# CHEMFLUX 13.0

## Create, Enhance & Sustain

## A National Level Technical Symposium

## Theme: Smart & Sustainable

**25 – 27 March 2026**

**SRM INSTITUTE OF SCIENCE AND TECHNOLOGY**

Department of Chemical Engineering


EDITORS

Dr. K. SELVAM
Dr. P. MUTHAMILSELVI
Dr. V. GANESH



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INTERNATIONAL BOOK & JOURNAL PUBLISHER

# THREE DAY NATIONAL LEVEL STUDENTS TECHNICAL SYMPOSIUM CHEMFLUX 13.0 BASED ON THE THEME SMART & SUSTAINABLE

Organized by

Department of Chemical Engineering, College of Engineering and Technology
SRM Institute of Science and Technology, Kattankulathur - 603 203.
Chengalpattu District, Tamil Nadu, India


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SRM Institute of Science and Technology, Kattankulathur.

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**CHEMFLUX 13.0**
Create, Enhance & Sustain

A National Level Technical Symposium

Theme: Smart & Sustainable

Date: 25 – 27 March 2026
Venue: Sir Visveswarayya Hall, CRC Block, Main Campus, SRMIST


# Department of Chemical Engineering
# SRM Institute of Science and Technology
# SRM Nagar, Kattankulathur – 603203
# Chengalpattu District, Tamil Nadu
# March 2026

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# ABSTRACT BOOK

Organized by

Department of Chemical Engineering
SRM Institute of Science and Technology, Kattankulathur
March 2026

## PREFACE

**Dr. S. Vishali, Head of the Department, Chemical Engineering**

Dear Readers,

It is my pleasure to present the Proceedings of **CHEMFLUX 13.0 – Create, Enhance & Sustain**, a National Level Technical Symposium organized by the Department of Chemical Engineering, SRM Institute of Science and Technology, Kattankulathur, during **25–27 March 2026**. Centered on the theme **"Smart & Sustainable,"** the symposium provided a platform for students, researchers, academicians, and industry professionals to share innovative ideas and sustainable engineering solutions.

The abstracts compiled in this volume cover a wide range of emerging areas, including hydrogen energy, sustainable materials, carbon capture, wastewater treatment, biotechnology, artificial intelligence, process optimization, and circular economy approaches. These contributions reflect the creativity, technical competence, and commitment of young researchers toward addressing contemporary industrial and environmental challenges.

I sincerely appreciate all authors, reviewers, faculty members, sponsors, and organizing committee members whose efforts contributed to the success of CHEMFLUX 13.0. I am confident that this proceedings volume will serve as a valuable source of knowledge and inspire further research, innovation, and collaboration in the pursuit of a sustainable future.

## About the SRMIST

SRM Institute of Science and Technology is one of the top ranking universities in India with over 60000+ full time students and more than 4460+ faculty across all the campuses – Kattankulathur, Ramapuram, Vadapalani, Baburayanpettai Campus – all in and around Chennai, Tiruchirappalli (in TN), Modinagar (in UP) & Sonepat (in Haryana) – both of which are located near Delhi NCR, Amaravati (in AP), Gangtok (in Sikkim) – offering a wide range of undergraduate, postgraduate and doctoral programs in six Faculties – Engineering & Technology, Management, Medicine & Health Sciences, Science & Humanities, Law and Agricultural Sciences.

**Vision**

To emerge as a world-class university in creating and disseminating knowledge and providing students a unique learning experience in Science, Technology, Medicine, Management, and other areas of Scholarship that will best serve the world and for the betterment of mankind.

**Mission**

MOVE UP through international alliances and collaborative initiatives to achieve global excellence.

ACCOMPLISH A PROCESS to advance knowledge in a rigorous academic and research environment.

ATTRACT AND BUILD PEOPLE in a rewarding and inspiring environment by fostering freedom, empowerment, creativity, and innovation.

**Ranking**

| | | | |
|---|---|---|---|
| Accredited by NAAC with A++ Grade | National Board of Accreditation (NBA) | Engineering Accreditation Commission of ABET | 11th In University |
| 1001 – 1200 in University World Ranking | 4th in 2025 | 4th in 2021 | 1001 – 1200 in World University (Combined) |
| Overall 30 | 753 in Global | 901 – 1000 in World Ranking | |

## About the Department

The Department of Chemical Engineering was established in 1995 as part of SRM Engineering College and started functioning under SRM Institute of Science and Technology (Deemed to be University) from the academic year 2003 – 2004. The department offers B.Tech., M.Tech., and Ph.D. programs. The B.Tech. in Chemical Engineering is accredited by the National Board of Accreditation (NBA) for three years, from July 2024 to June 2027. The Department of Chemical Engineering, SRMIST, is ranked in the 251–300 band globally in the QS World University Rankings and in the 401–500 band in the Shanghai Ranking (ARWU) for Chemical Engineering. The department has highly qualified faculty members from prestigious institutions with extensive experience in both academia and industry. Students are prepared for a wide range of career opportunities in industries such as refineries, fertilizers, pharmaceuticals, food processing, water treatment, environmental services, safety, energy, and IT-enabled sectors. To ensure students are up-to-date with technological advancements, the department regularly revises its curriculum, integrating core chemical engineering concepts with industry needs. This approach equips students with modern tools and sophisticated instrumentation, enhancing their career prospects in the field.

**Department of Chemical Engineering**

**Vision**

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To inculcate social responsibility in learners and train them to contribute effectively to science and society.

## About Chemflux 13.0

Chemflux is an annual national-level technical symposium organized by the Department of Chemical Engineering at SRM Institute of Science and Technology since 2014. Before that, the same event was held under the name Chemference. This event provides a platform for students across the country to showcase innovative ideas, compete for exciting prizes, and address real-world challenges through technical presentations, workshops, and non-technical activities. Featuring lectures by industry experts, Chemflux inspires the next generation of engineers and scientists. It encourages participation from all engineering and science disciplines, making it an opportunity to learn, compete, and innovate in a celebration of knowledge and creativity.

**Why not Smart today for Sustainable tomorrow?**

Smart Sustainable for the Future integrates advanced technology with responsible engineering to address growing industrial and environmental challenges. It emphasises intelligent system design, energy efficiency, and optimal resource utilisation. By minimising waste and emissions, it supports environmentally compliant and economically viable solutions. Smart Sustainable approaches enable data-driven decision-making and process optimisation. This ensures long-term industrial growth while safeguarding natural resources. Ultimately, it prepares engineers to build resilient systems for future generations.

Topic of the discussions include as paper and poster presentations are as follows: Smart Process Intensification (PI) & Optimisation, Circular Economy & Waste Valorisation, Green Chemistry & Advanced Solvent Technology, Sustainable Water Engineering & Marine Systems, Energy Transition: Hydrogen, Biofuels & Batteries, Sustainable Materials, Polymers & Bio-Tech., Green Pharma & Life Sciences Innovation, Heat Management & Utilities Integration, Process Safety, Infrastructure & Policy, Frontier Chem-Engg.: Space, Defence & Emerging Tech

Convenors of Chemflux 13.0

**Dr. S. Vishali**
**Dr. K. Selvam**
**Dr. P.Muthamil Selvi**
**Dr. V. Ganesh**

# Brochure Copy of Chemflux 13.0

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Mr. Philip Vattuthottam Paul (6012695721)
Ms. Y Justine Staines (9424224147)
Chemical Engineering, SRMIST

**CHEMFLUX 13.0 – Registration & Payment Details**

**Registration Deadline: March 15th, 2026**

Participants must complete their registration for CHEMFLUX 13.0 through the official Google Form using the link below:

**Link: https://forms.gle/4Uh4ksD8anCvL8rk9**

Please fill out and submit the Google form if all entries are correct, including payment. Your payment covers participation, refreshments, and both Technical and Non-Technical events. If any correction or discussions please contact
**Mr. Mukunthan R. Contact: 9159664040**

Accommodation will be allocated on a first-come, first-served basis (payment will be as per norms)

**Bank Account Details**

Account Name : CHEMICAL ENGG SRMIST
Account Number : 7111751087
Bank Name : Indian Bank
IFSC Code : IDIB000S181
Branch : SRM University, Kattankulathur, SRM Nagar, Potheri

The Total Prize Money is Valued at Rs. 50,000/-

Once the organizing committee successfully verifies the payment, an **official confirmation** email will be sent to your registered email ID.

