BOOK OF ABSTRACTS

International Conference on Sustainable Technologies for Energy and Environment

ICSTEE – 2025

27 – 29 November 2025

Editors

Dr. P. Biji, Dr. R. Selvakumar, Dr. Anuradha M. Ashok, and Dr. R. Kothandaraman

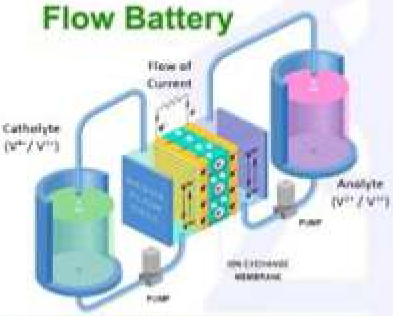
Jointly organized by

PSG Institute of Advanced
Studies, Coimbatore

ECS - IITM Student
Chapter, IIT Madras


H$_2$
O$_2$
H$_2$O
PEMFC
MEA
H$_2$/O$_2$ (Air)
ENERGY


H$_2$
O$_2$
H$_2$


Flow of Current
Catholyte (V^{4+}/V^{5+})
Anolyte (V^{2+}/V^{3+})
PUMP
ION EXCHANGE MEMBRANE
PUMP


CONTAINERIZED VRFB SYSTEM
10 kW/ 50kWh UNIT
RECYCLE


EV CHARGING STATION

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PSG Institute of Advanced Studies

PSG Institute of Advanced Studies (PSGIAS), established by PSG and Sons Charities in 2006, is an accredited research institute affiliated to Anna University and Bharathiar University. The institution offers MPhil and PhD programs in Chemistry, Physics, Nanoscience, Biotechnology, and Nanobiotechnology. The Nanotech Research Innovation and Incubation centre (NRIIC) of PSGIAS is equipped with state-of-the-art research facilities focusing on specialized research domains, including energy storage devices, solar cells, sensors, nanostructured thin films and coatings, functional materials, plasmonic materials, thin film transistors, water treatment, tissue engineering etc. PSGIAS takes pride in undertaking prestigious projects funded by organizations like DST, SERB, DRDO, ONGC, CHT, DBT, ICMR, etc. Additionally, the institute actively promotes academic and industrial collaborations, fostering growth and advancements in the fields of research and technology.

ECS IITM Student Chapter, IIT Madras

The ECS Indian Institute of Technology Madras student chapter was founded on 25th October, 2022. The faculty advisors are Prof. Kothandaraman Ramanujam, Prof. Raghuram Chetty, Prof. Ramanthan S, and Prof. Raman Vedarajan and its current president is Ms. Rubi Choudhary (PhD Scholar from IITM). This chapter aims to create a platform for disseminating the knowledge of electrochemistry, tailored for energy conversion and storage systems, among student peers. The activities of the chapter include talks by eminent professors, industrial visits, and conducting workshops having both pedagogical lectures and hands-on.

About the Conference

As the world grapples with the challenges of climate change, environmental degradation, and rising energy demands, the need for innovative solutions has never been more pressing. The global push for sustainability calls for urgent action, and technological innovation lies at the heart of these efforts. This international conference on "Sustainable Technologies for Energy and Environment" aims to bring together thought leaders, researchers, industry experts, and policymakers to explore cutting-edge technologies that are shaping the future of energy production, consumption, and environmental stewardship. The conference will explore the intersection of energy and the environment, focusing on how sustainable technologies can reduce carbon footprints, improve energy efficiency, and mitigate human impacts on the planet, while bringing together global experts to share knowledge and collaborate on solutions to sustainability challenges.

Conference Themes

Energy Conversion and Storage

- Fuel cells, batteries, supercapacitors and thermoelectric generators
- Advanced materials for energy storage
- Energy storage systems for renewable energy integration
- Green hydrogen production methods
- Advanced semiconductor technologies for energy conversion and storage
- Advanced computations and AI for energy conversion materials and devices

Carbon Capture, Utilization, and Storage

- Carbon utilization and conversion to valuable products
- Direct air capture and CO_2 removal technologies
- CCUS in industrial applications and usage of AI
- Storage technologies for carbon sequestration
- Biological CO_2 sequestration

Environmental Remediation and Water Treatment Technologies

- Advanced materials for pollutant removal
- Water purification technologies and desalination
- Wastewater treatment and resource recovery
- Sustainable solutions for soil and air pollution
- Innovations in environmental monitoring and data-driven remediation
- Advanced sensors for air, water and bioanalytes
- Surface and ground water contamination

Organizing Team

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Message from the
Managing Trustee

It is with immense pleasure that I extend my warmest greetings and congratulations on the successful organization of the International Conference on Sustainable Technologies for Energy and Environment (ICSTEE 2025), collaboratively hosted by the PSG Institute of Advanced Studies and the ECS - IIT Madras Students Chapter.

In our pursuit of excellence, we recognize that the most meaningful research is that which directly addresses the planet's pressing challenges. The theme of this conference is therefore profoundly timely, focusing on Sustainable Technologies for Energy and Environment—areas critical to societal well-being and future resilience.

I sincerely appreciate the high calibre of the research presented by the delegates, faculty, and scholars. May this intellectual confluence spark new ideas, foster enduring global collaborations, and ultimately, pave the way for translational breakthroughs that truly benefit humanity.

I look forward to the significant accomplishments that will emerge from the knowledge shared within these proceedings.

Shri L. Gopalakrishnan

Managing trustee
PSG and Sons' Charities

FOREWORD

It is a distinct honour and a great pleasure to write the Foreword for the proceedings of the International Conference on Sustainable Technologies for Energy and Environment (ICSTEE 2025).

The theme of this conference is profoundly important. As the world confronts the dual challenges of energy security and environmental sustainability, the research presented herein—ranging from novel materials to innovative systems—reflects a critical, global commitment to seeking solutions with significant technological maturity and societal impact.

I extend my heartfelt congratulations to the organizing bodies, the PSG Institute of Advanced Studies and the ECS - IIT Madras Students Chapter, along with the dedicated conference chairs, faculty, and research scholars whose tireless efforts have ensured the success and high calibre of this event.

I sincerely thank the PSG Management and our Managing Trustee, Mr. L. Gopalakrishnan, for their unwavering vision and support in fostering a culture of advanced research and international collaboration.

I look forward to the continued impact of the knowledge shared within these pages and trust that the intellectual property and technology transfers spurred by this dialogue will contribute meaningfully to a sustainable future.

Best wishes to all participants and readers.

PRadhakrishnan.

Dr. P. Radhakrishnan

Emeritus-Director, PSG Institute of Advanced Studies

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Homi Bhabha National Institute
प्रशिक्षण विद्यालय परिसर, अणुशक्तिनगर, मुंबई 400094, भारत Training School Complex, Anushaktinagar,
Mumbai – 400 094, India Tel. No. 91-22-69297638 Email: vicechancellor@hbni.ac.in

PLATINUM JUBILEE YEAR
70
Glorious Years
1954-2024
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FICS, FIIM, HFECSI, FIIChE, FIE,
FASch, HMIIM, HMUDCTAA
Vice Chancellor

प्रो. यू. कामाची मुदली
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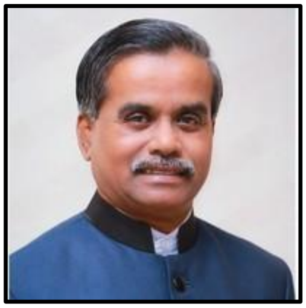
FICS, FIIM, HFECSI, FIIChE FIE
FASch, HMIIM, HMUDCTAA
कुलपति



Forwarding Message

I am pleased to learn that the PSG Institute of Advanced Studies and the ECS IITM Students Chapter, IIT Madras are jointly organizing the International Conference on Sustainable Technologies for Energy and Environment (ICSTEE 2025), during Nov 27-29, 2025 at PSG Convention Center, PSG iTech Campus, Neelambur, Coimbatore. Based on the deliberations of the Conference a proceeding of the presentations is bought out in this occasion. This conference arrives at a crucial juncture when nations worldwide are intensifying efforts to secure green energy solutions, develop advanced materials, and implement effective environment remediation strategies to meet the growing societal and industrial demands for sustainability. Thus ICSTEE 2025 has provided a distinguished scientific were fundamental research seamlessly interfaces with technological innovation. The breadth of topics discussed, ranging from electrochemical energy conversion systems, hydrogen production pathways, corrosion and materials integrity, advance catalysis, and functional materials, to environmental monitoring, and remediation technologies, reflects the multidisciplinary nature of the challenges ahead. The research contributions presented here underscore the scientific rigor and innovation essential for addressing the multifaceted challenges associated with climate change, energy security and environmental sustainability.

The papers included in this proceeding have undergone careful review and reflect high-quality intellectual contributions from diverse disciplines. They collectively highlight the critical role of fundamental understanding, advanced characterization, and integrated system design in accelerating the deployment of next-generation technologies. I am confident that this proceeding will serve as a valuable reference for research for researchers working towards sustainable and high-impact solutions.

I appreciate the exemplary efforts of PSGIAS and the ECS IITM, Students Chapter in coordinating this conference with academic precision and professionalism. Their collaborative spirit exemplifies the importance of institutional partnerships in driving impactful research and innovation. The dedicated work of the organizing committee, reviewers, and technical teams has ensured the successful realization of this scientific event.

I extend my best wishes to all authors and participants and encourage you to continue advancing research that strengthens India's technological capabilities and contributes meaningfully to global sustainability and societal progress.

UKamachi Mudali
Prof. U. Kamachi Mudali
Vice Chancellor, Homi Bhabha National Institute (HBNI), Mumbai
Distinguished Chief Guest, ICSTEE-2025

A Deemed to be University under the University Grants Commission Act, 1956 and a Grant-in-Aid Institute of the Department of Atomic Energy

Birla Institute of Technology & Science, Pilani
K K Birla Goa Campus

Prof. Ramakrishna Ramanath Sonde
Emeritus Professor – Department of Chemical Engineering
Adjunct at IIT D, IIT R, IIT Jodhpur, IIT GN, IIT-ISM Dhanbad
(Formerly with Atomic Energy Commission, NTPC Ltd., Thermax Ltd.)
Chairman ESTIC – EEC Thematic Vertical, Chairman – Jodhpur National Hydrogen Valley

Forwarding Message

It gives me immense pleasure to forward the proceedings of the *International Conference on Sustainable Technologies for Energy and Environment (ICSTEE 2025)*, jointly organized by PSG Institute of Advanced Studies and the ECS IITM Students Chapter, IIT Madras. This conference reflects a timely and purposeful convergence of researchers, innovators, and practitioners committed to shaping a sustainable energy future for our nation.

India today stands at the threshold of a transformative journey toward *Viksit Bharat 2047*, a vision that demands not only technological advancement but also systemic integration of clean, efficient, and secure energy solutions. The mission before us is clear: to decarbonize our economy, strengthen energy self-reliance, and build resilient ecosystems that support high-growth, low-emission development. Achieving this requires innovation across multiple fronts—renewable power systems, green hydrogen, advanced materials, circular economy principles, digitalization, and deep-tech manufacturing.

The time has come to reset our scientific approaches with new models that enable speed and scale while ensuring sustainability and equity. For a nation like India, which is on an exponential growth trajectory, the next 25 years leading to *Viksit Bharat @ 2047* will be pivotal. India's economy is projected to grow to USD 35 trillion, while its energy demand is expected to increase from the current ~8,500 TWh to nearly 32,000 TWh. Simultaneously, India has committed to reducing CO_2 emissions from ~3100 million tons to under 1300 million tons to achieve net zero by 2070. This represents a historic challenge that no developed nation has faced on such a scale and at such a pace.

Therefore, India must evolve new paradigms and new modes of conducting science—particularly translational science—to accelerate development, redesign legacy systems, and enable solutions that combine innovation, sustainability, and societal relevance.

ICSTEE 2025 has provided a valuable platform to deliberate on these pillars. The diverse contributions presented in these proceedings embody the spirit of scientific excellence and translational research. They highlight the critical role of advanced materials, catalysis, electrochemical systems, storage technologies, and environmental engineering in accelerating India's clean energy transition. Equally important is the emphasis on scalability and affordability—attributes essential for delivering real impact across India's vast social and industrial landscape.

As someone who has been privileged to lead several national missions in the energy domain, I firmly believe that India's progress in this century will be shaped by *sustainable engineering*, *disruptive innovation*, and *mission-driven collaboration*. Conferences like ICSTEE serve as a crucible where young researchers, technologists, and industry leaders co-create solutions that will ultimately power India's march toward a prosperous, carbon-neutral future.

I congratulate the organizers for their dedicated efforts and extend my best wishes to all contributors. May these proceedings inspire further breakthroughs and guide our collective stride toward realizing a *Viksit Bharat* by 2047.

RR Sonde

Dr. R. R. Sonde
Senior Professor Emeritus, BITS Pilani, Goa
Distinguished Plenary Speaker, ICSTEE 2025

सुनील कुमार
महानिदेशक
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DIRECTOR GENERAL

ओएनजीसी एनर्जी सेन्टर
छठवाँ तल, कोर-3, स्कोप मीनार, लक्ष्मी नगर, दिल्ली - 110092
दूरभाष : +91-11-22406601
ONGC Energy Centre
6th Floor, Core-3, SCOPE Minar, Laxmi Nagar, Delhi - 110092
Phone : +91-11-22406601
E-mail : kumar_sunil9@ongc.co.in, sunilkongc@gmail.com

Forwarding Message

I wish to extend my sincere appreciation for inviting me as the Guest of Honour for the International Conference on Sustainable Technologies for Energy and Environment (ICSTEE 2025).

It is a great privilege to join you as the guest of Honor at the International Conference on Sustainable Technologies for Energy and Environment, jointly organized by PSG Institute of Advanced Studies and ECS-IIT Madras Students Chapter, with the support of the Association of Hydrologists of India. The chosen themes—sustainability, technological innovation, and environmental stewardship—are crucial as we respond to the urgent challenges of climate change and rising energy needs. ONGC Energy Centre remains devoted to driving the transition to sustainable energy systems through research, innovation, and collaboration across academia and industry. At this conference, I encourage all participants—scientists, researchers, industry professionals, and policymakers—to engage deeply, share knowledge, and foster partnerships that can advance impactful solutions for a cleaner and more energy-efficient future.

Wishing you fruitful deliberations and meaningful collaborations at PSG Institute of Advanced Studies, Coimbatore, as you shape technologies for tomorrow’s world.

24.11.2025
SUNIL KUMAR
Director General

Telegram : Scienctech
दूरभाष/Tel : 26962819, 26567373, 26562134, 26562122 (EPBAX)
फैक्स/Fax : 26569908, 26864570, 26863847, 26862418
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नई दिल्ली–110 016

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MINISTRY OF SCIENCE AND TECHNOLOGY,
DEPARTMENT OF SCIENCE AND TECHNOLOGY,
TECHNOLOGY BHAVAN, NEW MEHRAULI ROAD,
NEW DELHI-110 016

Forwarding Message

I am pleased to forward the proceedings of the International Conference on Sustainable Technologies for Energy and Environment (ICSTEE 2025), jointly organized by PSG Institute of Advanced Studies and the ECS IITM Students Chapter, IIT Madras. This conference represents a timely and significant platform that brings together experts working across the clean energy and environmental innovation ecosystem, by enabling dialogue on emerging materials, advanced technologies, and system-level solutions, ICSTEE 2025 contributes meaningfully to national priorities in sustainable development.

The Department of Science and Technology (DST) remains deeply committed to accelerating India's efforts in clean and sustainable energy. Several ongoing and upcoming initiatives, particularly in Green Hydrogen, critical materials for energy storage, carbon capture and utilization, advanced fuel cells, and renewable-integrated systems, are being strategically developed to support India's transition toward energy security and a low-carbon economy. The next phases of the National Green Hydrogen Mission, expanded support for Hydrogen Valleys, and targeted programs in electrolyzer innovation, catalyst development, and waste to-energy technologies will play a pivotal role in enabling indigenous technology development, scale-up, and deployment.

Environmental sustainability continues to be a national imperative and DST actively promotes R&D in areas such as air and water quality, circular economy pathways, climate resilient materials, and sensor technologies for monitoring and mitigation. These initiatives are closely aligned with India's broader vision for Viksit Bharat @ 2047, where science, technology, and innovation will drive sustainable growth and societal well-being.

I commend the organizers of ICSTEE 2025 for establishing a platform that harmonizes scientific excellence with societal relevance. The contributions presented in this conference will undoubtedly support India's mission to build a clean, green, and technologically empowered future, I extend my best wishes for the continued success of this initiative and for future collaborations that advance our national energy and environmental objectives.

Dr. Ranjith Krishan Pai
Scientist F / Senior Director,
Department of Science and Technology,
Government of India
Distinguished Plenary Speaker, ICSTEE 2025

Message

Dr. R. Vijay
Director
International Advanced Research Centre for
Powder Metallurgy and New Materials (ARCI)
Hyderabad

Energy plays a pivotal role in the existence, development, and sustenance of humanity. As the global population continues to grow, the demand for energy is increasing at an unprecedented rate. At present, a major share of energy production depends on fossil fuels, leading to escalating CO_2 emissions, global warming, and environmental pollution. This reality underscores the urgent need for developing sustainable technologies for energy generation, conversion, and environmental protection. The global pursuit of sustainable development calls for continuous advancements in materials, processes, and systems that enable efficient energy utilization and responsible environmental stewardship.

I am happy to know that PSG Institute of Advanced Studies, Coimbatore has taken the commendable initiative to organize an International Conference on Sustainable Technologies for Energy and Environment (ICSTEE 2025) during 28-29 November 2025. The conference brings together leading thinkers, experienced professionals, and young researchers who are dedicated to addressing challenges critical to energy efficiency, environmental resilience, and technological sustainability.

ICSTEE 2025 provides an excellent platform for scientists, engineers, technologists, and industry leaders to exchange transformative ideas, showcase emerging research, and foster collaborations that will shape the next generation of sustainable technologies. I am confident that the deliberations and research contributions shared through this conference will inspire new pathways towards sustainable technological solutions.

I congratulate the organizers for their dedicated efforts in bringing together experts from diverse domains and for providing a forum that encourages meaningful dialogue and innovation. My best wishes for the success of ICSTEE 2025 and for the impactful dissemination of knowledge through its conference proceedings.

Dr. R. Vijay
Director,
ARCI, Hyderabad

Prof. Kothandaraman Ramanujam
Department of Chemistry
Indian Institute of Technology Madras
Email: rkraman@iitm.ac.in
Phone:044 2257 4249

Forwarding Message

I take this opportunity to forward the proceedings of *International Conference on Sustainable Technologies for Energy and Environment (ICSTEE 2025)*. It gives me great pleasure to welcome you to the ICSTEE 2025 to be held from 27–29 November 2025 at PSG Institute of Advanced Studies, Coimbatore. Jointly organized by PSGIAS and the ECS – IIT Madras Students Chapter, this conference aims to serve as a premier platform for scientists, researchers, industry professionals, and policymakers working at the critical intersection of energy and the environment.

In an era defined by climate change, escalating energy demands, and environmental degradation, ICSTEE-2025 focuses on sustainable technologies that can meaningfully reduce our carbon footprint, enhance energy efficiency, and promote responsible stewardship of our planet. The conference themes span cutting-edge areas such as energy conversion and storage, carbon capture, utilization and storage (CCUS), as well as environmental remediation and water treatment technologies, reflecting the breadth and depth of global research in these domains.

Besides we (Faculty advisors and Student Office Bearers of ECS-IITM Students Chapter) are excited to host the pre-conference workshop "*Charge Craft: Advanced Electrochemistry with Hands-on Electro-organic Synthesis, Battery Testing, and EIS*". Designed to bridge theory and practice, this workshop will introduce participants to advanced electrochemical energy systems and offer immersive, hands-on exposure to modern experimental techniques—nurturing the next generation of researchers and technologists in sustainable energy.

I warmly invite students, early-career researchers, and seasoned experts alike to participate actively—by presenting your work, engaging in discussions, and building collaborations that transcend disciplines and geographies. We look forward to welcoming you to Coimbatore and to ICSTEE-2025, and to collectively shaping innovative pathways toward a cleaner, more sustainable energy future.

Prof. Kothandaraman Ramanujam
Convenor of ICSTEE from IIT Madras
Department of Chemistry,
The Energy Consortium-IITM (https://energyconsortium.org/)
Indian Institute of Technology Madras, Tamil Nadu-600036, India.

Message from the
Director

It is my distinct pleasure to welcome all participants and contributors to the International Conference on Sustainable Technologies for Energy and Environment (ICSTEE 2025), a significant event jointly organized by the PSG Institute of Advanced Studies and the ECS - IIT Madras Students Chapter.

The assembly of brilliant minds gathered for ICSTEE underscores the critical importance of our collective work. The conference theme, focusing on sustainable technologies, directly aligns with our institutional mission to drive high-end, impactful research that addresses global challenges. I am confident that the deliberations, research articles, and insights contained within these proceedings will offer immense value to the academic and industrial communities worldwide.

I wholeheartedly acknowledge the unwavering dedication and commitment of our organizing faculty members and research scholars, whose efforts have been pivotal in shaping this successful international forum.

These achievements and collaborations have been made possible through the constant support and visionary guidance of our Managing Trustee, Shri L. Gopalakrishnan, and our Emeritus Director, Dr. P. Radhakrishnan. Their encouragement has been instrumental in fostering our progress and excellence in research and innovation. I also sincerely appreciate the ongoing support and collaborative spirit extended by the Heads of all PSG Institutions, our esteemed funding agencies, and our valuable industry partners.

As we look to the future, we are enthusiastic about continuing this journey toward greater accomplishments in translational research and innovation in the crucial fields of energy and environment.

I wish everyone a highly engaging and productive conference experience.

Dr. Kanchana Jeganathan
Director - Global Engagement,
PSG Institute of Advanced Studies

FOREWORD

It is my privilege, as the convener of ICSTEE 2025 from PSGIAS, to forward the Proceedings of the *International Conference on Sustainable Technologies for Energy and Environment (ICSTEE 2025)*, jointly organized by the PSG Institute of Advanced Studies and the ECS-IITM Students Chapter, IIT Madras. This partnership has enabled a vibrant platform for scientific dialogue and collaborative advancement in areas of global relevance.

ICSTEE 2025 provides a forum to explore emerging materials, processes, and technologies that support cleaner energy pathways and enhanced environmental quality. The conference highlights diverse research efforts aimed at developing innovative and practical solutions for sustainable energy generation, resource efficiency, and ecological well-being.

The event commences with pre-conference workshops that offer hands-on training and deeper technical exposure for students and young researchers. The subsequent two-day conference features insightful keynotes, thematic sessions, and engaging discussions, and I gratefully acknowledge the entire organizing committee from PSGIAS and IIT Madras for their dedicated efforts in ensuring its successful conduct.

I extend my sincere appreciation to all the delegates, speakers, sponsors and participants from various institutions from India and abroad for their valuable contributions. My heartfelt thanks also go to the management of PSG, mentors, faculty members, student volunteers and administrative staff for their consistent support throughout the organization of ICSTEE 2025.

I hope that the ideas and outcomes captured in these proceedings inspire meaningful collaborations and impactful research. My best wishes to all the participants in their future scientific endeavours.

Dr. P. Biji
Convener, ICSTEE 2025
Professor & Head, Department of Chemistry & Nanoscience
PSG Institute of Advanced Studies, Coimbatore

Let's Meet Our Experts


Dr. U. Kamachi Mudali
Homi Bhabha National Institute,
Mumbai


Prof. R. R. Sonde
BITS Goa


Dr. Ranjith Krishna Pai
DST, Government of India


Mr. Sunil Kumar,
ONGC Energy Center, New Delhi


Dr. R. Vijay
ARCI Hyderabad


Prof. Pratibha Sharma
IIT Bombay


Prof. Yun Hee Jang
DGIST, South Korea


Prof. Shanmugam Sangaraju
DGIST, South Korea


Prof. R. Kothandaraman
IIT Madras


Prof. Shobha Shukla
IIT Bombay


Dr. D. Parvatalu
ONGC Energy Center, Mumbai


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Radhakrishnan
Univ. of Pretoria, South Africa


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Dr. Raman Vedarajan
ARCI, Chennai


Dr. M. Sathish
CSIR-CECRI, Karaikudi


Dr. B. Rakhi
NIIST, Trivandrum


Dr. Vanchiappan Aravindhan
IISER, Tirupati


Dr. Rohini Kitture
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Dr. Bhuvneswari Sridhar
IIT Madras


Dr. Manjusha Battabyal
IITDM, Kancheepuram


Dr. B. Bhuvaneswari
IIT BHU


Dr. Dinesh Jagadeeshan
IIT Palakkad


Prof. Sumit Saxena
IIT Bombay


Dr. Rajini Antony
BARC, Kalpakkam


Dr. T. Maiyalagan
SRMIST, Kattankulathur


Dr. Ulaganathan Mani
Amrita Vishwa Vidyapeetham
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Dr. Rohit Srivastava
PDEU, Gujarat


Prof. Sudip Kumar Batabyal
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Limited, Trichy


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Bharathiar University,
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Dr. Ashish Pandey
Carl Zeiss India Pvt., Ltd,
Bengaluru

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PLENARY LECTURES

PL-1

Science - Speed-Scale in Sustainability and from Pilot to Policy for Industrial Impact

Dr. Ramakrishna Ramanath Sonde
Birla Institute of Technology and Science, Goa
Email: ramakrishnas@goa.bits-pilani.ac.in

Abstract

Humanity is at a turning point in its long history of evolution where on one hand due to positive disruptive science has created an enormous amount of wealth, economy resulting in a better life quality and on the other hand, the same science has created a negative disruption in ecology and climate change to the extent the existential crisis is nearly upon us! The cheap access to energy (fossil mainly) is the disruptor -in-chief for both. And time has come now to reset this very science to bring ecology back on track but still ensure that development does not take a hit. For a nation like India in its exponential trajectory where in next 25 years leading to our Viksit Bharat@2047 India will reach an economy of 35 trillion $ economy and its energy demand will grow from current 8500 TWh to 32000 TWh and India is committed to bring down the CO_2 emissions from current 3100 Million tons to under 1300 million tons for its net zero by 2070 means an enormous challenge no developed nations had ever to face.

So, India needs new paradigms and a new mode of doing science and needs to bring enormous speed and scale to its development and reset many of the current legacy systems both in R&D and its translational aspects.

The talk gives insights into the new models and methodology India will have to follow. Author's personal experience in many areas of sustainability and big technology development platforms like hydrogen, CCUS and decarbonization of the CO_2 guzzling industry.

PL-2

Research to Reality: Building India's Green Hydrogen Ecosystem through Innovation and Collaboration

Dr. Ranjith Krishna Pai
Department of Science and Technology
Ministry of Science and Technology, Government of India, New Delhi – 110016, India
Email: ranjith.krishnapai@gov.in

Abstract

The Department of Science and Technology (DST), Government of India, is leading the nation's transition toward sustainable and self-reliant energy in line with the PANCHAMRIT commitments and the Atmanirbhar Bharat vision. Since 2018, DST's Hydrogen and Fuel Cell (HFC) programme has been strengthening India's clean energy ecosystem through the development of critical infrastructure, demonstration projects, and global collaborations.

Under the Clean Energy Research Initiative, DST supports research on renewable-powered electrolysis and next-generation hydrogen production using wastewater and saltwater. The HFC and Advanced Hydrogen and Fuel Cell (AHFC) programmes have collectively funded over 50 projects across leading academic and R&D institutions. Centres of Excellence at IIT Bombay and NFTDC Hyderabad are advancing work in metal hydrides, solid oxide fuel cells, and hydrogen storage technologies.

To drive commercialization and regional adoption, Hydrogen Valley Innovation Clusters (HVICs) have been established in Jodhpur, Pune, Kochi, and Bhubaneswar, creating integrated hydrogen value chains across key sectors such as transport, refining, fertilizer, and steel. Complementary initiatives like Materials for Energy (M4E) and the Integrated Clean Energy–Material Acceleration Platform (IC-MAP) employ AI, automation, and data analytics for accelerated materials discovery and system integration.

Together, these initiatives provide a robust national framework connecting research, innovation, and global collaboration under Mission Innovation 2.0. This integrated approach positions India as a frontrunner in the global green hydrogen economy, advancing a low-carbon, technology-driven, and energy-secure future.

Keywords: Green hydrogen, Fuel cells, Electrolysis, Hydrogen Valley, Decarbonisation, Clean energy research

PL-3

Development of Materials and Processes for Energy @ ARCI

Dr. R. Vijay
International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI),
Balapur P.O, Hyderabad, Telengana, India 500005
Email: vijay@arci.res.in

Abstract

The energy demand for India is increasing as the country is marching to become a developed nation and hub for manufacturing and electric mobility. In order to meet the ever-increasing demand for energy without significant increase in CO_2 emission, there is a need to harness the renewable energy and also increase the efficiency of thermal power plants. Hydrogen, clean energy carrier, can be other option for energy generation. The challenge with renewable energy is its continuous availability and therefore the generation of energy also varies. In order to meet this challenge, the energy generated through renewable energy needs to be stored so that it can be supplied to the grid continuously as per the demand. So, the materials development plays a key role in generation, storage and conversion of energy and the processes employed to produce the materials should be sustainable

Advanced materials are being developed at ARCI for the above applications and the presentation gives an overview of these activities.

KEYNOTE LECTURES

KL-1

Metal Hydride Materials and Systems for various Applications

Dr. Pratibha Sharma
Department of Energy Science and Engineering, Indian Institute of Technology Bombay,
Powai Mumbai 400 076, India
Email: pratibha_sharma@iitb.ac.in

Abstract

Hydrogen as an energy carrier is viewed as a potential medium to decarbonize the energy economy in different forms of domestic and commercial sectors. Hydrogen has high gravimetric energy density and can be produced using greener routes such as renewable energy integrated water electrolysis thereby resolving the issue of renewable energy intermittency. Despite all advantages, hydrogen being a light gas, the storage of hydrogen in confined volume remains a major challenge. Compressed gas hydrogen storage and liquified hydrogen storage are two commercially matured technologies that are majorly used for end use applications in different utility sectors. However, these matured technologies suffer from major limitations such as higher compression pressure storage and boil off losses hindering the adoption of hydrogen-based technology on a global scale. In order to overcome the limitations associated with commercial hydrogen storage technologies, Metal hydride (MH) based hydrogen storage technology is viewed as one of the potential mediums of hydrogen storage in the present scenario.

Metal Hydride based hydrogen storage is a method of storing hydrogen in atomic form within interstitial metal alloys by means of absorption. The hydrogen can be safely stored at lower pressures (<100 bar) at near ambient temperature for long term with high volumetric density of 100 to 150 kg/m^3 compared to 40 kg/m^3 of 700 bar compressed hydrogen storage or 71 kg/m^3 of liquid hydrogen storage. The life cycle of MH alloys being more than 1500 cycles and having regeneration capability to initial storage capacity at the end of life eliminating the need to replace storage unit like batteries. These primary advantages of MH based hydrogen storage have led to increment in research and development at both materials and system development for commercial applications within research community. The hydrogen absorption/charging process is an exothermic process and hydrogen desorption/charging process is an endothermic process. The exothermicity and endothermicity yields a secondary benefit which can be utilized for space heating and cooling applications respectively. However, the exothermic and endothermic nature of charging a discharging reaction put forth a heat transfer challenges within storage system design and development impacting the charging or discharging time of hydrogen for end use. In order to address this challenge, different combinations of heat augmentation techniques are implemented within MH based hydrogen storage system for improving heat transfer from or to the core of MH bed during charging and discharging respectively. Apart from hydrogen storage, MH based hydrogen systems can be

utilized in stationary power generation, thermal energy storage, hydrogen compression, hydrogen purification, vehicular applications, heat pumps, heat transformers, refrigeration and air conditioning. The versatility of usage of MH system is related to capability of tailoring the properties of hydrogen storage alloys to accomplish necessary end objectives.

KL-2

Green Hydrogen Development Initiatives at ONGC Energy Centre

Dr. D. Parvatalu
Hydrogen Team, Oil and Natural Gas Corporation (ONGC) Energy Centre, India
Email: parvatalu@gmail.com

Abstract

The ongoing energy transition aims at gradual phasing out the fossil fuels from the world energy basket with the mediation of renewables and Hydrogen leading to attain the net zero economy. However, the journey is passing through rough patches in view of the inherent market related issues associated within the supply chain management of the GH2 at scales viz., generation, handling, storage, safety, transportation, end use applications etc. Commercially proven electrolytic water splitting technologies viz., Alkaline / PEM Electrolyzers are only option right now despite the associated high hydrogen costs that are being addressed using innovative technological advancements in the electrochemical system management especially to optimize costs of the materials and membranes. In addition, from a long-term perspective, alternate approaches using the renewable thermal power are seriously considered. One such area is the development of hybrid Thermochemical water splitting cycles viz., Iodine-Sulfur (I-S) and Copper Chlorine(Cu-Cl) that work at 900oC and 550 °C respectively that have potential for higher efficiencies (> 50%) in conjunction with the Solar / Nuclear thermal power; currently they are leading to pilot scale demonstrations. In line with the national GH2 initiatives, ONGC Energy Centre (OEC) set up by ONGC-India has been working on various alternatives for country specific sustainable energy solutions during and beyond hydrocarbons. Besides focusing on many activities related to GH2 Economy, the Centre is on the development of I-S and Cu-Cl technologies through concept to the commercialization using a collaborative consortium approach. Various national centres of excellence along with the Indian industry joined this drive. The present talk gives an overview of OEC initiatives in some key areas of GH2 economy that hold promise for further activity at scales in relation to global development.

KL-3

Reinforcing a Lithium-ion Battery Cathode (NCA) with Mn Doping

Swati Panigrahi[1], Kothandaraman Ramanujam[1,2*]
[1] Department of Chemistry, Indian Institute of Technology Madras, Chennai 600036
[2] Adjunct Faculty, University of Southern Queensland, Australia
Email: rkraman@iitm.ac.in

Abstract

Nickel-rich layered oxide cathodes have emerged as one of the leaders for next-generation lithium-ion batteries (LIBs), offering high energy density and a relatively lower cobalt content. However, challenges such as cation mixing, structural degradation, and poor cycle retention persist. In this study, we systematically investigate the effect of controlled manganese (Mn) substitution in a NCA cathode materials synthesized via a solid-state route, targeting enhanced structural and electrochemical stability. XRD, Rietveld and TEM analyses confirm single-phase layered α-$NaFeO_2$-type structures with decreasing phase purity and c/a ratios at high Mn content ($x \geq 0.2$), indicating an increased cation disorder in the samples with increasing Mn contents. Mn introduction oxidation states of both Ni and Co besides, due to Jahn-Teller distortion, particles undergo pulverization with the introduction of Mn. The presence of excess of Mn on the particle surface is confirmed with EELS. The sample with $x = 0.1$ (NMCA-1) demonstrated the optimal balance, exhibiting minimal lattice strain (0.0004%), the smallest crystallite size (~50 nm), and comparable structural integrity with an I(003)/I(104) ratio of 1.25. Electrochemically, NMCA-1 delivered the highest capacity retention (~85% after 100 cycles at 0.2C), outperforming both undoped NCA (~70%) and fully Mn-substituted NMA (~45%). Despite a slight reduction in initial capacity (137 mAh g^{-1}), NMCA-1 exhibited superior rate capability (77 mAh g^{-1} at 2C) and reduced overpotential growth, confirmed by CV and EIS analyses. Our findings highlight the synergistic effect of Mn and Al co-doping in optimizing cathode performance by tuning structural strain, mitigating phase degradation, and enhancing long-term cycling behaviour. This approach offers a cost-effective and scalable strategy to engineer high-performance cathode materials for future LIB applications.

