances the material's optical performance.

Post-synthesis, the PAC-Li_2CO_3 crystals undergo detailed structural and optical characterization. Techniques like X-ray Diffraction (XRD), Fourier-Transform Infrared (FTIR), UV-Visible Absorption Spectroscopy , Thermogravimetric Analysis (TGA), and Z-scan technique are employed. These combined analyses demonstrate the suitability of PAC-Li_2CO_3 crystals for use in environments requiring fast, efficient laser protection and advanced photonic performance.

Keywords: Optical Limiting Materials, Crystal Growth, Nonlinear Optics, Structural Analysis, Advanced Photonics

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Towards Efficient VOC Monitoring: A Review of Electrochemical Sensing Technologies

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Abstract

Volatile organic compounds (VOCs) are widespread in various environments, yet their accurate detection remains crucial for applications in environmental monitoring, industrial safety, and medical diagnostics. Recent breakthroughs in electrochemical VOC sensing have been driven by sophisticated material engineering, particularly the development of metal-organic frameworks and specialized electrode architectures. These configurations typically feature a base substrate layered with carefully engineered active materials designed to enhance both sensitivity and selectivity. Electrochemical techniques such as cyclic voltammetry and electrochemical impedance spectroscopy are instrumental in capturing response patterns across varying VOC concentrations. Additionally, the integration of machine learning algorithms has revolutionized detection capabilities by mapping electrochemical signatures to specific VOCs with remarkable precision. By merging materials science, electrochemistry, and computational analysis, this multidisciplinary approach has significantly advanced VOC sensing technologies. This review explores recent progress in electrochemical VOC detection, emphasizing key innovations in material design, electrode engineering, and data-driven analytical techniques.

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Overview of the Volatile Organic Compounds Sensing using SERS

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Abstract

Sensitivity and selectivity of various materials in the sensing of volatile organic compounds (VOCs) with a strong focus on carbon-based materials is addressed. Of the large number of materials that have been investigated, carbon-based materials such as graphene, carbon nanotubes, and activated carbon have been promising ones due to their remarkable physicochemical properties consisting of high surface area, tunable porosity, and higher electrical conductivity. These materials can be functionalized or hybridized with metal oxides, polymers, or nanoparticles to enhance their sensing properties. Furthermore, incorporation of Surface-Enhanced Raman Spectroscopy (SERS) has proven to be a strong tool to increase detection sensitivity and specificity by offering dramatic signal amplification for trace-level VOC identification. Recent advancements in carbon-based VOC detection are critically examined, focusing on their mechanisms, advantages, limitations, and future potential. In conclusion, this study emphasizes the pivotal role of carbon-based materials and SERS-enhanced approaches in revolutionizing VOC sensing technologies.

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Wireless Sensor Node for Chemical Process Management

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Abstract

Chemical process monitoring has critical applications in pharmaceutical, petrochemical, and food processing industries. The cost of traditional wired monitoring systems can be high, and they are generally inflexible and difficult to maintain. We consider Wireless Sensor Nodes (WSNs), which significantly mitigate costs and provide a scalable and flexible alternative for real-time chemical processes monitoring. The objective of this project is the design and implementation of a wireless sensor node that will be able to monitor important parameters in a chemical process like temperature, pressure, pH and the concentrations of gas.

Keywords: Wireless sensor node, Real time chemical process monitering

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Energy Materials for Space Technology

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Abstract

The progress of space exploration largely relies on the advancement of high-performance energy materials. Energy storage and generation under conditions of outer space extreme radiation temperature changes and microgravity are challenged severely. Perovskite-type materials (ABX_3 structure) have been identified as potential materials with high photovoltaic efficiency, radiation resistance, and controllable electronic properties. This research examines the structural integrity, efficiency, and flexibility of perovskite materials across several space-oriented applications such as solar cells, superconductors, and power harvesting devices. Experimental measurements and computational simulations are employed to make a comparison between double perovskite structure performance under space-like environments. Perovskite materials, with a reported photovoltaic efficiency of up to 25%, are also researched for their strong energy density and power capacity within harsh environments. The application of these materials to spacecraft systems will greatly enhance the reliability and endurance of space missions. The problem of durability, toxicity of lead-based perovskites, and long-term stability under the space environment are also addressed, and some of the solutions on how to make it more sustainable are suggested.