| Non-Technical Events | Registration Fees (INR) |
|---|---|
| Cricket | Rs.1800 per team (11 member) |
| Badminton | Rs.250 |
| Chess | Rs.150 |
| E sports | |
| 1. BGMI (Per Squad) | Rs.200 |
| 2. Free Fire (Per Squad) | Rs.200 |
| 3. Clash Royale | Rs.100 |
| Capture the content | Rs.200 |
| Whodunnit? | Rs.150 |
| Ethics jury | Rs.150 |

| Technical Events | Registration Fees (INR) (IIChe Members) | Registration Fees (INR) (Non-IIChe Members) |
|---|---|---|
| Workshops (Hands-on)<br>i. Process Simulation using Aspen Plus<br>ii. Membrane Fabrication<br>iii. OpenFOAM (Open-Source CFD Software) | i. Rs.400<br>ii. Rs.400<br>iii. Rs.400 | i. Rs.450<br>ii. Rs.450<br>iii. Rs.450 |
| Paper presentation | Rs.200 | Rs.250 |
| Poster presentation | Rs.200 | Rs.250 |
| Block and tackle | Rs.150 | Rs.150 |
| Chem E quiz | Rs.150 | Rs.150 |
| Hackathon 3 rounds | Rs.500 per team (Max 3 member) | Rs.600 per team (Max 3 member) |
| Chem E Auction | Rs.300 per team (Max 3 member) | Rs.350 per team (Max 3 member) |
| Combo (Any 2 events: Paper/Poster presentation) | Rs.350 | Rs.400 |
| Combo (Any 2 workshops) | Rs.500 | Rs.700 |

SRM

Department of Chemical Engineering
College of Engineering and Technology
SRM Institute of Science and Technology
Kattankulathur - 603 203, Chengalpattu District, Tamil Nadu, India.

Organizes a
Three Day
National Level Students Technical Symposium

# Chemflux 13.0

Create, Enhance, Sustain

Based on the theme
**Smart & Sustainable**
on
**25,26 & 27 March 2026**



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## About the Department

The Department of Chemical Engineering was established in 1985 as part of SRM Engineering College and began functioning under SRM Institute of Science and Technology (Deemed to be University) in the academic year 2003–2004. It offers Bachelor of Technology (B.Tech.), Master of Technology (M.Tech.), and Doctor of Philosophy (Ph.D.) programs. The B.Tech. program is accredited by the National Board of Accreditation (NBA) from July 2024 to June 2027. The faculty consists of highly qualified individuals with doctoral degrees from prestigious institutions such as Anna University, NIT, IIT, and IISc, along with significant industrial experience. The department boasts an 80.08% placement rate, with 24 dream job offers across various sectors, including refineries, pharmaceuticals, and environmental services. To ensure that students remain current with technological advancements, the curriculum is regularly updated to align with industry needs, equipping them with modern tools and instrumentation. Additionally, industry-collaborated value-added courses are provided to enhance students' readiness for the workforce. In Shanghai's global ranking, the department ranked 401-500 globally and 12-15 in India.

## Vision

Utilize Chemical Engineering and Technology to ensure overall socio- economic growth, welfare, and progress of Indian society and the World-at- large by supporting Academia, Industries through Research and Development, Consultancy and graduating high-quality Chemical Engineers.

## Mission

- To facilitate high quality education, well grounded in the fundamental and applied areas of engineering necessary for learners to contribute effectively to chemical and allied industries.
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## Call for Papers

CHEMFLUX 13.0 is themed "Smart Sustainable," reflecting present progress and future prospects. Original research contributions are invited for presentation in selected areas.

- Smart Process Intensification (PI) & Optimisation
- Circular Economy & Waste Valorisation
- Green Chemistry & Advanced Solvent Technology
- Sustainable Water Engineering & Marine Systems
- Energy Transition: Hydrogen, Biofuels & Batteries
- Sustainable Materials, Polymers & Bio-Tech.
- Green Pharma & Life Sciences Innovation
- Heat Management & Utilities Integration
- Process Safety, Infrastructure & Policy
- Frontier Chem-Engg.: Space, Defence & Emerging Tech.

## Guidelines for Abstract Submission

The main text and references for the abstract must be typed using Times New Roman, font size 12, and 1.15 line spacing. The abstract must not exceed 300 words. Abstracts should be submitted by email to chemflux13@srmist.edu.in.

**Last date for registration: 15th March 2026**

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# Programme Schedule of Chemflux 13.0

Program Schedule - Chemflux 13.0
March 25 – 27, 2026
Department of Chemical Engineering
SRM Institute of Science and Technology

| Day 1| 25th March 2026 | Wednesday | |
|---|---|---|
| 9:00 – 10:30 am | Inauguration Ceremony | Ramachandra Auditorium |
| 10:30 – 11:00 am: Tea Break | | |
| 11:00 – 1:30 pm | Paper Presentation | Ramachandra Auditorium |
| 11:00 – 4:00 pm | Workshop: Process Simulation using Aspen Plus | Product Development Lab |
| 11:00 – 12:30 pm | Clash Royale | M13 |
| 12:30 – 1:30 pm: Lunch Break | | |
| 1:30 – 2:30 pm | Poster Presentation | 1st Floor Hallway |
| 1:30 – 2:30 pm | BGMI | M13 |
| 2:30 – 3:00 pm: Tea Break | | |
| 3:00 – 4:00 pm | Whodunnit | M14 |
| 3:00 – 4:00 pm | FreeFire | M13 |

| Day 2 | 26th March 2026 | Thursday | |
|---|---|---|---|
| 9:00 – 12:30 pm | Hackathon (Round 1) | M15 |
| 9:00 – 12:30 pm | Chem E Auction | M14 |
| 9:00 – 4:00 pm | Workshop: Open FOAM | Department Conference Room |
| 9:00 – 4:00 pm | Cricket | Dental College Ground |
| 10:30 – 11:00 am: Tea Break | | |
| 12:30 – 1:30 pm: Lunch Break | | |
| 1:30 – 4:00 pm | Hackathon (Round 2) | M15 |
| 1:30 – 2:30 pm | Chem E Quiz | M14 |
| 1:30 – 4:00 pm | Badminton | Dental College Ground |
| 2:30 – 3:00 pm: Tea Break | | |
| 3:00 – 4:00 pm | Block and Tackle | M14 |

| Day 3 | 27th March 2026 | Friday | |
|---|---|---|---|
| 9:00 – 12:30 pm | Hackathon (Round 3) | M15 |
| 9-00 – 4:00 pm | Workshop: Membrane Separation | Industrial Visit: GES KO Membranes |
| 9:00 – 10:30 am | Paper Presentation | M14 |
| 9:00 – 10:30 am | Chess | M13 |
| 10:30 – 11:00 am: Tea Break | | |
| 11:00 – 12:30 pm | Ethics Jury | M14 |
| 11:00 – 12:30 pm | Poster Presentation | 1st Floor Hallway |
| 12:30 – 1:30 pm: Lunch Break | | |
| 1:30 – 2:30 pm | Capture the Content | M14 |
| 2:30 – 4:00 pm | Valedictory Ceremony | Vishweshwaraya Hall |

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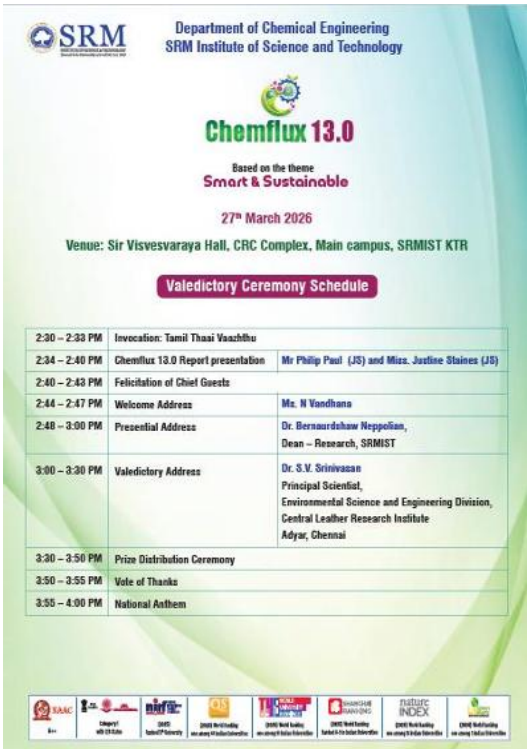
# Inaugural Ceremony Invitation