KL-4

Hard-Cation-Soft-Anion Ionic Liquids Enhancing PEDOT:PSS Conductivity and Stretchability. Multiscale Molecular Modeling

Prof. Yun Hee Jang
Department of Energy Systems Engineering, Daegu Gyeongbuk Institute of Science and Technology (DGIST), South Korea
Email: yhjang@dgist.ac.kr

Abstract

PEDOT:PSS, a water-processable mixture of cationic PEDOT and anionic PSS, is a stretchable, lightweight, and transparent organic semiconductor, electrochemical transistor, and ultimately artificial skin. With its high electrical conductivity, low thermal conductivity, flexibility, and water solubility, PEDOT:PSS is also an excellent choice for flexible, wearable, and eco-friendly thermoelectric devices. Its granular domains, where conducting-but-hydrophobic PEDOT-rich regions are surrounded by hydrophilic-but-insulating PSS-rich regions, hinders formation of large conducting PEDOT domains. It makes PEDOT:PSS water-soluble but poor in conductivity. Polar organic solvents, acids, and salts have enhanced the conductivity, and remarkable 5,000-fold improvement of conductivity has been achieved by mixing proper ionic liquids (ILs) in a PEDOT:PSS solution. Our free energy calculations combining density functional theory, molecular dynamics simulations, and the classic "hard soft acid (cation) base (anion)" principle have demonstrated that (1) ion exchange between PEDOT+:PSS– and A+:X– ILs help PEDOT+ to decouple from PSS– and grow into large-scale conducting domains of π-stacked PEDOT+ decorated by IL anions X–; (2) the most spontaneous decoupling between hydrophobic/soft PEDOT+ and hydrophilic/hard PSS– is induced by strong interaction with hydrophobic/soft anions X– and hydrophilic/hard cations A+, respectively; and (3) the most efficient IL anions X– remaining in the PEDOT domain after the ion exchange sustain the highest amount of charge carriers uniformly distributed along the PEDOT backbone to further enhance the conductivity as well as stretchability.

KL-5

Electrosynthesis of Green and Sustainable Fuels

Dr. Sangaraju Shanmugam
Department of Energy Science & Engineering
Daegu Gyeongbuk Institute of Science and Technology (DGIST)
Daegu, 42988, South Korea
Email: sangarajus@dgist.ac.kr

Abstract

The increasing demand for energy and growing environmental concerns have prompted global efforts to find and explore alternative energy sources to fossil fuels. Electrocatalysts have played a crucial role in various electrochemical energy devices, including polymer electrolyte fuel cells and electrolyzers. Innovative design for highly efficient and durable catalysts has been considered. Replacing noble metals or metal oxides is a promising approach to overcome the high cost and elemental scarcity that greatly hinders their widespread applications.

First, I will describe our recent research on developing low-cost, efficient, and robust electrocatalysts for water splitting to store sustainable energy resources. The transition metal-carbon electrode exhibits excellent activity for OER, demonstrating superior stability compared to the noble metal electrode. The long-term water electrolysis cell stability testing using alloy core-carbon shell catalysts demonstrates stable activity over 760 hours (voltage loss of 4%) and outperforms commercial (noble) catalysts. Electrochemical ammonia synthesis via NO conversion has proven to be a promising alternative to the energy-intensive, polluting Haber-Bosch process. We demonstrated a room-temperature approach to transform pollutants into value-added e-chemicals with high selectivity and efficiency. Our recent efforts have been focused on promoting the performance of single-atom catalysts in electrochemical NO reduction to ammonia, as well as the synthesis and characterization of dual-metal FeNi single-atom active sites anchored on porous graphitic nanospheres. The Cu nanowires in a multichannel carbon nanorod catalyst as a cathode for NORR will be discussed.

KL-6

Advanced Nanoarchitectures: Transforming Defence Capabilities with Multifunctional Nanomaterials

Dr. K. Kadirvelu
Scientist 'G' & Associate Director – DRDO-DEBEL, Bangalore
DRDO Coordinator, DRDO Industry Academia - Centre of Excellence, Bharathiar University (DIA-CoE, BU), Coimbatore – 641 046
Email: Kadirvelukrishna@yahoo.com

Abstract

Modern warfare and national security challenges demand the development of smart, stimuli-responsive, and multifunctional materials capable of real-time threat detection, protection, and operational resilience. Among these, advanced nanoarchitectured materials are emerging as strategic enablers across a wide spectrum of defence applications ranging from sensing and gas adsorption to electromagnetic shielding and hazard decontamination. This article presents a comprehensive overview of three pivotal nanomaterial platforms: Quantum Dots (QDs), Metal-Organic Frameworks (MOFs), and MXenes. QDs exhibit size-tunable optoelectronic properties, offering exceptional potential for high-resolution sensors, real-time imaging, and adaptive photonic systems. MOFs, characterized by ultrahigh surface areas and tunable porosity, have demonstrated strong capabilities in chemical detection, toxic gas adsorption, and controlled release systems. MXenes two-dimensional transition metal carbides and nitrides possess high conductivity, hydrophilicity, and surface reactivity, positioning them as ideal candidates for electromagnetic interference shielding, protective coatings, and electrochemical sensing. Recent research highlights the synergy achievable through the integration of these materials, unlocking multifunctionality in compact formats suitable for extreme environments. The article further explores strategies for hybrid material design, field-deployable system integration, and rapid-response fabrication. Amidst intensifying global competition in nanotechnology, the ability to indigenously develop and scale such advanced materials is both a technological and strategic imperative. Moving forward, scalable synthesis protocols, data-driven material optimization, and AI-assisted architecture design will be key to realizing the full potential of these nanostructures in future battlefield environments. The convergence of nanoarchitectonics and defence innovation is poised to redefine threat detection, mitigation, and survivability ushering in a new era of intelligent material systems for next-generation defence platforms.

Keywords: Defence Technologies, Quantum Dots (QDs), Metal-Organic Frameworks (MOFs), MXenes, Nanoarchitectonics, Smart Materials, Multifunctional Systems

KL-7

Sustainable Water Management through Circularity Principles: Case Studies

Dr. Ligy Philip
Nita and K.G. Ganapathi Institute Chair Professor
Department of Civil Engineering, Indian Institute of Technology Madras
Email: ligy@iitm.ac.in

Abstract

Water scarcity has emerged as one of the most pressing global challenges of the 21st century. Rapid population growth, urbanization, and industrialization have placed unprecedented stress on freshwater resources, leading to over-extraction and severe depletion of aquifers. Simultaneously, the discharge of untreated and partially treated wastewater continues to degrade the quality of surface and groundwater systems. Compounding this issue, poor solid waste management further exacerbates contamination and resource loss. Addressing these challenges calls for a transformative shift in the way water and waste are perceived and managed — moving from a linear "use and dispose" approach to a circular model that emphasizes recovery, reuse, and regeneration.

This presentation highlights practical case studies and innovative technologies developed and implemented for achieving circularity in water management. Examples include the recycling of treated wastewater for indirect potable reuse, deployment of zero liquid discharge (ZLD) toilet systems, and nature-based solutions for decentralized greywater treatment and reuse. In addition, the presentation explores nutrient recovery and valorization of sludge through the production of value-added products, as well as energy-efficient wastewater treatment systems that enable enhanced energy recovery and reduced carbon footprints.

Integration of digital technologies, including IoT-based monitoring and smart water management tools, further enhances efficiency, transparency, and adaptive decision-making. Collectively, these efforts demonstrate how a circular approach can ensure sustainable water management, mitigate environmental pollution, and support the transition toward a resilient and resource-secure future.

KL-8

Electrochemical Activation of Carbon dioxide

Dr. Shankara G Radhakrishnan
[2]*Department of Chemistry, University of Pretoria, Pretoria, 0002, South Africa*
Email: shankara.radhakrishnan@up.ac.za

Abstract

CO_2 is considered a valuable carbon source in both its free and ligated form. Unfortunately, it is also an unwanted molecule due to its large emission into the atmosphere, leading to climatic changes. It is now generally accepted that CO_2 emission has to be reduced significantly in order to prevent excessive global warming.

An obvious strategy consists in abandoning the use of fossil fuel, but an alternative option aims at recycling carbon dioxide to renewable fuels using solar energy, inspired by the natural photosynthesis process. Understanding the fundamentals of the catalytic activation of this molecule with a particular emphasis on its electrochemical reduction towards valuable products and liquid fuels shall be discussed. The electrochemical reduction of CO_2 using hydrogen obtained via water electrolysis (called renewable hydrogen) along with the use of renewable energy to produce valuable fuels, is termed “renewable fuels”. This is typically the function of an “Artificial leaf” as mimicked from nature which converts CO_2 and water to sugar. This turns out to be a major challenge. Thus, understanding the fundamentals of the catalytic activation of CO_2 molecule with a particular emphasis on its electrochemical reduction towards valuable products and liquid fuels shall be discussed.

Keywords: CO2RR, CO_2 activation, water electrolysis, PEM electrolysis.

KL-9

Aerobic Granular Sludge Technology: Advantages, Challenges and Perspectives

Dr. Y.V. Nancharaiah[1,2]

[1]*Biofouling and Biofilm Processes Section (BBPS), Water & Steam Chemistry Division,*
Bhabha Atomic Research Centre, Kalpakkam 603102, Tamilnadu, India.
[2]*Homi Bhabha National Institute, Anushakti Nagar, Mumbai 400 094.*
Email: venkatany@barc.gov.in; yvn@igcar.gov.in

Abstract

Advanced biological wastewater treatment is essential for providing sanitation, safeguarding public health and recovering resources. Aerobic granular sludge (AGS) is a breakthrough biotechnology for effectively removing common and emerging contaminants and achieving environmental sustainability in wastewater treatment plants. AGS represents compact bacteria-laden granules, emerged as the most sustainable option of 21st century for advanced biological wastewater treatment. AGS is suitable for achieving simultaneous COD, ammonium and phosphate in single bioreactors without requiring compartmentalization. However, there are concerns on formation of AGS and their long-term stability under field conditions. Various experimental strategies have shown enhancement in granulation, granular stability and biological nutrient removal (BNR). In AGS systems, partial nitrification and denitrification (PND) pathway is responsible for converting ammonium to dinitrogen gas. While, enhanced biological P removal (EBPR) pathway account for removing phosphate from the wastewater. Polyphosphate accumulating organisms (PAOs) play critical role in granulation and bio-P removal. Phosphate removals are dependent on the abundance of PAOs. Our research demonstrated sustained phosphate removals via EBPR, and enrichment of PAOs in bioreactors operated at 15 to 35°C and in granular activated carbon-amended condition. Overall, AGS is robust and resilient to toxic pollutants. The systems robustness is related to compact microbial structure and higher tolerance of AGS-bacteria. In addition to advanced treatment, AGS offers circular economy concept and environmental sustainability including lower land footprint and costs in wastewater treatment plants. The AGS-based BARC's technology - hybrid granular sequencing batch reactor (hgSBR) is in the deployment phase for sustainable wastewater treatment. This presentation covers AGS, its advantages, challenges and perspectives for water security and sustainable development.

Keywords: Granular SBR, Emerging Contaminants, Nutrient Removal, Resource Recovery, Sewage Treatment, Sustainability.

KL-10

DNA condensation and aggregation induced by condensing agents

Jingxuan Wang,[2] Yves Lansac,[1,2,3]* Yun Hee Jang[2]*

[1] GREMAN, CNRS UMR 7347, Université de Tours, 37200 Tours, France
[2] Department of Energy Science and Engineering, DGIST, Daegu 42988, Korea
[3] LPS, CNRS UMR 8502, Université Paris-Saclay, 91405 Orsay, France
Email: lansac@univ-tours.fr, yhjang@dgist.ac.kr

Abstract

While DNA is one of the longest and the stiffest molecules in nature and is negatively charged, they are strongly condensed in a tiny space of cell nuclei and in some virus thanks to polyvalent cations and/or small basic proteins. For example, protamine, a small arginine-rich basic protein plays an important role in packaging paternal genome into sperm nuclei during spermatogenesis, achieving a 10^6-fold compaction of DNA, corresponding to a 10-20 times higher compaction than in somatic cells. The microscopic mechanism at play and the resulting DNA organization are not yet fully understood.

Using molecular modeling, we investigate the condensation of dsDNA chains (up to 8000 bp) and the aggregation of short dsDNA fragments (50 to 150 bp) driven by biological-relevant condensing agents: a short polyamine (spermine 4+) and a strongly basic and internally disordered protein (salmon protamine +21). Idealized models for dsDNA (roughly reproducing grooves), polyamine and protein, incorporating solely long-range electrostatic with explicit ions and steric interactions are used to capture and highlight generic behaviors in semi-dilute solutions and in confined geometry. Induced DNA morphologies are explored as a function of the short / long polycation and nucleic acid charge ratio and relevance to microscopic organization in bacteriophage and in sperm nucleus is discussed.

KL-11

Development of Sustainable Heterogeneous Catalysts for Energy and Environmental Applications

Dr. Venkata Krishnan
School of Chemical Sciences, Indian Institute of Technology Mandi, Himachal Pradesh.
E-mail: vkn@iitmandi.ac.in

Abstract

Energy crisis and environmental deterioration has emerged as major problems around the world in recent times, mainly due to combustion of fossil fuels and their depletion. The utilization of light and thermal energy to produce chemical fuels is an attractive and major strategy to address the global energy crisis and other environmental issues. Our research group has recently developed several two-dimensional materials supported on nanostructured photocatalysts based on semiconductors, plasmonic materials, perovskite structures and upconversion nanoparticles for energy generation and environmental remediation applications. In addition to photocatalytic hydrogen generation, nitrogen fixation and pollutants degradation, our group has also utilized these materials for plastics upcycling, carbon dioxide conversion and Green organic transformations, either by functionalization or doping with a heteroatom. The highlights of the ongoing research work of our group in sustainable chemistry and heterogeneous catalysis will be presented.

KL-12

2G Ethanol: A Promising Alternative Renewable and Sustainable Energy Carrier in India

Dr. K. Chandraraj
Department of Biotechnology, Indian Institute of Technology Madras, Chennai 600036
Email: kcraj@iitm.ac.in

Abstract

Fossil fuels such as petrol and diesel are the major energy sources for vehicular transportation worldwide. The combustion of petrol and diesel releases greenhouse gases (GHG) leading to negative environmental impacts like increase in atmospheric temperature and climate change. Alternate clean energy sources are being developed globally to replace fossil fuels and prevent negative environmental effects. Cleaner energy carriers such as biofuels and green batteries, and green fuel cells have attracted global attention for transportation without detrimental effects on the environment. Bioethanol is a promising energy carrier for transportation since it can be used directly in internal combustion engine and energy source for fuel cells (Direct Ethanol Fuel Cell, DEFC). In India, bioethanol produced from 1G feedstock (grains and sugar) is blended with petrol to partially reduce the use of petrol. Through the ethanol blended petrol (EBP) program in India, the current national average of 20% EBP has been achieved in 2025. The EBP program has shown environmental and economic benefits such as saving foreign exchange, reduction of crude oil import, increasing rural income, and reduction of carbon emission. Government of India has further increased the EBP target to 27%, and supported ethanol production from second generation (2G) cellulosic feedstocks such as nonedible food crop residues and energy crops. 2G ethanol production is desirable because of lower GHG emissions and no food vs fuel conflict. Recently, commercial 2G ethanol industries have been built by Indian oil marketing companies, and there are many upcoming 2G ethanol manufacturing facilities. There are technoeconomic hurdles in 2G ethanol production related to the conversion processes, by-products generation, and other logistics. A continuous effort is required to achieve 2G ethanol production economically competitive to petrol.

KL-13

Functional Biopolymeric Micro/Nanostructures using Femtosecond Laser Lithography and their Applications

Dr. Shobha Shukla
Department of Metallurgical Engineering and Materials Science
Indian Institute of Technology Bombay, Mumbai, India.
Email: sshukla@iitb.ac.in

Abstract

Femtosecond (fs) laser lithography has emerged as a powerful micro/nanofabrication technique, enabling maskless, high-resolution structuring with exceptional spatial precision. Its versatility has opened new avenues across nanophotonics, sensing, and biophotonics. Our research harnesses this capability to fabricate functional micro/nanostructures in polymers, ceramics, and natural biopolymers with sub-100 nm resolution and high reproducibility. In the biomedical domain, fs lithography is employed to create two- and three-dimensional biopolymeric scaffolds that mimic native extracellular matrix (ECM) architecture to guide cell behavior. Traditional patterning methods often rely on complex, multistep fabrication and non-biocompatible materials requiring surface modifications. To overcome these challenges, we developed a single-step fs laser lithography process to fabricate biocompatible, micro/nanostructured chitosan substrates with anisotropic and isotropic patterns. These substrates supported direct adhesion, spreading, and alignment of human mesenchymal stem cells (hMSCs) without any ECM coating, demonstrating excellent cytocompatibility. Enhanced focal adhesion organization, actin remodeling, and nuclear elongation confirmed effective mechanotransduction. This work highlights fs laser lithography as a versatile, high-precision platform for engineering functional biomimetic architectures, advancing applications in mechanobiology, tissue engineering, and regenerative medicine.

KL-14

Thin film Electrodes by Physical and Chemical methods for Energy Storage

Dr. B Subramanian
CSIR –Central Electrochemical Research Institute, Karaikudi – 630 003
Email: bsmanian@cecri.res.in

Abstract

With the escalating demand for efficient energy storage systems, thin film supercapacitors have gained significant attention for next-generation technologies, and their performance is based on the design of advanced electrode materials with optimized morphology, porosity, and electrochemical properties. Among the fabrication techniques, hydrothermal synthesis is particularly known for its scalability, cost-effectiveness, and environmental friendliness. It allows the synthesis of bulk materials with well-defined 1D, 2D, and 3D nanostructures. By controlling parameters like temperature, pressure, reaction time, and surfactant concentration, this method enables precise tuning of crystallinity, pore structure, and surface area, which enhances ion transport and redox activity. Such control has led to high gravimetric capacitance values, reaching up to 1640 F/g in materials like Bi_2O_3, RuO_2, and $CoFe_2O_4$. Symmetric and asymmetric supercapacitor configurations employing transition metal selenides using electrodeposition such as CoMoSe, and BiFeSe thin film electrodes were systematically investigated. On the other hand, Pulsed Laser Deposition (PLD) is a highly precise vacuum based method suitable for depositing thin films with exceptional structural and compositional control. By adjusting parameters such as laser rate, ambient pressure, and substrate temperature, PLD enables the fabrication with customized micro and nanostructures. Electrodes fabricated using PLD such as MnO_2, ZnO, and V_2O_5 have demonstrated volumetric capacitances up to 141.9 F cm^{-3}, along with high energy densities and long-term cycling stability. More importantly, Sputtering is another widely used vacuum technique for depositing thin, uniform with strong adhesion. By fine-tuning sputtering conditions, one can control stoichiometry, grain size, and surface roughness, which are crucial for electrochemical behavior. Magnetron sputtered transition metal oxides, nitrides such as biocompatible Nb_2O_5–Ta_2O_5 and NbN, NbCN onto 3D architectures have shown higher capacitances reaching, with excellent rate capability and cycling retention. Finally, these methods support the development of scalable, tunable, and efficient supercapacitor electrodes, adaptable for applications ranging from miniaturized electronics to hybrid electric vehicles.

KL-15

Transition Metal Co-Doped WO_3 Nanorods as Efficient Electrocatalysts for the Oxygen Evolution Reaction

Dr. N. Ponpandian
Department of Nanoscience and Technology. Bharathiar University,
Coimbatore 641 046, INDIA
Email: ponpandian@buc.edu.in

Abstract

The development of efficient and stable oxygen evolution reaction (OER) catalysts is essential for sustainable hydrogen generation through water splitting. Pristine WO_3, while chemically robust, exhibits limited visible-light absorption and sub-optimal band-edge alignment, restricting its OER performance. Therefore, a co-doping strategy involving Fe, Co, and Ni is employed to precisely tune the optical and electronic properties of hexagonal WO_3 nanorods. Co-doping enables synergistic modulation of band gap, carrier density, and oxygen intermediate binding energies, thus addressing the intrinsic limitations of undoped WO_3.

Among the prepared systems, Fe–Ni co-doped WO_3 demonstrates significantly enhanced activity, showing a volcano-type dependence with Fe content in terms of overpotential and Tafel slope. The optimized W–Fe–Ni hybrid shows excellent long-term stability with negligible decay during extended electrolysis, confirming its durability for practical OER applications. XPS analysis reveals that an appropriate Fe oxidation state improves electronic configuration at active sites, facilitating favorable adsorption of OER intermediates. This study establishes an effective compositional engineering approach using transition-metal co-doping to elevate the OER performance of WO_3-based catalysts. The findings highlight a cost-effective and scalable pathway for the design of high-performance electrocatalysts for sustainable energy technologies.

Keywords: Oxygen evolution reaction, WO_3, transition-metal co-doping, electrocatalysis, water splitting, band-edge engineering.

KL-16

Application of Geospatial Technology in Water Resources Management

Dr. Girish Gopinath
Department of Climate Variability and Aquatic Ecosystems, Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi.
Email: ggkufos@kufos.ac.in

Abstract

Geospatial technology plays a crucial role in water resources management, offering innovative tools and solutions to monitor, analyze, and manage various water-related activities. Its applications span a wide range of activities, including data collection, mapping, analysis, and decision-making. One of the major applications of geospatial technology **is** remote sensing-based monitoring of surface water bodies and their quality**.** Satellite imagery enables continuous observation of water bodies, tracking of land-use changes, and assessment of water resource distribution and wetland changes. Such information helps in understanding the dynamics of water availability, identifying potential challenges, and formulating strategies for sustainable water management. In addition, spectral information derived from satellite data facilitates the estimation of key water quality parameters. Watershed management and conservation represent another important area where geospatial technology is extensively applied. In groundwater management, geospatial tools combined with statistical and geospatial models significantly enhance the identification of groundwater potential zones, assessment of recharge areas, and understanding of groundwater flow dynamics. Geospatial technology also supports decision-making by integrating data from diverse sources, providing a comprehensive spatial view of water resources**.** GIS-based decision support systems (DSS) assist planners and policymakers in designing and implementing sustainable water management strategies. In summary, the application of geospatial technology in water resources management strengthens our capacity to monitor, analyze, and sustainably utilize this vital natural resource. By delivering valuable spatial insights and supporting evidence-based decisions, geospatial technology contributes significantly to addressing challenges related to water scarcity, pollution, and climate change.

KL-17

India’s Governance and Recent Policies Addressing impacts of Climate Change

Dr. Arockia Lenin
Ministry of Environment, Forest and Climate Change
Email: arockia.lenin@gov.in

Abstract

India has now become the most populous nation in the world, with an estimated population of 1.4 billion people as of 2024. The country is divided into 29 states and seven Union Territories. Covering an area of 3,287,263 km, India ranks as the 7th largest country globally. Currently, India is recognized as one of the fastest-growing economies in the world, housing nearly one-sixth of the global population. The nation features an extensive coastline of 7,500 km, which supports diverse ecosystems and unique biodiversity. The pace of its growth is essential for global development and is instrumental in achieving sustainable development goals. India encounters numerous challenges in its development agenda, particularly concerning climate change. While India's contribution to global warming is relatively minor, the country is committed to addressing climate change by making development choices that foster economic growth along low-carbon pathways, with a target of achieving net zero emissions by 2070. Recognizing that climate change is a global challenge that necessitates collective action, India is dedicated to confronting this issue with a strong commitment to multilateralism, based on equity and the principle of common but differentiated responsibilities and respective capabilities, as stated in the United Nations Framework Convention on Climate Change (UNFCCC). India is executing eight National Missions that are pivotal to the National Action Plan. These missions are designed to improve the understanding of climate change and to foster adaptation, mitigation, energy efficiency, and the preservation of natural resources. Among these initiatives, significant missions are being carried out by the Ministry of Environment, Forest and Climate Change, including the Green India Mission and the National coastal mission. Furthermore, the Ministry is promoting new policies, notifications, rules, and programs, such as the MISHTI programme, the Amrit Amrit darohar Capacity Building Programme, the Nagar Van Yojana, the LiFE Mission, the EIA Notification of 2006, the CRZ Notifications of 2011 and 2019, the Plastic Management Rules, the E-Waste Management Rules of 2022, the Fly Ash Management and Utilization Rules of 2021, the Construction and Demolition Rules of 2016, and the Biomedical Waste Rules 2016, along with the Battery Waste Management Rules 2022. Through these initiatives, India is playing a crucial role in global climate change efforts.

KL-18

Climate Change and Harsh Environments: Postbiotics as Resilient Protectors of the Gut Microbiome

Dr. Joseph Kingston J
Head, Division of Microbiology, Defence Institute of Biodefence Technologies, Mysore.
Email: dfrl.drdo.in

Abstract

Climate change and extreme environmental conditions are reshaping global food consumption patterns by reshaping what foods are available, affordable, and culturally acceptable, with significant consequences for the human gut microbiome. The rising temperatures, droughts, floods, and shifting seasons alter agricultural productivity, thus affecting the availability of fresh fruits, vegetables, and whole grains. Populations increasingly turn toward processed, shelf-stable, and ultra-processed foods, which are more affordable and accessible during climate instability. These foods are typically low in dietary fiber, polyphenols, and micronutrients and enriched with refined carbohydrates, sugars, and saturated fats. Climate shocks besides driving food insecurity manifesting as meal skipping, reduced portion sizes, monotonous diets and protein deficiency cause food contamination with mycotoxins, heavy metals, and pathogens.

Limited intake of diverse plant-based foods diminishes key substrates that nourish beneficial gut microbes reducing microbial diversity and short-chain fatty acid–producing bacteria while promoting pro-inflammatory microbial profiles which are otherwise essential for maintenance of gut barrier integrity and immune regulation. These shifts collectively called as dysbiosis weaken microbial resilience, decrease abundance of health-promoting taxa like *Bifidobacteria* and *Lactobacillus*, and increase populations associated with metabolic inflammation often leading to and impaired host health. Over time, this contributes to higher risks of obesity, diabetes, gastrointestinal disorders, and weakened immune function. Rising global temperatures increase heat stress, dehydration, and oxidative damage, all of which can alter gut motility and cause dysbiosis.

Extreme environments, including high-altitude regions, deserts, deep-sea habitats, polar expeditions, and even space missions, introduce additional physiological stresses. Hypoxia at high altitude reduces microbial diversity and increases inflammatory species. Cold environments slow metabolism and shift the microbiome toward energy-harvesting taxa, while hot environments promote dehydration-induced gut permeability. Radiation, isolation, sleep disturbance, and psychological stress further disrupt microbial balance by suppressing beneficial bacteria and promoting proinflammatory pathways. Over time, these stressors impair immunity, digestion, and mental well-being.

Postbiotics—non-viable microbes and their biologically active metabolites—offer a promising strategy to mitigate these climate- and environment-driven disruptions. Unlike probiotics, postbiotics are stable under extreme temperatures, radiation, and storage limitations, making them practical for use in remote or resource-limited settings. Specific postbiotics such as short-chain fatty acids, polysaccharides, peptides, and cell-wall fragments, directly reinforce the gut barrier by strengthening epithelial junctions and reducing permeability, counteracting the

“leaky gut” commonly triggered by heat stress, hypoxia, and dehydration. They are also reported to modulate the immune system by enhancing anti-inflammatory responses and regulating cytokine production, thereby reducing inflammation associated with environmental stress. Moreover, postbiotics possess antioxidant properties that neutralize free radicals generated by heat, radiation, or oxygen deprivation. Their antimicrobial components help suppress pathogenic bacteria that proliferate during climate-related contamination events.

By restoring microbial balance, strengthening mucosal defenses, and supporting metabolic stability, postbiotics serve as a resilient, safe, and effective approach to maintain gut health in the face of climate change and extreme environments. They offer a forward-looking solution for protecting human health when external conditions challenge the survival of live probiotics and the stability of the microbiome.

INVITED LECTURES

IL-1

Next-Generation Carbazole-Based π-Conjugated Materials for High Performance Energy Solutions

Dr. Venkatakrishnan Parthasarathy
Department of Chemistry, Indian Institute of Technology Madras, Chennai – 600 036,
Tamil Nadu, INDIA.
Email: pvenkat@zmail.iitm.ac.in

Abstract

Over the past few decades, organic π-conjugated polycyclic arenes- and heteroarenes have garnered significant attention in the arena of organic electronics, particularly energy conversion and storage devices, due to their exceptional photophysical and electrochemical properties. Among these, carbazole stands out as a highly admired tricyclic heteroaromatic framework, celebrated for its excellent planarity, redox behavior, and ease of functionalization at the 3-, 6- and 9-positions. Recently, our research has focused on metal-free Scholl-type oxidative coupling reactions involving carbazole and its derivatives, leading to the successful synthesis of (i) bicarbazoles,6a (ii) polyarylcarbazole,7 and (iii) indole-annulated coronene. We have demonstrated the potential of these novel π-functional materials as cost effective alternatives for efficient charge-transporting components in both indoor- and outdoor perovskite solar cells as well as bright green-emitting organic light-emitting diodes. This presentation will highlight our recent findings and discuss the potential applications of these materials in sustainable energy technologies.

Keywords: Organic materials, organic light emitting diodes, perovskite solar cells, indoor and outdoor applications, energy conversion.

IL-2

High-Energy Supercapacitors: Integrating Nanocarbons and Advanced Electrolytes

Dr. M. Sathish
Senior Principal Scientist, Electrochemical Power Sources Division,
Council of Scientific and Industrial Research (CSIR)- Central Electrochemical Research
Institute Karaikudi -630 003, Tamilnadu, INDIA
E-mail: marappan.sathish@gmail.com; msathish.cecri@csir.res.in

Abstract

The development of high-performance supercapacitors (SCs) hinges on continuous advancements in nanocarbon-based electrodes coupled with suitable electrolytes. Nanocarbon materials including carbon nanotubes, multi-walled carbon nanotubes, and graphene are extensively researched due to their high surface area, which is critical for maximizing device performance. Achieving optimal SC performance, specifically the realization of high specific capacitance and high-power density, is widely believed to require a strategic combination of mesopores and micropores within the electrode structure. Fundamentally, high specific capacitance demands that the electrolyte effectively access the entire surface of the electrode material, whereas high power density relies on the ability of ions to move rapidly within the pores. To probe these requirements, various electrolytes (aqueous, organic, redox, and ionic liquids) have been investigated with different nanocarbon materials. A key finding across these studies is that the observed specific capacitance is often non-linear with the measured specific surface area of the electrode. This disparity strongly suggests that the performance is governed by factors beyond simple surface area, pointing instead to the critical influence of the nature of the electrolyte, the size of the ions, and their solvation state. Furthermore, research has not yet established a direct, predictable relationship between the size of the electrolyte ions and the optimal pore size of the nanocarbon electrodes. Though numerous mechanisms have been proposed to describe the adsorption dynamics of ions on carbon surfaces and within pores, a holistic, exact mechanistic understanding remains elusive. In addition to SCs, the potential of these nanocarbon materials as electrode components in metal-ion capacitors for achieving high energy density has also not been fully exploited or characterized. Herein, we present a novel, scalable, and facile route for preparing a porous nanocarbon material. The resulting structure exhibits properties favorable for simultaneous high capacitance and power delivery. This work not only advances the synthesis of high-performance carbon materials but also contributes to a deeper, mechanism-driven understanding required to tailor nanocarbon electrodes, device configuration and selection of electrolytes for next-generation, high-performance energy storage devices.

IL-3

Circular PEMFC Technology: High-Performance Functionalized Pt/C Electrocatalysts Coupled with Platinum and Nafion® Recycling Pathways

Dr. Raman Vedarajan
Centre for Fuel Cell Technology,
International Advanced Research Centre for Powder Metallurgy and New Materials
Indian Institute of Technology Madras Research Park, Chennai, India
Email: vedarajan.raman@arci.res.in

Abstract

Proton Exchange Membrane Fuel Cells (PEMFCs) offer a compelling pathway for clean energy conversion, but their commercialization is constrained by the high cost and limited circularity of platinum electrocatalysts and perfluorosulfonic acid (PFSA) membranes. This work presents a unified circular-materials framework that simultaneously enhances fuel cell performance and reduces lifecycle environmental impact.

A functionalized carbon–supported platinum electrocatalyst was engineered using advanced surface-modification strategies on acetylene black and MXene-derived carbons. Controlled introduction of oxygenated and heteroatom functionalities enabled uniform Pt nucleation, improved metal–support interaction, and high electrochemical stability. The optimized catalysts displayed enhanced ORR activity at reduced Pt loadings, demonstrating their viability for next-generation PEMFC stacks.

Complementing this, a robust recycling methodology for spent Pt electrocatalysts was developed, incorporating selective dissolution, purification, and controlled re-deposition. The regenerated Pt/C catalysts retained structural and electrochemical performance comparable to fresh materials, establishing a cost-effective circular pathway for precious metals.

Finally, an end-of-life Nafion® membrane recovery process involving ionomer purification, re-protonation, and structural rejuvenation was demonstrated. The recycled membranes preserved ionic conductivity and mechanical integrity, validating the feasibility of PFSA circularity in PEMFC systems.

Collectively, these practices define a comprehensive circular approach to PEMFC material development, aligning performance, resource efficiency, and sustainability for future hydrogen energy ecosystems.

IL-4

Waste Heat Recovery: Nanostructured Thermoelectrics for Sustainable Energy

Dr. Manjusha Battabyal
Department of Science and Humanities, Indian Institute of Information Technology Design and Manufacturing (IIITDM), Kancheepuram, Chennai 600127, India
Email: manjusha@iiitdm.ac.in

Abstract

Smart thermoelectrics are increasingly recognized as a sustainable energy solution capable of powering diverse applications. The performance of thermoelectric (TE) materials is measured by the dimensionless figure of merit (zT), which depends on electrical conductivity, thermal conductivity, the Seebeck coefficient, and the applied temperature gradient. However, widespread adoption of TE devices has been limited by relatively low zT values and high manufacturing costs. Among candidate materials, cobalt antimonide (Co4Sb12)-based skutterudites, zinc antimonide (ZnSb), and layered magnesium antimonides (Mg3Sb2) are particularly promising due to their cost- effectiveness, reliable fabrication methods, and thermal stability within the 450–773 K range. These advantages have spurred research into filled, doped, and composite antimonides, which show improved zT values at intermediate operating temperatures.

One effective approach to overcoming the inherent trade-offs between TE properties is nanostructuring combined with carrier filtering. Reducing structural dimensions below the phonon mean free path enhances phonon scattering, which lowers lattice thermal conductivity. At the same time, the Seebeck coefficient can be improved by exploiting quantum confinement effects in low-dimensional semiconductors. In this regard, oxide nanoparticles and one-dimensional nanowires or quantum wires are especially attractive, as they provide scattering centers for charge carriers. A notable achievement has been the realization of a zT of ~1.85 in n-type single-element filled skutterudites by incorporating nano-oxides into the skutterudite matrix [1]. The interfaces between the oxides and the host lattice act as carrier filtering sites, preferentially scattering high-energy carriers, thereby enhancing the Seebeck coefficient while simultaneously reducing thermal conductivity. Similar benefits of quantum-engineered nanostructures have also been demonstrated in ZnSb systems. Furthermore, codoping at the Mg site of Mg3Sb2 introduces a synergistic effect, improving electrical conductivity and optimizing p-type TE performance. Our recent studies further reveal that lattice anharmonicity in layered antimonides and selenides is dominated by three- phonon and four-phonon scattering processes, highlighting the critical role of optical phonons in thermal transport. Overall, our research work underscores the potential of combining carrier filtering, quantum confinement, and optical phonon scattering strategies to achieve significant improvements in thermoelectric efficeincy.