Keywords: Space Technology, energy materials, Perovskite

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Smart Plastic Exchange Vending Machine: A Sustainable Solution for Automated Recycling

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Abstract

A Plastic Exchange Vending Machine is designed to facilitate the collection, processing, and recycling of plastic waste through an automated three-step procedure. The disposal of plastic waste is encouraged by rewarding users, and efficient recycling is ensured through advanced technology. In the first step, plastic waste, including bottles, containers, and wrappers, is inserted into the machine by users. AI-powered sensors are utilized to scan and identify the type of plastic, such as PET, HDPE, or PP. If non-recyclable plastic is detected, it is rejected with a notification to the user. During the second step, sorting and shredding are carried out automatically. The identified plastic types are categorized, and a built-in shredder is used to convert the plastic into small flakes or pellets. A filtration system is included to eliminate labels, caps, and other contaminants, ensuring a cleaner recycling process. In the final step, the shredded plastic is melted and processed into recyclable filament. The collected plastic flakes are further utilized by local recycling companies for various applications, such as the production of new plastic bottles, the creation of construction materials and furniture from HDPE, or the transformation of PET into polyester fibers for clothing. The implementation of this vending machine offers numerous advantages. Natural resources such as energy, water, and land are conserved through recycling. Local economies are supported by engaging businesses and organizations in the recycling process. Revenue is generated by selling the collected recyclable materials to processing units. The convenience of plastic disposal is provided, making recycling more accessible. Additionally, brand visibility and reputation are enhanced through partnerships with businesses.

Keywords: Plastic; Sensors; Recycling; HDPE; PET.

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From Waste to Solutions: Addressing the Environmental Impact of Plastic Pens

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Abstract

Plastic pens are a major yet often ignored source of pollution. Their non-biodegradable components contribute to soil contamination, micro plastic accumulation, and landfill overflow, harming ecosystems and biodiversity. This study highlights the growing issue of plastic pen waste, particularly in academic and workplace settings, where large quantities are discarded with minimal recycling efforts. To tackle these issues, this study focuses on practical solutions. Encouraging the adoption of digital note-taking and refillable writing instruments can significantly reduce plastic waste. Establishing dedicated collection and recycling programs in schools and offices ensures proper waste management. Developing biodegradable alternatives, such as pens made from recycled paper, bamboo, or corn-starch-based plastics, provides a sustainable substitute. Additionally, regulatory measures like Extended Producer Responsibility and incentives for manufacturers to produce eco-friendly writing tools can drive systemic change. By prioritizing actionable solutions, this research emphasizes the need for immediate intervention. Implementing sustainable alternatives, raising consumer awareness, and enforcing stricter waste management policies can collectively mitigate the environmental impact of plastic pens and promote long-term ecological balance.

Keywords: Plastic Waste, Soil Pollution, Micro plastics, Sustainable Pens, Recycle.

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Quantum Machine Learning in Nanomaterials Research for Energy and Environment

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Abstract

Quantum Machine Learning (QML) revolutionizes nanomaterials research by providing precise quantum modeling and accelerating material discovery. This innovation reduces costs, enhances efficiency, and drives sustainable breakthroughs in energy, environment, and technology. The Role of Quantum Machine Learning (QML) in Advancing Nanomaterials Research for Energy and Environmental Applications. Advanced simulations are essential for designing and improving nanomaterials across various fields. By using computational tools, researchers can predict how nanomaterials interact at atomic levels, gaining insights into their behavior, reactivity, and stability under different conditions. These simulations also allow researchers to explore how changes in size, shape, or composition affect performance, cutting down on costly experimental trials. Additionally, simulations help model real-world scenarios, such as nanomaterials' interaction with pollutants, optimizing their design for tasks like water purification. They evaluate nanomaterial performance under varying conditions like temperature and pH, ensuring adaptability and robustness. The integration of artificial intelligence enhances this process by analyzing complex datasets, identifying patterns, and speeding up discoveries. By combining these advanced technologies, researchers can create tailored, cost-effective nanomaterials that are both efficient and sustainable. Quantum Machine Learning (QML) paves the way for groundbreaking advancements in nanomaterials by merging quantum precision with machine learning efficiency. It drives innovation while enabling sustainable solutions in energy, environment, and technology

Keywords: Nanomaterials, Advanced Simulations, Artificial Intelligence (AI), Sustainability, Environmental Applications, Energy Storage

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Sustainable Nanotechnology Nanorobots for Targeted Cancer Therapy

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Abstract

Objective: This study investigates nanorobots as a cutting-edge solution for targeted cancer therapy. By engineering microscopic, programmable devices to navigate the bloodstream and deliver drugs directly to tumors, researchers aim to enhance treatment efficacy while minimizing systemic side effects.

Methodology: Nanorobots are designed using biocompatible materials such as DNA, proteins, and metals. Techniques like DNA origami enable the construction of self- assembling nanostructures that recognize cancer markers. Preclinical trials incorporate magnetic, chemical, and AI-driven mechanisms to refine navigation and controlled drug release. Real-time imaging and computational modeling optimize tumor targeting and adaptive therapy.

Key Findings: Research demonstrates that nanorobots significantly improve drug delivery precision, reducing toxicity. DNA-based nanorobots successfully bind to tumor receptors, releasing therapeutic agents in response to biochemical signals. A major breakthrough involves vascular occlusion nanorobots, which selectively block blood supply to tumors, leading to effective shrinkage. AI-powered nanorobots enhance treatment adaptability by dynamically adjusting drug dosages based on tumor microenvironment analysis.