# Valedictaory Event Schedule

Program Schedule - Chemflux 13.0

March 25 – 27, 2026

Department of Chemical Engineering

SRM Institute of Science and Technology

| Day 1\| 25th March 2026 \| Wednesday | | |
|---|---|---|
| 9:00 – 10:30 am | Inauguration Ceremony | Sir Vishweshwaraya Hall |
| 10:30 – 11:00 am: Tea Break | | |
| 11:00 – 1:30 pm | Paper Presentation | Sir Vishweshwaraya Hall |
| 11:00 – 4:00 pm | Workshop: Process Simulation using Aspen Plus | Product Development Lab |
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# COMMITTEE MEMBERS

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**Secretaries, Chemflux 13.0, B.Tech. Chemical Engineering, 3rd year**

## Contact Persons

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**Mr. Philip Vattuthottam Paul (6012695721)**
**Ms. Y Justine Staines (9424224147)**
**B.Tech. Chemical Engineering, Third year**

# INDEX

# Paper/Poster Presentation Abstracts

*ISBN Number: 978-81-685283-1-4*

# PLC-Based Power Failure and Load Priority Management System with VFD-Based Energy Optimization Using Neural Network Feedback Control: A MATLAB Simulation Study

**Shri Viswath C K, Rima Rahath Easa**

Department of Electronics and Instrumentation Engineering,
SRM Institute of Science and Technology, Chennai, India

## Abstract

Industrial automation systems demand reliable power continuity and intelligent energy optimization to minimize operational costs and prevent critical process interruptions. This paper presents the design and MATLAB-based simulation of a PLC-style Power Failure and Load Priority Management System enhanced with Variable Frequency Drive (VFD)-based energy optimization and a Neural Network feedback control strategy. The proposed system monitors real-time voltage and current parameters across three prioritized load tiers — primary, secondary, and tertiary — and dynamically regulates energy consumption based on measured power conditions. A feedforward Neural Network, trained using the Levenberg-Marquardt algorithm, serves as a feedback controller that predicts system power demand from historical load profiles and solar generation data, enabling proactive load management decisions rather than purely reactive switching. During normal operation, the primary motor load is continuously regulated through a VFD-equivalent PWM control strategy, reducing motor speed in response to neural network output to minimize unnecessary energy consumption while maintaining operational continuity. Secondary and tertiary loads are progressively shed when predicted or measured power consumption exceeds predefined thresholds. Under power failure conditions, the system seamlessly transitions to battery backup mode, retaining only the critical primary load while disconnecting non-essential loads to conserve available energy. The neural network achieved convergence with a Mean Squared Error performance of 4.04 within 7 epochs, validating its predictive accuracy. MATLAB simulation results demonstrate that the neural network-guided closed-loop control effectively predicts demand, stabilizes load distribution across all priority tiers, and reduces unserved load occurrences over a 24-hour operational cycle, confirming the proposed framework as a practical and scalable solution for intelligent industrial power management.

Keywords: Power Management, Load Priority, Neural Network, VFD Energy Optimization, MATLAB Simulation

*ISBN Number: 978-81-685283-1-4*

# Development of an On-Demand Hydrogen-Powered Smart Cooking Stove for Sustainable Energy Applications

**Prartthana M P, Prisha R B, Lingesh Jayaraman**
Department of Chemical Engineering, SSN College Of Engineering, Chennai, Tamil Nadu, India

## Abstract

The growing dependence on conventional cooking fuels such as liquefied petroleum gas (LPG), kerosene, and firewood contributes to greenhouse gas emissions, indoor air pollution, and increasing fuel costs. There is a growing need for clean, safe, and sustainable alternatives for domestic cooking applications. Hydrogen is considered a promising clean energy carrier because its combustion produces only water vapor, eliminating harmful emissions. This work presents the design and development of a prototype hydrogen-powered smart cooking stove that generates hydrogen on demand through water electrolysis. A proton exchange membrane (PEM) electrolyser is used to split water into hydrogen and oxygen using electrical energy. Instead of storing hydrogen, the generated gas is directly supplied to a compact hydrogen burner through a controlled low-pressure flow system, reducing risks associated with high-pressure hydrogen storage. To enhance operational safety, an Arduino-based monitoring system integrated with a gas sensor and automated solenoid valve is incorporated. The system continuously monitors potential hydrogen leakage and can immediately shut off gas flow under unsafe conditions. This safety-focused design enables controlled combustion while minimizing operational hazards. The proposed prototype demonstrates the feasibility of integrating on-demand hydrogen generation, automated safety monitoring, and clean combustion within a compact and portable cooking system. The study highlights the potential of hydrogen as a sustainable domestic fuel while promoting safer and more accessible clean energy solutions aligned with global sustainable development goals.

Keywords: Hydrogen energy; Smart cooking stove; Water electrolysis; Sustainable energy; Safety monitoring systems

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# Engineering $CuWO_4/NiS_2$ Heterojunctions for Enhanced Photocatalytic Water Splitting Efficiency

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## Abstract

Photocatalytic hydrogen ($H_2$) generation represents a promising and environmentally benign approach for sustainable energy production. However, the development of efficient semiconductor materials with both high activity and long-term stability remain a critical challenge. In this study, we report the synthesis of a broadband-gap, UV-responsive $CuWO_4/NiS_2$ nanocomposite via a simple impregnation method. The photocatalytic performance of the hybrid system was systematically evaluated using microscopic, spectroscopic, and photophysical characterization techniques. Under light irradiation, the optimized $CuWO_4/NiS_2$ heterostructure exhibited a remarkable hydrogen evolution rate of 28.2 mmol $h^{-1}$ $g^{-1}$, which is approximately 2.71 and 3.28 times higher than that of pristine $CuWO_4$ (10.4 mmol $h^{-1}$ $g^{-1}$) and $NiS_2$ (8.6 mmol $h^{-1}$ $g^{-1}$), respectively. This enhanced performance is attributed to the synergistic interaction between the coupled semiconductors, leading to the formation of a Type-II heterojunction. Such a configuration facilitates efficient charge carrier separation and suppresses electron–hole recombination. Furthermore, the composite demonstrated significantly higher photocurrent density compared to the individual components, owing to increased active sites and improved light absorption. These findings highlight the potential of $CuWO_4/NiS_2$ as a noble-metal-free photocatalyst for efficient and sustainable hydrogen generation.

**Keywords**: Photocatalysis, Hydrogen generation, $CuWO_4/NiS_2$ heterojunction, Type-II heterostructure, Solar energy conversion

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# Nano-catalysts in Petroleum Refining

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## Abstract

Nanocatalysts are emerging as a significant opportunity in petroleum refining because nanoscale control of active phases and supports can increase the density of accessible active sites, reduce mass-transfer limitations, and tailor selectivity compared with conventional catalysts. These advantages typically stem from high surface-area-to-volume ratios, enhanced metal dispersion, adjustable acidity, and stronger metal–support interactions, attributes that strongly influence major refinery processes such as hydroprocessing (hydrotreating and hydrocracking), fluid catalytic cracking (FCC), catalytic reforming, and residue upgrading. In hydroprocessing, nanoscale sulfide-molybdenum based phases, both finely dispersed on supports and applied as dispersed catalysts along with supported noble or base-metal nanoparticles can enhance hydrogenation and accelerate sulfur and nitrogen removal by increasing the number of exposed edge and corner sites and minimizing intra-particle diffusion constraints. These improvements allow operation at lower severity, deliver higher-quality products, and potentially reduce the rate of catalyst deactivation. In FCC and heavy-feed upgrading, nano-engineered zeolites and hierarchical micro–mesoporous frameworks can ease diffusion limitations for large hydrocarbons, boosting conversion while steering selectivity toward gasoline-range products and light olefins and reducing coke and dry-gas yields. Beyond improving yields, nanocatalyst also contributes to lower energy use and emissions by achieving target performance at reduced temperature and pressure and by enhancing carbon efficiency through more selective reaction pathways. Industrial adoption is limited by scalable low-cost synthesis, durability against sintering/poisoning, attrition resistance, recovery and recycling of dispersed catalysts, and safe nanoparticle handling. Advances in scale-up, surface engineering, operando studies, and data-driven design are accelerating refinery deployment.