IL-5

Treatment of mining waste using a combination of technologies and the recovery of precious elements from the mining waste

Alseno Kagiso Mosai[1], Mildred Phasha[1,2], Lutricia Tladi[1]
[1]*Department of Chemistry, Faculty of Natural and Agricultural Sciences, University of Pretoria, Lynnwood Road, Pretoria 0002, South Africa*
[2]*Department of Geology, Faculty of Natural and Agricultural Sciences, University of Pretoria, Lynnwood Road, Pretoria 0002, South Africa*
Email: alseno.mosai@up.ac.za

Abstract

Large amounts of waste are released into the environment either directly or indirectly. The waste usually contains toxic elements including Cd, Cr, As, Hg and Pb. Acid mine drainage (AMD) which contains elevated levels of sulfate and other elements, is one of the major pollutants that result from mining processes, which tend to pose serious environmental issues. Different technologies have been developed for the treatment of AMD but, there is no "one-size-fits-all" solution. Moreover, these technologies produce secondary waste, which is another environmental problem that must be solved; hence a combination of available technologies should be considered to achieve effective treatment. The combination of technologies should be motivated by the quality of AMD to be treated, and the desired quality of effluent depending on end use (e.g., drinking, industrial, irrigation or release into the environment). Some of the mining waste (i.e., mine dumps, AMD and wastewater) contain valuable elements such as platinum group elements (PGEs), rare earth elements (REEs), Au, Co, Ni and Mn, which can be recovered to meet global demand. Some of the profits from these recoveries can be used to rehabilitate closed and abandoned mining sites which pose great risks (due to the presence of toxic elements) to residents living in the vicinity of the mines. The recovery of valuable elements from waste requires selective, cheap and efficient methods/technologies. The presentation will be based on the different technologies developed for the removal of toxic elements and the recovery of valuable elements from wastewater. The presentation will also cover the computational models used for speciation and the migration of pollutants from point sources.

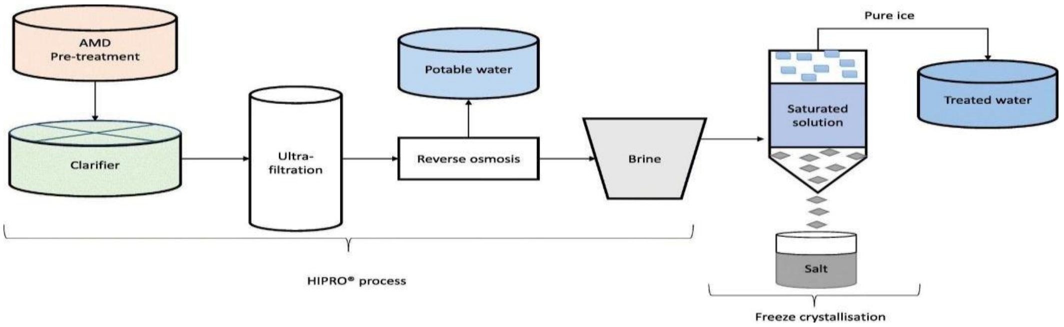


Figure 1. Combination of technologies for the treatment of acid mine drainage

Keywords: Mine waste, acid mine drainage, water treatment technologies, toxic elements, elements recovery.

IL-6

Energy Saving and Sustainability in Scaling Chemical Process – An Overview

Dr. Bhuvaneswari Sridhar
Indian institute of Technology Madras

Abstract

Electrochemistry as an area of research is being explored more widely in the last two decades focusing on greener processes, greener energy generation and efficient energy storage. The research has encompassed researchers across multiple disciplines to come together and find a solution that supports newer material generation and addresses the environmental issues by way of minimizing pollution.

Electro-organic synthesis has been playing a crucial role in scaling up unsafe and chemical intensive processes to a cleaner electrochemical synthesis Eg Kolbe Synthesis. Last 50 years there is intensive research on using electrochemical methodologies to solve complex synthesis problems. The presentation will cover the cyclical pathway towards generating oxidants and co-oxidants at electrode interface using electricity thereby avoiding use of excess reagents.

Energy saving is a critical factor in manufacturing industries and there is a continued focus on capacity improvement (reducing the volume per kg output) and cycle time improvement (reducing the overall hours for a given process). There is a structured analysis of current processes that are executed and any new process that is developed is put through multiple tools-LCA and the like. Water which was considered as a green solvent is no more a luxury in both chemical and biological processing.

Case studies will be presented from industry on the above subject and as equivalent to all the steps leading to a better technology the importance towards environmentally benign processes will surpass the cost elements in the coming decades.

IL-7

Recent Advances in Electrode Materials for Supercapacitors

Dr. Sumit Saxena
Nanostructure Engineering and Modeling Laboratory, Department of Metallurgical Engineering and Materials Science, Indian Institute of Technology Bombay, Mumbai, India
Email: sumit.saxena@iitb.ac.in

Abstract

The accelerating demand for efficient energy storage has driven extensive research into advanced materials for high-performance supercapacitor electrodes. Recent developments have spanned both computational design and experimental synthesis, leading to significant improvements in charge storage mechanisms. Notable progress includes the synthesis of novel morphologies with hierarchical structure offering enhanced porosity, enabling enhanced capacitance and excellent rate capability. Complementing carbon-based systems, transition metal oxides along with their nano/micro hierarchical structures and composites have demonstrated synergistic benefits of high surface area and rapid charge-transfer kinetics, yielding superior energy density in various electrode materials. Furthermore, the emergence of photo-responsive supercapacitors, facilitated by plasmonic heterostructures, highlights exciting opportunities for light-assisted energy storage. This talk will discuss these advancements, elucidating the underlying structure–property relationships, and outline promising pathways toward scalable, next-generation electrode materials for high-efficiency supercapacitors.

IL-8

Mastering Research Publishing: Insights from the Editor's Desk

Dr. Rohini Kitture
Deputy Editor, Wiley
Email: kitture.rohini7@gmail.com

Abstract

Publishing research is crucial in academia as it facilitates knowledge sharing and progress in various fields. However, the intricacies of the publishing process often pose challenges for researchers. This talk aims to provide valuable insights from an experienced editor to enhance the effectiveness of research publications. The session will begin with an overview of Wiley's journals, offering the attendees an idea of the range of potential venues for their research submissions. It will then delve into the detailed editorial review process, covering initial assessments and peer review, and clarifying reasons for desk rejections. By gaining a clearer understanding of these processes, attendees will be better equipped to avoid common pitfalls, thereby increasing the likelihood of their submissions being successful. Drawing on practical tips from editors, this talk aims to empower budding researchers to improve their publication outcomes and maximize the impact of their work

IL-9

Ti-Based MXenes and Their Hybrids as Efficient Electrode Materials for Sustainable Energy Storage Devices

Dr. R. B. Rakhi
Centre for Sustainable Energy Technologies, CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram, Kerala, India, 695019
Email: rakhirb.niist@csir.res.in

Abstract

The transition toward sustainable and eco-friendly energy technologies requires the development of advanced materials that enable efficient energy conversion and storage. Two-dimensional transition metal carbides (MXenes) have emerged as a new class of materials with unique structural and surface properties suitable for high-performance supercapacitors. The talk explores a series of strategies to enhance the electrochemical performance of Ti-based MXenes (Ti_2CT_x and $Ti_3C_2T_x$) through structural, compositional, and interfacial engineering. Controlled post-etch annealing in various ambients was used to optimize surface chemistry and improve charge storage behavior. Further modifications involving transition metal oxides (such as MnO_2, CuO, and Fe_3O_4) and conducting polymers (PANI, PPy) effectively prevented restacking and enhanced pseudocapacitive contributions. These hybrid architectures delivered remarkable improvements in capacitance, energy density, and cycling stability compared to pristine MXenes. Extending these findings to device-level applications, screen-printed MXene-based micro-supercapacitors demonstrated excellent mechanical flexibility, high areal capacitance, and long-term durability, highlighting their potential in wearable and IoT-oriented energy systems. This study highlights the sustainable potential of MXene-based materials as efficient, scalable, and environmentally compatible electrodes for clean energy storage technologies.

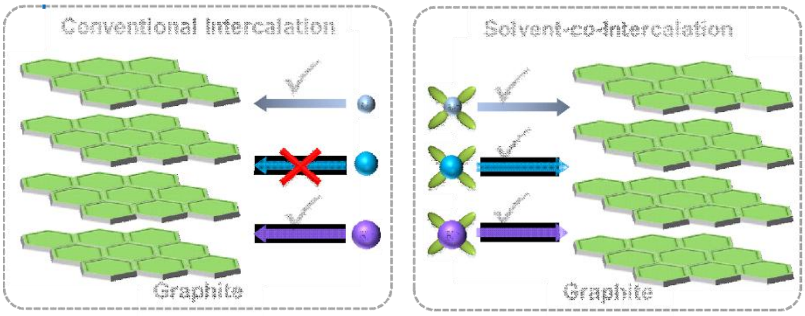
IL-10

High Performance Na-ion Batteries *via* Solvent-co-Intercalation

Dr. Vanchiappan Aravindan
Department of Chemistry, Indian Institute of Science Education and Research (IISER)
Tirupati-517619, India.
Email: aravindan@labs.iisertirupati.ac.in ; aravind.van@gmail.com

Abstract

Sodium-ion batteries (NIBs) are emerging as a promising next-generation energy-storage technology and a viable alternative to current state-of-the-art lithium-ion batteries (LIBs). However, unlike lithium, sodium cannot be efficiently intercalated into graphite to form the binary graphite intercalation compound (NaC_6 or NaC_8) because of its thermodynamic instability, especially in conventional ester-based electrolytes. In this study, we demonstrate an effective recovery strategy for both the graphite anode and the polypropylene (PP) separator from spent LIBs, enabling their reuse in NIB systems. Using ether-based solvents, we activate reversible Na-ion intercalation into the recovered graphite through a solvent-co-intercalation mechanism. This approach stabilizes the formation of a ternary graphite intercalation compound and enables highly reversible Na-ion storage. NIB full cells are assembled with carbon-coated $Na_3V_2(PO_4)_3$ as the cathode, the recovered graphite as the anode, and TEGDME as the electrolyte solvent, paired with the recovered PP separator under balanced mass-loading conditions. Comprehensive structural, morphological, and electrochemical characterizations are performed on each recycled component. The resulting C/PP/$Na_3V_2(PO_4)_3$ full-cell configuration delivers a maximum energy density of 78 Wh kg^{-1} (based on the total active-material mass) at room temperature. Full findings and additional insights will be discussed during the presentation.



Keywords: Na-ion battery; graphite anode; solvent-co-intercalation; spent Li-ion battery; recycling

IL-11

Boosting the cycle life of the $Zn-I_2$ Hybrid Redox Flow Battery

Dr. Mani Ulaganathan[1,2*]
[1]*Department of Physics, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, India*
[2]*Functional Materials Laboratory, Amrita School of Engineering Coimbatore, Amrita Vishwa Vidyapeetham, India*
Email: m_ulaganathan@cb.amrita.edu, nathanphysics@gmail.com

Abstract

Redox flow Batteries (RFBs) have attracted much attention due to their modular scalability, intrinsic safety, decoupling of energy and power, good cycle life, and large-scale energy storage range (> MWh). In recent times, Zn-based RFBs have been widely investigated for their high capacity and cell voltage, as well as for the earth-abundant Zn and low cost. However, the zinc dendrite formation, dead Zn-ion formation, sluggish reaction of the catholyte, hydrogen evolution, and unbalanced kinetics, etc., are constraining further development of these Zn-based RFBs. To improve cell performance, the electrode and electrolytes have been modified, along with a suitable flow design. As a result, the $Zn-I_2$ flow cell performance has been enhanced. Therefore, in this work, we aim to modify the electrode and optimize the electrolyte performance to enhance the flow cell performance by addressing the issues above. Specifically, the cycle life of the flow cell has been vastly improved. This work will cover the functioning, problems, and strategies for strengthening flow cell performance. The schematic representation and the GCD profile of the $Zn-I_2$ system (Figure 1) is shown below.

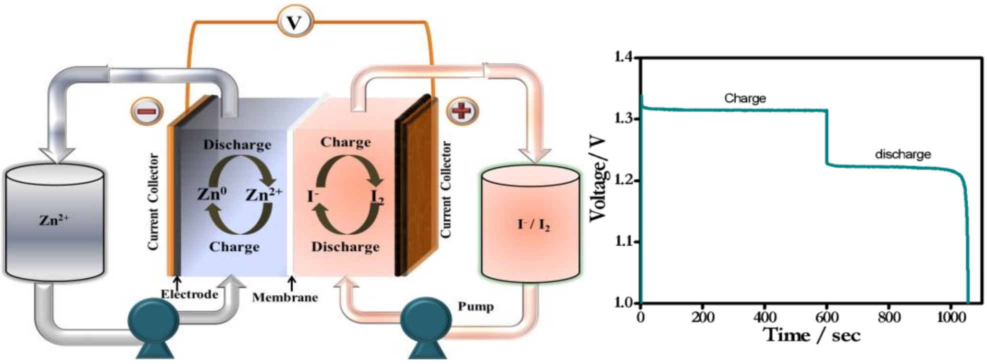


Figure 1. Schematic representation of the $Zn-I_2$ redox flow cell

Keywords: Redox Flow cell; High Energy; Electrolyte; Electrode Modification, Cycle Life.

IL-12

Green hydrogen pathways – An Indian Perspective

Dr. P. Bala Srinivasan
High Energy Batteries India Ltd

Abstract

The National Hydrogen Mission launched in January 2023 has set the tone for India's accelerated journey towards hydrogen economy. Though there have been many efforts in academia and research laboratories for the development of components, sub-systems & systems for green hydrogen production, the transitioning of the technologies to the Industrial scale in true spirits is still an exciting challenge. MNRE's push towards more renewables viz., wind & solar to the level of 500 GW installed capacity by AY2030 paves an excellent opportunity for green hydrogen production. This talk will touch upon the recent developments in the green hydrogen initiatives in the country & highlight the opportunities for the integration of energy storage & conversion technologies. The other possibilities & directions for usage of green hydrogen towards accomplishing India's target of net-zero by 2070 shall be briefly discussed.

IL-13

Green Carbon: An in-depth Understanding of its Fibrillar Nature and Doping Promoted Electrochemical Activity

Dr. Bhuvaneshwari Balasubramaniam
Department of Chemistry, Indian Institute of Technology (BHU) Varanasi,
Uttar Pradesh -221005, India
Email: bhuvana.chy@iitbhu.ac.in

Abstract

It is essential to ensure that the application that we are proposing is resource-friendly in terms of satisfying the continuous supply of recipes in order to fulfill the industrial-level demand. Wherein, the welcoming approach would be highly devoted to applications that are coming out of a green and resource-friendly nature, satisfying green chemistry principles. For instance, most of the time, applications with high performance will fail in fulfilling the requirement for a continuous supply of raw materials or non-cost effectiveness, or due to their energy-intensive nature. By learning these factors, a green approach was devoted to synthesizing green carbon from environmentally friendly resources. A careful processing method is devoted to obtaining a fiber-based biocarbon from biomass-based resources, and an effective doping methodology has been brought in for incorporating heteroatoms at an optimized level. As designed fiber fiber-based green carbon and doped biocarbons have been subjected to electrochemical applications. Further, the electrochemical performances of these green carbons are deeply understood with the support of input data derived from the micro-analytical characterization studies performed.

IL-14

Surface Charge Engineering for Hydrovoltaic Power Generation

Dr. Sudip K Batabyal
Department of Sciences, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, India.
Email: s_batabyal@cb.amrita.edu

Abstract

The interaction between water molecules and surface charges of nanostructured materials can be harnessed as hydrovoltaic power. This is an innovative technology for generating electrical power from water. This process involves capturing energy from natural water cycles, such as rain, waves, moisture, and evaporation. The surface charge of the nanostructures materials plays a great role to generate the hydrovoltaic power. Here we try to modulate the surface charges of different materials and try to understand the mechanism of hydrovoltaic power generation. Different nanostructured powder materials were packed in a cylindrical shaped tube with water on the bottom, and water evaporated from the top surfaces, coming with capillary action. Water evaporation from the top generates the dynamic electrical double layers on the surface of the nanomaterials and that develops voltages along the length of the tubes. Evaporation induced power generation was used in several practical applications from lighting lamp to running consumable electronics. It is to be noted that the devices can be able to give a stable output after one year of fabrication. Our group mostly focused on activated carbon, nano clay, and metal oxide nanostructured for water evaporation-induced power generation. For a typical example, activated carbon-based 3D hydrovoltaics devices show a maximum open circuit voltage of more than 0.9 V and a short circuit current of 0.72 mA. These hydrovoltaics devices will be useful for powering the low power IOT-based devices.

IL-15

Investigation of Electrochemical Interfaces by Scanning Probe and Spectroelectrochemical tools for industrially relevant electrochemical devices

Dr Rajini P Antony

Water and Steam Chemistry Division, Bhabha Atomic Research Centre-Kalpakkam facilities,
Tamilnadu, 603102, India.
Email: rajiniantony@igcar.gov.in

Abstract

Probing the local electrochemistry is crucial in technologically relevant electrochemical interfaces, involving proton-coupled electron transfer reactions. The activity, selectivity, and stability of the electrocatalysts are influenced by local electrochemistry, where the formation of reactants modulates the microenvironment. A key parameter is the local pH, which alters due to the consumption or generation of protons and hydroxyl species during electrochemical reactions, leading to a significant difference between the pH at the electrochemical interface and the bulk. Furthermore, the electrocatalyst can undergo structural transitions, forming active sites responsible for catalytic reactions. Monitoring such changes is vital for understanding the reaction mechanism which helps in optimizing the catalysts performance for efficiency and stability. The talk will highlight the importance of scanning probe and operando tools in investigating the electrochemical interface, give a brief overview of the instrumentation setup developed in-house and the major findings.

Keywords: Local electrochemistry, Electrocatalysis, Electrolyzers, Spectro-electrochemistry.

IL-16

Innovative Materials for Low-Cost Green Hydrogen Generation

Dr. T. Maiyalagan
Electrochemical Energy Laboratory, Department of Chemistry,
SRM Institute of Science and Technology, Kattankulathur, 603203, India.
Email**:** maiyalagan@gmail.com

Abstract

Electrochemical water splitting represents a promising pathway for large-scale, sustainable hydrogen production with zero carbon emissions. However, its sluggish reaction kinetics and dependence on precious metal catalysts significantly limit widespread implementation. To address these challenges, intensive research efforts have focused on developing low-cost, highly efficient, and durable electrocatalysts for both the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER).

In our research, we have developed various noble-metal-free materials that serve as effective catalysts for HER, OER, and overall water splitting. An efficient electrocatalyst must simultaneously exhibit: (1) highly active intrinsic sites, (2) abundant accessible active surfaces, (3) rapid electron and mass transport, (4) strong chemical and structural durability, and (5) low-cost, scalable synthesis routes. Although significant progress has been made, most reported approaches address only one or a few of these factors, often emphasizing electronic modulation of active sites.

In this presentation, I will highlight recent advancements in the design of noble-metal-free electrocatalysts for HER, with a particular emphasis on molybdenum-based materials such as MoO_2, MoS_2, and Mo_2C. These earth-abundant catalysts have attracted considerable attention for their high activity and cost-effectiveness. Furthermore, I will discuss state-of-the-art strategies to enhance their performance and durability, including (i) integration into Mo-based carbon composites, (ii) heteroatom doping to tune electronic structures, and (iii) construction of heterostructures to achieve synergistic effects. Finally, I will address the key challenges and outline future research directions for Mo-based electrocatalysts, with the goal of advancing scalable and sustainable hydrogen production technologies.

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IL-17

Process Reconfiguration of High-Solids Anaerobic Co-Digestion of Food Waste and Sewage Sludge Using Novel HOLAnD® System

S. Hemapriya, Sankar Ganesh Palani*

BITS Environmental Science and Technology (BEST) Lab, Birla Institute of Technology and Science (BITS), Pilani, Hyderabad Campus, Jawahar Nagar, Kapra Mandal, Medchal District, Hyderabad 500078, Telangana, India.

Email: *sangan@hyderabad.bits-pilani.ac.in*

Abstract

Anaerobic digestion (AD) is a well-established method for treating food waste (FW) and recovering methane-rich biogas. However, during high-solids anaerobic digestion, rapid hydrolysis often leads to the accumulation of volatile fatty acids, resulting in unstable methanogenesis. To address these challenges, this study investigates the performance of the novel high-organic-loaded anaerobic digestion (HOLAnD®) system, which is fed with a three times higher organic load than conventional anaerobic reactors. The FW was anaerobically co-digested with sewage sludge (SS) at a volatile solids load of 240 g/L, under both mesophilic and thermophilic conditions. Among the five FW: SS ratios investigated, thermophilic operation at 75% FW: 25% SS exhibited the highest conversion efficiency, with maximum and cumulative biogas yields of 0.059 m^3/kg VS/day and 0.55 m^3/kg VS, respectively. The cumulative biogas yield from thermophilic reactors was 1.5 times higher than that of mesophilic reactors, which yielded 0.37 m^3/kg VS. Thermophilic reactors also achieved higher organic removal efficiencies, with VS and chemical oxygen demand (COD) reductions of 49.96 and 70.32% respectively, compared to 42.37 and 66.77% under mesophilic conditions, which corroborated with improved process kinetics. Pathway dynamics, based on pH–pKa, hydrogen, and CH_4/CO_2, exhibited transient shifts between acetoclastic and hydrogenotrophic methanogenesis, driven by acid stress. Microbial profiling through 16S rRNA metagenomics analysis revealed a strong thermophilic selection for *Pseudomonadota*, while *Methylobacterium* was present in both reactors. Metagenomic annotation confirmed the enrichment of complete methanogenic pathways, including key enzymes such as *methyl-coenzyme M reductase* and *F420-dependent oxidoreductases*, along with increased coenzyme biosynthesis (*F_{420}, CoB*, *Methanofuran*) under thermophilic conditions. The overall results demonstrate that thermophilic FW-SS anaerobic co-digestion in the HOLAnD® system ensured improved metabolic coordination between the microorganisms, leading to enhanced methanogenesis that synchronized with hydrolysis and acidogenesis. Thereby confirming HOLAnD® as a robust system for high-solid biowaste valorization and decentralized waste-to-energy technologies.

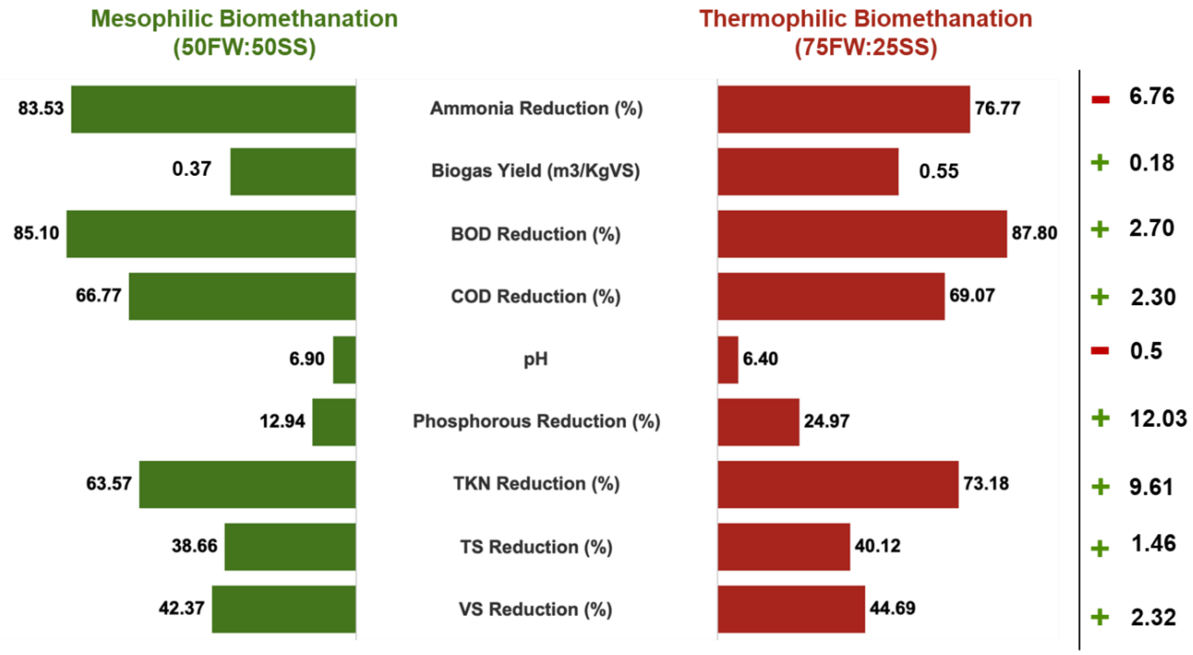


Figure 1: Snapshot of the comparative performance evaluation of mesophilic (50% FW:50% SS) and thermophilic (75% FW:25% SS) HOLAnD® systems

Keywords: Acetoclastic, Hydrogenotrophic, High organic load, Thermophilic, Co-digestion.

IL-18

In pursuit of low temperature ethylene oxidation.

Dr. Dinesh Jagadheesan
Indian Institute of Technology, Palakkad, Kerala.
Email: d.jagadeesan@iitpkd.ac.in

Abstract

Defects in solids are inevitable due to their thermodynamic stabilization of the materials. However, defects play a central role in its chemical reactivity, which can be used beneficially to improve the catalytic property of the material. Oxygen vacancy is one such point defect in the transition metal oxides which has been known to play an important role in oxidation of volatile organic compounds such as ethylene. In our pursuit to develop a low temperature catalyst for ethylene oxidation (273 - 523 K), we have been exploring many aspects of the synthesis and stabilization of the vacancy defects in metal oxides. Interestingly, it appears that in addition to the oxygen vacancy, its neighbourhood too plays a critical part in the oxidation reaction. In the talk, we will be discussing a few examples of our recent works where we systematically reduced the energy required for ethylene oxidation without compromising the selectivity of the reaction.

IL-19

The Strategic Role of Green Hydrogen in Achieving Sustainable and Low-Carbon Energy Futures

Dr. Rohit Srivastava
Catalysis & Hydrogen Research Lab, Department of Petroleum Engineering, School of Energy Technology, Pandit Deendayal Energy University, Gandhinagar-382007, Gujarat India
Email: rohit.s@spt.pdpu.ac.in

Abstract

The transition to a net-zero future requires scalable solutions that integrate environmental sustainability with economic growth. Green hydrogen—produced via renewable-poweredelectrolysis—has emerged as a pivotal clean energy carrier capable of decarbonizing hard-to-abatesectors such as heavy industry, transport, oil and gas, and power generation. This talk examines how green hydrogen can drive sustainable development by simultaneously advancing climate action, energy security, and economic opportunity. It explores the technology's potential to reduce greenhouse gas emissions, stimulate clean innovation, and generate employment across the hydrogen value chain. Furthermore, it discusses the policy frameworks, investment strategies, and international collaborations essential for large-scale deployment. Drawing on global initiatives and case studies, the talk underscores green hydrogen's strategic role in building a resilient, inclusive,and low-carbon global economy—positioning it as both an environmental necessity and a catalyst for equitable prosperity.

Key words: Electrolyzer, Fuel Cell, Green Hydrogen, Net Zero, Electrocatalyst.

IL-20

Traditional and Sustainable Packaging: A Paradigm for the Future

Dr. R. Ariharasuthan
Department of Communication Design, DJ Academy of Design, Coimbatore, Tamil Nadu.

Abstract

Historically, human labour generated production, and the necessity to transport and exchange goods and surplus based on need, coupled with the requirement for storage, subsequently evolved. Early communities met these needs by developing packaging techniques using locally sourced natural materials. However, the Industrial Revolution introduced manufacturing processes based on non-natural raw materials, and packaging methods followed suit, increasingly relying on unsustainable synthetic materials. The pervasive use of non-biodegradable packaging poses a significant threat to the environment. This study aims to explore the traditional methods of packaging used by past generations. In addition, this study will focus on the materials, techniques, and efficacy of these traditional practices.

Keywords: Traditional packaging, sustainable packaging, sustainable environment, environment awareness, packaging techniques.

ORAL PRESENTATION

OP- 01

Mn_3O_4/RuO_2 Composite as Bifunctional Electrocatalyst for Efficient Oxygen Reactions Rechargeable in Zinc-Air Batteries

Suruthi V[1,2] and S.T. Nishanthi[1,2*]

[1]*Electrochemical Power Sources Division, CSIR-CECRI, Karaikudi-630003, India*
[2]*Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India*
[*]Email: stnisha.cecri@csir.res.in

Abstract

The escalating global demand for sustainable and secure energy solutions has intensified research into advanced electrochemical energy storage systems. Among these, metal–air batteries (MABs) have emerged as promising candidates due to their exceptionally high theoretical energy densities, aligning well with the principles of green energy and resource sustainability. Zinc–air batteries (ZABs) have garnered significant attention owing to their remarkable theoretical energy density (1353 kWh/kg), high specific capacity (825 mAh/g), low cost, and environmental benignity. However, their widespread adoption is limited by the sluggish kinetics of oxygen reduction and evolution reactions (ORR and OER) at the air cathode. Developing efficient and durable bifunctional electrocatalysts remains a major challenge. In this study, we synthesized a Mn_3O_4/RuO_2 composite using a facile, eco-friendly glucose and urea assisted combustion method. The synergistic interface between Mn_3O_4 and RuO_2 in composite have significantly enhanced oxygen reaction kinetics. The porous network of spherical particles of the composite aided in mass transport and exhibited a minimal bifunctionality index of 0.67 V vs RHE. Furthermore, a prototype zinc–air cell fabricated using this catalyst demonstrated excellent electrochemical performance in full cell studies by efficiently reducing charge–discharge polarization and improving cycling durability. This study underscores the potential of Mn_3O_4/RuO_2 composites as high-performance bifunctional electrocatalysts for next-generation zinc–air batteries, contributing meaningfully to the global transition toward cleaner and more sustainable energy technologies.

Keywords: Zinc-air battery, bifunctional electrocatalyst, cell voltage and specific capacity

OP-2

CO_2 Capture and Mineralization by a Zinc-based Molecular Complex Under Industrially Relevant Conditions

B Rajeshwaree[1], Suhana Karim[1], and Arnab Dutta[1,2,3*]
[1]*Department of Chemistry, Indian Institute of Technology Bombay, Mumbai, India*
[2]*National Center of Excellence for CO_2 Capture and Utilization (NCoE-CCU), Indian Institute of Technology Bombay, Mumbai, India*
[3]*Centre for Climate Studies, Indian Institute of Technology Bombay, Mumbai, India*
*Email: anabdutta.iitb@gmail.com , arnab.dutta@iitb.ac.in

Abstract

The incessant increase in energy demand has led to an exponential rise in CO_2 emissions over the decades, causing severe environmental consequences. To mitigate this issue, we have developed a *Carbonic anhydrase*-inspired Zinc-based molecular catalyst (Zn_2L) for CO_2 capture and mineralization in near-neutral aqueous solution under ambient temperature and pressure. Featuring a pK_a of 7.24 for the Zn-OH_2 moiety, Zn_2L facilitates the conversion of CO_2 into bicarbonate (HCO_3^-) with a 30% higher efficiency than the uncatalyzed solution. The catalytic rate constant was determined to be 19.995×10^{-3} M^{-1} s^{-1} by pNPA (p-Nitrophenyl Acetate) hydrolysis. The remarkable robustness of this catalyst is proven by its propensity to capture and mineralize CO_2 into pure calcium carbonate ($CaCO_3$) in non-potable water resources (like industrial wastewater, RO reject water, and seawater). It also demonstrates exceptional selectivity towards CO_2 by capturing it from lean sources like flue gas (15% CO_2) and air (0.04% CO_2). Further, Zn_2L offers excellent heat tolerance, re-usability and resistance towards SO_x and NO_x, corroborating its versatility for real-world deployment. This work is an attempt to validate our vision of a sustainable CCUS (Carbon Capture Utilization and Storage) technology that can foster a carbon-neutral circular economy.

OP-3

Defect-Engineered Sulfur-Doped Graphene/Polyaniline Nanocomposites as High-Energy Electrodes for Asymmetric Supercapacitors

Chandni A P[1], and Binitha N Narayanan[2*]
[1]*Department of Chemistry, University of Calicut, Calicut University (PO), Malappuram (DT), Kerala - 673635, India*
[2]*Inter University Centre for Hydrogen & Energy Storage, University of Calicut, Calicut University (PO), Malappuram (DT), Kerala - 673635, India*
*Email: binithann@yahoo.co.in

Abstract

Supercapacitors offer high power density, rapid charge–discharge capability, and long cycle life, yet their energy density remains limited. Designing hybrid electrodes that integrate both electric double-layer capacitance and Faradaic pseudocapacitive behaviors provides an effective approach to address this challenge. In this work, a polyaniline (PANI)/sulfur-doped graphene (S-graphene) nanocomposite was synthesized through in-situ oxidative polymerization of aniline within an S-graphene dispersion. The S-graphene was obtained via ball milling of graphite with a sulfur-containing aromatic compound, enabling uniform sulfur incorporation and defect engineering within the graphene lattice. This process enhances electrical conductivity and introduces additional electroactive sites for charge storage. The intimate coupling between PANI and S-graphene promotes efficient charge transport and ion diffusion, leading to improved electrochemical performance. The optimized hybrid electrode delivered a promising areal capacitance, while an asymmetric device employing PANI/S-graphene as the cathode and S-graphene as the anode retained 100% of its capacitance after 5000 cycles. These results highlight the effectiveness of ball milling-assisted sulfur doping combined with conductive polymer integration in developing high-performance, sustainable graphene-based supercapacitor electrodes.

Keywords: S-doped graphene, Polyaniline/S-doped graphene, Asymmetric supercapacitor

OP-4

NIRVANA-2618: A Sustainable Hydrogen-Based Engine for Zero-Emission Mobility

Sreyesha Akella, Sanjay Shetye, Ankit Kumar Singh and Tejas R Nadig
SRM Institute of Science and Technology, Chennai, India.
Department of Aerospace Engineering, SRM Institute of Science and Technology, Chennai, India.
*Email: sreyeshaa@gmail.com

Abstract

The NIRVANA-2618 project addresses the inefficiencies of fossil-fuel engines and the infrastructure challenges of electric vehicles (EVs), including long charging times, limited range, and the high cost of lithium-ion batteries. The proposed solution is a retrofit-friendly, hydrogen-powered internal combustion engine that generates its own fuel through onboard electrolysis using water and electricity. The 4-stroke, single-piston engine configuration operates at a 13:1 compression ratio, achieving an indicated efficiency of approximately 64%. The hydrogen–oxygen mixture produced via electrolysis is directly supplied to the combustion chamber, eliminating the need for external fuel storage. Aluminium alloys 4130 and A356 are employed for the piston, connecting rod, and casing to ensure high strength, corrosion resistance, and effective heat dissipation. The engine emits only water vapour, producing zero CO_2, SO_x, or NO_x emissions. Advanced ignition timing, optimised air-cooling, and modular construction enable safe operation, ease of maintenance, and integration into existing vehicles. Designed to serve both urban and rural users, NIRVANA-2618 bridges the transition from conventional to electric mobility, combining sustainability, affordability, and practicality. The system provides a realistic pathway toward decentralised hydrogen generation and zero-emission transportation.

Keywords: Sustainable mobility, Hydrogen combustion, Electrolysis engine, Zero emissions, Retrofitting.