Conclusion: Nanorobots offer a transformative advancement in oncology, enabling targeted, minimally invasive, and highly efficient treatments. Challenges such as large-scale manufacturing and immune system evasion persist, but ongoing research focuses on enhancing biocompatibility and accelerating clinical trials. The integration of nanorobots with personalized medicine and AI-driven diagnostics holds the potential to redefine cancer therapy, making it more precise and patient-specific.

Keywords: Nanorobots, targeted drug delivery, cancer therapy, DNA origami, AI-driven medicine.

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Artificial Intelligence-Driven Optimization of 4D-Printed Shape Memory Materials for Next-Generation Smart Systems

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Abstract

The lack of precise control over the shape transformation, multi-stimuli responsiveness, and long-term durability of 4D-printed Shape Memory Materials (SMMs) limits their efficiency in advanced applications like soft robotics, biomedical devices, and deployable structuresThe integration of Artificial Intelligence (AI) with 4D printing is transforming Shape Memory Materials (SMMs) by enabling precise control over their shape transformation, durability, and multi-stimuli responsiveness. AI-driven simulations and machine learning models can analyze vast datasets to predict material behavior, optimize microstructures, and enhance actuation speed. This reduces energy consumption, material fatigue, and response time, making SMMs more reliable for soft robotics, biomedical devices, and aerospace applications. Additionally, AI can enable self-adaptive designs, allowing materials to reconfigure dynamically based on environmental conditions. By combining computational intelligence with advanced manufacturing, AI-driven 4D printing ensures smarter, more efficient, and highly customizable SMMs for next-generation deployable, flexible, and self-healing structuresAI-driven 4D printing has made Shape Memory Materials (SMMs) faster, more precise, and energy-efficient, improving their durability and adaptability for soft robotics, biomedical devices, and aerospace. These materials now offer real-time shape transformation, reduced fatigue, and enhanced performance, enabling next-generation smart structuresThis problem statement helps drive research, innovation, and development in 4D-printed smart materials, focusing on improving precision, adaptability, and durability. It supports advancements in soft robotics, biomedical devices, and deployable structures, guiding efforts to create more efficient and responsive materials for real-world applications.

Keywords: 4D Printing, Shape Memory Materials (SMMs), Artificial Intelligence (AI), Smart

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Graphene-Based Sensors for Environmental Monitoring

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Abstract

Graphene-based sensors offer high sensitivity for detecting pollutants in air and water. Develop a portable graphene-based sensor to monitor CO_2 and NO_2 levels in urban areas. Analyze the sensor's accuracy, response time and durability in different environmental conditions.Air pollution, particularly CO_2 and NO_2 emissions, poses serious environmental and health risks, necessitating efficient and accurate monitoring solutions. Graphene-based sensors offer significant advantages due to their high sensitivity, fast response time and excellent stability. This study focuses on developing a portable graphene-based sensor to detect CO_2 and NO_2 levels in urban environments. It is designed to operate in diverse environmental conditions, ensuring reliable real-time air quality monitoring. Key performance metrics, including accuracy, response time, and durability are evaluated under controlled and real-world scenarios. The experimental analysis demonstrates that the graphene-based sensor provides precise pollutant detection with rapid response times and long-term stability. By enabling real-time data collection, this sensor can support air quality management strategies and contribute to reducing pollution-related health risks. The study highlights the potential of graphene-based technology in advancing environmental monitoring and underscores its role in future smart city applications.

Keywords: Graphene-based sensors, CO_2 detection, NO_2 detection, Air quality monitoring, Urban pollution, Environmental monitoring, Sensor accuracy.

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Phycocyanin-Mediated Photocatalysis for Effluent Treatment: Impact on the Growth and Biochemical Profile of Hydroponically Grown Allium cepa

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Abstract

This study explores the application of phycocyanin-mediated photocatalysis for effluent treatment and its subsequent effects on hydroponically grown onions (Allium cepa). Under light irradiation, phycocyanin efficiently degrades pollutants, as demonstrated by increased degradation rates and distinct UV-Vis spectral shifts. While the treated effluent supports onion growth, initial development is slower compared to plants grown in normal water, exhibiting a reduced growth rate over three weeks. FTIR spectroscopy reveals subtle alterations in the protein secondary structure of onion pulp and leaves, suggesting molecular-level responses to residual stress or potential nutrient imbalances. These findings highlight the potential of phycocyanin-based photocatalysis for wastewater treatment; however, residual effects on plant growth indicate the need for further optimization and comprehensive biological assessments to ensure its viability for agricultural applications.

Keywords: Phycocyanin; Photocatalysis; Onion; Degradation; Effluent.

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Application of Carbon Nanotubes in the Internet

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Abstract

Objectives

This study investigates carbon nanotubes as a Enhance Internet Speed and Performance, Improve Energy Efficiency and Sustainability, Enable Advanced Wireless and 5G Networks, Strengthen Internet Security and Data Storage, Revolutionize Computing and AI for the Internet, Reduce the Size and Cost of Internet Hardware, As research advances, carbon nanotubes could revolutionize the internet's speed, efficiency, and sustainability, impacting everything from cloud computing to real-time global communication.