Keywords: Nanocatalyst, Selectivity, Fluid catalyst cracking, Hydrogenation, Carbon efficiency.

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# Next-Generation Desalination Techniques from the GCC and Their Application in India

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## Abstract

Water scarcity has become a critical global concern, particularly for rapidly growing and water-stressed nations such as India. In January 2026, the United Nations University Institute for Water, Environment and Health (UNU-INWEH) released a landmark scientific assessment titled "Global Water Bankruptcy: Living Beyond Our Hydrological Means in the Post-Crisis Era", declaring that the world has entered a state of water bankruptcy. Desalination has emerged as a vital solution to address this challenge, especially in coastal regions like Chennai, where freshwater demand continues to rise. Rapid urbanisation, groundwater-dependent agriculture, climate variability, and rising economic demand are placing pressure on already fragile hydrological systems. The purpose of this paper is to evaluate whether advanced desalination technologies used in Gulf countries such as Saudi Arabia, Qatar, and the United Arab Emirates can be effectively applied in India. The main aim is to identify cost-effective, environmentally sustainable, and energy-efficient solutions suitable for India's current status. This study uses a comparative approach to analyse key desalination methods, including hybrid systems, Multi-Effect Distillation (MED), Multi-Stage Flash (MSF), and Reverse Osmosis (RO) with energy recovery systems. Special focus is given to vacuum-based technologies like Low-Temperature Vacuum Evaporation (LTVE) and Vacuum Membrane Distillation (VMD), which operate at lower temperatures and require less energy. Additionally, the paper explores emerging technologies such as electrochemical ion pumps, Forward Osmosis (FO), and Capacitive Deionization (CDI) to understand their future potential. Before the construction of any desalination facility, environmental impact assessment must be conducted. With the integration of renewable energy sources into desalination processes, it is recommended to minimize environmental impacts and reduce high energy costs associated with conventional systems. The findings indicate that integrating GCC desalination advancements—particularly hybrid systems, vacuum-assisted thermal technologies, and emerging electrochemical methods—can significantly enhance water security in India while minimizing environmental impact. The paper concludes by recommending energy-efficient, low-temperature, and sustainable

desalination systems as a pathway towards sustainable and future-ready water management systems.

Keywords: Desalination, GCC Technologies, Reverse Osmosis (RO), Thermal Vacuum Desalination, Renewable Energy Integration, Electrochemical Ion Pump

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# Sustainable Materials, Polymers and Biotech

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## Abstract

Biomaterials are essential in modern medicine, driving advancements in tissue engineering (TE), drug delivery, and medical devices. This review explores the intersection of biomaterials and sustainability, highlighting efforts to develop environmentally friendly materials through advanced technology. It examines key biomaterial characteristics for example, biodegradability, mechanical strength, and biocompatibility, and discusses the influence of polymers on medical technology. From inert substances to bioactive materials, biomaterials have evolved to elicit biological responses. Notably, 3D-printed biomaterials are revolutionizing implant development with their customization and tissue facilitation advantages. The emergence of production-on-demand (POD) in 3D printing promises environmental sustainability and cost efficiency. Forecasts indicate significant growth in the global biomaterials market, particularly in Asia, reflecting increasing demand for biomaterial-based medical products. With applications ranging from synthetic skin to dental implants, biomaterials showcase versatility and importance in healthcare. Advanced characterization techniques and bioprocessing technologies enable the production of sustainable biomaterials, addressing environmental concerns. Despite challenges for example scalability and regulatory hurdles, ongoing research and collaboration are vital. Future efforts should prioritize bioprocessing optimization, novel biomaterial formulations, and life cycle assessments to enhance sustainability. Overall, sustainable biomaterials play an essential part in direction of environment related issues and advancing healthcare, necessitating continuous innovation and collaboration.

Keywords: Biomaterials, healthcare devices, Polymers

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# Enzymatic Degradation of Plastic Waste for Fuel Production

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## Abstract

Plastic waste is a major environmental problem; plastics, in general, do not easily break down in nature. Traditional recycling methods are often energy-intensive and are highly inefficient. Our project explores the idea of utilizing enzymes (biocatalysts) to break down plastic into smaller chemical components that can be further converted into useful fuel precursors. Certain microorganisms such as Ideonella sakaiensis have been discovered to produce enzymes capable of degrading specific plastics like PET. By utilizing such enzymes in controlled conditions, plastic polymers can be broken into simpler molecules. We claim that these smaller molecules can potentially be processed into fuels. Our method combines principles from biology and engineering to develop sustainable method for managing plastic waste. Microbes (bacteria/fungi) secrete enzymes primarily hydrolases like PETase, cutinase, and lipase that break down complex polymer chains into smaller monomers or oligomers. Depending upon biology alone has its own demerits, mainly the rate of decomposition. We intend to incorporate protein engineering techniques, not limited to surfactants, to optimize the enzymatic breakdown of polymers as well to maximize the output. Compared to conventional methods, enzymatic degradation has the possibility to require less energy and offer a more environmentally friendly alternative. While challenges such as reaction speed and large-scale implementation remain, this claim highlights the potential of biotechnology in addressing global plastic pollution while contributing to renewable energy solutions.

Keywords: Plastic waste, Ideonella sakaiensis, PETase (Hydrolase Enzyme), Fuel Precursors, Renewable Energy.

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# Fuzzy Logic Based Smart Energy Saving Controller for Home Appliances

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## Abstract

Fuzzy Logic Based Smart Energy Saving Controller for Home Appliances aimed at reducing unnecessary energy consumption in residential environments. The system continuously monitors real-time parameters such as temperature, light intensity, and occupancy using appropriate sensors. Instead of conventional ON/OFF or PID-based control methods, fuzzy logic is employed to imitate human decision-making using linguistic variables such as low, medium, and high. Based on predefined IF–THEN rules, the controller determines the optimal operating level of home appliances like lights and fans, ensuring energy efficiency while maintaining user comfort. The proposed system is implemented using a microcontroller with relay or PWM-based output control and provides a flexible and intelligent solution for smart home energy management.

Keywords: Fuzzy Logic, Smart Home, Energy Saving, Home Appliances, Intelligent Control System, Energy Management

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# FUZZY LOGIC BASED TEMPERATURE CONTROL SYSTEM FOR COLD STORAGE FACILITIES

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## Abstract

Cold storage compressor systems use 60-70% of total facility energy. The conventional on/off controller wastes too much energy through start-stop cycling and operation at full power. The fuzzy logic controller is designed to minimize this waste and increase efficiency through variable speed control of compressors (0-100%) instead of on/off control. Two inputs are used: temperature error (±5°C of 2°C set point) and rate of change (±1°C/min). Five fuzzy sets partition each input. Trapezoidal membership functions are used. Twenty-five fuzzy rules produce control output. The weighted average method of defuzzification is used to produce the optimal output. Implementation of this fuzzy logic controller in Scilab shows that 30-40% of total facility energy can be saved compared to conventional control. The controller allows compressors to operate modulated instead of full-power cycling. The number of start-stop cycles is reduced to 1/3 of 15-20 cycles/hour. The lifespan of compressors is extended by 40-50%. The temperature is maintained within ±0.5°C. The intelligent controller saves much operating cost and is suitable for cold storage applications.

Keywords: Energy efficiency, fuzzy logic control, cold storage, variable speed control of compressors, reduction of power consumption.

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# Harnessing Body Heat: Wearable Thermoelectric Generator Using Antimony Sulphides

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Thermoelectric technologies enable the conversion of heat into electricity and vice versa, offering sustainable energy solutions across industries. This project demonstrates how waste body heat can be harvested and transformed into useful power through a scalable, cost-efficient, and environmentally benign route for synthesizing antimony sulfide ($Sb_2S_3$) nanowires, integrated into wearable thermoelectric generators (TEGs). Using non-toxic precursors and aqueous processing, $Sb_2S_3$ nanowires are synthesized via a green hydrothermal method from $SbCl_3$ and $Na_2S$, with urea and ethylene glycol at 210 °C for 24 hours, incorporating varying concentrations of $BiCl_3$ as a dopant. Structural and morphological characterization through X-ray diffraction (XRD), scanning electron microscopy (SEM), confirms uniform, high-crystallinity nanowires. These are embedded within a flexible polymer matrix to fabricate wearable TEG prototypes capable of efficiently converting body heat into electricity. The resulting devices can power small electronics such as sensors, health monitors, and communication systems, providing a lightweight and user-friendly energy source. The study also evaluates long-term stability and durability under real-world conditions, ensuring reliable industrial application. By leveraging green chemistry and advanced nanostructures, this work proposes a sustainable pathway for wearable energy harvesting devices, contributing to cleaner technologies and reduced energy waste.