OP-5

Modified Nickel Oxide for Enhanced Supercapacitor and OER Electrocatalyst Applications

Madeshwaran Mohanraj[1,2], K. S. Rajni[1,2*], Mani Ulaganathan[1,2*]
[1] *Department of Physics, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, Coimbatore, 641 112, India*
[2] *Functional Materials Laboratory, Amrita School of Engineering Coimbatore, Amrita Vishwa Vidyapeetham, Coimbatore, 641 112, India*
[*] Email: ks_rajani@cb.amrita.edu,m_ulaganathan@cb.amrita.edu, nathanphysics@gmail.com

Abstract

In this present work, the fluorine nickel oxide has been synthesised by various concentrations of fluorine and annealing temperature of 500 ºC. The synthesised materials physicochemical properties have been evaluated by various characterisation techniques, namely, XRD, UV visible Spectroscopy, Raman Spectroscopy, BET, XPS, FE-SEM, and TEM. The optimised annealing temperature and fluorine-doped electrode of NF52 delivers the maximum specific capacitance of ~80 F g^{-1}. In contrast, the optimised calcination temperature of bare nickel oxide electrode delivers the specific capacitance of ~50 F g^{-1} at the same current density. Based on the half-cell performance, the hybrid supercapacitor has been fabricated using activated carbon as the negative electrode and NF50 and NF52 as the positive electrode by using 2M PVA-KOH gel electrolyte. The specific energy and power of 24.17 Wh kg^{-1} at 1515.78 W kg^{-1} for the AC||PVA-KOH|NF52 supercapacitor. The long-term stability has been ensured by continuous 20,000 GCD cycles, it delivers the maximum capacitance retention percentage of 78.231% with the coulombic efficiency of ~99%. The best performing OER electrocatalyst of NF52 delivers the minimum overpotential of 299 mV to reach the current density of 10 mA cm^{-2} with the excellent electrode stability of 150 hours at the same current density.

Keywords: Doping, Hybrid capacitor, Electrocatalyst, OER activity, Long cycle life

OP-6

Influence of Fe $^{3+}$ ions on Structural, Morphology, Elemental and Optical Properties of Lanthanum Aluminate Nanoparticles

S. Nandhini [1], S. Yuvaraj [1*]
Department of Physics, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Vel Nagar, Avadi, Chennai-600 062, Tamil Nadu, India
Email*: phyuvaraj@gmail.com

Abstract

Lanthanum aluminate ($LaAlO_3$) and iron-doped lanthanum aluminate ($La_{1-x}Fe_xAlO_3$: x=0 and 0.05) nanoparticles were effectively prepared via a microwave combustion process (MCP) using L-alanine as a green and cost-effective fuel. The structural, morphological, compositional, and optical characteristics of the synthesized nanoparticles were step by step investigated using X-ray diffraction (XRD),field emission scanning electron microscopy (FE-SEM), energy dispersive X-ray spectroscopy (EDX), and diffuse reflectance UV-visible spectroscopy (DRS-UV).XRD analysis confirmed the formation of a single-phase rhombohedral perovskite structure with the average crystallite size ranging between 27.4 and 27.3 nm.The gradual substitution of Fe ions into the $LaAlO_3$ lattice was found to impact the optical properties notably as evidenced by a reduction in the optical band gap from 5.41 eV to 3.49 eV.EDX spectra verified the presence of La,Al,Fe and O elements confirming the optimized incorporation of Fe into the host lattice.FE-SEM pictures revealed a highly porous sponge-like morphology composed of interconnected macropores and thin pore walls typical of rapid combustion processes. These characteristicsmake the synthesized nanoparticles emerging materials for versatile applications such as solid oxide fuel cells,supercapacitors, catalytic converters,gas sensors,magnetic and electrochemical device and environmental and thermoelectric technologies.

Keywords: $La_{1-x}Fe_xAlO_3$ nanoparticle, Structural, Morphological and Optical.

OP-7

Performance Evaluation of PEM Fuel Cells under Varying Active Area: An Experimental and Numerical Approach

Vivek Vijayan Geetha[*1], Manoj Kumar Panthalingal[2], Ajay Edupppiladath[3]
Fuel Cell Laboratory, Mechanical Department, PSG Institute of Technology and Applied Research, Coimbatore 641407
*Email: vvgvivek@gmail.com

Abstract

Proton Exchange Membrane Fuel cells (PEMFCs) play a key role in advancing sustainable development by clean and efficient energy without any producing any harmful emissions. The power density from a fuel cell is strongly dependent on the active area of Membrane Electrode

Assembly (MEA). In this study, numerical modelling is performed for different active areas different areas of 9cm^2, 25 cm^2 and 200 cm^2 with incremental increase in aspect ratio (AR). As the Aspect ratio increased, there was a considerable drop in the performance ranging from 15 to 25 %. Factors such as pressure drop, water flooding and increase contact resistance significantly contributed to the reduction in the performance of the PEMFCs with varying active areas. The numerical model was validated with fabricated MEAs of the active area 9cm^2, 25 cm^2 and 200 cm^2. Experimental results revealed that as the active area increases the optimum operating parameters changes considerably and cell temperature plays a key role in raising the performance to its optimum value. For the Aspect ratio 1, the 9 cm^2 produced a maximum power density of 730 mW cm$^{-2,}$ 25 cm^2 cell reached 610 mW cm^{-2} and the 200 cm^2 produced 250 mw mW cm^{-2}. These results indicates that geometric parametrs must be proportionally optimized with respect to the active area to achieve maximum power output.

OP-8

Quantitative Determination of Diffusivity in Ferro/Ferricyanide System Using Warburg Impedance under DC Bias

Anoop Naikkath[1,2*], Kothandaraman Ramanujam[2], Ramanathan Srinivasan[1]
[1]*Department of Chemical Engineering, IIT Madras, Chennai, Tamil Nadu, 600036*
[2]*Department of Chemistry, IIT Madras, Chennai, Tamil Nadu, 600036*
[*]Email: anoopmeleri@gmail.com

Abstract

Electrochemical Impedance Spectroscopy (EIS) is a versatile technique that provides valuable insights into the kinetic and transport processes governing electrochemical systems. However, its quantitative application is often limited by insufficient understanding of the underlying principles. In this study, we demonstrate the use of Warburg impedance under non-zero DC bias to determine the diffusivity of ferrocyanide and ferricyanide in an equimolar potassium ferro/ferricyanide solution. A rotating disk electrode (RDE) was employed to transform the semi-infinite Warburg element into a finite one, enabling accurate modelling of diffusion effects. The diffusivities were extracted by fitting the impedance data using an electrical equivalent circuit (EEC) model. The DC bias and AC amplitude were carefully optimized to ensure reliable diffusivity estimation. The obtained diffusivity values were further validated against those derived from potentiodynamic polarization (PDP) experiments, showing good agreement with both PDP-derived and literature-reported values.

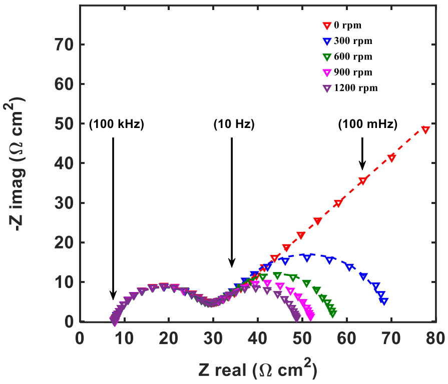


Figure 1. Nyquist plots of the equimolar ferro/ferricyanide system recorded at different rotation speeds.

Keywords: Electrochemical Impedance Spectroscopy, Warburg, Potentiodynamic polarization, Rotating Disk Electrode.

OP-9

Mechanistic Analysis of Anodic Dissolution of Mg in Simulated Seawater

Sreelakshmi Paruvayakode*, **Dr Ramanathan Srinivasan**
Department. of Chemical Engineering, IIT Madras, Chennai, Tamil Nadu, 600036
*Email: sreelakshmiparuvayakodephd@gmail.com

Abstract

Understanding the dissolution mechanism of magnesium in chloride media is crucial for improving its stability in Mg aqueous battery systems. In this study, the dissolution behavior of Mg in 3.5 wt% NaCl solution was investigated through the simultaneous fitting of potentiodynamic polarization (PDP) and electrochemical impedance spectroscopy (EIS) data. Measurements were performed using a rotating disk electrode (RDE) at different rotation speeds under kinetically controlled conditions. The impedance response, obtained at multiple DC biases, was analyzed using both electrical equivalent circuit (EEC) as well as mechanistic modeling. A circuit incorporating Maxwell elements effectively captured the faradaic behavior, while mechanistic fitting of the polarization and impedance data yielded the kinetic parameters. A three-step dissolution mechanism involving two surface-adsorbed intermediates was proposed, with the formation of adsorbed intermediate species, Mg^{+}_{ads} in the dissolution process. The proposed model successfully captures the essential features of the experimental polarization and impedance data, thereby offering mechanistic insight relevant to the design of Mg-based electrochemical energy systems.

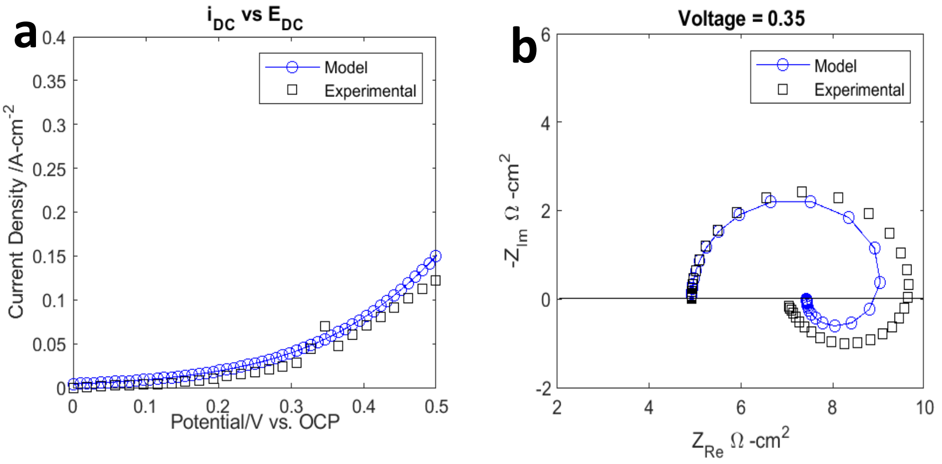


Figure. 1(a) Experimental and model polarization data for Mg dissolution in 3.5 wt% NaCl solution. (b). Complex plane plots of experimental and model EIS data of Mg dissolving in 3.5 wt% NaCl solution at *dc* potential of 0.35 V. The continuous lines with blue markers represent the model results and the black markers represent the experimental data.

Keywords: Potentiodynamic polarization, Electrochemical impedance spectroscopy, Rotating disk electrode.

OP-10

Nickel–Cobalt Phosphide Nanoneedle Arrays Supported on Biomass-Derived 3D Activated Carbon as a High-Efficiency Electrode for Advanced Asymmetric Supercapacitors

Irshad Moonam Kandathil[1], Athul Pradeep aringalayan[1] Sowmya B[2], Biji Pullithadathil[1*]
[1]*Nanosensors & Clean Energy Laboratory, Department of Chemistry & Nanoscience and Technology, PSG Institute of Advanced Studies, Coimbatore-641004, INDIA*
[2]*Department of Chemistry, PSG College of Technology, Coimbatore, 641004, India*
[*]Email: bijuja123@yahoo.co.in, pbm@psgias.ac.in

Abstract

Biomass-derived Pineapple waste was utilized to fabricate a three-dimensional continuous network of homogeneous micro/mesopore structure activated carbon (PLAC) through a hydrothermal and followed by KOH activation yielded highly porous activated carbon. Developing layered double hydroxide (LDH) nanosheets through rational design and low-cost fabrication remains a pivotal challenge in achieving exceptional electrochemical performance for hybrid supercapacitors. Herein an eco-friendly in situ growth approach has been demonstrated for the synthesis of hydrophilic NiCo-Phosphide-LDH nanosheets directly anchored on biomass waste-derived porous carbon, enabling a durable and high-performance cathode for hybrid supercapacitors, with leveraging the synergistic interaction between PLAC and Nickel Cobalt phosphide, a novel Ni$_1$Co$_3$-P@PLAC composite was developed, exhibiting remarkable specific capacitance and superior rate performance as an electrode material for supercapacitors. The asymmetric supercapacitor assembled using the Ni_1Co_3-P@PLAC composite as the cathode and PLAC as the anode retained the intrinsic 3D porous framework and high surface area of PLAC. Owing to the enhanced redox activity of the Ni_1Co_3-P@PLAC electrode and the complementary capacitive behavior of PLAC, the device achieved a broadened potential window, elevated energy density, and prolonged cycling stability, highlighting the feasibility of converting agricultural biomass waste into efficient and sustainable energy storage systems.

Keywords: Metal phosphide; Self-supported electrode; Micro-carbon spheres; Asymmetric supercapacitor.

OP-11

Viologen-Based Zn–Electrochromic Energy Storage Device with Polymer Electrolyte for Smart and Scalable Applications

Vansh Bhutani[1], Prof. Kothandaraman R[*]
[1]*Department of Chemistry, IIT Madras, Chennai, India,* [*]*Department of Chemistry, IIT Madras, Chennai, India*
[*]Email: rkraman@iitm.ac.in

Abstract

Electrochromic energy storage devices combine optical modulation with charge storage, enabling the development of smart, energy-efficient technologies such as self-powered windows and adaptive displays. In this work, we report on a large-area viologen-based zinc electrochromic energy storage device (Zn-EESD) that realizes both high optical contrast and excellent energy performance. A custom synthesised dihydroxyhexyl viologen, $[DHHV][Br]_2$, was incorporated into a flexible polymer electrolyte composed of polyvinyl butyral, lithium perchlorate, and propylene carbonate to achieve high ionic conductivity and reversible redox behavior. Devices featuring this material exhibit vivid and reversible color changes from colorless to deep blue, with a large optical modulation ($\Delta T = 82.84\%$ at 603 nm) and high coloration efficiency of 402.5 $cm^2\ C^{-1}$. Paired with a Zn anode, the Zn-EESD demonstrated a self-coloration contrast of 92%, delivered 86.06 mAh g^{-1} discharge capacity, and maintained 95.25% energy efficiency. A larger 5 cm^2 device retained an efficiency of 89.07%, and three connected cells successfully powered a 3 V LED for 120 minutes. This work demonstrates how designing polymer electrolytes in conjunction with molecular engineering can facilitate the scale-up of multifunctional electrochromic energy storage systems.

OP-12

Reducing Tree Contact Faults via Partial Patterned Insulation

Liam Pereira [1], Ramesh C. Bansal [2, 1*], Raj M. Naidoo [1]
[1] Department of Electrical, Electronic & Computer Engineering, University of Pretoria, Pretoria, South Africa, u16242115@tuks.co.za, Raj.Naidoo@up.ac.za
[2] Department of Electrical Engineering, University of Sharjah, Sharjah, United Arab Emirates
*Email: rcbansal@ieee.org

Abstract

Tree branches contacting overhead low-voltage power lines frequently cause power outages, especially in rainy weather, creating challenges for utilities. At the same time, urban trees provide significant environmental benefits and contribute to the aesthetic quality of residential and city areas, making their removal or aggressive trimming undesirable. This research proposes a retrofitted solution involving partial insulation of power lines through strategically placed short sleeve sections with a breathable conduit-like design. This design aims to reduce the likelihood of vegetation related faults while maintaining line breathability and minimising material use. The study focuses on optimising the length, spacing, and configuration patterns of these conduit-like segments to achieve effective coverage with reduced cost and thermal impact. Stochastic simulations are employed to model branch contact scenarios and evaluate various configurations. A simulation-based optimisation, is then performed to identify optimal patterns that minimise fault risk and material requirements, offering a cost-effective and environmentally sensitive strategy to enhance distribution network reliability and potentially extend equipment lifespan without extensive tree removal or full line insulation.

Keywords: Tree-related power outages, Partial insulation, Simulation based Optimisation, Fault mitigation, Retrofitted solution

OP-13

Treatment and Energy Recovery from Fish-Market Wastewater Using a Constructed Wetland–Microbial Fuel Cell (CW-MFC) with *Phragmites australis*

Saranraj G, Paul Giftson S, Man Mohan K, Kiran Kumar V and Gajalakshmi S*
Bioremediation Lab, Centre for Pollution Control and Environmental Engineering, Pondicherry University, Pondicherry 605014, India
Email*: gajalakshmis@pondiuni.ac.in

Abstract

Clean-water scarcity and dwindling non-renewable resources constitute significant global challenges. Traditional wastewater treatment is costly and energy-intensive, prompting the pursuit of sustainable alternatives. The Constructed Wetland–Microbial Fuel Cell (CW-MFC) system presents a promising solution by embedding a microbial fuel cell within a constructed wetland. In this synergy, electroactive bacteria degrade organic contaminants in anaerobic zones, releasing electrons that flow through an external circuit to a cathode and generate electricity. Studies demonstrate that CW-MFCs can treat various industrial and domestic wastewater while producing bio-electricity; however, their application to complex effluents such as fish-market wastewater remains largely unexplored. This study evaluated a pilot-scale CW-MFC system, consisting of three units planted with *Phragmites australis*, for treating real fish market wastewater. Operated in fed-batch mode with an inlet Chemical Oxygen Demand (COD) of approximately 2055 mg/L, the system achieved remarkable removal efficiencies: up to 99.13% for COD, 98.36% for sulphate, 65.55% for phosphate, and 97.39% for nitrate. Simultaneously, the CW-MFCs generated bioelectricity, attaining peak power and current densities of 41.27 mW/m^2 and 285.71 mA/m^2, respectively, with a maximum operating voltage of 440 mV. These results underscore the significant potential of CW-MFC systems with *Phragmites australis* for effective fish market wastewater treatment alongside sustainable bioelectricity production.

Keywords: constructed wetland, microbial fuel cell, fish-market wastewater, bioelectricity, *Phragmites australis*

OP-14

A Sustainable Pathway for Carbon Recycling through Dry Reforming of Methane

Harsha M. Dhanwani[1], G. D. Yadav[2*]
[1]*Chemical Engineering, Institute of Chemical Technology, Mumbai, India*
*Email: grt21gm.dhanwani@pg.ictmumbai.edu.in

Abstract

Dry Reforming of Methane (DRM) converts two major greenhouse gases, CH_4 and CO_2, into syngas (a mixture of H_2 and CO), which serves as a key feedstock for Fischer–Tropsch synthesis and other fuel production processes. Despite its potential for sustainable energy generation and carbon utilization, DRM is a highly endothermic reaction that requires high operating temperatures (700–1000 °C), often leading to catalyst deactivation due to coke deposition and metal sintering. Nickel-based catalysts are widely studied for their cost-effectiveness and activity but suffer from poor long-term stability, while noble metals such as Rh, Ru, Pt, and Pd offer better coking resistance but are too expensive for large-scale use. To address these challenges, recent research has focused on developing thermally stable catalysts with strong metal–support interactions using crystalline oxides such as perovskites, pyrochlores, spinels, and layered double hydroxides (LDHs), as well as novel supports like hexagonal boron nitride (h-BN), clays, and metal–organic frameworks (MOFs). Particularly, perovskite-derived and lanthanoid-supported Ni catalysts have shown improved redox behavior, oxygen mobility, and coking resistance, making them promising candidates for efficient and durable DRM systems that contribute toward carbon-neutral syngas production

OP-15

Sustainable Conversion of CO_2 to Methane Using Biochar-Based Supported Catalysts

Priyanka B. Shivde[1] and G. D. Yadav[2*]
[1,2]Chemical Engineering, Institute of chemical technology, Mumbai, India,
*Email: shivde.priya777@gmail.com

Abstract

The most common catalysts used for CO_2 methanation are nickel-based materials supported on metal oxides. Nevertheless, these catalysts often need high operating temperatures and face stability challenges, which researchers have addressed by incorporating expensive metal oxides like CeO_2, ZrO_2, etc. In this study, we propose an alternative approach by employing biomass-derived supports such as biochar. Furthermore, the potential to enhance catalyst performance by modifying the carbon support was evaluated, and it was found that nitrogen doped activated biochar (N-ABC), featuring an increased concentration of Lewis basic sites, exhibited the best performance among the ABC-based catalyst achieving a CO_2 conversion of ~65% and CH_4 selectivity of ~85% at 400 °C. Methanation reactions were carried out at different temperatures, with the using a catalyst containing 20 wt.% Ni. Catalysts with increased Ni loading demonstrated enhanced durability, exhibiting notably lower deactivation rates. Future work should aim to clarify how metal–support interactions and metal dispersion affect catalytic performance and long-term stability in CO_2 methanation.

OP-16

Iodine adsorption by thiophene-based covalent organic polymer: a study of structural influence on performance

Purushothaman P[1], Karpagam S[*]
[1] Department of Chemistry, School of Advanced Sciences, Vellore Institute of Technology, Vellore-632014, India
*Email: skarpagam@vit.ac.in

Abstract

A novel microporous covalent organic polymer (TPAT - COP) derived from tris(4-aminophenyl) amine (TPA) and 4,4’-(thiophene 2,5-diyl) dibenzaldehyde (T) moieties. The synthesized polymer has a surface area of 1199 $m^2 g^{-1}$ and mean pore diameter of 1.54 A° with high thermal stability. Accompanying this, TPAT-COP exhibits an exceptionally high iodine (I_2) adsorption capacity (467 wt%) in the vapour phase and 3.89 g g^{-1} in liquid phase, which surpasses the advanced thiophene based COPs. These results are the outcome of the meticulous design of the polymer embedded with sulphur sites and covalent bridges, which can counterbalance the low surface area and pore volume. Comprehensive analysis using FT-IR, XPS, and FE-SEM data corroborated with DFT calculation and Non-Covalent Interaction (NCI) using multiwfn software demonstrates the higher affinity of the sulphur atom in thiophene ring and the nitrogen atom in imine linkage towards iodine. Further, the outcomes were compared with organometallic based COP (DAPA-COP) to validate the introduction of thiophene units has significantly improved the adsorption capacity of iodine. As a result, a remarkably high retention rate and reversibility were achieved. Thus, a simple, cost-effective design and strategy defined the synthesized COP as a viable tool for rapid I_2 adsorption

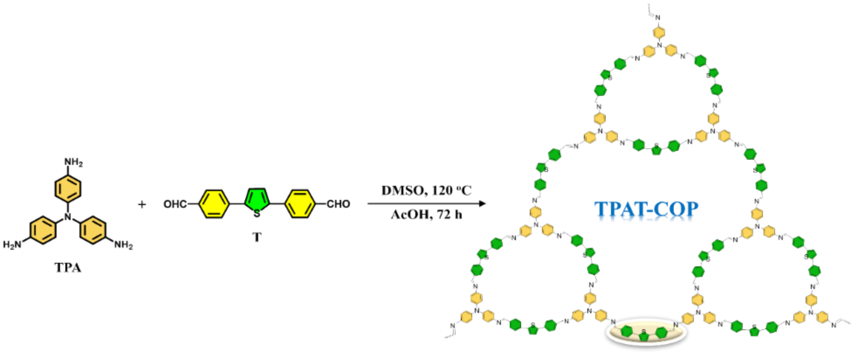


Figure 1. Synthetic route of **TPAT-COP** by solvothermal method

Keywords: COP, Microporous, Gas sequestration, Iodine uptake, XPS analysis

OP-17

Valorized Cassava Waste as a Sustainable Adsorbent for Vancomycin: Performance and Interaction Mechanisms

Blessy Silvaster[1] and Johnravindar D[*]
[1]*Department of Nanobiotechnology, PSG Institute of Advanced Studies, Coimbatore - 641004, Tamil Nadu, India*
[*]Email: jrd@psgias.ac.in

Abstract

Emerging contaminants include antibiotics as they pose health risk to public even though they are useful for humankind. During the hospital wastewater treatment, they sometimes escape and enter the environment causing resistance in human and aquatic life. The spread of multi-drug-resistant bacteria from hospital effluents is a major ongoing public health concern. The usage of antibiotic vancomycin is seen against the action of *Staphylococcus aureus* bacterial actions. This study focuses on the effective removal of the glycopeptide antibiotic vancomycin from the aqueous solution using an adsorbent synthesized from cassava waste residue, a biomass industrial waste. The biochar synthesized from the CWR in different temperatures like 300°C, 500°C and 700°C using pyrolysis were characterized and their properties were studied. The adsorption efficiency was studied at each stage by varying the conditions like different temperature synthesized biochar, pH of solution, antibiotic concentration, adsorbent (biochar) dosage to finalize the optimum working condition with the removal efficiency of 80% approximately was noted. The isothermal and kinetic studies using different models supported that the adsorption mechanism showed chemisorption, multilayer adsorption, and an increase in the interaction between adsorbent and adsorbate was noted as the higher temperature pyrolyzed biochar used showing the co-relation between the surface factors and the adsorption.

Keywords: Emerging contaminants, Biochar, Vancomycin, Adsorption Kinetics & Isotherm.

OP-18

Catalytic Activity of Copper decorated Scandium Carbonitride MXene (Cu@Sc_3CN) towards Electrochemical Carbon dioxide reduction to CH_3OH- A DFT Study

Karthiga Manivannan[1], Senthilkumar Lakshmipathi[1*]
[1]*Department of Physics, Bharathiar University, Coimbatore 641 046, Tamil Nadu, India*
[*]Email: lsenthilkumar@buc.edu.in

Abstract

Release of anthropogenic CO_2 from various factors such as transportation, industries etc. is a major reason for global warming. Global warming has several adverse effects on the environment, such as rising sea levels and climate change. To mitigate these issues, carbon capture, utilization and storage (CCUS) has been proposed as a vital solution. In this study, we focus on converting anthropogenic CO_2 to CH_3OH (methanol) using the Cu@Sc_3CN single-atom catalyst via an electrochemical reduction reaction. The optimized Cu@Sc3CN is shown in Fig.1a, which is metallic and thermally stable from the AIMD plot is shown in Fig.1b at T=300 K. The catalyst was found to activate CO_2 in a side-on orientation with a ΔG of -0.03 eV. Furthermore, the rate-determining step (RDS) for the overall reaction is the formation of *COOH with ΔG=0.18 eV. The limiting potential (U_L) and overpotential (η) were calculated to be -0.18 V and 0.20 V. The free energy profile for the electrochemical CO_2 reduction to CH_3OH is shown in Fig.1c. Overall, the obtained first-principles theoretical investigation results suggest that Cu@Sc_3CN is a promising candidate for the electrochemical CO_2 reduction to methanol.

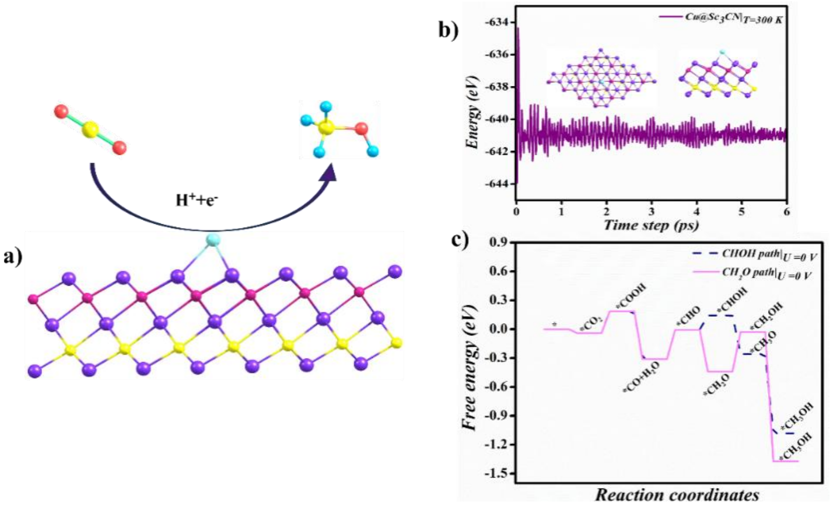


Figure 1. a) Schematic representation of Electrochemical CO_2 reduction to CH_3OH on optimized Cu@Sc_3CN, b) AIMD plot of Cu@Sc_3CN at T=300 K and c) Free energy profile for electrochemical CO_2 reduction to CH_3OH.

Keywords: eCO_2RR, Sc-based carbonitride (Sc_3CN) MXene, DFT, methanol (CH_3OH).

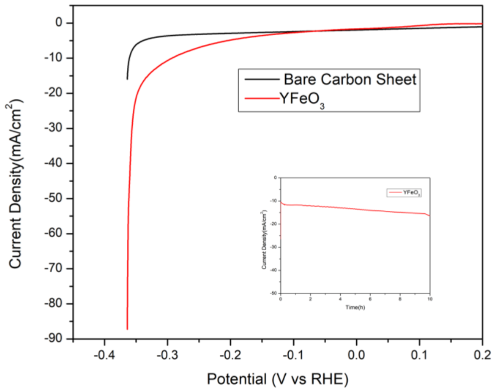
OP-19

Green Combusted $YFeO_3$ nanomaterial as a promising electrocatalyst for green hydrogen production

T.Thilagavathi[1], Dr.Y.Vidyalakshmi[1,2*]
[1] *Department of Physics, Anna University, Chennai-60025, Tamilnadu, India.*
[2] *Centre for Energy Storage Technologies, Anna University, Chennai-600025, Tamilnadu, India.*
[*] Email: yvlakshmi69@gmail.com

Abstract

With the augmenting requirement for clean energy, production of green hydrogen through water splitting is an exemplary approach to reduce the dependence on fossil fuels. This work focuses on the synthesis of Yttrium ferrite ($YFeO_3$) via green combustion to evaluate it's HER activity. XRD analysis confirmed the orthorhombic and hexagonal phases of $YFeO_3$ with an average crystalline size of around 22 nm. Distinct Fe-O peaks were displayed at 560 cm^{-1} by FTIR, while XPS substantiated the occurrence of Fe^{3+} and Y^{3+} Oxidation states. FESEM and TEM revealed the particle size distribution and morphology of $YFeO_3$. Elemental composition of $YFeO_3$ was confirmed by EDX. Electrochemical Performance displayed an overpotential of 262mV at $10mA/cm^2$ and a tafel slope of 107mV/decade with low charge transfer resistance, indicating appreciable HER activity. The catalyst exhibited remarkable durability, maintaining its activity over 10 hours of chronoamperometry suggesting the green combusted $YFeO_3$ as a prominent electrocatalyst for HER.



Keywords: Green Hydrogen, $YFeO_3$, Green Combustion, Electrocatalyst, clean energy

OP-20

Sputter deposition of Bi_2Se_3 and SnSe thin films for thermoelectric applications

Bhagyashree Ponmudi, Geetha Priyadarshini Badhirappan*
Nano structured surface and thin films laboratory, Department of Physics, Nanotech Research Innovation & Incubation Centre, PSG Institute of Advanced Studies, Peelamedu, Coimbatore– 641 004, Tamil Nadu, India.
*Email: bgp@psgias.ac.in

Abstract

Thermoelectricity is a phenomenon that allows for the direct conversion of thermal energy (heat) into electrical energy. Semiconducting thin films composed of tellurides, selenides, and sulfides, particularly narrow band gap materials, have garnered significant interest for thermoelectric applications. This work focuses on the fabrication of chalcogenide thin films, specifically bismuth selenide (Bi_2Se_3) and tin selenide (SnSe) sputter deposited on glass substrates using the physical vapor deposition (PVD) technique. Sputtering allows for precise control over film thickness and composition, which is crucial for optimizing thermoelectric properties. The characterization of the fabricated thin films includes x-ray diffraction (XRD) studies confirmed the crystal as rhombohedral and orthorhombic for Bi_2Se_3 and SnSe respectively. Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM) were employed to analyze the surface morphology and topography of thin films. Raman spectroscopy was further examined to identify the vibrational modes, while Seebeck coefficient measurements of SnSe exhibited a positive S value, reaching a maximum of 732 µV/K at 92 °C, indicating p-type character. Conversely, Bi_2Se_3 showed a negative S value of -79.37 µV/K at 240 °C, signifying n-type behavior. These findings contribute significantly to the advancement of efficient and sustainable thermoelectric devices made from sputtered thin films.

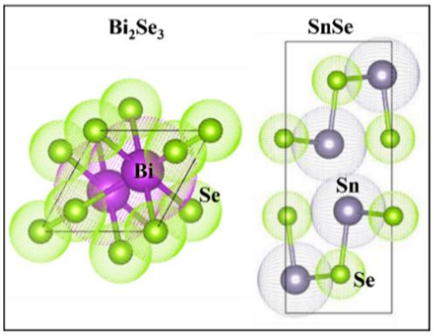


Figure 1. Schematic representation of crystal structure of Bi_2Se_3 and SnSe

Keywords: Chalcogenide; Binary, Thermoelectricity, Sputtering, Thin film.

OP-21

Design and Development of Naphthalic-Based Organic Single Crystals for Enhanced Self-Powered Photodetection

P. S. Sugatha[1], Rakesh Ganguly[2], Apurba Lal Koner[3*], Sudip Kumar Batabyal[1,4 *]
[1]Department of Physics, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, India.
[2] Department of Chemistry Shiv Nadar Institution of Eminence NH91, Tehsil Dadri, Gautam Buddha Nagar, Uttar Pradesh 201314, India
[3] Bionanotechnology Lab, Department of Chemistry, Indian Institute of Science Education and Research Bhopal, Bhopal Bypass Road, Bhauri, Bhopal, Madhya Pradesh, India.
[4] Center of Excellence in Advanced Materials and Green Technologies, Amrita School of Engineering Coimbatore, Amrita Vishwa Vidyapeetham, India.
*Email: akoner@iiserb.ac.in (ALK), s_batabyal@cb.amrita.edu (SKB)

Abstract

The distinctive properties of organic single crystals enable a wide range of applications. In this study, we developed a simple and scalable solvothermal method for synthesizing organic single crystals, using o-phenylenediamine and 1,8-naphthalic anhydride as precursors through a solvothermal process. The growth behavior of the crystals was further explored by examining how different synthesis conditions affect their development. To overcome the limitations of traditional inorganic photodetectors, the crystals were designed to efficiently absorb light within the UV and visible spectra. Notably, the material showed exceptional UV sensitivity, highlighting its potential as a self-powered, cost-effective, and environmentally friendly photodetector for future optoelectronic applications.

Keywords: Organic Single crystals, Solvothermal, Organic photodetector, Organic electronics, Low-cost.

OP-22

Open Source AI Framework for Simplified PEM Fuel Cell Modelling

Vijai Kaarthi V[1*], Karthikeyan P[2], Third author[2] and Fourth Author[3*]
[1]Department of Mechanical Engineering, PSG Institute of Technology and Applied Research, Coimbatore, India, [2]Department of Automobile Engineering, PSG College of Technology, Coimbatore, India
*Email: vvk.mech@psgitech.ac.in

Abstract

Proton Exchange Membrane Fuel Cells (PEMFCs) play a critical role in the transition toward sustainable energy systems, yet their computational modeling often relies on complex commercial CFD tools or extensive experimental data. This study presents an open-source, and programming-based approach for rapid PEMFC performance prediction using a hybrid 1D

physics–AI model. A simplified electrochemical model incorporating the Nernst equation, activation losses, ohmic resistance, and concentration effects was implemented in Python to generate baseline voltage–current characteristics under varying operating conditions. To enhance predictive accuracy and compensate for limitations of the simplified physics, a machine learning regression model was trained to learn correction terms between the analytical output and perturbed simulation data. The resulting hybrid model significantly improved voltage prediction accuracy while maintaining extremely low computational cost. The approach enables instantaneous simulation of fuel cell behavior, making it suitable for real-time control, digital twins, system optimization, and educational use. This work demonstrates that combining lightweight electrochemical modeling with AI provides a transparent, reproducible, and non-commercial method for accelerating PEMFC simulation, supporting broader adoption of hydrogen technologies in sustainable energy applications.