Methodology

Chemical vapor deposition method. Sources for carbon: The precursor for carbon nanotubes are hydrocarbon gases such as acetylene, ethylene, methane, etc. Substrate used: Substrates are materials on which the CNTS are grown. The commonly used substrates in CVD method are zeolite, silica, silicon plate coated with iron particles, etc. Catalyst used: To produce single-walled carbon nanotubes metal catalyst nanoparticles such as iron, cobalt, nickel, molybdenum, iron- molybdenum alloys, etc. are used. Sources for CVD used: Based on the heating source, the CVD can be: Thermal activated CVD which is heated by IR radiation, RF heater, etc.Photo assisted CVD which is heated by Arc lamps, CO2 laser, Argon ion laser, etc. Conditions maintained: The following conditions are maintained inside the furnace. Temperature: 500–900°C. Inert gas atmosphere: Argon gas.

Conclusion

The applications of carbon nanotubes in the Internet aim to revolutionize connectivity, security, speed, and sustainability while supporting emerging technologies like 5G, AI, and quantum computing.

Keywords: Carbon nanotubes, Zeolites, Data storage, catalyst

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Nanotechnology - Driven Tissue Regeneration: The Role of Nanobots in Cellular Repair

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Abstract

This study explores the advent of nanotechnology has revolutionized the field of regenerative medicine, introducing nanobots as groundbreaking tools for tissue repair and healing at the cellular level. This paper explores the innovative application of nanobots in facilitating tissue regeneration through precision-driven mechanisms. Nanobots are engineered to act as intelligent carriers, capable of delivering growth factors, stem cells and bioactive molecules directly to damaged tissues, thereby enhancing cell proliferation, angiogenesis and structural remodeling. Additionally , these nanoscale devices can function as biodegradable scaffolds, providing mechanical support and biochemical cues essential for new tissue formation. Beyond delivery systems, nanobots can clear cellular debris, stimulate electrical signals to activate regenerative pathways, and interact dynamically with host cells to accelerate natural healing processes. Despite challenges such as biocompatibility, immune response management, and precise control mechanisms, the integration of nanobots into regenerative therapies holds immense potential for personalized medicine. From wound healing to neural repair and organ regeneration, nanobots are poised to redefine the future of tissue engineering.

Keywords: TISSUE REGENERATION; CELL REPAIR ; TISSUE ENGINEERING; CELL PROLIFERATION

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Nanotechnology for Removing Contaminants from Dyeing Industry Wastewater

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Abstract

Nanotechnology plays a crucial role in water purification by improving filtration, adsorption, and disinfection processes. It enhances the removal of heavy metals, pathogens, organic pollutants, and microplastics from water.

The textile and dyeing industries produce large volumes of wastewater containing toxic dyes, heavy metals, and organic pollutants. These contaminants pose severe environmental risks, including water pollution, ecosystem damage, and human health hazards. Traditional wastewater treatment methods such as coagulation, adsorption, and biological treatment often fail to completely remove these pollutants, leading to persistent contamination.

Nanotechnology offers a highly effective alternative for wastewater treatment due to the high surface area, reactivity, and adsorption capacity of nanomaterials. Various types of nanoparticles have been developed for dye and metal removal, including carbon-based, metal oxide, and silica-based nanomaterials.

Nanotechnology provides a sustainable and cost-effective solution for removing dyeing industry pollutants, improving wastewater quality, and reducing environmental impact. Future research aims to develop biodegradable nanomaterials and energy-efficient processes for large-scale industrial applications.

Keywords: Nanotechnology, Pollutants, Water, Treatment, Industries

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Smart Plastic Exchange Vending Machine: A Sustainable Solution for Automated Recycling

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Abstract

A Plastic Exchange Vending Machine is designed to facilitate the collection, processing, and recycling of plastic waste through an automated three-step procedure. The disposal of plastic waste is encouraged by rewarding users, and efficient recycling is ensured through advanced technology. In the first step, plastic waste, including bottles, containers, and wrappers, is inserted into the machine by users. AI-powered sensors are utilized to scan and identify the type of plastic, such as PET, HDPE, or PP. If non-recyclable plastic is detected, it is rejected with a notification to the user. During the second step, sorting and shredding are carried out automatically. The identified plastic types are categorized, and a built-in shredder is used to convert the plastic into small flakes or pellets. A filtration system is included to eliminate labels, caps, and other contaminants, ensuring a cleaner recycling process. In the final step, the shredded plastic is melted and processed into recyclable filament. The collected plastic flakes are further utilized by local recycling companies for various applications, such as the production of new plastic bottles, the creation of construction materials and furniture from HDPE, or the transformation of PET into polyester fibers for clothing. The implementation of this vending machine offers numerous advantages. Natural resources such as energy, water, and land are conserved through recycling. Local economies are supported by engaging businesses and organizations in the recycling process. Revenue is generated by selling the collected recyclable materials to processing units. The convenience of plastic disposal is provided, making recycling more accessible. Additionally, brand visibility and reputation are enhanced through partnerships with businesses.