**Keywords:** Wearable thermoelectric generator, Antimony sulfide ($Sb_2S_3$), Bismuth doping, Flexible substrates, Body heat conversion, Thermoelectric power

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# Enhancement of Battery Thermal Management Using Phase Change Material Nanocomposites

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## Abstract

The integration of phase change material (PCM) nanocomposites into battery systems has emerged as an effective strategy for improving thermal management and operational safety. This study investigates the performance of various PCM configurations, focusing on their thermal conductivity, heat storage capacity, and compatibility with battery materials. The objective is to evaluate the ability of PCM nanocomposites to regulate temperature and enhance battery efficiency under high thermal loads. The methodology involves the preparation of paraffin-based PCM nanocomposites incorporated with thermally conductive nanofillers, followed by experimental analysis and simulation to assess heat dissipation characteristics during charging and discharging cycles. Results indicate that the addition of nanofillers significantly improves thermal conductivity, leading to faster heat distribution and reduced peak temperatures. The PCM matrix effectively absorbs excess heat through latent heat storage, thereby minimizing temperature fluctuations and preventing thermal runaway. Furthermore, the nanocomposite structure enhances cyclic stability and reduces thermal stress on battery components, contributing to extended battery lifespan. The study also highlights key challenges, including material compatibility, optimization of filler concentration, and scalability of production techniques. Overall, the findings demonstrate that PCM nanocomposites provide a reliable and efficient solution for advanced battery thermal management, with strong potential for application in electric vehicles and large-scale energy storage systems.

**Keywords:** Phase Change Materials, Nanocomposites, Battery Thermal Management, Thermal Conductivity, Energy Storage

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# Production Of Biodegradable Plastic Using Cassava Starch

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## Abstract

The extensive use of conventional petroleum-based plastics has resulted in serious environmental problems due to their non-biodegradable nature, leading to soil, water, and marine pollution. To overcome these challenges, the development of biodegradable and eco-friendly alternatives from renewable resources has gained significant attention. In this project, biodegradable plastic is synthesized using cassava (Kesava) starch, which is an inexpensive, renewable, biodegradable, and abundantly available natural polymer. The biodegradable plastic is prepared by gelatinizing cassava starch in water, followed by the addition of glycerine as a plasticizer to improve flexibility and mechanical properties. The resulting viscous solution is cast into thin films and dried at room temperature to obtain biodegradable plastic sheets. The prepared bioplastic films exhibit good transparency, flexibility, and film-forming ability. The study also highlights the effect of plasticizer concentration on the physical properties of the bioplastic. The synthesized biodegradable plastic demonstrates potential applications in packaging, agriculture, and disposable products. This simple, low-cost, and environmentally friendly method offers a promising approach for reducing dependence on petroleum-based plastics and contributes toward sustainable material development and environmental protection.

Keywords: Biodegradable Plastic; Cassava Starch; Gelatinization; Plasticizer; sustainable material development; Environmental protection

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# Bio Pigments

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## Abstract

Recently there has been a huge global demand for natural plant derived pigments. The pigments are enriched with antioxidants potentiality and can replace artificial pigments , especially in the food, Pharmaceutical and cosmeceutical based industries. Most of the petroleum(hexane) based synthetic pigments causes ill effects and are carcinogenic. It is very essential and needy now to think an alternative how to extracts the carotenoids with some green solvents or some alternative method like fermentation technology to enhance the colour intensity of the carotenoids so that it shall be safely used in the food industry as natural colorant and even in the cosmeceuticals industry as natural pigments. Carotenoids are natural pigments produced as secondary metabolites in fruits, Normally, the carotenoids are extracted with various solvents that have much toxicological effects. solvents are almost unavoidable due to their crucial roles in dissolving solids, vegetables, algae, fungi, and bacteria. Recently there has been a huge global demand for natural plant derived pigments. The pigments are enriched with antioxidants potentiality and can replace artificial pigments, especially in the food, Pharmaceutical and cosmeceutical based industries. Most of the petroleum(hexane) based synthetic pigments causes ill effects and are carcinogenic. The artificial pigments are ill effects to the consumers and every domain especially the food and fabric industry is looking for the natural pigments as alternative. Even then the extraction of the pigments was done with organic solvents when it is coming to the bulk quantity, that again it reflects in the organic solvent residue causing skin allergy and carcinogenic.

Keywords: Natural Pigments, Extraction

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# Sustainable Modifications in PVDF Membrane

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## Abstract

Sustainable Modifications in PVDF Membrane explores the development of eco-friendly and cost-effective alternatives for water filtration systems, specifically focusing on Polyvinylidene fluoride (PVDF) membranes. Traditional reverse osmosis (RO) and filtration systems rely heavily on synthetic materials such as Polyvinylpyrrolidone (PVP) as pore formers and silica nanoparticles as adsorbents, which are often petroleum-derived and non-biodegradable.

Keywords: PVDF, Membrane Filtration

# AI-Driven Adaptive Waste-to-Hydrogen Microgrid with Hybrid Energy Buffering for Next-Generation Smart Cities

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Urban energy systems face a dual challenge of increasing electricity demand and inefficient waste management. This project introduces a novel AI-driven adaptive microgrid that transforms heterogeneous urban waste streams into hydrogen-based energy while dynamically balancing power through hybrid storage mechanisms. Unlike conventional waste-to-energy systems, the proposed model incorporates a self-learning control layer that continuously adapts to variations in waste composition, energy demand, and environmental conditions. The system utilizes a multi-pathway conversion approach, where segregated waste is processed through optimized gasification and bio-digestion units to simultaneously produce hydrogen-rich gas and biofuels. A real-time purification and compression unit ensures safe hydrogen storage, which is later used in fuel cells for clean electricity generation. To address intermittency, a hybrid buffering system combining batteries and hydrogen storage is employed, enabling both short-term and long-term energy stabilization. A key innovation lies in the integration of predictive AI algorithms that forecast waste inflow patterns and energy consumption at a micro-zone level. This enables intelligent energy routing, minimizes conversion losses, and improves operational efficiency without human intervention. The decentralized architecture allows each urban sector to operate semi-autonomously while remaining interconnected within a smart grid network. The proposed framework is expected to reduce landfill dependency, lower greenhouse gas emissions, and enhance grid resilience. By converting waste into a flexible hydrogen energy carrier, this system presents a scalable and future-ready solution for sustainable smart city infrastructure.

Keywords: AI, Waste to Hydrogen, Hybrid Energy

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# Energy Transition: Hydrogen, Biofuels & Batteries

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## Abstract

The global transition toward sustainable energy systems has become a critical priority to mitigate climate change, reduce greenhouse gas emissions, and ensure long-term energy security. The concept of Energy Transition refers to the shift from fossil-fuel-based energy systems to low-carbon and renewable energy technologies. Among the emerging solutions, Hydrogen Energy, Biofuels, and Battery Energy Storage Systems play a significant role in enabling a cleaner and more efficient energy future. Hydrogen is considered a promising clean energy carrier due to its high energy density and zero carbon emissions during utilization. Green hydrogen produced through water electrolysis using renewable electricity can significantly decarbonize industrial sectors, transportation, and power generation. Advanced hydrogen storage and fuel cell technologies further enhance its applicability in sustainable energy systems. Biofuels, derived from biomass such as agricultural waste, algae, and organic materials, provide a renewable alternative to conventional fossil fuels. First-generation biofuels include bioethanol and biodiesel produced from food crops, while second- and third-generation biofuels utilize non-food biomass and algae, improving sustainability and reducing competition with food resources. Biofuels contribute to carbon neutrality by recycling atmospheric carbon through biological processes. Battery technologies are another key component of modern energy systems, especially for integrating intermittent renewable energy sources such as solar and wind power. Advanced batteries, including lithium-ion, solid-state, and flow batteries, enable efficient energy storage, grid stabilization, and electrification of transportation systems. These technologies improve energy reliability, reduce power fluctuations, and support decentralized energy infrastructure. This paper examines the technological advancements, challenges, and prospects of hydrogen, biofuels, and battery systems within the framework of global energy transition. It highlights their potential to complement renewable energy technologies and accelerate the shift toward sustainable and low-carbon energy systems. The study emphasizes that integrating these energy solutions can significantly contribute to achieving climate goals and creating a resilient energy ecosystem for future generations.