1D Physics based model	AI model	Hybrid physics AI model

Figure1. AI - Enhanced 1D Model for Rapid PEMFC Performance Prediction.

Keywords: PEMFC, 1D Electrochemical Modelling, Artificial Intelligence, Hybrid Physics - Machine Learning Model, Fast simulation/ computational efficiency.

OP-23

Influence of lower valent element substitution on tailoring carrier transport modulation in *n*- type $ZnFe_2O_4$ for enhanced high temperature thermoelectric performance

Navya John[1], Bhuvanesh Srinivasan[2], Anuradha M Ashok[1*]
[1]*Functional Materials Laboratory, PSG Institute of Advanced Studies, Peelamedu, Coimbatore – 641004, T. N., India*
[2]*Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, Chennai – 600036, T. N., India*
[*]Email: anu@psgias.ac.in

Abstract

Worldwide, a huge amount of energy in the form of waste heat has been discharged into the atmosphere through high-temperature processes. Harnessing waste heat is a clean energy solution for the energy and environmental issues. Herein, an effort is made to investigate the complex oxide form of ZnO with the multivalent transition elements for thermoelectric applications. Spinel ferrite has excellent structural, electrical, and magnetic properties, which make them appropriate for thermoelectric applications; however, very few studies have tried to convert n type spinel ferrite material into p type by doping lower valent element for thermoelectric module fabrication. $Zn_{1-x}Li_xFeO_4$(x = 0.03, 0.05, 0.3, 0.5 and 1.0) and $Zn_{1-x}Cu_xFe_2O_4$(x = 0.01, 0.03, 0.3, 0.5, 0.8 and 1.0) was synthesized by the sol-gel method. In the present investigation, From the Seebeck measurement $Zn_{1-x}Cu_xFe_2O_4$(x = 0.8 and 1.0) compositions show positive value, confirming the *p*-type conductivity with holes as the major

charge carriers. This is due to its electronic structure and ability to create acceptor states due to doping. Potential of Cu to form Cu^+ ions and vacancies at relatively low energies favors p-type behavior, making it a more effective and suitable dopant to convert *n*-type $ZnFe_2O_4$ to *p*-type.

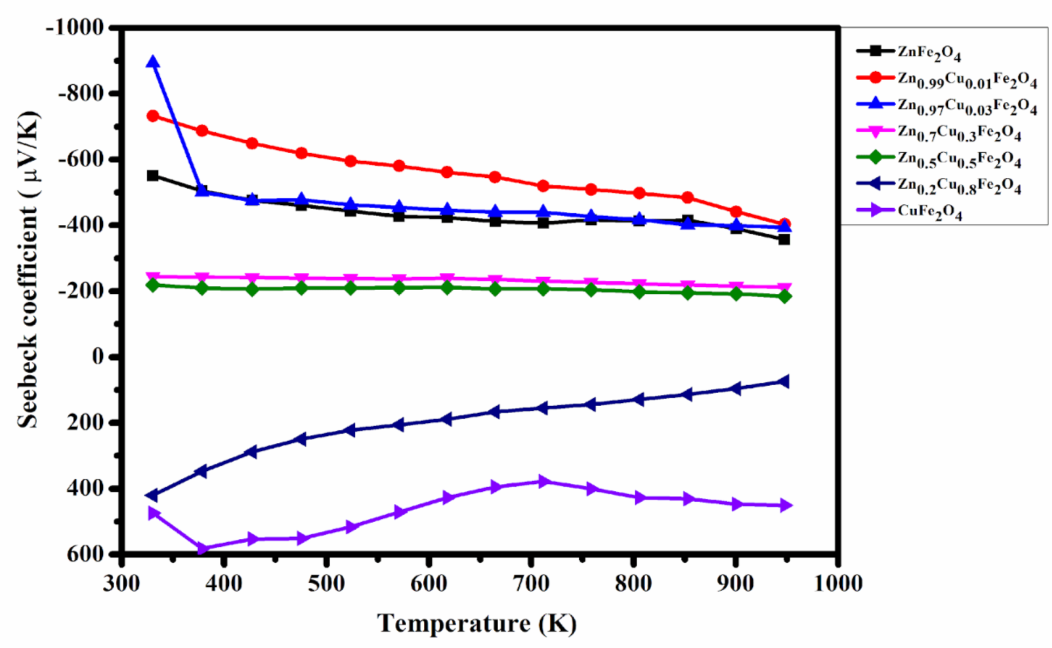


Figure 1. Temperature dependent Seebeck measurement of $Zn_{1-x}Cu_xFe_2O_4$(x = 0.01, 0.03, 0.3, 0.5, 0.8 and 1.0)

Keywords: Spinels, Thermoelectrics, Sol-gel processes, Electrical conductivity, Thermal conductivity.

OP-24

Moisture-Activated Energy Generation in Interface-Tailored Lead-Free Halide Perovskites

Darsana Sudarsan[1], Stevin S Pramanna[2], Sudip K Batabyal[1,*]
[1] Department of Physics, Amrita School of Physical Sciences, Coimbatore, Amrita Vishwa Vidyapeetham, 641112 India, [2] Newcastle University, Newcastle, United Kingdom
*Email: _batabyal@cb.amrita.edu

Abstract

Moisture-electricity generators (MEGs) directly convert ambient moisture to useful electrical energy via water molecule-surface interactions. Despite this potential, practical applications of the MEGs have been limited due to low output power and slow response to moisture. Herein, an efficient MEG system based on $Cs_2CuCl_4/Cs_2MnCl_4(H_2O)_2$ heterostructure is developed to highlight the impact of interfaces in enhancing the electrical output. Moisture-sensitive interfaces in the heterostructures activate the migration of free ions in the halide perovskite system upon exposure to moisture, resulting in the formation of electric double layers (EDLs) at grain boundaries, which generates a potential difference and delivers continuous power generation. Remarkably, a single lateral device with an active area of 0.3 cm^2 can deliver an

open-circuit voltage of 0.8 V and a short-circuit current of 82 μA at 85% relative humidity (RH), significantly higher than the other reported halide perovskite system. The MEGs maintain a continuous output voltage of 0.78 V for 48 hours and can power LEDs *via* three capacitors connected in series charged by MEG. Additionally, the MEGs also demonstrate an ultra-fast response to 33% and 85% RH, with rise time and decay times of 1.31/0.67s, respectively, which can be engineered, beyond energy harvesting, to function as a self-powered health monitoring sensor, thereby showcasing its multifunctionality.

Keywords: Halide perovskite; ionovoltaics, moisture induced power generation, respiratory sensing

OP-25

Metal Cation intercalated layered Sulphoselenides for Next-Generation optoelectronic applications

Edita Joseph[a], Sathiyamoorthy Buvaneswaran[b], Saurabh Gosh[b], Sudip K Batabyal[ac]*
[a]*Department of Physics, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, Coimbatore, Tamil Nadu 641112, India.*
[b]*Department of Physics and Nanotechnology, Faculty of Engineering and Technology, SRM Institute of Science and Technology, Kattankulathur 603 203, Tamil Nadu, India*
[c]*Center of Excellence in Advanced Materials and Green Technologies, Amrita School of Engineering Coimbatore, Amrita Vishwa Vidyapeetham, Coimbatore, Tamil Nadu 641112, India*
*Email: s_batabyal@cb.amrita.edu

Abstract

In this study, different metal cation-incorporated sulphoselenide thin films were successfully produced using the SILAR technique, which provides cost-effective, solution-based, and scalable deposition method without annealing techniques. By selectively integrating cations such as Cd^{2+}, Zn^{2+}, Sn^{2+}, and Sb^{3+} into the sulphoselenide structure, the optical band gap and electrical properties of the thin films were effectively adjusted. Structural analysis verified the formation of uniform, adherent thin films with controlled crystallinity, while optical investigations indicated broad absorption spanning the visible to near-infrared spectrum. Electrical and photoresponse evaluations demonstrated that incorporating metal cations significantly enhanced the separation and transport of photogenerated carriers, with optimized compositions exhibiting stable and reproducible self-powered photodetection. Among the four metal ions incorporated into sulphoselenide systems, the Cd^{2+} cation incorporated thin film produced the best performance in terms of efficiency. The Cd^{2+} ions incorporated SSe device shows the highest responsivity of 0.18 mA/W and a detectivity of 3×10^9 Jones. First-principles density functional theory (DFT) and density of states (DOS) analyses further verified the structural stability and semiconducting nature of the doped systems, revealing that cation incorporation narrows the band gap (1.60–1.63 eV) and enhances charge delocalization near the Fermi level, in strong agreement with experimental observations.

Keywords: Metal cation, sulphoselenide, self-powered photodetector, SILAR, carbon electrode

OP-26

Fluorine-incorporated graphene oxide for hydrovoltaic power generation: Improving proton migration and storage capacity

Neethu Manikandan[1], Abhinand K B[1], Hridya C Prakash[1], Kaushik Suvigya[2], Sudip K Batabyal [1,3*]

[1]*Department of Physics, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, India.*

[2]*Department of Physics, Indian Institute of Technology Gandhinagar, Gujarat 382355, India.*

[3]*Center of Excellence in Advanced Materials and Green Technologies, Amrita School of Engineering Coimbatore, Amrita Vishwa Vidyapeetham, India.*

*Email: s_batabyal@cb.amrita.edu

Abstract

Here, we present a device using fluorinated graphene oxide and ethylene glycol to efficiently harvest energy using hydrovoltaics. By incorporating fluorine, hydrophilic GO became partially hydrophobic FGO with enhanced surface charge and ethylene glycol was added to generate hydro-polymeric network that facilitates water transport. The device fabricated using a centimeter-sized silicon ice tray with top and bottom electrodes loaded with 40 mg of fluorinated graphene oxide, generates a streaming potential and current when exposed to water. A mere 20 µl of water on the top electrode yielded an open circuit voltage in a range of 250 mV, a short circuit current in a range of 100 µA, with an output power of 0.625 mW/g.. We validated the streaming potential and current of hydrovoltaic devices by comparing our experimental data with theoretical electrokinetic models of hydrodynamic flow. Furthermore, we explored the energy storage capacity of the same material, resulted in a significant increase in active sites, leading to a capacitance of 350 F/g with improved cyclic stability. The hydrovoltaic cell was also used to charge a coin cell made from the same material, presenting a novel approach for integrated systems. This study highlights the multi-functional applications of fluorinated graphene oxide.

Keywords: Hydrovoltaics; Streaming potential; Diffusion, Fluorinated graphene oxide; Smoluchowski equation.

OP-27

Structural, Morphological, and Optical properties of sputtered amorphous Indium-Tin-Zinc-Calcium Oxide thinfilms for display applications

Catherine Jesinthamary. D[1] and S. Parthiban[2*]
[1]*Department of physics, PSG Institute of Advanced Studies, Coimbatore-641004, India,*
[2]*Department of physics and Centre for Research and De velopment, KPR Institute of Engineering and technology, Coimbatore-641407, India,*
Email[*]: parthimsc@email.com

Abstract

Amorphous metal oxide thin films have attracted significant attention for use as switching transistors in OLED and LCD displays due to their amorphous nature, wide bandgap, high mobility, and industrial scalability. Among them, amorphous indium–gallium–zinc oxide (a-IGZO) is widely used as the active channel layer in thin-film transistors (TFTs) for OLED and LED applications. However, achieving higher mobility in amorphous metal oxide TFTs is essential to surpass the performance of low-temperature polysilicon (LTPS) TFTs. Although amorphous indium–tin–zinc oxide (a-IZTO) TFTs exhibit superior mobility compared to a-IGZO TFTs, their performance still falls short of LTPS TFTs. In this work, calcium was introduced as a carrier suppressor due to its strong reducing nature in the a-In–Zn–Sn–O active channel layer. Amorphous indium–zinc–tin–calcium oxide (a-In–Zn–Sn–Ca–O) thin films were sputtered at room temperature and post-annealed at various temperatures. The X-ray diffraction and high-resolution transmission electron microscopy studies confirmed amorphous nature. The morphological properties were investigated by atomic force microscopy (AFM). UV–Vis spectra show optical transparency exceeding 90 per cent, and bandgap extracted from the tauc plot is 2.7 eV. Hall measurements reveal a transition in transport behaviour with increasing annealing temperature. Higher-temperature annealing activates stable n-type conduction, characterised by a substantial rise in carrier concentration to the 10^{18} cm^{-3} range, a reduction in resistivity to 0.1–0.2 Ω·cm, and mobility stabilisation around 10–13 $cm^2/V\cdot s$, indicating improved structural relaxation and reduced defect compensation in the amorphous network. Overall, Ca-ITZO emerges as a structurally robust, optically transparent, and electronically tuneable amorphous oxide, demonstrating strong potential as a high-performance channel material for advanced thin-film transistor technologies.

Keywords: Sputtering, optical properties, electrical properties, Morphological properties.

OP-28

Efficient Smog and CO_2 Removal using Adsorption-Based DAC System: Field Deployment in Urban Environments

Nishanth Kumar [1,2], Sravanthi Loganathan [1, 2*] and Ravi Babu Valapa [1, 2*]

[1]*Electrochemical Process Engineering Division, CSIR-Central Electrochemical Research Institute (CECRI), Karaikudi-630003, Tamil Nadu, India.*

[2]*Academy of Scientific and Innovative Research (AcSIR), Ghaziabad- 201002, India.*

*Email: l.sravanthi@alumni.iitg.ac.in,lsravanthi09@gmail.com
vravibabu@cecri.res.in,vravibabucecri@gmail.com

Abstract

The Escalating urban air pollution and recurring smog events pose major environmental and public health risks. Smog, consisting mainly of PM $_{2.5}$, PM_{10}, and gaseous pollutants, reduces visibility, affects radiative balance, and causes chronic respiratory and cardiovascular issues. In megacities like New Delhi, combined emissions from transport, industry, and households intensify these problems, creating demand for sustainable, high-efficiency mitigation solutions. This study reports the development and real-time testing of an indigenously engineered Direct Air Capture (DAC) system integrating filtration and adsorption for particulate and gaseous pollutant removal. Using advanced sorbents and catalytic surfaces, the system captures atmospheric CO_2 and smog components under ultra-dilute conditions. Designed for low energy use and safe operation, it was field-tested in open, semi-open, and enclosed environments within New Delhi. Results show 97.7% particulate removal, along with notable reductions in ambient CO_2 and visible smog. Adsorption–desorption studies confirmed stable cyclic performance and reusability. The study highlights the dual functionality of DAC as a tool for carbon capture and smog abatement, demonstrating its readiness for commercial deployment in high-pollution zones and its potential contribution to urban air quality improvement and climate mitigation.

Keywords: Air pollution, smog, DAC, Particulate removal, cleaner air

OP-29

Investigation of Structural and Optical Properties of CeO_2 Nanoparticles for UV Photodetector Applications

Sankaran Venkatachalam[1], Kathirvel Ponnusamy[1*],Gopalram S.D.[1] and Saravanan. K[2]

[1]GRD Center for Materials Research, Department of Physics, PSG College of Technology, Coimbatore, Tamil Nadu – 641004, India

[2]UGC-DAE Consortium for Scientific Research, Kalpakkam node, Kokilamedu, Tamil Nadu – 603104, India

[*]Email: ponkathirvel@gmail.com

Abstract

Cerium oxide (CeO_2) is a high-k dielectric material with strong ultraviolet (UV) absorption and a wide bandgap, making it a promising candidate for UV photodetectors (PD) by ensuring low dark current and high selectivity toward UV radiation. Its remarkable optical properties arise from the abundance of oxygen vacancies and the distinctive Ce^{4+}/Ce^{3+} redox cycles, which facilitate efficient charge transfer and enhance photoresponse characteristics. In this work, CeO_2 nanoparticles were synthesized and characterized using X-ray diffraction (XRD), transmission electron microscopy (TEM), Raman spectroscopy, and UV–Vis diffuse reflectance spectroscopy (UV–DRS). The findings highlight that the synthesized CeO_2 exhibits a highly crystalline fluorite structure with an optical bandgap of approximately 3.1 eV. The Raman spectrum shows the characteristic F_2g band of CeO_2 around 470 cm^{-1}, while an additional peak near 1064 cm^{-1} indicates the presence of oxygen vacancy defects that enhance charge carrier activity under UV light. TEM analysis reveals that the CeO_2 nanoparticles possess a cubic-like morphology and exhibit a polycrystalline nature, as evidenced by the presence of multiple lattice fringes corresponding to different crystallographic planes. The results demonstrate that CeO_2 nanoparticles can serve as promising UV-sensitive materials for optoelectronic devices.

Keywords: CeO_2, Photodetector, optoelectronic materials

OP-30

Assessing the carbon sequestration potential of soil and water conservation interventions at the watershed level

V. Kasthuri Thilagam[1] and S. Manivannan[2]

[1]ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu, India

[2]ICAR-Indian Agricultural Research Institute, Assam

[*]Email: kasthurisk@gmail.com

Abstract

Climate change effects in the atmosphere and soil pose a significant threat to agricultural productivity. Soil degradation is one of the important consequences of declining soil organic carbon content. Enhancing crop productivity and maintaining have become significant challenges to farmers. This can be tackled effectively through various management practices. Watershed management programmes aim to reduce runoff and soil erosion and maintain soil health by adopting suitable soil and water conservation measures. ICAR-IISWC, RC, Udhagamandalam implemented an integrated watershed development programme in Gobi Taluk of Erode district, Tamil Nadu and developed a 782 ha model watershed Ayalur from 2008-09 to 2013-14. The present study was conducted to assess the soil carbon stock under various soil and water conservation interventions. The soil profile was dug, and sampling was done systematically within the influence zone of each selected structure. Soil samples at every 10 cm depth up to 1 m or up to the parent rock were collected from the soil profile. Based on soil organic carbon and other soil parameters, the organic carbon stock was worked out in the influence zone of the structures. The estimated carbon stock in the influence zone of the Random Rubble Check Dam (RRCD) is highest (13.13 MgC ha-1) at a distance of 10 m and decreases with increasing distance. The Loose Boulder Check Dam (LBCD) also has a high carbon stock of 5.12 MgC ha^{-1} at 10 m distance. At the same time, the organic carbon stock was higher in the surface soils and reduced with depth. The estimated carbon stock in the influence zone of farm ponds and percolation ponds is nearly equal at 10 and 50 m distances and slightly reduced at 100 m. Check dams contribute to groundwater recharge and improve water availability for vegetation and agriculture by storing runoff. As soil and water conservation structures significantly influence SOC stock, their implementation not only reduces soil loss but also improves soil health and productivity at the watershed level.

Keywords: Carbon stock, check dams, engineering measures, influence zone

OP-31

Sonochemical reduction of Nitrates to Ammonia for facile removal of nitrates from water

Nikhil George Mohan[1], and Kothandaraman Ramanujam[1,2,3]*
[1] *Clean Energy Lab, Department of Chemistry, Indian Institute of Technology Madras, Chennai 600036, India*
[2] *Department of Chemistry, Indian Institute of Technology Madras, Chennai 600036, India*
[3] *Energy Consortium, IIT Madras, Chennai 600036*
*Email: rkraman@iitm.ac.in

Abstract

Ammonia (NH_3) is essential for fertilisers, chemicals, and emerging energy systems, yet the conventional Haber-Bosch process for its synthesis remains energy-intensive. Simultaneously, nitrate (NO_3^-) contamination in wastewater presents both an environmental challenge and an opportunity to produce ammonia. We report a sonochemical route that converts aqueous nitrates to ammonia using an electrically driven probe sonicator, enabling radical-mediated reduction in near-neutral media without the need for expensive electrodes or sacrificial reagents. Under optimised conditions (0.1–0.2 M KNO_3, 62.5 W, 1 h), baseline NH_3 formation is ≈2.5 mg h^{-1} and is mainly independent of the alkali metal cation (Li^+/Na^+/K^+), indicating that nitrate availability and radical chemistry, rather than the identity of the cation, govern rates. Further studies support a mechanism in which cavitation-induced H• radicals from water homolysis reduce nitrate via multi-electron steps; controlling concomitant H_2O_2 (formed by the combination of two hydroxyl radicals) pathways is therefore critical. We find that adding GaO(OH) suppresses hydroxyl-radical–driven back-oxidation and increases the NH_3 yield to 32 ± 10.5 mg h^{-1}, whereas the addition of Fe^{3+} (causing the Fenton reaction) accelerates NH_3 loss. Adding EDTA (•OH scavenger) further boosts yields, corroborating that mitigating oxidative radical pathways preserves the product. Time-dependent studies reveal an optimum at ~1 hour; beyond this point, the apparent rate of the reaction decreases. The approach couples wastewater nitrate recovery with ammonia synthesis, is compatible with renewable electricity, and suggests a pathway toward decentralised, atom-efficient NH_3 generation.

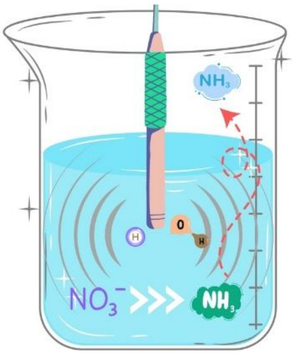


Fig. 1: Schematic representation of the sonochemical conversion of nitrates to ammonia

Keywords: Sonochemistry; Nitrate reduction; Ammonia synthesis; Wastewater remediation; Gallium oxyhydroxide; Radical scavenging.

OP-32

Fluorescent Carbon Quantum Dots as Dual-Function Probes for Ultra-Sensitive Chromium (VI) Detection and In Vivo/In Vitro Bioimaging

Nithya kasirajan[1], Kadirvelu Krishna[2]*
[1,2] DRDO Industry Academia Centre of Excellence, Bharathiar University, (DIA-CoE, BU), Coimbatore, Tamil Nadu, India – 641 046
*Email: Kadirvelukrishna@yahoo.com

Abstract

Carbon Quantum Dots (CQDs) were prepared through a sustainable hydrothermal method using rice starch & citric acid as the carbon source and urea as the nitrogen dopant. The CQDs exhibited strong intrinsic fluorescence, excellent aqueous stability, and abundant surface functional groups. Structural and optical characterisation (HR-TEM, XRD, FTIR, UV-Vis, ZETA, PL,) confirmed their uniform spherical morphology size (~2.9 nm), and demonstrated stable surface charge (+28 mV), high aqueous dispersibility, amorphous carbon structure, and excitation-dependent emission, supporting their suitability for sensing and bioimaging applications. The CQDs functioned as highly sensitive fluorescent probes for Cr (VI) detection by a static photoluminescence quenching mechanism. The sensing platform demonstrated a

linear response in the 0-10 nM range and achieved an ultralow detection limit of 0.098 nM, enabling trace-level monitoring of toxic metal ions in aquatic systems [1]. Biocompatibility was confirmed through zebrafish developmental toxicity assays, which showed normal embryonic development at functional CQD concentrations, with developmental abnormalities only at higher exposures. The strong fluorescence enabled imaging in plant cells, bacterial cells, and zebrafish embryos. This material demonstrates excellent potential as dual-function nanoprobes for ultrasensitive Cr (VI) sensing and safe invivo/invitro bioimaging applications.

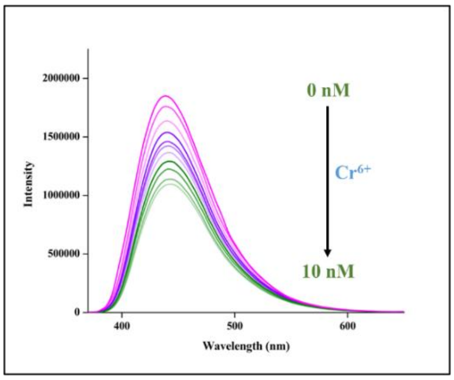


Figure 1. Photoluminescence spectrum of CQDs with concentrations ranging from 0 to 10 nM of Cr^{6+}

Keywords: Carbon Quantum Dots (CQDs), Cr (VI) Ultrasensitive Detection, Bioimaging probes, Zebrafish Biocompatibility, Sustainable Nanobiotechnology.

OP-33

Sustainable SERS platform for Pesticide Detection Using Silver Nanoparticles on Black Silicon Recycled from Solar Cells

Rajesh Unnathpadi[1], Navami Sunil[1], Athira Suresh[1], Athul Pradeep[1], Irshad M. K[1], Divya Sreetha Murugan[1], Ajith Manayil Parambil[2], Biji Pullithadathil[1]*

[1]Department of Chemistry & Nanoscience and Technology, PSG Institute of Advanced Studies, Coimbatore, INDIA

[2]Centre for Energy and Environmental Technologies, VSB–Technical University of Ostrava, Ostrava–Poruba, Czech Republic

*Email: bijuja123@yahoo.co.in; pbm@psgias.ac.in

Abstract

The increasing presence of pesticide residues in aquatic environments necessitates the development of rapid, sensitive, and cost-effective detection techniques for effective water quality monitoring. In this study, a low-cost, label-free Surface-Enhanced Raman Spectroscopy (SERS) biosensor platform based on silver nanoparticles functionalized black silicon (Ag/BSi) has been developed for the sensitive detection of pesticides in waterbodies. The black silicon substrate was fabricated via a two-step process: nickel electroless deposition followed by metal-assisted chemical etching. Subsequently, silver nanoparticles were uniformly deposited onto the black silicon surface using an electroless deposition technique via the Tollens reaction. The SERS properties of the Ag/BSi substrate have been evaluated using Rhodamine 6G, demonstrating a high enhancement factor on the order of 10^7 and a detection limit down to10^{-7} M, indicating its potential for trace-level detection. As a proof-of-concept, the Ag/BSi platform was utilized to detect the pesticide thiram in water samples, demonstrating effective and reliable sensing performance over a broad concentration range, from 10^{-3} M to 10^{-9}M. Notably, the sensor also successfully detected thiram at levels as low as 2 ppm in real pond water samples. These results highlight the potential of Ag/BSi-based SERS substrates as a promising tool for ultra-sensitive and cost-effective environmental monitoring.

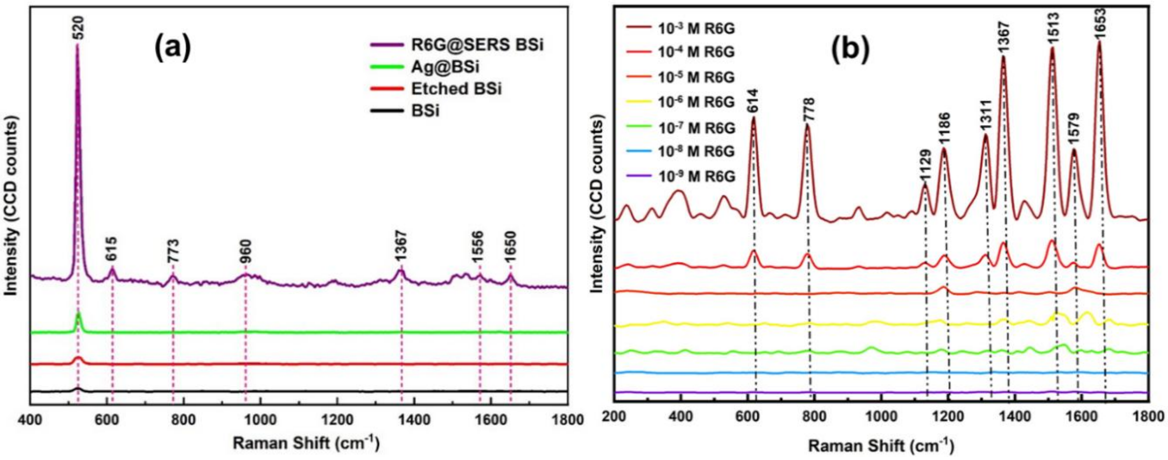


Figure 1. Raman signals of (a) BSi, Etched BSi, Ag/BSi, and (b) with R6G on BSi.

Keywords: Black silicon, Surface Enhanced Raman Spectroscopy, Ag nanoparticle, Thiram, Water quality monitoring.

OP-34

Comparative assessment of pure culture vs mixed culture fermentation in synthesis of commercially viable products

Rajkumari Kumaraswamy

[1]*Department of Water & Enviornmental Engineering,Khalifa University,Abu Dhabi,Unted*

*Email: rajkumarik@zohomail.in

Abstract

Pure culture and mixed culture fermentations are used in converting organic waste in to industrially viable products such as Volatile Fatty Acids (VFA), polyhydroxyalkanoates (PHAs), poly-3-hydroxybutyrate (PHB), biofertilizers etc (3). These processes promote the circular economy where waste landfills are reduced and recovered substrates or resources are utilized for various commercial purposes. In this presentation the author explores the potential of mixed culture fermentation over pure culture fermentation in waste recovery and how the microbial community diversity can be exploited to alter or improve the recovery of the potential products (1, 3. The biotic stability can be efficiently maintained by the mixed culture

fermentations where community composition and stability can be highly influenced by both source of inocula as well as characteristics of waste to be recycled and reused (1, 2).

Keywords: Fermentation, substrate recovery, microbial community diversity, waste removal.

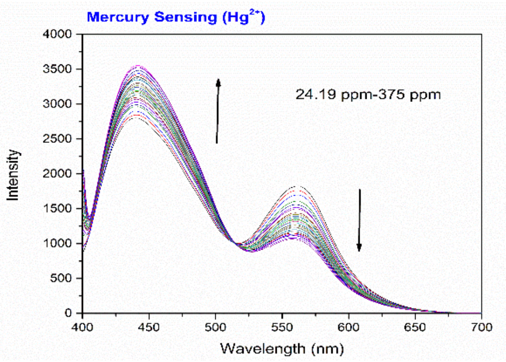
OP-35

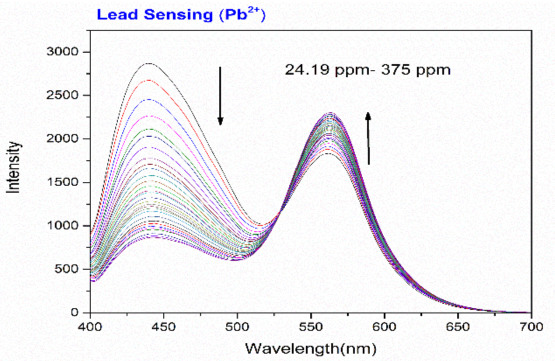
Carbon Dot-Based Ratiometric Fluorescent Probe for Sensitive Detection of Mercury and Lead Ions

Nikita Vyawahare[1], Divya Ottoor[1*]
[1]*Department of Chemistry, Savitribai Phule Pune University, Pune, India*
[*]Email: divya.ottoor@gmail.com/ divya.ottoor@unipune.ac.in

Abstract

Heavy metal ions pose significant threats to both human health and the environment due to their toxicity, persistence and bio accumulative nature. Their detrimental effect highlights the urgent need for effective detection of these metal ions. This study presents a novel ratiometric sensor based on yellow emissive carbon dots conjugated with the blue emissive 2-amino terephthalic acid. The covalent conjugation between the -COOH group of carbon dots and -NH_2 of 2-amino terephthalic acid is achieved through carbodiimide bond formation via EDC-NHS reaction.The surface-functionalized carbon dots exhibited unique fluorescence properties and were evaluated for the selective detection of heavy metal ions, including lead (Pb^{2+}) and mercury (Hg^{2+}). The sensor demonstrated ratiometric sensing for Pb^{2+} and Hg^{2+}, with inverse fluorescence trends at 442 nm and 563 nm as metal concentrations varied. This approach offers a promising avenue for the development of sensitive and selective probes for environmental heavy metal monitoring.





Keywords: Fluorescence sensor, carbon dots, ratiometric, heavy metals, environmental monitoring.

OP-36

A seaweed-based 3D bioprinted scaffolds for multiple critical metal recovery from spiked aqueous solution

S. Unnamalai, S. Punniyadharshini, S. Suriyaprakash, P. B. Sathish, R. Selvakumar*
Department of Nanobiotechnology, PSG Institute of Advanced Studies, Coimbatore, Tamil Nadu – 641004
*Email: rsk@psgias.ac.in

Abstract

The growing dependence on critical metals has heightened global concern over resource scarcity, environmental damage from mining, and inefficiencies in current recovery technologies. As industrial effluents and mining leachates remain underutilized secondary sources, the development of sustainable, efficient, and selective adsorbent materials has become an urgent priority. Conventional adsorbents such as activated carbon, resins, and silica-based adsorbents often lack renewability, structural tunability, or environmental compatibility. These adsorbents also pose huge disposal issues post adsorption therefore underscoring the need for bio-derived alternatives capable of supporting circular resource recovery.In response to this need, in this study we report a sustainable scaffold-based adsorbent that has tunable 3D architecture. The formulated ulvan hydrogel bioink exhibited shear-thinning behavior and favorable viscoelasticity suitable for extrusion printing, enabling fabrication of mechanically stable, porous scaffolds with high shape fidelity after crosslinking.Metal adsorption efficiency revealed a clear shift in selectivity and efficiency associated with scaffold fabrication. The control natural ulvan powder showed measurable affinity primarily toward Li, Sc, Y, and Cd. In contrast, the engineered 3D ulvan scaffold demonstrated enhanced adsorption capacity and broadened specificity, exhibiting strong binding to Bismuth, Cu, Ga, In, Ni, U, Ce, and Co. This adsorption can be attributed to increased accessibility of functional groups such as sulfate and carboxyl groups. This work demonstrates a pathway toward sustainable, customizable adsorbent platforms that support circular resource utilization and environmentally responsible remediation strategies.

Keywords:3D bioprinting, Environmental remediation, Biosorption, Marine polysaccharide

POSTER PRESENTATION

PP- 01

Energy Enhancement of a Nickel−Cobalt-Mixed Metallic Metal−Organic Framework Electrode and a Potassium Iodide Redox Mediator Bound with an Aqueous Electrolyte for High-Performance Redox-Aided Asymmetric Supercapacitors

Ganesan Shanmugam[1*]
[1]*Energy Conversion and Energy Storage Laboratory, Department of Chemistry, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, Chengalpattu District, Tamil Nadu - 603203, India.*
[*]Email: sakthi_ganesan@rediffmail.com, ganesans2@srmist.edu.in

Abstract

In recent years, increasing energy demands in industry and human science call for efficient, clean energy conversion and storage devices. Therefore, improved energy storage technologies are urgently required. Batteries and supercapacitors have emerged as promising possibilities, and they have seen a lot of use in electronic vehicles and electronic gadgets. Compared with batteries, supercapacitors exhibit a fast charge and discharge capability, high power density, and high cycle stability. Generally, Various materials such as metal oxides, metal organic frameworks (MOFs), covalent organic frameworks (COFs), conducting polymers (CPs), metal chalcogenides, etc., exhibits pseudocapacitance. Contemporarily, researchers have increasingly focused on Metal−organic framework (MOF) materials with redox active metal ions have improved the pore structure and have been continually exploited for energy storage because of their unique Pseudocapacitive nature. By using KI redox mediator electrolyte, pseudo capacitance can increase the power density, and cycle stability is observed in the electrode material for supercapacitors.