Keywords: Plastic, Sensors, Recycling.

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Advanced Sensors

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Abstract

Advanced sensors are highly sophisticated devices that detect and measure physical phenomena with enhanced accuracy and real-time data capabilities. Utilizing cutting-edge technologies such as MEMS, optical sensors, and IoT-enabled devices, they play a vital role in industries like healthcare, automotive, industrial automation, and environmental monitoring.

Key trends in advanced sensors include miniaturization, IoT integration, AI-driven analytics, and environmental sensitivity, enabling smarter decision-making and automation. Applications range from wearable health monitoring and vehicle safety to smart homes and industrial automation. Future advancements will focus on 5G connectivity, advanced materials, personalization, and sustainability, while challenges such as data security, interoperability, and cost remain critical considerations.

As advanced sensors continue to evolve, their impact on society is profound, enhancing safety, efficiency, and quality of life. Regulatory measures must adapt to ensure data privacy, performance standards, and safety protocols. With ongoing innovation, advanced sensors are set to revolutionize technology, shaping a more connected and intelligent world.

Keywords: Advanced sensors, IoT, AI, MEMS, smart technology, industrial automation, healthcare, sustainability, data security.

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'Carbon – based materials'

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Abstract

Carbon-based materials have emerged as a game-changer in various fields, including energy, electronics, and biomedical applications. These materials, including graphene, carbon nanotubes, and fullerenes, exhibit exceptional mechanical, thermal, and electrical properties. This poster highlights the synthesis, properties, and applications of carbon-based materials, with a focus on their potential to revolutionize energy storage, water purification, and biomedical devices. By highlighting the versatility and transformative potential of carbon-based materials, this poster aims to inspire further interdisciplinary research and innovation, bridging the gap between fundamental science and real-world applications.

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An Introductory Study On Disaster Debris Search Module Using Vision Transformer (ViT)

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Abstract

Many regions, especially people in high-risk zones, lack the necessary infrastructure, resources, or expertise to prepare for or respond to disasters adequately. In addition, the aftermath of such events can lead to population deduction, destruction of vital services, and long-lasting environmental degradation. To avoid these situations, the DDSM (Disaster Debris Search Module) comes to help. This bot has a special WHEEL SYSTEM, which allows the bot to move freely through the debris. The DDSM does not have a definite shape, which allows the bot to move through any debris blocking its way. The entire bot is made up of silicon and the working components are placed safely in an aluminum capsule. The DDSM uses ViT (vision transformer), a deep learning model that is very efficient and can multitask easily, which helps the bot to identify and inform about the person or people stuck between landslide debris (or) stuck in a borewell hole (or) stuck in a dark cave. The DDSM will analyze the debris and search for people or any living organisms stuck in the debris. The bot will help the workers as it works very fast and decreases the search radius drastically due to the advanced technologies used in it. The Tech stack is easily implementable and readily available. DDSM is a Onetime investment to save multiple lives in the future in times in crisis.

Keywords: DDSM-Disaster Debris Search Module; ViT (Vision Transformer); Wheel System; Silicon; Aluminum

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Smart and Sensor Materials: Innovations in Responsive Materials for Adaptive Systems and Technologies – An Overview

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Abstract

Smart and sensor materials are innovative materials that can sense and respond to external stimuli, such as temperature, pressure, light, magnetic fields in a reversible manner. The development of these materials has revolutionized various industries, including healthcare, aerospace, automotive, and electronics, by enabling more efficient and adaptive systems. Smart materials, such as shape memory alloys (SMAs), piezoelectric materials, and thermochromic polymers, are designed to change shape, color, or stiffness in response to stimuli. SMAs can "remember" a particular shape and return to it after deformation when subjected to a specific temperature, are used as actuators in robotic systems or self-healing structures. Piezoelectric materials generate an electric charge when mechanically deformed and are widely used in sensors, actuators, and energy harvesting devices. But, Sensor materials, are primarily designed to detect and respond to external stimuli, providing real-time data on environmental conditions. These materials are integral in applications such as environmental monitoring, healthcare diagnostics, and structural health monitoring. Semiconductor-based sensors detect gas or humidity levels and polymer-based sensors for detecting mechanical strain. The integration of smart and sensor materials into everyday devices has led to the development of advanced systems with enhanced performance, adaptability, and energy efficiency. With ongoing advancements in nanotechnology and materials science, the potential applications of these materials continue to expand, offering promising solutions to current technological challenges and opening the door to future innovations in smart technologies and systems. Hence, smart and sensor materials represent a critical frontier in material science, with profound implications for the development of adaptive, intelligent systems that improve the functionality, efficiency, and sustainability of various applications.