Keywords: Biofuels, Batteries, Energy Transition

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# Development and testing of biodiesel by a sustainable catalyst

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## Abstract

This project focuses on the development and testing of biodiesel using a sustainable, low-cost catalyst derived from waste materials. The increasing disposal of waste cooking oil (WCO) poses serious environmental concerns, including water and soil pollution. At the same time, conventional biodiesel production methods rely on homogeneous catalysts such as NaOH or KOH, which are non-reusable, generate chemical waste, and increase overall production costs. To address these challenges, this study proposes a waste-to-value approach by converting discarded eggshells into a calcium oxide (CaO) catalyst. This catalyst is used in the transesterification of waste cooking oil with methanol to produce biodiesel and glycerol as a by-product. The process operates at moderate conditions (around 60°C), making it energy-efficient and suitable for small-scale applications. The catalyst demonstrates good reusability (3–5 cycles) and allows easy separation, reducing water usage and purification steps. Experimental analysis indicates that approximately 1 kg of waste oil can yield about 0.9 kg of biodiesel, with minimal catalyst loss and a glycerol by-product that can be commercially utilized. Economically, the production cost is significantly lower than conventional diesel, enhancing feasibility. Overall, this project presents an eco-friendly, cost-effective, and scalable solution for biodiesel production, promoting sustainability by utilizing waste resources while minimizing environmental impact.

**Keywords:** Biodiesel Production; Waste Cooking Oil (WCO); Transesterification; Calcium Oxide Catalyst; Sustainable Energy

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# Green-Solvent-Based and Membrane-Assisted Solvent Extraction for Sustainable Nickel and Lithium Removal from Wastewater

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## ABSTRACT

The rapid expansion of battery manufacturing, electroplating, and metal processing industries has led to increasing discharge of nickel and lithium into wastewater, posing environmental and regulatory challenges. Conventional wastewater treatment techniques often suffer from poor selectivity, high chemical consumption, and secondary waste generation, while traditional solvent extraction processes rely on toxic and volatile organic solvents. In this study, a green-solvent-based membrane-assisted solvent extraction (MASE) process is developed for the sustainable removal of nickel and lithium from wastewater. Hydrophobic deep eutectic solvents (HDES) prepared from menthol and capric acid were employed as the extraction medium and diluted with dimethyl carbonate, a green diluent, to improve viscosity and mass transfer characteristics. A polyvinylidene fluoride (PVDF) membrane contactor was used to facilitate non-dispersive contact between the aqueous and organic phases, minimizing solvent loss and enhancing operational stability. The effects of key operating parameters such as pH, flow rate, and solvent composition on metal removal efficiency were systematically investigated. The proposed MASE system demonstrated effective removal of nickel and lithium under mild operating conditions, along with good solvent regeneration ability and membrane stability. The developed process offers an environmentally benign and scalable approach for the selective removal and potential recovery of nickel and lithium from industrial wastewater, contributing to sustainable wastewater treatment and resource recovery.

Keywords:

Membrane-assisted solvent extraction, Green solvents, Hydrophobic deep eutectic solvents
Nickel and lithium removal, Wastewater treatment

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# PLC-Based Power Failure and Load Priority Management System with VFD-Based Energy Optimization Using Neural Network Feedback Control: A MATLAB Simulation Study

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## Abstract

Industrial automation systems demand reliable power continuity and intelligent energy optimization to minimize operational costs and prevent critical process interruptions. This paper presents the design and MATLAB-based simulation of a PLC-style Power Failure and Load Priority Management System enhanced with Variable Frequency Drive (VFD)-based energy optimization and a Neural Network feedback control strategy. The proposed system monitors real-time voltage and current parameters across three prioritized load tiers — primary, secondary, and tertiary — and dynamically regulates energy consumption based on measured power conditions. A feedforward Neural Network, trained using the Levenberg-Marquardt algorithm, serves as a feedback controller that predicts system power demand from historical load profiles and solar generation data, enabling proactive load management decisions rather than purely reactive switching. During normal operation, the primary motor load is continuously regulated through a VFD-equivalent PWM control strategy, reducing motor speed in response to neural network output to minimize unnecessary energy consumption while maintaining operational continuity. Secondary and tertiary loads are progressively shed when predicted or measured power consumption exceeds predefined thresholds. Under power failure conditions, the system seamlessly transitions to battery backup mode, retaining only the critical primary load while disconnecting non-essential loads to conserve available energy. The neural network achieved convergence with a Mean Squared Error performance of 4.04 within 7 epochs, validating its predictive accuracy. MATLAB simulation results demonstrate that the neural network-guided closed-loop control effectively predicts demand, stabilizes load distribution across all priority tiers, and reduces unserved load occurrences over a 24-hour operational cycle, confirming the proposed framework as a practical and scalable solution for intelligent industrial power management.

**Keywords:** Power Management, Load Priority, Neural Network, VFD Energy Optimization, MATLAB Simulation

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# Sustainable Carbon Capture and Sequestration Frameworks: Agricultural Waste-Derived Cellulose Nanocrystals in Hybrid Polymer and Aerogel Systems

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## Abstract

It is common knowledge that carbon emissions are harmful to the atmosphere and represent a growing global challenge. In recent years, numerous solutions have been proposed to mitigate the effects of anthropogenic carbon output on the environment. One such solution is the capture of carbon dioxide $CO_2$ from flue gas through Carbon Capture and Sequestration (CCS) systems. This paper explores a framework for capturing $CO_2$ using cellulose nanocrystal (CNC) aided polymers and aerogels derived primarily from agricultural waste. Specifically, this paper suggests utilizing common runoff materials, such as coconut husk and banana fiber, as raw sources for nanocellulose extraction. CNCs produced from these sources can be processed, blended, and doped onto high-performance polymers, such as Pebax®, or integrated into porous aerogels to increase CCS efficiency beyond that of neat materials. By leveraging the high surface area and tunable surface chemistry of CNCs, these hybrid membranes exhibit enhanced gas permeability and selectivity. This results in sustainably manufactured filtration systems that reduce reliance on synthetic precursors. Furthermore, this study evaluates the mechanical integrity and thermal stability of these bio-based composites under simulated industrial flue gas conditions. Finally, this paper explores the deployment, economic feasibility, and potential scalability challenges associated with this framework, arguing that the integration of agricultural waste into CCS technologies offers a dual benefit: effective carbon mitigation and the promotion of a circular bio-economy.

**Keywords:**

Carbon Capture and Sequestration (CCS); Cellulose Nanocrystals (CNCs); Agricultural Waste; Bio-aerogels; Green Material Science; Circular Economy.

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# Piezoelectric Crystal Sensors

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## Abstract

Piezoelectric crystals are extensively used in maritime technology to perform many marine operations such as underwater detection, communication and navigation. For navigation, there are primarily two modes of converting pressure into electricity and further into sound waves which are active sonar and passive sonar/hydrophone. Piezoelectric crystals in marine applications are categorized by their operational mode: passive (sensor/harvester) or active (actuator/emitter) based on whether they require an external power source to function or generate their own energy.

Passive (Sensors/Harvesters): Generate electrical signals from mechanical strain (pressure, vibration, waves) without external power.

Active (Actuators/Projectors): Convert electrical energy into mechanical vibration (sound) for emission.

A material of particular interest is Bismuth Sodium Titanium (BNT), or $Bi_{0.5}Na_{0.5}TiO_3$, is a piezoelectric ceramic used underwater acoustic transducers, sensors and high-temperature monitoring systems. It is a metastable perovskite obtained under high-pressure (6 GPa) and high-temperature (1270 K) conditions. It is non-toxic as it is lead-free and can be doped to attain more favourable physical properties.