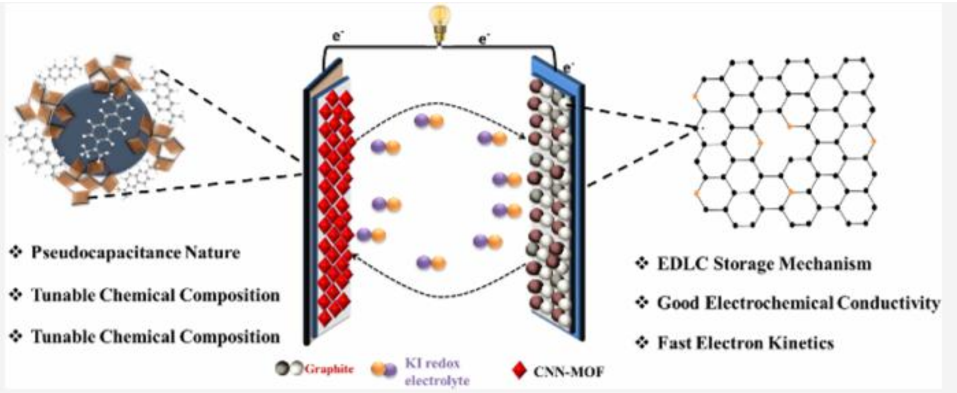


Figure 1. Graphical abstract of the fabricated RAASC device.

Enhancing the energy density of supercapacitors requires the development of novel electrode and electrolyte materials that can endure high voltages and exhibit fast electrochemical kinetics. Pseudo capacitance, high energy density, and specific capacitance can be achieved

through electrodes and redox mediator electrolytes used in redox-aided asymmetric supercapacitors (RAASC), which are vital for their practical application. In this study, a rod and microsphere structure of Ni/Co-mixed metal-organic framework (MOF) was synthesized using a hydrothermal method for the positive electrode material. The rod and microsphere structure provides numerous active sites and smooth ionic channels, making Ni/Co-MOF a suitable material with three different organic linkers. The CNN-MOF material, which has a rod-like structure, demonstrated good capacitance. To further improve its capacitance, a KI redox mediator combined with a KOH electrolyte was introduced, achieving a specific capacitance of up to 612 F g^{-1} in a three-electrode system. Additionally, in the assembled RAASC, a graphite anode with CNN-MOF as the cathode and a KI redox mediator bound with a KOH gel polymer electrolyte exhibited electrical double-layer capacitor behavior. The RAASC device achieved an energy density of 84.2 W h kg^{-1} and a power density of 532 W kg^{-1}. It also displayed excellent cyclic stability, retaining 97.4% of its initial capacitance after 11,200 charge/discharge cycles. This work highlights the efficient fabrication of high-performance MOF electrodes and introduces the KI redox electrolyte-constructed RAASC device as a promising approach for advanced energy storage systems.

Keywords: metal organic frameworks (MOFs), asymmetric supercapacitors, KI

PP- 02

Carbon microfiber-based flexible solid-state interdigitated micro-supercapacitor

Mariyarathinam Vinoth Inbaraj[1], and Govindhan Maduraiveeran[1*]
Materials Electrochemistry Laboratory, Department of Chemistry, SRM Institute of Science and Technology, Kattankulathur - 603 203, Chengalpattu, Tamil Nadu, India
[*]Email: maduraig@srmist.edu.in

Abstract

Micro-supercapacitors are emerging as key energy storage devices for next-generation portable and wearable electronics, owing to their small footprint and rapid charge–discharge capability. To meet practical demands, there is a strong focus on developing cost-effective materials with high electrochemical activity and simple fabrication strategies. In this study, activated carbon microfibers were employed as electrodes, prepared through an electrochemical activation process. This treatment enlarged the accessible surface area and introduced abundant oxygen functional groups, thereby enhancing charge storage behavior. The fabricated carbon microelectrode demonstrated an impressive areal capacitance of ~30.5 mF cm^{-2} and exceptional cycling performance, sustaining 142.8% of its capacitance even after 50,000 cycles. When assembled into a symmetric solid-state interdigitated micro supercapacitor, the device achieved an energy density of 0.015 µWh cm^{-2} at a current density of 0.3 mA cm^{-2}, along with a power density of 11.24 µW cm^{-2}. Remarkably, it retained 125% of its initial capacitance after 20,000 cycles, confirming both high efficiency and long-term stability.

PP -03

Bridging Dimension: 2D ultrathin g-C_3N_4 interfused 3D $Nd_2(WO_4)_3$ architecture for hybrid energy storage

Navaneeth Kumar Ravikumar[1] and Panneerselvam Perumal[1*]
[1] Department of Chemistry, SRM Institute of Science and Technology, Kattankulathur,
Chengalpattu District, 603 203,
Tamil Nadu, India.
*Email: panneerp1@srmist.edu.in

Abstract

As global energy demand continues to rise, the need for sustainable materials becomes increasingly critical. Graphitic carbon nitride, which can be sourced from abundant resources, is an environmentally friendly option. When combined with transition and lanthanide elements, it forms a powerful hybrid material that provides structural integrity. A significant advancement in this area is the synthesis of a graphitic carbon nitride-incorporated neodymium tungsten oxide (GCN@NW) nanocomposite through a hydrothermal method, intended for use in high-performance supercapacitors. Analytical techniques confirmed the crystallinity and morphology of the composite, while electrochemical evaluations demonstrated its pseudocapacitive behaviour. The GCN@NW composite exhibits an electrochemically active surface area of 0.13×10^{-3} cm^2 and a specific capacitance of 397.7 F/g at a current density of 1 A/g. It retains 96.7% of its capacitance after 5,000 cycles and has a low charge transfer resistance (Rct) of 3.3 Ω. The GCN@NW-ASC electrode demonstrated an asymmetric supercapacitor device with a specific capacitance of 62.98 F/g at 1 A/g, a power density of 2,605.74 kW/kg, and an energy density of 45.34 Wh/kg, while maintaining 96.5% of its initial capacitance after 2,000 cycles. These findings underscore the potential of advanced functional materials as eco-friendly candidates for future energy storage technologies.

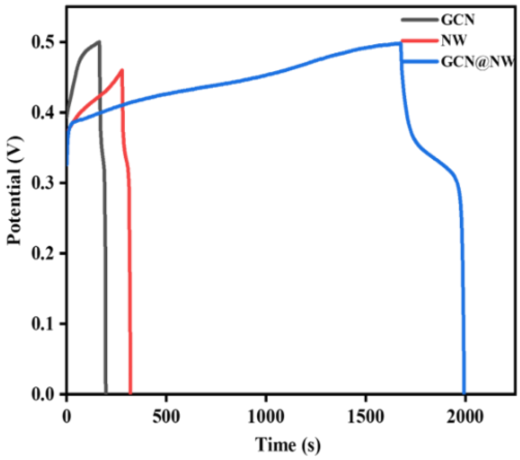


Figure 1. GCD curves for GCN, NW, and GCN@NW.

Keywords: Graphitic carbon nitride; Neodymium tungsten oxide; Pseudocapacitance; Asymmetric supercapacitors; Hybrid architectures.

PP -04

Phase Engineering of 1T-MoS_2 via Tungsten Doping and PEDOT:PSS for Binder-Free Cathodes in Coin Cell Asymmetric Supercapacitors

Chandru Gunasekaran[1], **Ganesan Shanmugam**[1]*

[1]*Energy Conversion and Energy Storage Laboratory, Department of Chemistry, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, Chengalpattu District, Tamil Nadu - 603 203, India.*

*Email: ganesans2@srmist.edu.in

Abstract

Transition metal dichalcogenides (TMDs) combined with guest molecules, are an emergent material for improving supercapacitor performance. In our approach, an innovative hybrid electrode material, Tungsten-molybdenum disulfide/Poly(3,4-ethylenedioxythiophene): polystyrene sulfonate (W-MS/P), synthesized through a sustainable one-step hydrothermal route. By varying the tungsten and molybdenum concentrations (5:95, 10:90, 15:85) with the constant PEDOT:PSS, three distinct W-MS/P variants were synthesized, namely 5W-MS/P, 10W-MS/P and 15W-MS/P each having unique features. Among these, 10W-MS/P variant exhibited excellent crystallinity and ultrathin structure, delivering a high specific capacitance of 845.14 F/g and areal capacitance of 4.73 F/cm^2 at 1 A/g. It maintained 89% of its capacitance after 10,000 charge-discharge cycles, underlining its long-term electrochemical stability. A hybrid material asymmetric supercapacitor (ASC-CC) device was fabricated using 10W-MS/P. The device unveiled admirable energy-storage performance, with a specific capacitance of 7.73 F/g and areal capacitance of 1.19×10^{-2} F/cm^2 at 1 A/g. Additionally, it maintained 75% of its capacitance even after 20,000 cycles, highlighting its durability and longevity. These results indicate the 10W-MS/P hybrid material as a highly promising candidate for future supercapacitor technologies, offering an ideal balance between high energy and power density along with superior cycle stability.

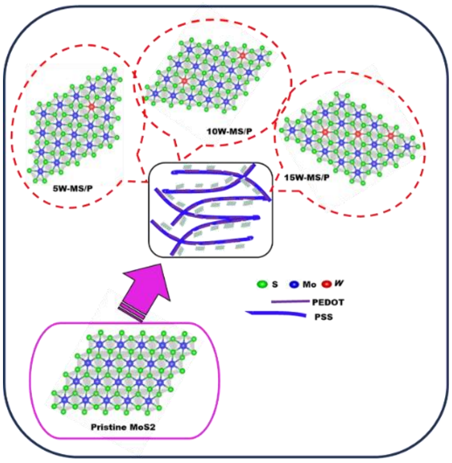


Figure 1. Schematic representation of synthesis of hybrid materials.

Keywords: Transition Metal Dichalcogenides, Conducting polymer, Doping

PP -05

Bimetallic FeCo Alloy supported by Fe oxides as Highly Efficient Electrocatalysts for the Oxygen Evolution Reactions

R Barath[a], Panneerselvam Perumal [a*]

Department of Chemistry, Faculty of Engineering and Technology, SRM Institute of Science and Technology, Kattankulathur, Chennai, Tamil Nadu 603203, India.

*Email: panneerp1@srmist.edu.in

Abstract

A main challenge in renewable energy technologies such as water splitting is the development of efficient, earth-abundant electrocatalysts for the oxygen evolution process (OER). We report the design and synthesis of cobalt-iron (Co-Fe) nanocomposites embedded in nitrogen in order to raise OER performance. The Co-Fe nanocomposites were developed using solvothermal method and pyrolyzed to generate a homogenous dispersion of metal nanoparticles inside a carbon matrix doped with nitrogen. All materials' physicochemical characteristics were explored by X-ray diffraction (XRD), Raman analysis, ultraviolet-visible (UV–Vis), Fourier transform infrared spectroscopy (FTIR), field emission scanning electron microscopy (FESEM), transmission electron microscopy (TEM), energy-dispersive X-ray spectroscopy (EDS), The fabricated heterostructure electrodes are optimized to enhance the oxygen evolution reaction (OER) in 1.0 M KOH. Optimal Co_3Fe_7/Fe_3O_4 exhibit the smallest OER overpotential of 279 mV @ 10 mA·cm^{-2}, the lowest Tafel slope of 42.28 mV·dec^{-1}, and long-term stability of 12 h at a polarization current of 60 mA cm^{-2}.The double layer capacitance (Cdl) of the Co_3Fe_7/Fe_3O_4 (4.09 mF cm^{-2}) is greater than that of the CoFe(MOF) indicating that the Co_3Fe_7/Fe_3O_4 electrocatalyst has a larger electrochemical active surface area. Finally, it is demonstrated that the structural characteristics of the synergetic effect of Co_3Fe_7/Fe_3O_4 contribute to its excellent stability in long-term OER analysis.

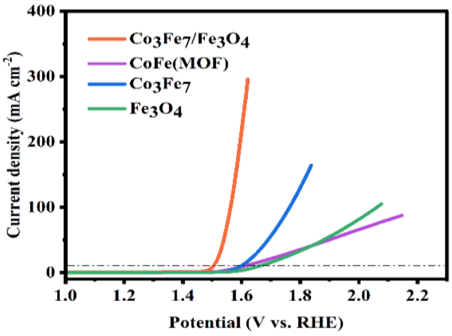


Fig. 1 (a) LSV curves of CoFe (MOF), Co_3Fe_7/Fe_3O_4, Co_3Fe_7, Fe_3O_4.

Keywords: Electrocatalytic water splitting, Cobalt-iron nanocomposites, Oxygen evolution reaction (OER).

PP -06

Engineering High-Performance Anion Exchange Membranes: Cerium Oxide Nanoarchitectures in ABPBI Matrix for Next-Generation Water Electrolysis

Dhanavath Devilal[1], Rama Bhattacharya[2], Prof. Prakash Chandra Ghosh[3]
[1]Department of energy science and engineering, Indian Institute of Technology Bombay, Mumbai, Mumbai, India
*Email: pcghosh@iitb.ac.in, pcghose@ese.iitb.ac.in

Abstract

The quest for sustainable hydrogen production via water electrolysis demands breakthrough materials with exceptional ionic transport properties. The work reports the rational design and synthesis of cerium oxide (CeO_2) nanoparticle reinforced poly(2,5-benzimidazole) (ABPBI) composite membranes, demonstrating unprecedented enhancement in anion exchange membrane performance. Comprehensive structural characterization via XRD, FTIR, SEM, and TEM confirmed homogeneous dispersion of crystalline CeO_2 nanoparticles within the ABPBI matrix with critical polymer-nanoparticle interfacial coupling. The nanocomposite membranes exhibited remarkable multi-fold enhancement in hydroxide conductivity compared to pristine ABPBI, achieving exceptional values at room temperature in 2M KOH electrolyte. Mechanical characterization revealed superior tensile strength and dimensional stability, addressing critical durability challenges. Oxygen-vacancy-rich CeO_2 nanoparticles synergistically couple with the ABPBI framework, creating facilitated ion-conduction pathways with robust alkaline stability. This work bridges fundamental nanoscale engineering with practical energy conversion, establishing new design principles for advanced membrane materials in sustainable hydrogen production.

Keywords: AEM (anion exchange membrane), AEMWE (anion exchange membrane water electrolyser) Nanocomposite membranes, Cerium oxide (CeO_2), ABPBI (poly(2,5-benzimidazole))

PP -07

Transition metal-based Layered Double Hydroxide Nanostructures for Efficient Alkaline Electrolysis

S Rohith[1], Arockia Selvi J[1]*
Department of Chemistry, SRM Institute of Science and Technology, Kattankulathur 603203, Tamil Nadu, India
*Email: arockiaj@srmist.edu.in

Abstract

The increasing global demand for clean and sustainable energy has directed significant attention toward electrochemical water splitting as a promising method for hydrogen production. Layered double hydroxides (LDHs) have attracted increasing attention as efficient electrocatalysts due to their tunable composition, layered structure, and rich redox chemistry.

In this study, we synthesized Transition metal-doped LDH using a simple one-step hydrothermal method with urea and NH4F as structure-directing agents. The incorporation of transition metal into the LDH lattice modulates the electronic structure and enhances the catalytic activity toward overall water splitting. X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), Raman spectroscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray photoelectron spectroscopy (XPS) were used to confirm the structural, morphological, and chemical characteristics of the synthesized materials. Electrochemical tests in alkaline revealed that the material exhibits excellent bifunctional catalytic performance for both the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER). The variation in dopant metal content influences the electrocatalytic performance, and the optimal doping ratio will be determined. This study provides a simple and effective strategy to design high-performance, non-precious metal-based LDH electrocatalysts for energy conversion applications.

Keywords: LDH, Hydrothermal method, water splitting

PP -08

Scalable Spray Pyrolysis-Derived Nanostructured $LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ Cathode for Lithium-ion battery with Superior Structural and Electrochemical Stability

P. Saravanakumar[1], S. Gokulnath[1,2], M. Raju[*1,2] and M. Sathish[*1,2]

[1] *Electrochemical Power Sources Division, CSIR-CECRI, Karaikudi-630 003, Tamil Nadu, India.*

[2] *Academy of Scientific and Innovative Research (AcSIR), Ghaziabad 201 002, India.*

[*]Email: mraju.cecri@csir.res.in, msathish.cecri@csir.res.in

Abstract

Lithium-ion batteries (LIBs) using the layered NMC cathode material have a wide range of applications from electronics to electric vehicles due to their high nominal voltage, and low self-discharge, high capacity and low cost. The cost effective, high performance with hazard free positive electrode material is the focus of attention in developing lithium-ion battery for various application. However, the scale-up preparation of NMC via traditional methods like co-precipitation, hydrothermal, solid state and sol-gel techniques are difficult, and have disadvantages including poor uniformity, performance instability etc. The introduction of novel methods for the materials' production is essential and need of the hour to meet this challenge. Spray pyrolysis is a promising technique for the production of nickel-rich cathode materials due to its simplicity, scalability, controllability and time saving process. In this study, spray pyrolysis technique has been employed to synthesize under nano size nickel rich NMC532 positive electrode material with improved performance. The XRD and FESEM analysis of synthesized NMC532 exhibits high crystallinity and uniform morphology. Galvanostatic charge/discharge experiments revealed a high specific capacity of 180mAh at C/10 rate, it establishing the effectiveness of the synthesis method. Moreover, CV and EIS were engaged to study the kinetic properties of the material. The results suggest that the cost-effective spray pyrolysis technique could be utilized to scale-up the positive electrode material production in

bulk with better performance. Detailed material preparation, characterization and electrochemical properties will be discussed during the presentation.

PP -09

Dual Heteroatom-Doped Graphene in Redox-Based Electrolytes for High-Performance Supercapacitor

Vignesh V, Pandurangan A[*]
Department of Chemistry, Anna University, Chennai-600025, Tamil Nadu, India.
[*]Email: pandurangan_a@yahoo.com

Abstract

The growing demand for efficient and sustainable energy storage devices has driven significant research into the development of high-performance electrode materials for supercapacitors. In this work, heteroatoms were incorporated into the graphene sheets via a hydrothermal synthesis route. Sodium fluoride and sodium phosphate were used as precursor sources for fluorine and phosphorus atoms, respectively. Graphene oxide was synthesized from graphite using modified Hummer's method. The co-doped graphene samples were prepared in different weight ratios and characterized using X-ray, Raman, SEM, and EDAX spectra. Electrochemical measurements revealed that the co-doped graphene electrode exhibits a high specific capacitance attributed to the synergistic effects of heteroatom doping. The half-cell investigation of supercapacitor gravimetric capacitance of 1:1, 1:2, and 2:1 ratios is 372, 330, and 479 F/g at 1 A/g in 1 M H_2SO_4 electrolyte medium. By incorporating a redox additive like potassium iodide and hydroquinone into 1 M H_2SO_4, an enriched gravimetric capacitance was observed in galvanostatic charge-discharge.

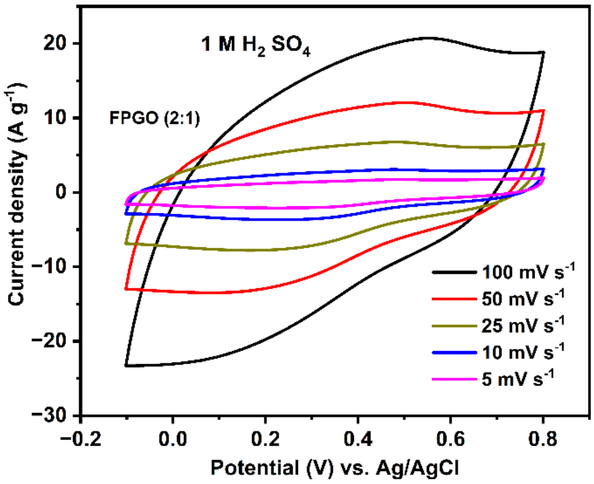


Figure: Cyclic Voltammetry profile in 1 M H_2SO_4 solution at different scan rate.

Keywords: Heteroatom, Supercapacitor, Redox additive, Gravimetric capacitance.

PP -10

Ball-Milled Graphene-Integrated V_2O_5 Composite Cathode for High-Performance Aqueous Zinc-Ion Hybrid Supercapacitors

Sumisha Surendran[1], Binitha N Narayanan[1,2*]

[1]*Department of Chemistry, University of Calicut, Calicut University (PO), Thenhipalam, Malappuram (DT), Kerala - 673635, India,*

[2]*Inter University Centre for Hydrogen & Energy Storage, University of Calicut, Calicut University (PO), Thenhipalam, Malappuram (DT), Kerala - 673635, India.*

[*]Email: binithann@yahoo.co.in

Abstract

The rapid depletion of fossil fuel reserves and the global shift toward clean energy have intensified the demand for efficient sustainable energy storage systems. To address the intermittent nature of renewable sources, the development of high-performance energy storage systems with rapid charge–discharge and long-term stability is essential. In this context, aqueous zinc-ion supercapacitors have emerged as promising owing to their eco-friendliness, intrinsic safety, and high energy and power densities. Here, we report a ball-mill-assisted synthesis of graphene and its integration with vanadium pentoxide to form a V_2O_5/graphene nanocomposite with enhanced electrochemical properties. The ball-milling route provides a scalable, environmentally benign approach to graphene with tunable edge functionalities, promoting strong interfacial contact and efficient charge transport. The nanocomposite exhibits a synergistic effect, combining the double-layer capacitance of graphene with the pseudocapacitance of V_2O_5, yielding improved specific capacitance, energy density, and power density. Structural analyses (XRD, AFM, FESEM, HRTEM, XPS, Raman & FTIR) confirmed the uniform distribution of V_2O_5 over graphene. Electrochemical measurements, including cyclic voltammetry, galvanostatic charge–discharge, and impedance spectroscopy, demonstrated excellent capacitive performance. The device successfully powered an LED, validating its real-world applicability. This work presents a sustainable and scalable strategy for next-generation aqueous zinc-ion energy storage systems.

Keywords: Zinc ion supercapacitor, V_2O_5/graphene nanocomposite, Ball milling

PP -11

Enhanced conductivity of Y and Gd-doped $La_2Ti_2O_7$ pyrochlore oxides for solid oxide fuel cell applications

Shatheesh C[1], Prakash S[1], and Dr. Bradha Madhavan[1*]
[1]*Rathinam Research Hub, Rathinam Technical Campus, Coimbatore, India*
[*]Email: bradhaaraj@gmail.com

Abstract

In the current energy-intensive era, there is a consistent increase in energy demand, and many innovative materials have been invented to meet the required energy needs. Among them, the solid oxide fuel cell is a prominent and renewable source that converts chemical energy into electrical energy. The fuel cell takes hydrogen as the input and gives electricity as output at temperatures ranging from 600 °C to 1000 °C (Singh et al., 2021) (Anantharaman & Dasari, 2021). Furthermore, by adjusting the electrode and electrolyte material composition and tuning it, a stable material can be employed to utilize SOFCs effectively. Nonetheless, the extreme operating temperatures associated with YSZ-based systems result in material deterioration and increased costs. Recent research has focused on developing alternative electrolytes such as gadolinium-doped ceria (GDC) and lanthanum gallate-based materials to enhance lower-temperature operation while retaining ionic conductivity (Supriya, 2023). In this work, Y and Gd doped with pyrochlore oxide $La_2Ti_2O_7$ were synthesized using a typical solid-state synthesis technique and examined through certain physical characterizations. The structural and morphological analyses for the doped and undoped pyrochlore were conducted using X-ray Diffraction studies, Scanning Electron Microscopy, and Transmission Electron Microscopy. The impedance analysis was performed to observe the change in electrical conductivity behavior of the doped samples at different temperatures.

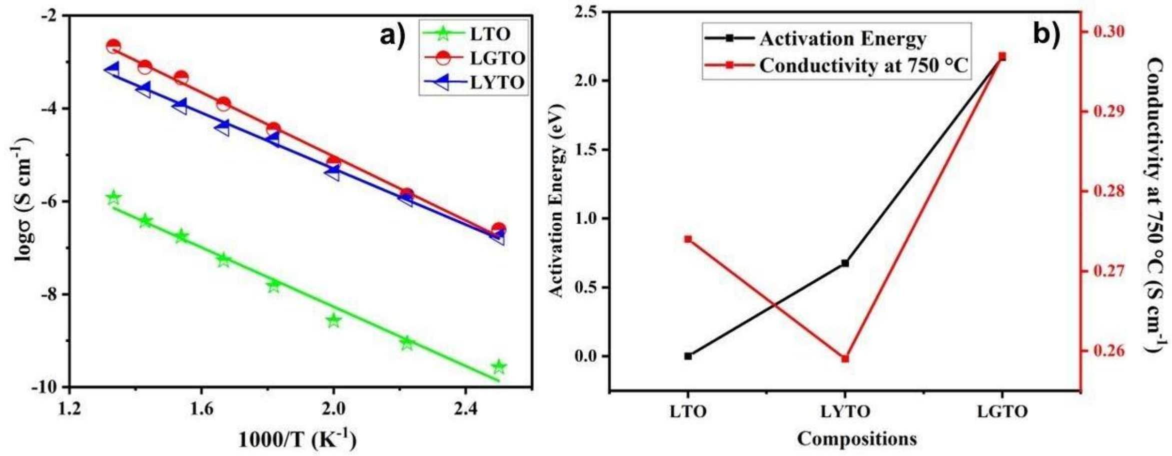


Figure 1(a) Comparison of Arrhenius plot between the undoped $La_2Ti_2O_7$ and Y & Gd-doped $La_2Ti_2O_7$ & **(b)** Comparison between the activation energy and conductivity at 750 °C of the doped and undoped samples

Keywords: Rietveld refinement, SOFC, Ionic conductivity, Layered perovskites

PP -12

Fabrication of Ion Exchange membrane based microbial bioreactor for enhanced electricity generation and desalination

Karen Christina [1], Kavitha Subbaiah*

[1]*Department of Biotechnology, Karunya Institute of Technology and Sciences, Coimbatore, India*

*Email: kavibiotec@karunya.edu

Abstract

The growth of the world's population is leading directly to a rise in energy demand. The depletion of fossil fuel reserves has hastened the development of renewable power sources that produce less pollution. This study explores the fabrication and application of ion exchange membrane-based microbial bioreactors for enhancing electricity generation and desalination. Addressing the intertwined global challenges of water scarcity and energy demand, microbial electrolysis cells (MECs) offer a promising approach through integrated energy recovery and wastewater treatment. The research focuses on developing cost-effective and durable ion exchange membranes, as well as optimizing membrane and electrode materials to improve overall system efficiency. Experimentation involved the use of both manually ground and ball-milled membranes, which were subjected to detailed FTIR analysis for characterization. Results demonstrated significant improvements in voltage generation and effective desalination in ball milled membrane, as evidenced by notable reductions in chloride and sodium ion concentration desalination cell. Bacterial identification revealed strains with strong bio electrochemical activity, contributing to enhanced electricity generation. The work underscores the necessity of balancing energy production and desalination while integrating sustainable and economic materials, paving the way for scalable solutions that meet sustainable development goals. Future research will focus on further refining the membrane fabrication process, increasing system durability, and exploring additional integration strategies for maximized efficiency and environmental benefit.

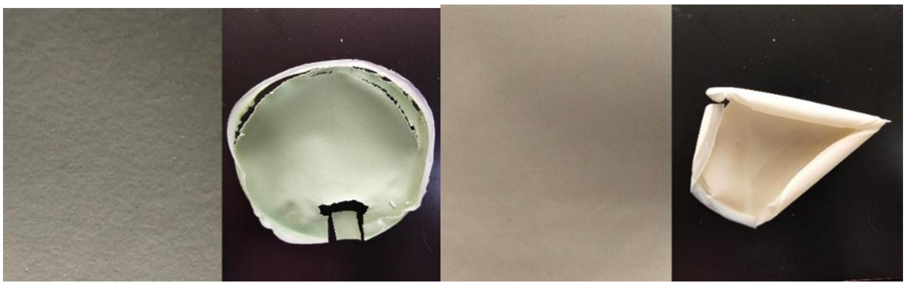


Figure 1. Anion and Cation membranes

Keywords: anion, cation, desalination, membranes, electricity

PP -13

Structural and Electrochemical Insights into Mn (IV) Complexes for Efficient Hydrogen Evolution in Acidic Media

Murugesan Muthumeena[1], Janardhanan Aiswarya [1], Balasubramanian Murugesapandian[1*]
Department of Chemistry, Bharathiar University, Coimbatore, India
[*]Email: mpandian@gmail.com

Abstract

Designing highly efficient, eco-friendly, sustainable, and durable catalysts for water electrolysis is essential to advance renewable energy systems, as our continued dependence on fossil fuels causes energy shortages and severe environmental pollution. We have synthesized three novel mononuclear Mn(IV) complexes supported by tridentate dianionic ligands and structurally characterized by single-crystal X-ray diffraction. The Mn oxidation state (+4) in all complexes was confirmed through bond valence sum (BVS) analysis, UV–Vis spectroscopy, EPR, and XPS measurements. Electrochemical investigations demonstrated that among the three complexes, 3ESADTMn exhibited the most efficient hydrogen evolution reaction (HER) performance in 0.1 M H_2SO_4 solution, delivering a low overpotential of 48 mV at 10 mA cm^{-2}. The enhanced catalytic activity of 3ESADTMn is attributed to its favorable electronic configuration and structural features. The calculated turnover frequency (TOF) of 0.0225×10^{-3} s^{-1} for 3ESADTMn surpasses those of the other two complexes, indicating its superior catalytic efficiency. Chronopotentiometric measurements over 12 hours confirmed excellent electrochemical stability, while FE-SEM analysis revealed no morphological degradation after prolonged operation, validating the structural robustness of the complexes. This study highlights the potential of Mn (IV)-based molecular systems as efficient and durable electrocatalysts for hydrogen evolution in acidic media.

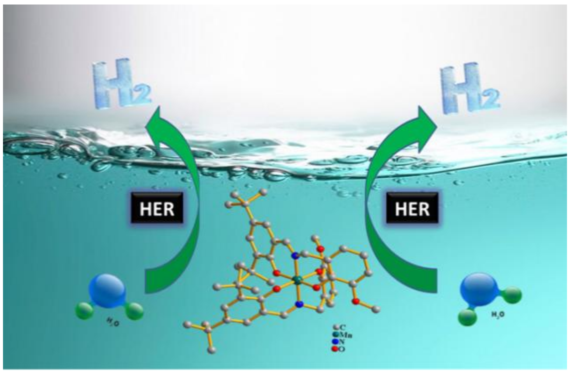


Figure 1. Schematic representation of Hydrogen Evolution Reaction by Mn catalyst

Keywords: Mn (IV) complex, Electrocatalyst, Hydrogen Evolution Reaction (HER), Overpotential, Stability

PP -14

Design and Development of a $CdS/WO_3/NiNb_2O_6$ Ternary Heterostructure Photocatalyst for Superior Hydrogen Evolution Performance

S.Kesavan[1], V.Bharathi Mohan[1,2], S.Raganandhini[1], M. Sathish[1,2*]

[1]*Electrochemical Power Sources Division, CSIR-CECRI, Karaikudi-630 003, Tamil Nadu, India.*

[2]*Academy of Scientific and Innovative Research (AcSIR), Ghaziabad 201 002, India.*

[*]Email: msathish.cecri@csir.res.in

Abstract

Efficient semiconductor-based photocatalysts with superior light absorption and charge separation properties are critical for advancing solar-driven hydrogen production. In this study, we report the fabrication of a novel ternary $CdS/WO_3/NiNb_2O_6$ heterojunction photocatalyst synthesized via a two-step process: hydrothermal synthesis followed by wet impregnation. Cadmium sulfide (CdS) nano capsules with a narrow band gap of 2.4 eV were synthesized via a solvothermal method. The use of polyvinylpyrrolidone (PVP) as a stabilizing agent enabled precise control over particle size and improved dispersion. To mitigate photocorrosion and improve charge separation, tungsten oxide (WO_3) and nickel niobate ($NiNb_2O_6$) nanoparticles were integrated with CdS via a wet impregnation technique. The resulting ternary $CdS/WO_3/NiNb_2O_6$ heterojunction exhibited significantly enhanced photocatalytic hydrogen evolution activity under both Xenon lamp illumination and natural sunlight, in the presence of lactic acid as a sacrificial electron donor. The optimized CdS/WO_3 and $CdS/WO_3/NiNb_2O_6$ composites achieved hydrogen evolution rates of approximately 40mmol/h/g_{cat} and 60mmol/h/g_{cat}, respectively. The observed enhancement is attributed to the formation of a Z-scheme heterojunction between materials with distinct morphologies and electronic properties, which promotes efficient charge carrier separation and prolongs electron lifetime. This work highlights the potential of rationally designed ternary nanocomposites for efficient and stable solar hydrogen production. The detailed synthesis strategy and mechanism will be discussed during the presentation.

Keywords: CdS/WO_3, $NiNb_2O_6$, Z-scheme, Photocatalyst, Hydrogen production.

PP -15

Rational design of Bi_2S_3@Zn-MOF nanocomposites for efficient Electrochemical energy storage

A. Christin Jenifer[1], G. Kanchana[1*], D. Kathirvel[1], V. Siva[2,3], A. Murugan[4]
[1]*PG and Research Department of Physics, Government Arts College (Autonomous)*
Coimbatore – 641018, Tamil Nadu, India.
[2]*Department of Physics, Karpagam Academy of Higher Education,*
Coimbatore 641 021, Tamil Nadu, India.
[3]*Centre for Energy and Environment, Karpagam Academy of Higher Education,*
Coimbatore 641 021, Tamil Nadu, India.
[4]*Department of Science and Humanities, Karpagam College of Engineering,*
Coimbatore 641 032, Tamil Nadu, India.
*Email: kanchanagopinath@gmail.com

Abstract

Exploring higher surface area electrode materials is critical for developing efficient supercapacitors with excellent electrochemical performance. The nanoscale hybrid Bi_2S_3@ZIF-8 composites were manufactured using an in situ chemical technique. Structural investigation techniques such as X-ray diffraction, X-ray photoelectron spectroscopy, Fourier transform infrared spectroscopy, and Brunauer-Emmett-Teller confirmed the successful synthesis of Bi_2S_3 with ZIF-8. Scanning electron microscopy and high-resolution transmission electron microscopy revealed the core-shell-structured shape with the polyhedral nature. The electrochemical performance of the composites was evaluated in two- and three-electrode configurations. The designed Bi_2S_3@ZIF-8 electrode demonstrated good electrochemical performance in 6 M KOH, with a specific capacitance of 765 F/g at 5 mV/s. The Bi_2S_3@ZIF-8 electrode was fabricated into an asymmetric supercapacitor device, delivering 345 F g^{-1} of capacitance. The nanocomposite electrode has exhibited good cyclic stability, with capacity retained after 6000 cycles at 5 A/g in 6M KOH and RAE. The asymmetric supercapacitors' energy and power densities are 33.23 Wh kg^{-1} and 565 W kg^{-1} at a current density of 1 A g^{-1}.

Keywords: ZIF-8; Supercapacitor; Cyclic voltammetry; Galvanostatic charge-discharge; Nanocomposites

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PP -16

Combining NiCo-Prussian Blue Analogue Nanocubes with reduced Graphene Oxide for the Application towards Supercapattery

Gayathri. H and Pandurangan. A*
Department of Chemistry, Anna University, Chennai -025, Tamil Nadu, India.
*Email: panducatalysis@gmail.com

Abstract

It is vital to create dependable renewable energy that is low-cost, ecologically benign, and abundant in resources. Electrochemical Energy Storage Systems [EESS] will help the environment by establishing themselves as renewable fuel supplies that can replace or reduce the consumption of fossil fuels. Among the several types of EESS, supercapattery is a novel genre of hybrid supercapacitor. They use a combination of faradaic and non-faradaic processes. Prussian blue analogues (PBAs) have a unique face-centred cubic structure and an open three-dimensional skeleton that not only allows rapid K+ intercalation/extraction but also withstands structural stress changes induced by alkali metal ion doping, resulting in improved cycling stability. The NiCO-based PBA is integrated with rGO and synthesised using the co-precipitation technique. Various analyses, including the FE-SEM, TEM, XRD, and XPS, have been performed to elucidate the structural details. The supercapacitor is evaluated using CV, GCD, and cyclic stability. The specific capacitance is 770 F/g at a current density of 1 A/g. Capacitance retention remains at 98% even after 5,000 cycles at 20 A/g. The average energy and power density are 60 Wh/kg and 7500 W/kg, respectively. This work presents a revolutionary paradigm for developing electrode materials related to energy storage.