Keywords: Smart materials; Sensor materials; Shape memory alloys (SMAs); Piezoelectric materials; Thermochromic polymers; Structural health monitoring; Energy harvesting

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Engineering Perspectives on Autonomous Delivery Vehicles Transform Logistics and Supply Chain Efficiency

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Abstract

Autonomous Delivery Vehicles (ADV) are transforming the logistics landscape by enhancing efficiency, safety, and sustainability. ADV is a compact, electric, self-driving vehicle designed specifically for last-mile deliveries in urban environments. By leveraging cutting-edge hardware and software systems, these vehicles ensure safe, contactless delivery while minimizing human intervention. The ADV's hardware system integrates a robust vehicle platform equipped with motors, multiple sensors (LiDAR, cameras, ultrasonic sensors, radar sensors, GPS modules, IMU, and encoders), and a reliable power supply. These components work in tandem to support real-time navigation, object detection, and environmental awareness. The software stack features a Linux-based operating system, SLAM-based navigation algorithms, perception systems, and simulation tools to enable precise control and decision-making. Key features of the ADV include its self-driving capabilities, modular storage with multiple temperature zones for diverse deliveries, and intelligent traffic and pedestrian awareness systems. The inclusion of swarm coordination further enhances delivery efficiency by allowing multiple ADVs to operate collaboratively. Additionally, eco-friendly power solutions and adaptive terrain control ensure sustainable operation in various environments. Despite these advancements, several challenges must be addressed. Regulatory approvals require collaboration with city authorities to ensure compliance with local laws. Navigation in crowded areas is managed through advanced AI algorithms for real-time decision-making. Public acceptance remains vital, requiring community awareness campaigns and trials to build trust and familiarity. With increasing reliance on technology and the demand for contactless deliveries rising, ADVs are poised to become integral to modern logistics. These vehicles will not only reduce costs but also enhance urban mobility and sustainability, representing a significant step forward in automated delivery solutions.

Keywords: Autonomous Delivery Vehicles (ADV): Logistics; Software stack; LiDAR; SLAM (Simultaneous Localization and Mapping); Navigation algorithms.

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Preliminary Studies On Energy Storage Materials for Sustainable Renewable Energy System

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Abstract

Energy storage materials are essential for the efficient management, distribution, and utilization of energy, particularly in the growing field of renewable energy systems. As the demand for clean and sustainable energy solutions increases, the role of these materials in capturing, storing, and releasing energy becomes even more critical. One of the biggest challenges in renewable energy is the intermittent nature of sources like solar and wind, which do not generate power consistently. Energy storage materials help bridge this gap by ensuring that excess energy produced during peak times can be stored and used when generation is low. The most widely studied and utilized energy storage materials include batteries such as lithium-ion and sodium-ion, along with supercapacitors and phase change materials (PCMs). Each of these materials offers distinct advantages in terms of energy density, charge/discharge rates, cycle life, efficiency, and cost-effectiveness. Lithium-ion batteries, for instance, are widely used in electric vehicles and portable electronics due to their high energy density and long lifespan. Sodium-ion batteries present a promising alternative, offering lower costs and improved sustainability. Meanwhile, supercapacitors provide rapid charge and discharge capabilities, making them ideal for applications requiring bursts of power. Phase change materials, on the other hand, store energy through latent heat absorption and release, finding applications in thermal energy management. Recent advancements focus on enhancing performance, scalability, and sustainability, higher energy densities, faster charge/discharge rates, and longer operational lifetimes. Additionally, significant efforts are directed toward environmentally friendly solutions, reducing reliance on rare or toxic materials, and improving the recyclability of storage systems. As energy storage becomes increasingly important for applications like electric vehicles, grid stabilization, and portable electronics, continuous innovation in advanced materials is crucial for ensuring a sustainable and energy-efficient future.

Keywords: Energy storage; Super-capacitors; Phase change materials; Renewable energy; Energy density; Sustainability.

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Rhizobium-Based Biofuel: A Sustainable and Cost-Effective Alternative for Clean Energy

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Abstract

This research work aims to develop a cost-efficient and sustainable Rhizobium-based biogas system as an alternative to conventional biogas production methods. Rhizobium, a nitrogen-fixing bacterium found in the root nodules of leguminous plants, plays a crucial role in soil enrichment and nitrogen fixation, benefiting agricultural productivity. Beyond its well-established agricultural advantages, Rhizobium also produces small amounts of hydrogen gas as a byproduct of its metabolic processes. This hydrogen can be captured and utilized as a biofuel, presenting a promising avenue for renewable energy generation. Additionally, the ammonia fixed by Rhizobium can be further processed into bio-ammonia, offering another viable energy source that can be integrated into sustainable fuel production systems. Despite its potential, Rhizobium-based biofuel production faces several challenges, including low hydrogen yield, complex cultivation processes, and the requirement for a controlled environment to optimize gas production. To overcome these limitations, our research incorporates advanced bio-hydrogen production techniques such as dark fermentation, bio-photolysis, and microbial electrolysis. These approaches aim to enhance hydrogen extraction efficiency, improve overall yield, and optimize sustainability. This innovative system presents a dual benefit for farmers, as it not only enhances soil fertility but also enables biofuel generation, reducing dependency on fossil fuels and contributing to energy security. While large-scale urban implementation may require infrastructure modifications, rural and suburban areas are better suited for immediate adoption due to the availability of farmland and agricultural waste. By offering a low-cost, efficient, and scalable solution, this project aims to promote sustainable energy adoption, making biofuels more accessible while supporting the global transition to cleaner, greener, and more renewable energy sources. This research contributes to a more environmentally friendly and energy-secure future for both urban and rural communities.