Keywords: piezoelectric, perovskite, sonar, pressure, mechanical energy

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# Development of a Sustainable Process for the Extraction of Curcumin from *Curcuma longa* Using Ionic Liquids and Process Optimization

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## ABSTRACT

Curcumin is a polyphenolic biomaterial derived from *Curcuma longa* (turmeric). It has a variety of applications, including pharmaceuticals and food processing. The conventional solvents such as ethanol, acetone, and ethyl acetate have been used for the extraction of curcumin. Although the conventional solvents possess promising characteristics such as high selectivity, abundance, stability, and yield, their inherent toxicity, energy consumption, and non-biodegradability are harmful to the ecosystem. In the past few decades, research has been progressing towards green solvents that impose less harmful impact on the ecosystem and improve process efficiency in terms of separation and economy. Hence, this study focuses on the development of a sustainable process for the extraction of curcumin using ionic liquids [ChOH][Gly] (choline hydroxide-glycine), and 1-Ethyl-3-Methylimidazolium Ethyl Sulfate. The ionic liquids were synthesized, and their characteristics were studied using FTIR and XRD. The key process variables, such as solid-to-solvent ratio, extraction time, and temperature, were investigated in the range of 1:5 – 1:20, 0.5 – 4 hr, 30˚C – 60˚C, respectively, for the efficient separation of curcumin. The process modeling and optimization were performed using Response Surface Methodology (RSM) to predict the maximum yield of curcumin. The predicted values were compared with the experimental results, showing the close agreement between the predicted and experimental findings. Hence, the proposed work provides an eco-friendly and feasible alternative to conventional processes and offers a robust framework for scaling up curcumin extraction for industrial applications.

**Keywords**: Curcumin; Extraction; Green solvents; Ionic Liquids; Sustainable process

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# Fuzzy Logic-Based Intelligent Cruise Control System

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## Abstract

Conventional cruise control systems rely on precise mathematical models that often fail to perform efficiently under uncertain driving conditions such as varying road slopes, traffic disturbances, and changing vehicle dynamics. To overcome these limitations, this study presents the design and implementation of an intelligent cruise control system based on fuzzy logic, which mimics human driving behavior to provide smoother and more adaptive speed control. The proposed system takes two primary inputs: speed error, defined as the difference between desired speed and actual speed, and the rate of change of error. These inputs are processed through a set of predefined linguistic rules within a fuzzy inference system (FIS), which determines the appropriate throttle response to maintain the desired speed across different driving scenarios, ensuring both stability and passenger comfort. The fuzzy rule base was designed and validated through simulation, with performance benchmarked against a conventional PID-based cruise control system. Simulation results demonstrate that the fuzzy logic controller (FLC) achieves significantly reduced overshoot, faster settling time, and improved robustness under dynamic driving conditions, all without requiring an exact mathematical model of the vehicle. This study highlights the practical potential of fuzzy logic in automotive control applications, offering a reliable, model-free, and efficient alternative for intelligent transportation systems.

**Keywords:** Fuzzy logic, cruise control, intelligent transportation systems, speed control, fuzzy inference system

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# Waste-to-Print: High-Performance 3D Printing Filament from Recycled Plastics

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## Abstract

The rapid increase in plastic waste has become a major environmental concern, while the demand for affordable and sustainable 3D printing materials continues to rise. This study aims to develop high-performance 3D printing filament from recycled plastic waste such as bottles and disposable cups, providing a cost-effective and eco-friendly alternative to conventional filaments. The methodology involves collection and segregation of plastic waste, followed by cleaning, drying, and shredding into uniform flakes. To improve material performance, selected chemical additives including antioxidants (BHT) as stabilizers and fillers such as silica ($SiO_2$) and calcium carbonate ($CaCO_3$) are incorporated to enhance thermal stability and mechanical strength. The modified polymer is processed through an extrusion system at controlled temperatures of 250–260°C to produce filament with consistent diameter suitable for 3D printing applications. The developed filament demonstrates adequate strength, dimensional stability, and printability for prototyping and educational uses. This approach significantly reduces plastic waste accumulation and promotes a circular economy by converting waste into a valuable engineering material. The study concludes that recycled plastic-based filament can serve as a sustainable and economically viable solution for additive manufacturing. Future work includes AI-based plastic sorting and development of reinforced composite filaments for advanced applications.

Keywords: Recycled Plastics, 3D Printing Filament, Polymer Engineering, Sustainable Materials, Circular Economy

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# Fuzzy Logic Based Temperature Control System for Cold Storage Facilities

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## Abstract

Cold storage compressor systems use 60-70% of total facility energy. The conventional on/off controller wastes too much energy through start-stop cycling and operation at full power. The fuzzy logic controller is designed to minimize this waste and increase efficiency through variable speed control of compressors (0-100%) instead of on/off control.Two inputs are used: temperature error (±5°C of 2°C set point) and rate of change (±1°C/min). Five fuzzy sets partition each input. Trapezoidal membership functions are used. Twenty-five fuzzy rules produce control output. The weighted average method of defuzzification is used to produce the optimal output.Implementation of this fuzzy logic controller in Scilab shows that 30-40% of total facility energy can be saved compared to conventional control. The controller allows compressors to operate modulated instead of full-power cycling. The number of start-stop cycles is reduced to 1/3 of 15-20 cycles/hour. The lifespan of compressors is extended by 40-50%. The temperature is maintained within ±0.5°C. The intelligent controller saves much operating cost and is suitable for cold storage applications.

Keywords: Energy efficiency, fuzzy logic control, cold storage, variable speed control of compressors, reduction of power consumption.

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# Fuzzy Logic-Based Intelligent Cruise Control System

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## Abstract

Conventional cruise control systems rely on precise mathematical models that often fail to perform efficiently under uncertain driving conditions such as varying road slopes, traffic disturbances, and changing vehicle dynamics. To overcome these limitations, this study presents the design and implementation of an intelligent cruise control system based on fuzzy logic, which mimics human driving behavior to provide smoother and more adaptive speed control. The proposed system takes two primary inputs: speed error, defined as the difference between desired speed and actual speed, and the rate of change of error. These inputs are processed through a set of predefined linguistic rules within a fuzzy inference system (FIS), which determines the appropriate throttle response to maintain the desired speed across different driving scenarios, ensuring both stability and passenger comfort. The fuzzy rule base was designed and validated through simulation, with performance benchmarked against a conventional PID-based cruise control system. Simulation results demonstrate that the fuzzy logic controller (FLC) achieves significantly reduced overshoot, faster settling time, and improved robustness under dynamic driving conditions, all without requiring an exact mathematical model of the vehicle. This study highlights the practical potential of fuzzy logic in automotive control applications, offering a reliable, model-free, and efficient alternative for intelligent transportation systems.

**Keywords:** Fuzzy logic, cruise control, intelligent transportation systems, speed control, fuzzy inference system

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# Extraction of Lutein from Marigold Flower Using Assisted Extraction Techniques

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ABSTRACT

Marigold flowers (Tagetes spp.) are a major natural source of xanthophyll carotenoids, particularly lutein and zeaxanthin, which are predominantly present as fatty acid Di-Esters in the petals. Lutein is an essential antioxidant that cannot be synthesized by the human body and must be obtained through diet or supplementation. However, its extraction is challenging due to its sensitivity to heat, light, and oxidation, as well as the requirement for effective cell wall disruption and ester hydrolysis. This study aims to develop and optimize assisted extraction techniques to enhance lutein recovery from marigold flowers using ethanol and hexane as solvents. Ethanol was selected as a green solvent due to its low toxicity, environmental compatibility, renewability, and suitability for nutraceutical applications. Its moderate polarity improves solvent penetration and extraction efficiency. Hexane, a non-polar solvent, was employed for its strong affinity toward lipid-soluble carotenoids, enabling effective solubilization and improved recovery of lutein. Currently, ultrasonic-assisted extraction, mechanical stirring extraction, and pressure-assisted extraction methods are employed to improve mass transfer efficiency and lutein yield at a 1:4 solid-to-liquid ratio. These techniques enhance solvent penetration, promote cell wall disruption, and increase extraction efficiency under controlled operating conditions. Initial findings indicate that these assisted methods provide promising yields comparable to reported literature values while maintaining scalability and cost-effectiveness. Furthermore, future work will explore additional assisted extraction techniques to further optimize lutein recovery, solvent efficiency, and overall process sustainability. Overall, this project establishes a sustainable and efficient framework for the recovery of highvalue lutein suitable for applications in nutraceutical, pharmaceutical, and cosmetic industries.