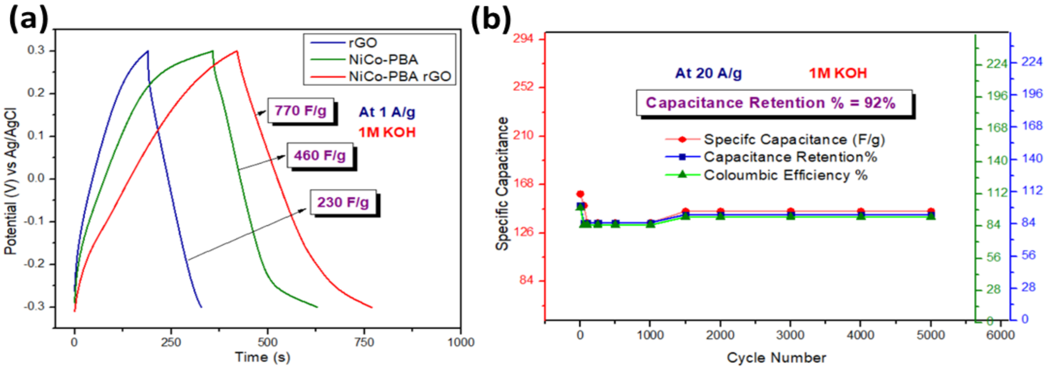


Figure 1. (a) GCD Comparison of the composite with its individual components; (b) Cycle Stability Test.

Keywords: Supercapattery, Prussian Blue Analogue, Co-Precipitation, CV and GCD.

PP -17

SOH Prediction under Dynamic Conditions

Urvashi Saini[2,*], K. Ranjaani Priya[1], G. Rajasekar[1], P. Janani[1] and R. Sindhuja[1,2,*]
[1]*Central Electrochemical Research Institute, Karaikudi-630003, Tamil Nadu, India*
[2]*Academy of Scientific and Innovative Research (AcSIR), Ghaziabad- 201002, India*
[*]Email: rsindhuja.cecri@csir.res.in , urvashi.cecri23a@acsir.res.in

Abstract

Lithium-ion batteries are essential components in modern energy storage systems, widely used in electric vehicles, portable electronics, and renewable energy applications. Their performance and reliability are closely linked to the battery's State of Health (SOH), which represents the ratio of usable capacity at a given time to its initial rated capacity. Accurate SOH prediction is critical for ensuring dependable operation, minimizing maintenance costs, and optimizing battery life-cycle management. However, battery behavior is influenced by dynamic operating conditions such as load patterns and temperature, making precise prediction challenging. This study focuses on the systematic generation and utilization of two complementary datasets, one obtained from experimental testing of lithium-ion cells under diverse charge–discharge profiles and temperature conditions, and another derived from open-source data. The collected parameters include voltage, current, capacity, and temperature, continuously monitored throughout the cycling process. The experimental data were pre-processed to remove noise, synchronize time intervals, and ensure accuracy. Using these datasets, a data-driven framework is developed for SOH prediction employing Artificial Intelligence (AI) and Machine Learning (ML) models. The proposed approach establishes a reliable basis for understanding cell performance, degradation behavior, and health prediction under realistic operating conditions, thereby supporting future advancements in lithium-ion battery management and modelling.

Keywords - State of Health, Prediction, Lithium-ion Battery, Artificial Intelligence

PP -18

Versatile Ni-rich NMC532 as a cathode material for superior performance in lithium-ion batteries

Supriya S[1], S.T. Nishanthi[2,*]
[1]*Electrochemical Power Sources Division, CSIR-CECRI, Karaikudi-630003, India*
[2]*Academy of Scientific and Innovative Research (AcSIR), Ghaziabad- 201002, UP, India*
*Email: stnisha.cecri@csir.res.in

Abstract

Lithium-ion (Li-ion) batteries are critical energy storage technology, widely used in consumer electronics and electric vehicles due to their high energy density typically ~150–250 Wh/kg, long lifespan, and low self-discharge. Amongst all other cathode materials, $Li_{1.0}Ni_{0.5}Mn_{0.3}Co_{0.2}O_2$ (NMC532), a layered metal oxide, are valued for their performance in high-energy Li-ion batteries. It provides a good compromise, offering higher energy than NMC111 while maintaining a reasonable balance of safety, lower cobalt dependency, cycle life and versatile balance of power output that can be tailored to specific needs. The use of Continuous Stirred Tank Reactor (CSTR) method for the synthesis of NMC offers significant advantages over conventional batch processes, including enhanced scalability, superior control over particle size distribution, tap density and excellent compositional homogeneity due to its efficient, well-mixed steady-state operation. Here, we have synthesised NMC532 cathode material using CSTR, obtained hydroxide precursor $NMC(OH)_2$ followed by calcination. Characterisations like XRD, FESEM, XPS and HRTEM were taken to analyse the crystallinity, morphology, particle size and oxidation states. Electrochemical testing like cyclic voltammetry, EIS, and galvanostatic charge-discharge at various rates was performed in half-cell studies. The cathode material exhibited good cycling performance and stability, overcoming the shortcomings of other synthesis methods.

Keywords: Li-ion battery, CSTR, NMC532, high-energy materials, Scalability

PP -19

Ternary Nanocomposites of $NiCo_2O_4$/rGO/CNT Framework for Symmetric Supercapacitor

Aishwarya R[1], Thangaraj A[1], Aruna K Kunhiraman[1]*
Department of Physics, Advanced Electrochemical Energy Materials Lab (AEEM)
Rathinam Research Center, Rathinam Technical Campus
Eachanari, Coimbatore – 641021, Tamil Nadu, India.
*Email: arunakk2007@gmail.com

Abstract

Supercapacitors (SCs) have attracted great interest from the scientific community. It improves the extensive cycle life, significant power storage capacity, and rapid recharge ability. In modern days, considerable performance of SCs can be obtained from the transitional metal oxides (Chen et al., 2022). Among them, spinel-based nanostructures are commonly used as promising electrode materials for SCs, along with carbonaceous materials, which substantially improve the specific capacitance and cyclic stability (Ansarinejad et al., 2023; Rao et al., 2025). In this work, $NiCo_2O_4$(NCO), a spinel-based nanocomposite with various carbon structures, was synthesized hydrothermal method followed by calcination. The materials' structural and morphological studies were obtained from XRD, Raman, and SEM. The electrochemical properties, like cyclic voltammetry, electrochemical impedance spectroscopy, and galvanostatic charging-discharging, were thoroughly tested in an alkaline medium. The synthesized ternary composites exhibited the highest specific capacitance of 2121.76 F/g compared to the bare and binary nano composites. The enhanced performance of the composite might benefit from the synergistic effect between NCO nanostructure and the conductive nanocarbon-hybrid framework. A symmetric supercapacitor with these electrodes (both as cathode and anode) has reached an energy density of 40.19 Wh kg^{-1} at a power density of 1,200.8 W kg^{-1}. A capacitance and coulombic efficiency retention of 90.4% and 93.28% at 6 A g^{-1} was observed and maintained even after 2,000 cycles. This shows a promising pathway for NCO/NCHy towards supercapacitance-related applications.

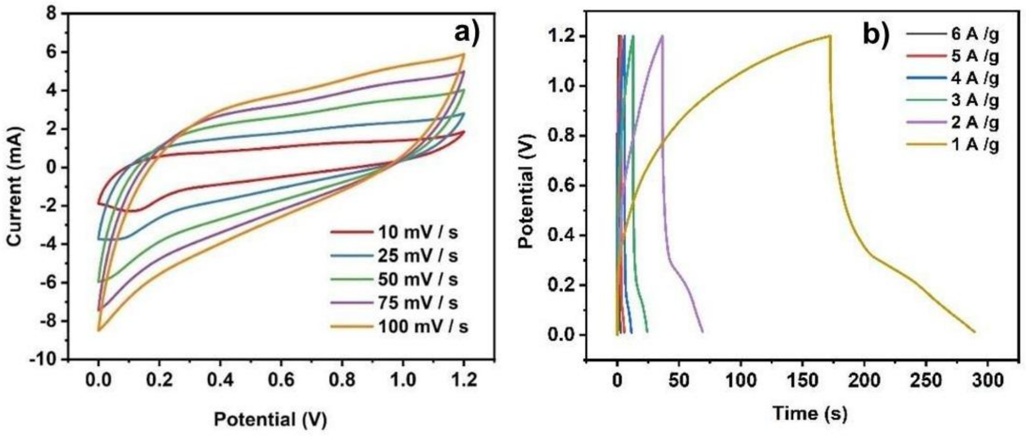


Figure 1(a): Cyclic-Voltammetry at various scan rates & (b) Galvanostatic charging and discharging at different current densities of the composite material

Keywords: Transition Metal Oxide, Supercapacitor, Reduced graphene oxide, Carbon Nanotube, Electrochemical Properties

PP -20

Citrus waste derived functional carbon as a negative electrode material for lithium-ion battery

R. Parthasaarathy[1], M. Sathish[1,2*] and S. T. Nishanthi[1,2*]
[1]*Electrochemical Power Sources Division, CSIR-CECRI, Karaikudi – 630003, India*
[2]*Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India*
*Email: stnisha.cecri@csir.res.in, msathish.cecri@csir.res.in

Abstract

The rapid growth of energy storage technologies has intensified the demand for sustainable electrode materials with high performance and low environmental impact. In this study, citrus waste (orange peel) was recycled and converted into functional activated carbon by a two-step synthesis via carbonization followed by KOH activation at 600°C in an argon atmosphere, offering an eco-friendly route for waste valorization. The carbonaceous material possesses a high theoretical capacity of 372 mAh g^{-1}, and the host sites for lithium accommodation are highly dependent on various factors such as crystallinity, surface morphology, active surface area and pore size distributions. The orange peel derived activated carbon prepared by carbonization with restrained chemical activation are characterized by N_2 adsorption-desorption isotherm which exhibited a high specific surface area with a mesoporous in nature. The electron microscopic imaging also confirmed the formation of pores on the carbonized carbon surface by KOH chemical activation. The electrochemical performance of negative electrodes is measured by cyclic voltammetry, impedance spectroscopy and galvanostatic charge-discharge. Electrochemical testing demonstrated outstanding capacity retention, superior rate capability, and stable cycling performance, approaching the theoretical limits. This work underscores the promise of waste-derived carbon precursors for fabricating high-performance LIB cathode materials, providing a sustainable approach that supports battery recycling and the circular economy.

PP -21

Carbon Supported PtPdNi Nanoparticles for Electrochemical Water Splitting

Thanga Raj A[1]**, Aishwarya R**[1] **and Aruna K Kunhiraman**[*1]
[1]*Advanced Electrochemical Energy Materials Lab (AEEM), Rathinam Research Hub, Rathinam Technical Campus, Eachanari, Coimbatore – 641021, Tamil Nadu, India*
[*]Email: arunakk2007@gmail.com

Abstract

Our environment is frequently harmed by the burning of fossil fuels which emits greenhouse gases and results in climatic changes. Furthermore, due to the rise in conventional fuel prices caused by the increased energy demand which are needed by a nation relies on imported fuel is not considerable. So, researcher have been focusing on renewable energy sources and among them hydrogen is the suitable energy source which can be used as an alternative fuel source. It can be produced by various methods but electrolysis is one way for clean and sustainable way to produce green hydrogen. In this work carbon supported PtPdNi nanoparticles are synthesized by reduction method tested for the electrochemical water splitting. Carbon as substrate enhanced the electrical conductivity, stability, and electrochemical activity of the catalyst. Noble metals like Pt and Pd combined with transition metal like Ni resulted in a tri-metallic alloy system with superior catalytic activity in low cost. Several physciochemical analyses like XRD, Raman, SEM, TEM and XPS were carried out to understand the structural characteristics, morphology and elemental compositions of the sample. Various electrochemical techniques like linear sweep voltammetry, cyclic voltammetry, impedance spectroscopy, and chronoamperometry were performed to evaluate the electrocatalytic behavior of the materials towards overall water splitting.

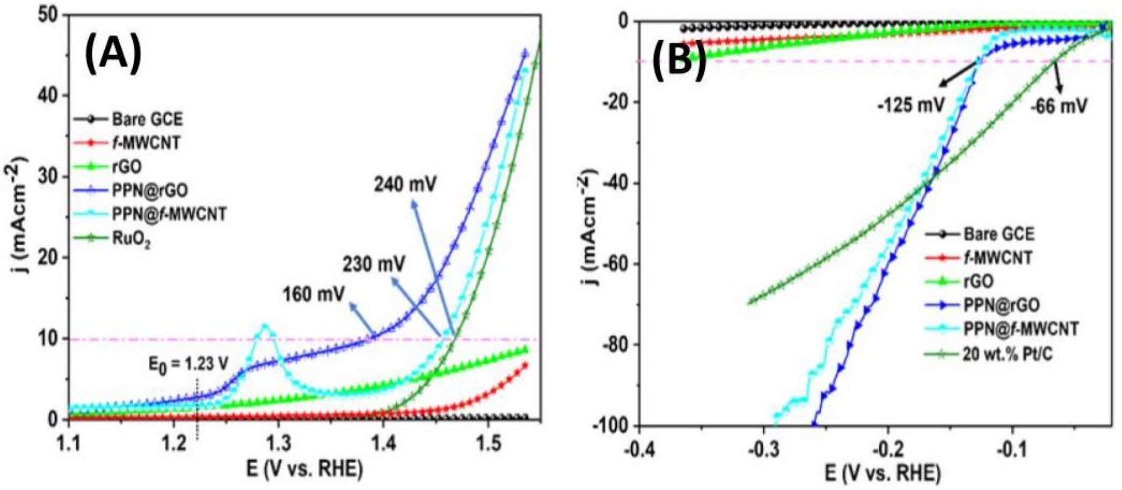


Figure 1. (A) OER polarization curve (B) HER polarization curve

Keywords: Water splitting, Oxygen Evolution Reaction, Hydrogen evolution reaction, Electrocatalyst, Trimetallic alloy.

PP -22

Guanidinium-Grafted Poly (Vinyl Alcohol) based Anion-Exchange Membrane with Enhanced Stability for High-Performance Alkaline Water Electrolyzers

Moly Peter Pulikottil [1,2] Irshad Moonam Kandathil[1], Athul Pradeep Aringalayan[1], Gowri Sankar Shaju[1], Biji Pullithadathil[1*]

[1]Nanosensors & Clean Energy Laboratory, Department of Chemistry & Nanoscience and Technology, PSG Institute of Advanced Studies, Coimbatore-641004, India.

[2]Department of Chemistry, Little Flower College (Autonomous), Guruvayur, Puthenpally P.O – 680 103, Kerala, India.

[*]Email: pbm@psgias.ac.in

Abstract

Hydrogen production by green methods, such as water electrolysis, is conditioned by the development of membranes offering superior performance combined with long-term stability. Herein, we report an easy and cost-effective method for synthesizing an AEM membrane based on an oxidized poly-vinyl alcohol backbone grafted with stable cationic head groups like guanidinium. The morphological and thermal characteristics of the developed AEM membrane have been investigated using AFM, SEM, and TGA techniques, while its water uptake, ion-exchange capacity, and hydroxide ion conductivity have been systematically evaluated. The membrane exhibited an improved hydroxide ion conductivity of 29 mS cm^{-1}, while its improved mechanical robustness ensured sustained chemical stability under alkaline operating conditions. The OER polarization curves of the AEM membrane were assessed using a customized 3D-printed H-cell configuration that showed a current density of 0.2 A cm^{-2} at an applied potential of 1.9 V under alkaline operating conditions. This approach points towards its strong potential for the development of cost-effective AEM membranes enriched with abundant ion-exchange groups for high-performance AEM electrolyzers in sustainable hydrogen production.

Keywords: Hydrogen production, water electrolysis, anion exchange membrane, Ion conductivity.

PP -23

Investigation of surface and electrochemical behavior on binary Sn-Zn alloy electrode materials for their improved capacitance

A.R. Pavithraa[1], RM. Gnanamuthu[2], R. Abdullah[1], K. Jothivenkatachalam[1*]
[1]Department of Chemistry, UCE-BIT Campus, Anna University, Tiruchirappalli 620024, TamilNadu, India.
[2]Centre for Smart Energy System, Chennai Institute of Technology, Chennai 600069, Tamil Nadu, India.
[*]Email: kjothivenkatachalam@gmail.com

Abstract

Increasing global demand for high-performance and low-cost energy storage systems has encouraged the search for alternative electrode materials that can replace expensive noble metals. Among various candidates, binary alloy-based electrodes, particularly Sn–Zn systems, have attracted considerable research interest due to their high electrical conductivity, low cost, environmental safety, and strong electrochemical activity. These materials exhibit excellent charge storage behavior and improved cycling performance, making them suitable for next-generation energy storage applications. In this work, we have successfully fabricated Sn–Zn alloy thin film electrodes on copper substrates using a simple and scalable electrochemical deposition technique. Structural analysis confirmed the formation of a biphasic alloy, while morphological studies revealed uniform surface texturing, which enhances ion diffusion and electron transport. Electrochemical studies demonstrate high specific capacitance and stable redox behavior, attributed to the synergistic interaction between Sn and Zn, which improves charge transfer and reduces volume expansion during cycling. This Sn–Zn alloy electrode shows strong potential for use in supercapacitors and rechargeable battery systems. The best-performing electrode will be further optimized toward practical device-level applications.

Keywords: Sn–Zn Alloy; Electrodeposition; Energy Storage; Supercapacitor; Cyclic Voltammetry; Electrochemical Performance

PP -24

Melt Diffusion Assisted Performance Enhancement of Organic Cathode Materials for Zinc-Ion Batteries

Manavi Rajan[1], Sethuraman Sankararaman[2]* and Kothandaraman Ramanujam[1,3]*
[1] *Clean Energy Lab, Department of Chemistry, Indian Institute of Technology Madras, Chennai 600036, India*
[2] *Department of Chemistry, Indian Institute of Technology Madras, Chennai 600036, India*
[3] *Energy Consortium, IIT Madras, Chennai 600036*
*Email: rkraman@iitm.ac.in, sanka@iitm.ac.in

Abstract

Aqueous zinc-ion batteries present safer and sustainable alternatives to lithium-ion batteries. Organic cathode materials have been extensively explored in place of inorganic oxide cathode materials due to the strong electrostatic interaction of Zn^{2+} with oxides. However, organic cathode materials generally exhibit solubility in the electrolyte with cycling leading to capacity decay. To address it, we proposed a melt-diffusion-based electrode engineering technique to infuse the organic molecule into the carbon pores, imparting better conductivity and capacity as the infused molecules strongly interact (through $\pi-\pi$ interactions) with the graphitic carbon matrix. To demonstrate the efficiency of this process, 2,7- ditertbutylpyrene-4,5,9,10-tetraone (DTB-PTO) and 2,11- ditertbutylquinoxalino[2′,3′:9,10]phenanthro[4,5-abc]-phenazine (DTBQPP) were explored. The electrode with melt-diffused DTB-PTO and DTB-QPP gave specific capacities of 110 and 120 mAh g respectively, at a current density of 500 mA g^{-1}, while the hand-mixed slurry only gave respective capacities of 95 and 45 mAh g^{-1}. The difference in capacity between hand mixing and melt-diffusion is higher in the case of DTB-QPP due to its extended conjugation and planarity compared to DTB-PTO, leading to an effective $\pi-\pi$ stack with carbon.

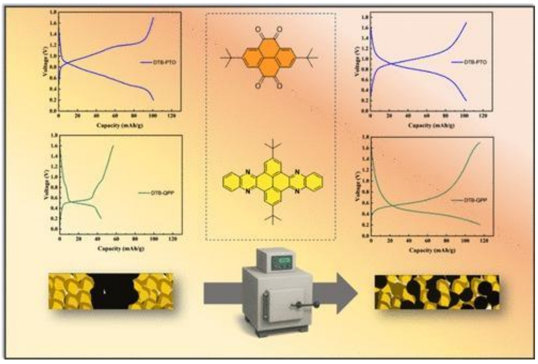


Figure 1. Melt diffusion-based electrodes for improvised electrode uniformity and high capacity.

Keywords: Zinc-ion batteries, melt diffusion, aqueous batteries, organic cathode materials

PP -25

ZrO_2 integrated Composite Polymer Electrolyte with Enhanced Na^+ Transport for High-Performance Room-Temperature Sodium-Metal Batteries

Santhoshini Murugan[1], Mohana Priya Babu[2], Kothandaraman Ramanujam[1*]
[1] *Clean Energy Lab, Department of Chemistry, Indian Institute of Technology (IIT) Madras, Chennai 600036, Tamil Nadu, India.*
[2] *The Energy Consortium, IIT Madras, Chennai 600036*
[3] *Centre for Future Materials, University of Southern Queensland, Australia*
*Email: rkraman@smail.iitm.ac.in

Abstract

Sodium metal batteries (SMBs) offer high energy density but are hindered by interfacial instability, dendrite formation, and safety concerns from flammable liquid electrolytes. In this study, a composite polymer electrolyte (CPE) was developed using a PVDF-HFP/PEO blend plasticized with succinonitrile (SN) and reinforced with 5 wt.% ZrO_2 (NPPE Zr 5%) via a simple solution casting method. The optimized CPE, NPPE Zr 5%, demonstrated a high ionic conductivity (1.26×10^{-3} S cm^{-1}), excellent electrochemical stability up to 4.96 V vs. Na/Na^+, and strong mechanical integrity (10.47 MPa, confirmed by UTM). ZrO_2 incorporation enhanced the Na^+ transference number and reduced crystallinity, facilitating amorphous phase formation and improved ion transport. ZrO_2 enhances Na^+ conduction through its Lewis acidic Zr^{4+} centres and O^{2-} sites, which anchor anions (e.g., PF_6^-), reduce ion pairing, and promote Na^+ dissociation, resulting in higher transference numbers and improved interfacial stability. NPPE Zr 5% delivered a capacity of 107.5 mAh g^{-1} at 0.1C with 97.6% coulombic efficiency and 95% retention over 200 cycles in $Na_3V_2(PO_4)_3$/Na cells. Na||Na plating/stripping showed low overpotentials and stable cycling for 2000 hours. These results underscore ZrO_2's synergistic role in enabling high-performance, stable sodium-metal batteries.

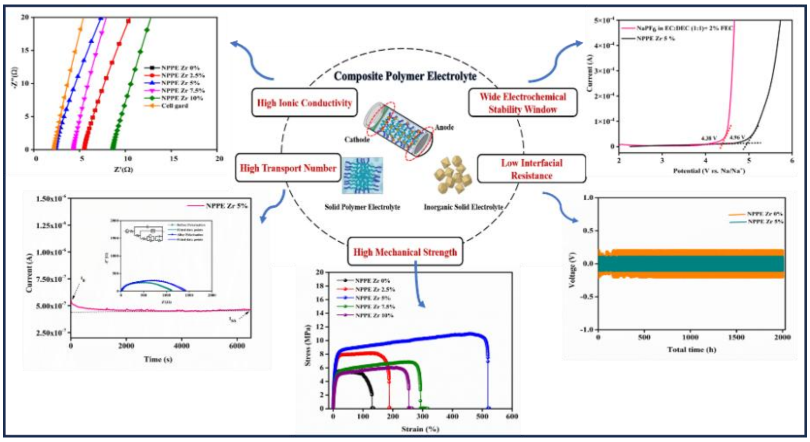


Fig 1. Performance index of the developed composite polymer electrolyte

Keywords: solid state sodium-metal batteries, composite polymer electrolytes, inorganic filler, interfacial adhesion, Lewis's acid-base interaction

PP -26

Synthesis and Characterisation of bimetallic Metal-organic frameworks for energy applications

Mathumitha Babu[1], Nejat Redwan Habib[1], Athira Suresh[2], Henrietta W Langmi[1], Biji Pullithadathil[2], Dinesh Jagadeesan[3] and Shankara G Radhakrishnan[1*].
[1]Department of Chemistry, University of Pretoria, Pretoria, 0002 South Africa,
[2]Nanosensors & Clean Energy Materials Laboratory, Department of Chemistry & Nanoscience and Technology, PSG Institute of Advanced Studies, Coimbatore, Tamilnadu, 641004 India,
[3]Department of Chemistry and Centre for Renewable Energy, Indian Institute of Technology Palakkad, Kanjikode, Palakkad 678623, India.
[*]Email: shankara.radhakrishnan@up.ac.za

Abstract

To unravel the thermodynamic stability, structural integrity of rapidly developing metal-organic frameworks (MOFs) it is crucial to study their morphology and functional properties. The dilating utilities of MOFs in energy storage applications such as electrocatalysis, CO_2 capture & storage, requires comprehensive physicochemical and electrochemical characterizations. In this study, a set of novel MIL type metal-organic frameworks containing BDC organic linkers were synthesized via solvothermal route and characterized via Fourier transform infrared spectroscopy (FT-IR), x-ray diffraction (XRD). The morphology of these MOFs were observed under scanning electron microscope (SEM), thermal behavior via thermo gravimetric analysis (TGA). Further the porosity of these systems were also determined. These results shall form the basis of the CO_2 capture applications and these results shall be presented.

Keywords: Metal-organic frameworks (MOF), adsorption, CO_2 capture & storage

PP -27

Enhanced Thermoelectric Performance of $LaCoO_3$/Multilayered Graphene Composites for High-Temperature Applications

S. Bharathi[1], Navya John[1], Ihar Razanau[2], Uladzimir Novikau[2]. Anuradha M Ashok[1]*,
[1]Functional materials laboratory, Dept. of Physics, PSG Institute of Advanced studies, Peelamedu, Coimbatore– 641004.
[2] Laboratory of physical-chemical technologies, Scientific-Practical Materials Research Centre of National Academy of Sciences of Belarus, Minsk, Belarus – 220072.
[*]Email: anu@psgias.ac.in,

Abstract

In the era of rapidly rising global energy demand, the reduction in natural resources and increasing greenhouse gas emissions has created serious environmental concerns. Thermoelectric materials provide a sustainable solution by directly converting waste heat into electricity. Cobalt-based perovskite oxides, such as $LaCoO_3$, are promising candidates because of their high Seebeck coefficients and electrical conductivity. In this work, lanthanum cobalt oxide (*p*–type) material was synthesized and characterized to confirm its phase purity. To further improve efficiency, three types of multilayered graphene (MLG1, MLG2 and MLG3) were incorporated into the $LaCoO_3$ matrix with different weight percentages (0.02–0.1wt%) by composite preparation. The composites exhibited enhanced carrier concentration, electrical conductivity and power factor compared to the bare $LaCoO_3$ samples. Graphene addition increases the grain boundary, which increases phonon scattering centers and reduces lattice thermal conductivity, thus improving overall performance. Analysis of Seebeck coefficient measurement data shows *p*-type conduction for the composites with higher MLG concentrations, whereas for the low MLG concentrations, it shows *n*-type conduction at room temperature and then shifts into *p*-type conduction at higher temperatures. The highest power factor and figure of merit (*zT*) value of 0.0315 was observed for the composite LCO – 0.08wt% of MLG2.

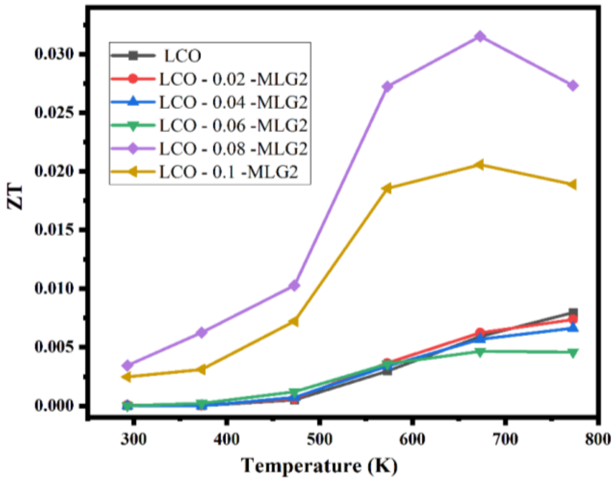


Figure 1. Figure of merit value of lanthanum cobalt oxide – Multilayered graphene composite of MLG

Keywords: Thermoelectrics, Perovskites, Composites, Electrical conductivity, Thermal conductivity.

PP -28

Production of Bioethanol from Banana Peel by *Sacchromyces Cerevisiae, Bacillus Subtills*

Kanageshwaran V, Dr. S. Gowri, Sathish L
Department of Biochemistry, Dr. N.G.P Arts and Science College, Coimbatore, India
*Email: drgowri@drngpasc.ac.in

Abstract

The pressing need for sustainable energy alternatives and effective agricultural waste management drives the exploration of inexpensive, non-food feedstocks for biofuel production. The present study investigates the efficient and optimized production of bioethanol from banana peel, a globally abundant lignocellulosic agricultural waste. The core objective was to develop and optimize a synergistic fermentation process to maximize ethanol yield. The proposed methodology employs a collaborative microbial approach: utilizing the bacterium Bacillus subtilis for preliminary saccharification—the enzymatic breakdown of complex biopolymers into readily fermentable sugars—followed by fermentation using the yeast Saccharomyces cerevisiae. Initial pre-treatment of the banana peel was essential to enhance carbohydrate accessibility. Through systematic optimization of critical fermentation parameters, including initial pH, incubation temperature, and substrate loading, the process achieved a significant bioethanol concentration, peaking at 12.5 g/L These results conclusively establish banana peel as an exceptionally promising and sustainable feedstock. The successful demonstration of high-yield conversion provides a scalable, zero-waste model that contributes to a circular bio-economy, offers environmental benefits through waste valorization, and supports the critical global effort to reduce reliance on non-renewable energy sources.

Keywords: (Bioethanol production, Banana peel, Lignocellulosic biomass, Bacillus subtilis, Saccharomyces cerevisiae)

PP -29

Tri-Doped Hierarchical Graphene Anchored Pt–Ni Core–Shell Catalysts: A Synergistic Route to Ultra-Stable and High-Mass-Activity PEM Fuel Cells

Athul pradeep A[1], Irshad M K[1], Gowri Sankar[1] and Biji Pullithadathil[1*]
[1]Department of Chemistry & Nanoscience and Technology, PSG Institute of Advanced Studies, Coimbatore-641004, India.
[*]Email: pbm@psgias.ac.in

Abstract

The rational design of cost-effective and durable electrocatalysts for the oxygen reduction reaction (ORR) remains a key challenge for high-efficiency proton exchange membrane fuel cells (PEMFCs). In this work, a hierarchically porous N–B–S tri-doped graphene (NBSG) has been developed as an advanced support for Pt–Ni core–shell nanoparticles (Pt–Ni@NBSG) through a controlled two-step synthesis strategy. The synergistic effects of multi-heteroatom doping and hierarchical porosity provide abundant anchoring sites, enhanced electronic conductivity, and improved mass transport pathways, facilitating uniform nanoparticle dispersion and superior catalytic interfaces. The formation of a Pt-skin over a Ni-rich core, achieved by mild thermal alloying and selective dealloying, further optimizes oxygen adsorption energy and strengthens structural stability. Comprehensive characterization by XRD, Raman, XPS, FTIR, BET, SEM, TEM, EDS mapping, and TGA confirms successful tri-doping, porous morphology, and core–shell architecture. Electrochemical evaluations including CV, LSV, and accelerated durability tests reveal significantly enhanced ORR mass activity, reduced Pt loading, and exceptional long-term stability compared to commercial Pt/C. The Pt–Ni@NBSG hybrid demonstrates a promising pathway toward sustainable, high-performance PEMFC cathode catalysts.

Keywords: Heteroatom, ORR, Core shell, PEM fuel cells, Graphene Oxide

PP -30

Bifunctional metallic nanocomposite integrated MXenes for Green Hydrogen production

Madhubala Kothapalli[1], Ramakanth Illa[1*], and Shankara G. Radhakrishnan*[2]
[1]Department of Chemistry, School of Advanced Sciences, VIT-AP University, Amaravati 522 241 AP, India,
[2]Department of Chemistry, University of Pretoria, Pretoria, 0002, South Africa.
*Email: ramakanth.illa@vitap.ac.in, shankara.radhakrishnan@up.ac.za

Abstract

MXenes, 2-D materials, are favourable in hybrid electrocatalysts on account of intrinsic metallic conductivity, large surface area, and chemical stability. However, enhancing their catalytic performance for both the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) remains a significant challenge. In this study, multi-layered MXenes were integrated with bimetallic oxide-based nanoparticles and a comprehensive structural and surface characterizations, including X-Ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), Xray Photon Spectroscopy (XPS), and Scanning electron microscopy (SEM), confirmed the successful formation of the heterostructure, with reduced crystallinity, strong interfacial bonding, and homogeneous dispersion of nanoparticles on the MXene surface. Based on our electrochemical studies, the viability of these electrocatalytic systems as HER electrocatalysts shall be presented in this work.

Keywords: MXene, bifunctional nanocomposites, electrocatalysis, water splitting, hydrogen evolution reaction (HER)

PP -31

Evaluating the impact of pH on Organic matter removal and Electricity Generation in Microbial Fuel Cell Using Sago Industry Effluent

K. Priyadharshini, V. Shruthi, S. Niju*
Department of Biotechnology, PSG College of Technology, Coimbatore, India
*Email: sn.bio@psgtech.ac.in, nijuwillbe@gmail.com

Abstract

The growing global energy crisis and environmental concerns posed by industrial wastewater have increased the demand for sustainable and energy-efficient treatment technologies. The sago industry generates large volumes of high-strength wastewater rich in organic pollutants. Microbial Fuel Cells (MFCs) offer a promising solution by utilizing exo-electrogenic microbes that degrades organic matter and generates electricity simultaneously. This study focuses on performance evaluation of a dual-chamber MFC for pre-treated sago wastewater treatment and bioelectricity generation under varying pH conditions. The system was operated under multiple batches with varying pH conditions: neutral, acidic, and alkaline—to analyze COD removal, open circuit voltage (OCV), power density, and coulombic efficiency (CE). The initial cycles reflected microbial adaptation, with biofilm development leading to improved OCV and COD removal. The batches operated under neutral pH exhibited stable performance with a peak COD removal of 83% and a power density of 63.8 mW/m². Acidic pH conditions negatively impacted the system performance, reducing COD removal to 11%. In contrast, alkaline pH conditions supported moderate COD removal of 54% with highest power density of 98.4 mW/m². These findings highlight the DC-MFC's potential as an eco-friendly solution for treating pre-treated starch-based wastewater, with optimal performance under neutral to mildly alkaline conditions.

Keywords: MXene, bifunctional nanocomposites, electrocatalysis, water splitting, hydrogen evolution reaction (HER).