Keywords: Rhizobium; Biofuel; Biogas; Hydrogen Production; Sustainable Energy; Renewable Energy.

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Scientific Approach to Crime Management and Weapon Detection Using Drone Technology

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Abstract

Drones are revolutionizing crime management and threat detection by offering faster, safer, and more flexible solutions compared to traditional methods. Law enforcement agencies increasingly rely on drones for real-time surveillance, enabling them to monitor vast and hard-to-reach areas such as busy urban centers or remote locations. Equipped with high-resolution cameras and advanced sensors, drones assist in detecting unusual activities and making informed decisions. In weapon and bomb detection, drones play a crucial role by utilizing specialized tools such as explosive detection sensors, thermal imaging, and radioactive material detectors. These technologies help identify potential threats without putting officers at risk. Additionally, drones can carry bomb disposal equipment or deploy small robotic units to neutralize hazards efficiently. The advantages of drones in law enforcement include real-time information gathering, enhanced officer safety, cost-effectiveness, and quick response capabilities. However, some challenges remain, such as limited battery life, susceptibility to harsh weather conditions, technical failures, and concerns over privacy and data security. Addressing these issues is essential for maximizing the effectiveness of drones in crime prevention and public safety. Looking ahead, advancements in drone technology will further improve their threat detection capabilities, autonomy, and operational efficiency. Alongside technological progress, the development of regulatory frameworks and ethical guidelines will be crucial to ensuring responsible drone use. As these systems continue to evolve, drones will play an increasingly vital role in modern law enforcement, providing innovative solutions to crime prevention and emergency response while balancing security and privacy considerations.

Keywords: Drones; Crime Management; Weapon Detection; Surveillance; Real-Time Monitoring; Security Technology; Remote Sensing.

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Enhancing Agricultural Efficiency and Sustainability Through Smart Greenhouse Technology

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Abstract

A smart greenhouse is a sophisticated agricultural system that combines technology to develop a perfect condition for plant growth. Contrary to conventional greenhouses, smart greenhouses employ sensors, automation, and artificial intelligence (AI) to measure and control variables such as temperature, humidity, soil moisture, and light levels. The real-time adjustments optimize plant growth, eliminate resource wastage, and minimize human intervention. This paper discusses the use of smart greenhouses through Internet of Things (IoT), cloud computing, and AI-based automation. IoT sensors continuously gather environmental information, which is processed to maximize irrigation, lighting, and climate control. Compared to traditional greenhouses, smart greenhouses significantly reduce human intervention, ensuring optimal conditions for crops while minimizing water and energy waste. Automated irrigation and climate control systems adjust based on real-time data, leading to higher yields and sustainability. Additionally, integration with cloud computing provides valuable insights and historical data for precision farming. Computerized systems automatically regulate conditions in real-time, providing plants with the precise quantity of water, nutrients, and light required for healthy development. AI models also forecast plant disease and recommend remedial measures before problems arise. Sustainability is one of the most important benefits of smart greenhouses. By optimizing water and energy use through precision farming, they make agriculture more efficient. Though they have advantages, smart greenhouses are hampered by factors like high initial installation costs, poor connectivity in rural locations, and the requirement for technical skills. Nevertheless, continuous developments in AI, IoT, and edge computing are making these systems cheaper and easier to use. As technology advances further, smart greenhouses are capable of transforming modern-day agriculture through boosting productivity, saving resources, and making it possible to farm throughout the year. With more development, such systems may significantly contribute to mitigating food security and climate change issues worldwide.

Keywords: Hydroponics; Aeroponics; Vertical Farming; Smart Irrigation; Nutrient Film Technique (NFT); Efficient Greenhouse; Resilient Farming.

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Insight into the Blue Eyes Technology: Revolutionizing Human-Machine Interaction

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Abstract

Improvisation in human health is much needed and is crucial to analyze the well-being and their medical conditions. Therefore, to improvise and to combat the problems in analyzing Health problems, the "Blue Eyes Technology" is evolved. This technology refers to a field of study and development focused on creating computational machines with human-like perceptual and sensory abilities, enabling them to understand and interact with humans through non-obtrusive methods like cameras, microphones, and analysis of physiological data. The primary goal is to bridge the gap between humans and computers, allowing for more natural and intuitive interaction. Blue Eyes Technology aims to equip machines with the ability to "see" (through cameras), "hear" (through microphones), and potentially "feel" (through physiological sensors) like humans. The technology seeks to enable computers to understand a user's actions, intentions, and even emotional state based on their facial expressions, eye movements, speech, and other physiological cues. However, the technology relies on unobtrusive methods, meaning the sensors and systems are designed to be discreet and not interfere with the user's normal activities. Data Acquisition Unit (DAU)-collects data from various sensors, including cameras, microphones, and potentially other physiological sensors. And Central System Unit (CSU): The CSU analyzes and processes the data collected by the DAU, interprets the user's actions and emotions, and then responds accordingly.