Keywords:

Marigold (Tagetes spp.), Lutein, Green solvent extraction (Ethanol), Assisted extraction techniques, Sustainable bioactive recovery

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# DEVELOPMENT OF SILVER NANOPARTICLES-EMBEDDED PAPER BASED SENSOR FOR DETECTION OF FOOD CONTAMINANTS IN MILK

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**ABSTRACT:**

This project reports the synthesis, characterization, and application of caffeic acid-capped silver nanoparticles (AgNPs) embedded in a paper-based platform for sensitive, low-cost, and portable detection of milk adulterants such as melamine and formaldehyde. AgNPs were synthesized by chemical reduction of silver nitrate with sodium borohydride in the presence of polyvinylpyrrolidone (PVP) as stabilizer, followed by surface functionalization with caffeic acid as capping agent and trisodium citrate to prevent aggregation, and subsequently purified by centrifugation. The nanoparticles exhibited characteristic surface plasmon resonance peaks in UV–Vis spectra, photoluminescence emission indicative of uniform and well-passivated particles, and zeta potential values confirming good colloidal stability. Paper-based sensor was prepared using Whatman No. 1 chromatography paper and impregnated with the AgNP suspension by drop casting, forming a stable AgNP–cellulose interface with excellent optical properties. The sensor showed rapid, concentration-dependent color changes from pale yellow to yellow and red upon exposure to formaldehyde and melamine in milk respectively. These visible transitions were due to AgNP aggregation and were quantified using RGB (Red,Green,Blue) image analysis, where pale yellow, yellow, and red responses corresponded respectively. Calibration curves constructed from the changes in RGB intensity enabled quantitative estimation of adulterant levels using only a smartphone camera, without the need for laboratory instrumentation. This AgNP-based paper sensor thus offers a practical, portable, and cost-effective approach for on-site milk quality monitoring and food safety assurance.

**Key Words:**

Food Contaminants, Melamine, Formaldehyde, Silver Nanoparticles and Sensor.

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# Performance Analysis of a Fuzzy Logic-Based Temperature Control System for Industrial Boiler Applications

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## Abstract

This study presents the design and quantitative performance evaluation of a fuzzy logic-based temperature control system for industrial boiler applications characterized by slow and nonlinear thermal dynamics. The objective is to achieve stable and accurate temperature regulation and compare its performance with conventional controllers and Fuzzy Logic controller. The boiler is modeled as a first-order thermal system and simulated in Scilab under closed-loop conditions with an initial temperature of 25°C and a setpoint of 100°C. Performance metrics including rise time, settling time, maximum overshoot, and steady-state error are analyzed. The P controller exhibits a steady-state error of approximately 33%, failing to reach the desired setpoint. The PI controller eliminates steady-state error but shows a settling time of approximately 245 s. The PID controller achieves faster response with reduced settling time while maintaining negligible steady-state error. The fuzzy logic controller demonstrates a smooth response with negligible overshoot and effective disturbance rejection, recovering from a 10°C disturbance within a shorter duration compared to classical controllers, although a minor steady-state error of approximately 10% is observed due to conservative rule tuning. These results indicate that fuzzy logic control provides enhanced stability and robustness for nonlinear thermal systems, making it a suitable alternative for industrial temperature regulation.

Keywords: Fuzzy Logic Controller, Boiler Temperature Control, PID Control, First-Order System, Disturbance Rejection

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# BIO-ZWITTERIONIC ELECTROLYTE FOR DENDRITE-FREE FAST CHARGING $LI^+$ BATTERIES

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## ABSTRACT

Lithium-ion batteries are widely used in modern energy storage systems because of their high energy density, lightweight nature, and long cycle life. However, lithium dendrite formation during repeated charging remains a major challenge, as it can cause internal short circuits, capacity loss, and serious safety hazards. This study proposes a bio-zwitterionic electrolyte derived from shrimp waste to address dendrite growth and improve battery safety and performance. The electrolyte is synthesized using chitosan, sulfobetaine methacrylate (SBMA), and TEMPO redox shuttle, forming a solid gel polymer membrane with enhanced ionic conductivity and electrochemical stability. The zwitterionic structure promotes lithium salt dissociation, improves $Li^+$ transport, and suppresses dendrite formation on the lithium anode. Experimental results indicate that the developed electrolyte enables more than 300 charge–discharge cycles at a 5C rate, maintains about 85% capacity after 300 cycles, and significantly reduces dendrite growth compared to conventional electrolytes. In addition, the material offers cost advantages (≈ ₹600 per litre) due to the use of renewable shrimp shell waste, making it environmentally sustainable and economically viable. Overall, this research demonstrates a promising strategy for safe, fast-charging, and long-life lithium-ion batteries, particularly for future electric vehicle and high-energy storage applications.

Keywords: Lithium Battery, bio-zwitterionic, Electrolyte

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# A Sustainable Approach for the Separation and Recovery of Dyes via Bio-polymer Based Complexation Ultrafiltration

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## ABSTRACT

Freshwater resources are under increasing stress worldwide due to rapid population growth and expanding industrial activities. As a result, large quantities of wastewater are generated and often released into natural water bodies without adequate treatment. Among various contaminants present in wastewater, dye effluents pose a significant environmental concern because of their complex chemical structure and high toxicity. Synthetic dyes are particularly problematic, as they are persistent, resistant to biodegradation, and capable of bioaccumulation even at low concentrations. Conventional wastewater treatment techniques, including adsorption, coagulation, and precipitation, have been widely employed for dye removal; however, their efficiency is often limited. In recent years, membrane-based separation techniques, especially complexation ultrafiltration (C-UF), have emerged as promising alternatives for dye effluent treatment. This technique relies on water-soluble complexing agents to facilitate dye separation. Biopolymer-based complexing agents, such as chitosan derivatives, have attracted considerable interest due to their renewability and biodegradable nature. In this study, carboxymethyl chitosan (CMC) was employed as a complexing agent to remove cationic dye Rhodamine B. A key advantage of CMC is its ability to interact effectively with dye. The effects of operating parameters, including solution pH, CMC-to-dye ratio (w/w), and initial dye concentration, were systematically examined to evaluate their influence on dye removal efficiency. The findings demonstrate that C-UF using CMC is an effective and reliable method for removing Rhodamine B from wastewater.

**Keywords**: Chitosan; Complexation ultrafiltration; Dye effluent; Anionic dye; Rhodamine B

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# Energy Transition: Hydrogen, Bio-Fuels and Batteries

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Abstract

The global transition toward sustainable energy systems has become a critical priority to mitigate climate change, reduce greenhouse gas emissions, and ensure long-term energy security. The concept of Energy Transition refers to the shift from fossil-fuel-based energy systems to low-carbon and renewable energy technologies. Among the emerging solutions, Hydrogen Energy, Biofuels, and Battery Energy Storage Systems play a significant role in enabling a cleaner and more efficient energy future. Hydrogen is considered a promising clean energy carrier due to its high energy density and zero carbon emissions during utilization. Green hydrogen produced through water electrolysis using renewable electricity can significantly decarbonize industrial sectors, transportation, and power generation. Advanced hydrogen storage and fuel cell technologies further enhance its applicability in sustainable energy systems. Biofuels, derived from biomass such as agricultural waste, algae, and organic materials, provide a renewable alternative to conventional fossil fuels. First-generation biofuels include bioethanol and biodiesel produced from food crops, while second- and third-generation biofuels utilize non-food biomass and algae, improving sustainability and reducing competition with food resources. Biofuels contribute to carbon neutrality by recycling atmospheric carbon through biological processes. Battery technologies are another key component of modern energy systems, especially for integrating intermittent renewable energy sources such as solar and wind power. Advanced batteries, including lithium-ion, solid-state, and flow batteries, enable efficient energy storage, grid stabilization, and electrification of transportation systems. These technologies improve energy reliability, reduce power fluctuations, and support decentralized energy infrastructure. This paper examines the technological advancements, challenges, and future prospects of hydrogen, biofuels, and battery systems within the framework of global energy transition. It highlights their potential to complement renewable energy technologies and accelerate the shift toward sustainable and low-carbon energy systems. The study emphasizes that integrating these energy solutions can significantly contribute to achieving climate goals and creating a resilient energy ecosystem for future generations

Keywords: sustainable energy, biofuels, Batteries

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