Keywords: Human-computer interaction; facial recognition; eye movement tracking; Data Acquisition Unit (DAU); Central System Unit (CSU); Biometrics; Healthcare monitoring.

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A Brief Review on Advanced Materials For Environmental Remediation Through Sustainable Pollution Mitigation

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Abstract

Environmental pollution remains a persistent global challenge, driven by industrial activities, rapid urbanization, and agricultural expansion. Traditional treatment methods, including chemical treatments and physical filtration, often suffer from limitations such as high costs, inefficiency, and secondary environmental effects. Consequently, the development of advanced, sustainable, and cost-effective treatment strategies has become a priority in environmental science. This study evaluates the effectiveness, cost efficiency, and environmental impact of various advanced materials for pollution remediation. These materials include adsorbents (e.g., activated carbon, biochar), catalysts (e.g., titanium dioxide), nanomaterials (e.g., graphene, metal-organic frameworks), and bio-based materials. Among these, nanomaterials—particularly metal-organic frameworks (MOFs) and carbon-based structures—stand out due to their high surface area, chemical stability, and porosity. These properties enable superior adsorption and catalytic performance, making them highly effective in removing organic pollutants, heavy metals, and contaminants from air, water, and soil. Additionally, catalysts such as titanium dioxide facilitate photocatalytic degradation, allowing pollutants to break down under mild conditions, thereby reducing environmental risk. This process not only enhances pollutant removal but also minimizes the formation of hazardous byproducts. Bio-based materials, including microbial consortia and biopolymers, offer an eco-friendly alternative by harnessing natural biodegradation processes. These materials effectively remove pollutants while mitigating secondary environmental effects, presenting a sustainable long-term approach to environmental treatment. Overall, integrating advanced materials into pollution treatment strategies holds great potential for improving remediation efficiency while reducing environmental impact. Future research should focus on optimizing these materials for large-scale applications, enhancing cost-effectiveness, and ensuring their safe implementation in various environmental settings. By adopting such innovative approaches, we can develop more sustainable solutions for addressing pollution and safeguarding ecological balance.

Keywords: Environmental pollution; Advanced materials ; Nanomaterials ; Adsorption ; Photocatalysis; Bio-based materials; Remediation efficiency

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An Innovative AI Discourse Solution for the Banking Sector

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Abstract

A chatbot in the banking sector is an AI-powered tool designed to make banking easier and more convenient for both customers and bank employees. It allows the users to perform tasks by providing financial advice through simple text or voice conversations, seeking solutions for their queries, such as how to fill the challan, cheque, how to deposit and credit their money, and sending remainders for due payments, minimum balances, or upcoming deadlines for any payments. The AI chatbot is specifically to allow users to clarify their questions related to banking sector and provides relevant information. It also ensures users' security and privacy. In banking applications, it will be very useful that customers need not needed to contact the bank for their doubts. It is also helpful for banking employees to satisfy the needs of the customers through online. The AI chatbot provides 24/7 support and personalized services for the customers, which cannot be provided by the human employees. Our chatbot includes GDPR (General Data Protection Regulation) compliance. It also ensures that the responses are quick and easily understood by customers. It provides information to the customers in their native language. It also helps in customers report issues and track their resolution status. It assists the users in identifying fraud activities like scams and includes warning alerts. The implementation of AI chatbots in the banking sector is expected to be a significant trend in the near future.

Keywords: Chatbot; AI powered tool; Banking applications; General Data Protection Regulation (GDPR); Natural language.

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About the Institution

St. Joseph's College of Engineering, established in 1994, is celebrating 31 years of distinguished academic performance and leadership in Engineering Education. The Institution is regarded as one of the foremost Autonomous Engineering Colleges in Tamil Nadu, affiliated with Anna University, Chennai, and has received accreditation from the NBA. Each year, a significant number of students from the college achieve notable National and International accolades for their projects, cultural contributions, and athletic successes. Many graduates find employment with leading organizations and gain admission to prestigious universities both in India and abroad. The college promotes a culture of continuous support, enabling students to discover their potential and excel across various disciplines, thereby ensuring their success in both academic and professional realms.

About the Department

The Department of Science has been an integral part of the college since its establishment, playing a key role in fostering academic and research excellence. It is home to 26 highly accomplished and dedicated faculty members who bring a wealth of expertise in diverse specializations across Physics and Chemistry. The faculty members, many of whom hold doctoral degrees, are sincerely committed to provide high-quality education and mentorship, ensuring that students receive both theoretical knowledge and practical insights. The Department has successfully acquired the status of Research Centre. It has well established and fully equipped laboratories which enhances the Student's and Research scholar's practical skills and provide hands on experience with analytical instruments.

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