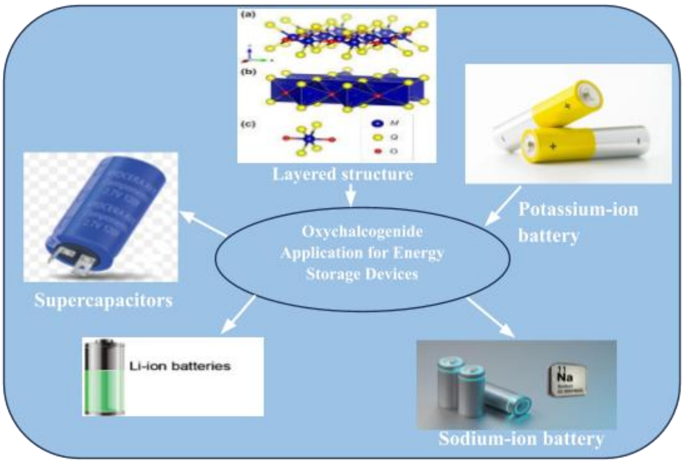
PP -32

Review on Multifunctional Oxychalcogenides as Emerging Materials for Energy Applications

Manopriya.A[1*], and B. Geetha Priyadarshini[2]
[1]Nanostructured Surfaces and Thin Films Lab, PSG Institute of Advanced Studies, Coimbatore, Tamil Nadu 641004, India
[*]Email: bgp@psgias.ac.in

Abstract

The 2D/3D Metal oxychalcogenides are promising materials to fabricate next-generation energy storage devices, such as lithium-ion, sodium-ion, and potassium-ion batteries and flexible supercapacitors. The transition-metal oxychalcogenide nanocrystals and thin films have enhanced electroactive sites for redox reactions and flexibility of structure and electronic properties in the multinary compositions. These properties make them attractive and more viable new electrode materials for energy storage devices compared to traditional materials. The use of various chalcogenide nanocrystals supported on carbonaceous substrates, two-dimensional transition metal oxychalcogenides, and novel MXene-based chalcogenide heterostructures are used as electrode materials in lithium-ion batteries. Likewise, layered chalcogenides and chalcogenide nanowire demonstrate excellent potential for flexible supercapacitors. The review summarizes the recent developments in the synthesis, structural design, and electrochemical performance of these materials, emphasizing how the alternating ionic oxide and covalent chalcogenide layers enable property tuning through targeted chemical substitutions.



Keywords: Oxychalcogenides, electrodes, energy storage, layered materials.

PP -33

Performance evaluation of 2 kW/ 1kWh vanadium redox flow battery enabled by an interpenetrating cation exchange membrane

Prashant Kumar[1,2], Aneena Simon[3], Dhanapriya M[4], A. Manoj Kumar, K. Kanagasabapathi[4], Rajesh Kumar[5], Vaibhav Kulshrestha [1], Kothandaraman R and M. Raja[4*]

[1] *Council of Scientific and Industrial Research-Central Salt & Marine Chemicals Research Institute (CSIR-CSMCRI), Bhavnagar, Gujarat, India-364002.*
[2] *Academy of Scientific & Innovative Research (AcSIR), Ghaziabad, Uttar Pradesh, India - 201002*
[3] *Department of chemistry, Indian Institute of Technology Madras, Chennai, Tamil Nadu, India- 600 036.*
[4] *High Energy Batteries (India) Limited, Mathur, Pudukkottai, Tamil Nadu, India – 622 515.*
[5] *ONGC Energy Trust Centre, IEOT Complex, Phase-II, Panvel, Raigad, Maharashtra, India- 410 221.*
[*]Email: rajamurugan@highenergy.co.in

Abstract

Vanadium Redox flow batteries (VRFB) are one of the promising battery technologies that will be able to meet the growing global need for energy storage solutions ranging from kWh to MWh. The use of Li-ion batteries for large scale storge is reported to be challenging due to the safety concerns, especially if the storage is of the order GWh capacity. However, the overall cost of components of this system is one of the big challenges to implantation in growing countries like India. However, indigenization and enhancing the performance of the stack are one of the best solutions for commercialization. This study focused on a recent demonstration of a vanadium redox flow battery using an interpenetrating cation exchange membrane (IP-CEM) at 2-kW scale. Battery testing in the 2-kW VRFB prototype stack having a series of 20 cells with an area of 1500 cm^2 demonstrated stable discharge capacities (~30 Ah), and maximum power density (2.5 W cm^{-2}) at 100 mA cm^{-2} with an energy efficiency of 95%. IP-CEMs synthesized using high and low-density polyethylene (HDPE/LDPE) copolymerization followed by sulfonation, yielded an enhanced proton conductivity (12.56 mS cm^{-1}), but registered high-water uptake (27.56%). Electrochemical characterization revealed that the IP-

CEM membrane exhibited higher ion-exchange capacity (1.78 meq g^{-1}), ion selectivity (52.98 × 10^3 S min^{-1} cm^{-3}) and a lower vanadium ion permeability (1.94 × 10^{-6} cm^2 min^{-1}) than the commercial Nafion-117 membrane. Further, the post-operation autopsy of membranes showed their elemental composition and structure remain unchanged after prolonged cycling. These results indicate that the IP-CEM membrane offers an improved capacity retention, and cost-effective than Nafion, making them as a durable candidate for future grid-scale VRFB applications.

Keywords: Large-scale (2-kW) VRFB stack, low-cost interpenetrating cation exchange membrane, high-capacity retention, low vanadium permeability

PP -34

Design and Characterization of porous Vanadium Oxide Foam for energy storage application

Helen Anna Toms[1], Hridya C Prakash [1], and Sudip K Batabyal[1*]
[1]Department of physical sciences, Amrita Vishwa Vidyapeetham, Coimbatore, India,
[*]Email: s_batabyal@cb.amrita.edu

Abstract

The world is facing a growing energy crisis. To solve this, we need energy storage systems that are both efficient and sustainable. One promising solution is the supercapacitor. Supercapacitors can charge and discharge quickly, deliver high power, and last for many cycles. This makes them useful for modern energy needs. Among the materials used for supercapacitors, transition metal oxides are becoming very important. This is because they have multiple oxidation states which help in fast redox (oxidation–reduction) reactions, enabling better charge storage. It also has higher theoretical capacitance. Among the TMOs, Vanadium oxide is one of the most promising transition metal oxides. It has a layered structure that helps ions move easily. It can exist in several oxidation states (from V^{2+} to V^{5+}), which supports efficient redox reactions. It also has a high surface area and good stability. These properties make it a strong candidate for energy storage applications. However, vanadium oxide alone has some limits. Its performance can be improved by optimising temperature. This helps to improve ion movement, increase the number of active sites, and make the material more stable during longer cycles. In this project, we aim to design, synthesize, and test porous vanadium oxide foam at different temperature. Our goal is to improve the energy storage capacity and long-term stability of these materials, making them more useful for future energy storage systems.

Keywords: Supercapacitor, Vanadium Oxide

PP -35

Hydrothermal Synthesis and Optoelectronic properties of $CsNiCl_3$

K. Priyadharshni[1], R. Althaf[1], K. Satish Kumar[1], Anuradha M. Ashok[1*].
[1]*Functional Materials Laboratory, PSG Institute of Advanced Studies, Coimbatore-641004, Tamil Nadu, India.*
*Email: anu@psgias.ac.in.

Abstract

Over the last few years, all-inorganic lead halide perovskites (in general $CsPbX_3$) have attracted the attention of many researchers due to their excellent optoelectronic properties than hybrid halide perovskites. Although they have many intriguing characteristics, their practical device implementation is abiding from the existence of hazardous lead and instability. Herein, we effectively synthesize $CsNiCl_3$ through hydrothermal route. The structural, morphology and optical properties were determined using X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), UV-vis and Photo Luminescence (PL) Spectroscopy. To the best of our knowledge, no reports have been discussed yet about the optoelectronic properties of hydrothermally prepared $CsNiCl_3$. In this work, we focus on the structural stability of $CsNiCl_3$ and its relative optoelectronic properties. The compound crystallized as hexagonal with space group p63/mmc with improved structural stability and exhibited better optical sensing properties. This investigation provides a novel insight into the development of structurally stable lead-free halide perovskites for better enhancement of optoelectronic devices.

Keywords: Lead free halide perovskite, $CsNiCl_3$, Hydrothermal synthesis and structural stability.

PP-36

PEDOT:PSS Incorporated Solar thermal evaporation and Hydrovoltaic power generation

Krishna.P[1], Sujith K lal[2], Sudip K Batabyal[1,3]*
[1]*Department of Physics, Amrita School of Physical Sciences, Coimbatore, Amrita Vishwa Vidyapeetham, India.*
[2]*School of Integrative Engineering, Chung-Ang University, Seoul 06974, Republic of Korea*
[3]*Center of Excellence in Advanced Materials and Green Technologies, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, India.*
*Email: s_batabyal@cb.amrita.edu

Abstract

The emergence of renewable energy technologies has sparked significant interest in the integration of organic materials for enhanced power generation. This study explores the dual functionality of PEDOT:PSS in solar thermal evaporation and hydrovoltaic power generation. By leveraging the favorable conductivity and environmental stability of PEDOT:PSS, we

developed a hybrid energy system capable of harnessing solar energy while simultaneously generating electricity from water evaporation processes. Under controlled conditions of 1 sun irradiance, the efficiency of the thermal evaporation and subsequent hydrovoltaic output is evaluated at a rate of 1.91 kg m^{-2} h^{-1}. Future work will focus on enhancing performance and scalability for practical applications. The tunability of PEDOT:PSS, including its hydrophilicity and charge-transport characteristics, enables optimization for both rapid water diffusion and efficient carrier separation during evaporation.

Keywords: Hydro-Voltaics, Solar-driven evaporation, Power generation

PP-37

Flexible and portable Hydrovoltaic Power generator device using MgAl LDH/GO Composite

Devaki S Kumar[1], Neethu anikandan[1] and Dr. Sudip Kumar Batabyal[1]

[1]Department of Physical Sciences, Amrita Vishwa Vidyapeetham, Coimbatore, India,

*Email: s_batabyal@cb.amrita.edu

Abstract

The rapid growth of Hydrovoltaic technologies by scavenging renewable energy sources for power generation provides a promising approach for self-powered devices. Out of recent literature, carbon-based materials with tunable properties were considered preferred choices to harvest electrical energy through Hydrovoltaics due to their higher surface charge and porous nature. Here in this work, we are going to explore carbon-based derivatives in energy harvesting sectors. Commercially available carbon paste is used as the electrodes, allowing electrons, generated by water interaction to travel efficiently to the external circuit, enhancing output voltage and current. The MgAl-GO composite is coated evenly over the interdigitated carbon electrodes. This LDH-GO composite has a naturally high affinity for water and increased ion mobility pathways, which enhances the Hydrovoltaic performance. The hydrogel is the main essence of the device which improves moisture-induced electricity generation. The gel is pasted on one end of the device evenly, and this holds water in a semi-solid form, allowing ions to move through it like in a liquid electrolyte. When water contacts the device, the hydrogel absorbs and retains moisture on one side, creating a strong wet–dry gradient. The water then diffuses into the MgAl-GO layer, where high surface charge density and hydrophilicity promote ion dissociation. These ions then migrate across the interdigitated carbon electrodes, generating a streaming current and potential. The layered structure greatly enhances moisture adsorption, ion mobility, and charge separation, resulting in efficient hydrovoltaic power generation.

Keywords: Hydrovoltaic power generation, Layered Double Hydroxide, Hydrogel, Streaming potential, Wearable electronics.

PP-38

Fe-CNT composites as promising anode material for energy storage applications

Bhargavi B S, Manav Saxena*
Centre for Nano and Material Sciences, Jain (Deemed-to-be University)
Jain Global Campus, Kanakapura, Ramanagara, Bangalore, 562112, India.
*Email: s.manav@jainuniversity.ac.in

Abstract

Fe-decorated carbon nanotubes (Fe-CNTs) have emerged as a promising anode material for high-performance energy-storage systems owing to their unique combination of electrical conductivity, catalytic activity, and structural stability. In this study, Fe nanoparticles uniformly anchored on CNT frameworks synergistically enhance charge-transfer kinetics and provide abundant electrochemically active sites, leading to improved lithium/ion storage capability. The CNT network offers a highly conductive and flexible backbone that accommodates volume changes during cycling, while Fe nanoparticles promote reversible redox reactions and facilitate pseudocapacitive contributions. As a result, Fe-CNT anodes exhibit high specific capacity, excellent rate capability, and long-term cycling stability compared to pristine CNTs or conventional carbon anodes. These findings highlight the potential of Fe-CNT hybrids as efficient and durable anode materials for next-generation batteries and supercapacitors.

Keywords: Energy storage, anode material batteries and supercapacitors.

PP-39

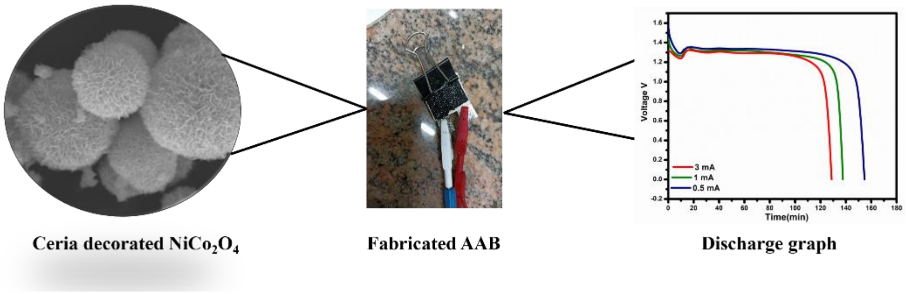
Unravelling the potential of ceria decorated $NiCo_2O_4$ hierarchical micro flowers as an electrocatalyst for ORR in an Al-air battery

Swathi Tharani. D[1], and R. Sivasubramanian[2]*
[1]*Electrochemical Sensors and Energy Materials Laboratory, Department of Chemistry, PSG Institute of Advanced Studies, Coimbatore-641 004.*
[2]*Department of Chemistry, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Amaravati, Andhra Pradesh.*
*Email: s_subramanian@av.amrita.edu

Abstract

Al-air batteries (AAB) have received much attention in recent years due to their high energy density and high capacity. However, the self-corrosion of Al and sluggish ORR kinetics have limited its practical application. In the case of anodes, several Al-based alloys have been employed in recent years to reduce self-corrosion rates. However, till date efficient electrocatalyst for ORR at the cathode remains elusive. Generally, for an ORR the catalyst should undergo a 4 e^- pathway to exhibit fast reaction kinetics. Several carbon and metal-based nanocomposites have been studied in this context. In this work, Ceria decorated $NiCo_2O_4$ hierarchical micro flowers were synthesized and characterized using morphological analysis,

like SEM and the chemical structure was elucidated using XRD, XPS, Raman, and FTIR spectroscopy, respectively. $NiCo_2O_4$ and ceria-decorated $NiCo_2O_4$ hierarchical microflowers were used as electrocatalysts for the oxygen reduction reaction (ORR), and full-cell discharge tests were performed on the fabricated AAB. The results showed that the discharge performances were 1.56 V, 1.54 V, and 1.62 V, respectively at the current density of 0.5 mA/cm^2, 1 $mA/cm^{2,}$ and 3 mA/cm^2.



Ceria decorated $NiCo_2O_4$ Fabricated AAB Discharge graph

Keywords: Al-air batteries, oxygen reduction reaction (ORR), electrocatalyst, $NiCo_2O_4$, CeO_2.

PP-40

Selective Transport of Lithium-Ion Using PVDF-HFP/TOPO–TBP Based Polymer Inclusion Membranes for Sustainable Battery Recycling

B. Kavitha[1], Pavul Raj Rayappan[2]*
[1]*Department of Chemistry, PSG Polytechnic College, Coimbatore – 641004, INDIA*
Electrochemistry Lab, PSG Institute of Advanced Studies, Coimbatore – 641004, INDIA
[2]*Department of Chemistry, PSG Institute of Technology & Applied Research, Coimbatore – 641062, INDIA*
*Email: pavulraj@psgitech.ac.in, or pvr@psgias.ac.in

Abstract

Polymer Inclusion Membranes (PIMs) are emerging as efficient and environmentally benign alternatives for metal-ion separation in hydrometallurgical and battery recycling processes. In this study, we report the development and characterisation of PVDF-HFP–based PIMs incorporating two neutral extractants – trioctylphosphine oxide (TOPO) and tributyl phosphate (TBP) - as carrier molecules for the selective transport of lithium ions. The membranes were fabricated using a solvent-evaporation route, yielding flexible, defect-free films with excellent mechanical integrity. Structural characterisation using Raman spectroscopy confirmed the successful incorporation of TOPO/TBP without disrupting the semi-crystalline nature of the PVDF-HFP matrix. SEM analysis revealed uniform surface morphology, well-distributed carrier domains, and microstructural features correlating with enhanced ionic mobility. The membranes exhibited high thermal and electrochemical stability, with a wide potential window (>2 V) suitable for integration into electrochemical separation platforms. Contact angle confirms the hydrophilic surface. Key physicochemical parameters - hydration number, porosity, and ionic transference number – were quantified to establish transport behaviour. The PVDF-HFP/TOPO membrane showed higher porosity and a greater lithium transference number than its TBP counterpart, indicating stronger solvation and coordination interactions.

Electrochemical Impedance Spectroscopy (EIS) demonstrated low bulk resistance and favourable interfacial charge transport, validating the role of carrier-assisted ion mobility. Preliminary ion-transport experiments confirmed selective uptake and facilitated diffusion of Li^+ over competing transition-metal ions, highlighting the potential of these membranes for critical-metal recovery from spent lithium-ion batteries. Overall, the PVDF-HFP/TOPO–TBP PIM system represents a promising platform for scalable, green, and energy-efficient separation technologies.

Keywords: Polymer Inclusion Membrane, Li-ion transport, Raman Spectroscopy, Dual Carrier, PVDF-HFP

PP-41

Titanium Carbide MXene Based Carbon Nanotube Composites: Innovations in Supercapacitor Design

Richu Rajan[1], Dr. Sanu Mathew Simon[1], Dr. Smitha Thankachan[*]
[1]Department of Physics, Mar Athanasius College, Kothamangalam, India
[*]Email: smithathankachan@macollege.in

Abstract

In the present scenario, MXenes with their composites have shown attractive capabilities in various fields of electronics, photocatalysis, sensing, batteries, supercapacitors etc. In this aspect, MXene based carbon nanotube (CNT) composites have been deeply studied and constructed that improves environmental stability, good electrical conductivity, and excellent mechanical properties which provides greater opportunity for developing modern and intelligent systems with diagnostic, electronic and environmental applications. Herewith we report the supercapacitance behaviour of Titanium Carbide MXene based CNT composites prepared in different ratios. The capacitance of these composites were measured at different scan rates to evaluate the charge storage behaviour. In addition, electrochemical characteristics of Titanium Carbide MXenes were compared with Carbon nanotubes. Attractive capacitance values are reported showing the capability and excellent charge retention of the material.

Keywords: MXenes, Titanium Carbide, Carbon nanotubes, Composites, Energy storage

PP-42

Optical Performance & Solar Insolation Transmittance of Solar Cell Cover Glass Using SnO_2 / TiO_2 Silane based Anti- Reflection Coatings

C.Vinisha,*N.R.Chandralekha, *J.Shanthi
Department of Physics, Avinashilingam University, Coimbatore – 641 043,
*Email: shanthi_phy@avinuty.ac.in

Abstract

Anti- reflection Coating Using TEOS, MTMS, MTES Silanes with metal oxides SnO_2/ TiO_2 was synthesized. In this study, the prepared samples were deposited on glass substrate using Spin Coating. The prepared samples were characterized by Fourier Transform Infrared Spectroscopy, XRD, Water Contact Angle, UV- Visible Spectroscopy, 3D Laser Profilometer and Pyranometer calculation. The prepared SnO_2/ TiO_2/ TEOS/MTMS & SnO_2/ TiO_2 /TEOS/ MTES showed water contact angle of 105.2˚ & 103.3˚ respectively. Histogram revealed peak height of 75.95 nm & 51.25 nm proving flat smooth surface. Solar insolation computed using Pyranometer agreed fairly with UV- Vis absorbance.

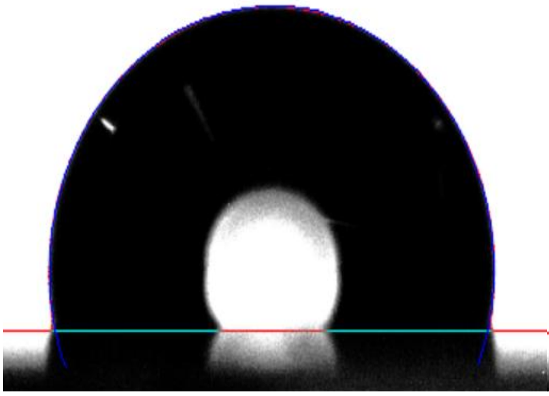


Figure 1: WCA of SnO_2/ TiO_2/ TEOS/MTMS

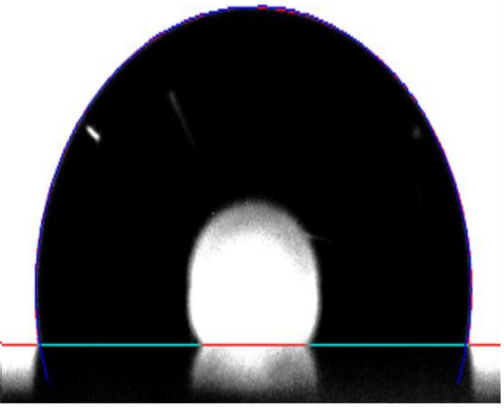


Figure 2 : WCA of SnO_2/ TiO_2 /TEOS/ MTES

Keywords: Spin Coating, Water Contact Angle, Solar Insolation Reading, Histogram

PP-43

Sustainable Taurine-Doped PANI/PVA Electrospun Nanofiber for High-Capacitance Supercapacitors and Biomedical Applications

Archana M S[1], Chitra Lekha C S[2], Deepa S[1*], Nandakumar Kalarikkal[3]
[1]*Department of Physics Mar Athanasius College (Autonomous) Kothamangalam*
[2]*School of Nano Science and Nanotechnology, Mahatma Gandhi University, Kottayam Kerala*
[3]*School of Pure and Applied Physics, Mahatma Gandhi University, Kottayam Kerala.*
*Email: sdeepa@macollege.in.

Abstract

Electrospinning provides a sustainable route to fabricate one-dimensional nanofibers with high surface-area-to-volume ratios, vital for energy and biomedical devices. In this work, taurine-doped polyaniline (T-PANI) was synthesized via eco-friendly oxidative polymerization at 0 °C and blended with biocompatible polyvinyl alcohol (PVA) to produce composite nanofibers. Renewable precursors and aqueous processing highlight the green approach to advanced functional materials. X-ray diffraction (XRD) confirmed enhanced crystallinity due to taurine doping, while FTIR verified quinoid, benzenoid, and sulfonic acid groups that promote redox activity. FESEM revealed uniform nanofibers with narrow diameter distribution, enabling efficient ion transport. BET analysis classified the fibers as mesoporous (surface area: 15.88 $m^2\ g^{-1}$; pore radius: 2.44 nm), ideal for electrolyte diffusion in high-capacitance supercapacitors**.** UV–Vis spectroscopy indicated π–π* and polaron transitions, reflecting extended conjugation and improved conductivity. Electrical studies showed stable capacitance, low dielectric loss, and both ohmic and non-linear transport, while thermal analyses (DSC/TGA) confirmed multi-step decomposition with robust stability. Cytotoxicity assays demonstrated excellent biocompatibility, and mechanical testing revealed strong, flexible fibers suited for flexible devices. The sustainable synthesis**,** mesoporous structure, and enhanced electrochemical behavior establish T-PANI/PVA nanofibers as promising electrode materials for supercapacitors and versatile candidates for flexible electronics, sensors, and tissue-engineering scaffolds.

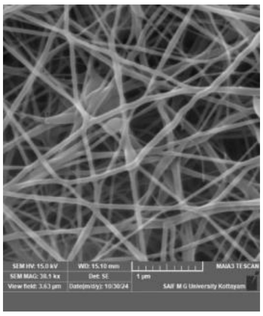


Figure 1. FESEM image of Taurine doped polyaniline/PVA composite fiber

Keywords: Electrospinning, Taurine, Polyaniline, Poly Vinyl Alcohol, Composite Nanofibers.

PP-44

Impact of Calcination on the Electrochemical Performance of NiCo-LDH/NiMoO4 Composites for Supercapacitor Applications

Saranraj A[1], Sujin P Jose[1*]
[1]*Advanced Materials Laboratory, School of Physics, Madurai Kamaraj University, Madurai- 625021, Tamil Nadu, India*
*Email: sujamystica@yahoo.com

Abstract

The growing demand for high-performance energy storage systems has directed significant attention toward hybrid supercapacitor materials that combine high energy and power densities. In this study, NiCo-layered double hydroxide (NiCo-LDH) and nickel molybdate ($NiMoO_4$) composites were synthesized via a hydrothermal method, followed by systematic calcination at varying temperatures to investigate their structural and electrochemical evolution. X-ray diffraction (XRD) confirmed the successful formation of crystalline phases and revealed enhanced crystallinity with increasing calcination temperature. X-ray photoelectron spectroscopy (XPS) and transmission electron microscopy (TEM) analyses provided insights into the surface composition and morphology, demonstrating strong interfacial coupling between NiCo-LDH and $NiMoO_4$ nanosheets. Electrochemical characterization in a three-electrode configuration showed that optimized calcination significantly improved specific capacitance and cycling stability due to enhanced conductivity and redox activity. Among the samples, NiCo-LDH (100)/$NiMoO_4$ exhibited superior specific capacitance and rate capability, highlighting the importance of controlled thermal treatment in tailoring electrochemical behavior. These findings suggest that the calcination-optimized NiCo-LDH/$NiMoO_4$ composite is a promising electrode material for high-performance supercapacitor applications.

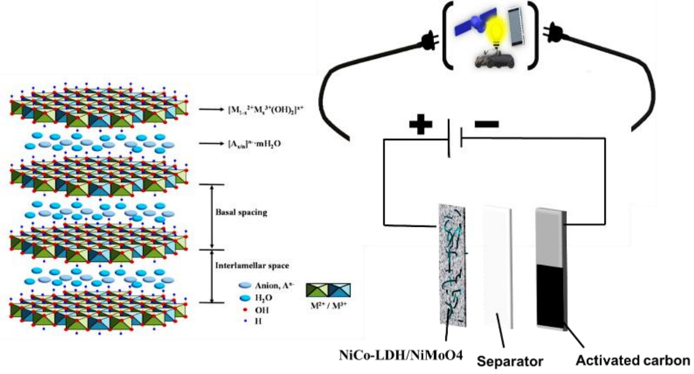


Figure 1. Graphical Abstract

Keywords: NiCo-LDH/$NiMoO_4$ composites; Supercapacitors; Calcination; Electrochemical performance; Energy storage materials

PP-45

Studies on the novel WS_2-WO_3 nanocomposites for energy storage applications

Rajani S Nair[1], Dr Reshmi R[1] and Dr Alex Mathew[1]
[1]*Department of Physics, Optoelectronics and Nanomaterials Research Laboratory (ONRL),*
Union Christian College,
Aluva, Kerala,
*Email: rreshmi@gmail.com

Abstract

The nanocomposites of transition metal dichalcogenides (TMDs) and transition metal oxides (TMOs) shows enhanced properties for supercapacitor applications. In the present study, we have reported the synthesis of a series of tungsten sulphide/tungsten oxide (WS_2-WO_3) nanocomposites, wherein the concentration of HCl has been gradually varied to achieve the optimized properties for supercapacitor applications. The synthesis time and temperature was fixed at 24h and 200^0C respectively. Low cost and efficient one-step facile hydrothermal method was used to synthesis WS_2-WO_3 nanocomposites and evaluated as an electrode material for supercapacitor applications. The samples were analysed for structural, optical and morphological properties by various characterization techniques. The supercapacitive performance parameters of the device have been investigated through cyclic voltammetry (CV), galvanostatic charge/ discharge (GCD) curves, and electrochemical impedance spectroscopy (EIS). Among the samples, WS_2-WO_3 nanocomposites shows enhanced supercapacitor performance compared with the WO_3 nanomaterials.

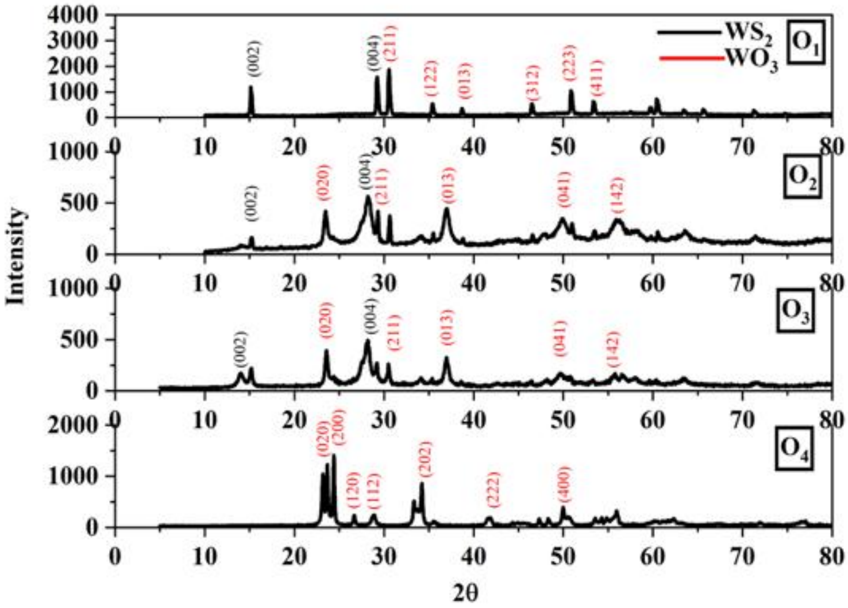


Figure 1. XRD of WS_2-WO_3 nanocomposites and WO_3 synthesized at different concentrations of HCl

Keywords: WS_2-WO_3, HCl, supercapacitor, CV, GCD

PP-46

Optimization and Analysis of Passive Cooling Systems in Electric Vehicles – A Comprehensive Review

Vinayak Arun Sankar Vijayasankar [1]*, Dharshan V N[2], Hareesh Akash C[2] and Rajadurai M[2]
[1]*Assistant Professor, Department of Mechanical Engineering, Karpagam College of Engineering, Coimbatore, India*
[2]*UG Scholar, Department of Mechanical Engineering, Karpagam College of Engineering, Coimbatore, India*
*Email: arunsankar@kce.ac.in

Abstract

Thermal management is critical to ensure the safety, performance, and longevity of electrical vehicles (EVs), particularly for battery and power electronics. The passive cooling methods have become an interesting option to active ones, as they work without any noise and use no additional energy as well as can be fitted in tight spaces. Passive cooling methods such as phase change materials, heat pipes, thermosiphons, and natural convection chambers with recent advances in their optimization are presented in this review. Investigations have been conducted to achieve better thermal uniformity by increasing temperature and minimizing the rise in temperature by potential material selection, fin geometry, and enclosure design. Numerical optimization techniques such as computational fluid dynamics, response surface methodology, and data-driven algorithms are gaining popularity to approximate temperature distribution and optimize design parameters. It is observed from these studies that PCM coupled with aluminum heat spreaders or infiltrated fins can lead to considerable retardation of the temperature rise in a battery at high discharge rates. While encouraging results have been achieved, upscaling performance is hindered by issues relative to long-term predictability and real-world validation. This work demonstrates that the optimized passive cooling is an effective and sustainable solution for next-generation EVs to achieve high energy efficiency, guarantees high safety, and boosts driving performance. This paper proposes a self-sustaining thermoelectric cooling system for vehicles parked in open and when the climate is hot. This system is designed to maintain a cabin temperature around 25°C using renewable energy. The system integrates solar panels, Peltier modules, Seebeck generators and Phase-Change Material (RT35HC) enclosed within servo controlled ceramic doors. When the vehicle is parked, the ceramic doors open to expose the PCM that is placed at the four corners and roof centre inside the car to absorb heat and maintain the cabin temperature near 35°C around for 60 to 90 minutes through passive cooling. Once the temperature exceeds this threshold, a thermocouple sends a signal to the Electronic Control Unit (ECU), which closes the ceramic doors to prevent heat dissipation from PCM and activates the Peltier modules powered by solar panel, the cold side is reduces the cabin temperature to 25°C. The Seebeck generator utilizes waste heat from the Peltier's hot side to generate additional electricity and other surface of Seebeck generator's cold side cools the solar panels to increase its efficiency. The ceramic doors act as thermal insulators safeguarding the absorbed heat that remains confined. This will lead to reduce Peltier's workload and minimizing energy consumption. When the vehicle starts, the servo ceramic doors reopen to gradually release the stored heat, allowing the PCM to solidify for reuse. This eco-friendly, energy efficient, and smart thermal management system ensures sustainable cabin cooling and is best suited for electric and hybrid vehicles of the future.

Keywords: electric vehicles, passive cooling, phase change materials, heat pipes, thermal management, CFD analysis

PP-47

Solar-Powered Smart Thermoelectric Cooling System for Parked Vehicles

Kondusamy Vasudevan[1*], Vinopaul Kirubhagaran B[2], Shahid Karna M[2] and Mohana Shrihari S[2]

[1]*Department of Mechanical Engineering, Karpagam College of Engineering, Coimbatore, India*

[2]*Department of Mechanical Engineering, Karpagam College of Engineering, Coimbatore, India*

*Email: kondusamy.v@kce.ac.in

Abstract

This project proposes a self-sustaining thermoelectric cooling system for vehicles parked in open and when the climate is hot. This system is designed to maintain a cabin temperature around 25°C using renewable energy. The system integrates solar panels, Peltier modules, Seebeck generators and Phase-Change Material (RT35HC) enclosed within servo controlled ceramic doors. When the vehicle is parked, the ceramic doors open to expose the PCM that is placed at the four corners and roof centre inside the car to absorb heat and maintain the cabin temperature near 35°C around for 60 to 90 minutes through passive cooling. Once the temperature exceeds this threshold, a thermocouple sends a signal to the Electronic Control Unit (ECU), which closes the ceramic doors to prevent heat dissipation from PCM and activates the Peltier modules powered by solar panel, the cold side is reduces the cabin temperature to 25°C. The Seebeck generator utilizes waste heat from the Peltier's hot side to generate additional electricity and other surface of Seebeck generator's cold side cools the solar panels to increase its efficiency. The ceramic doors act as thermal insulators safeguarding the absorbed heat that remains confined. This will lead to reduce Peltier's workload and minimizing energy consumption. When the vehicle starts, the servo ceramic doors reopen to gradually release the stored heat, allowing the PCM to solidify for reuse. This eco-friendly, energy efficient, and smart thermal management system ensures sustainable cabin cooling and is best suited for electric and hybrid vehicles of the future.

Keywords: Thermoelectric Cooling System, solar panels, Seebeck generator, sustainability, Peltier, PCM

PP-48

Dual-Plasma Tailored NiFeCoMnCr High-Entropy Nanoparticles for Enhanced Supercapacitor Performance

Bharani Narayanan, Vijay Dhanabal M.H, Vijay Lakshmanan, Shanmugavelayutham Gurusamy*
Plasma Physics and Processing Laboratory, Department of Physics, Bharathiar University, Coimbatore - 641 046, Tamil Nadu, India
*Email: sgsvelu@buc.edu.in

Abstract

Driven by the escalating need for efficient and long-lived energy-storage solutions, current research is increasingly focused on next-generation electrode materials to realize high-performance supercapacitors. High-entropy materials, composed of multiple principal elements, exhibit tunable electronic configurations, high structural stability, and abundant redox-active sites, making them promising candidates for energy applications. In this work, NiFeCoMnCr nanoparticles were synthesized via thermal plasma arc discharge method, which enables rapid melting and evaporation of multimetallic precursors into a homogeneous nanoparticle. The as-synthesized nanoparticles delivered a specific capacitance of 596Fg^{-1} at 1mA cm^{-2}, demonstrating excellent intrinsic charge-storage capability. The electrodes were subjected to non-thermal plasma surface modification, which introduces high-energy reactive species to enhance catalytic activity. This treatment promotes defect generation and lattice disorder, tunes the surface oxidation states toward more catalytically favorable configurations, increases surface wettability and exposes additional active sites collectively contributing to improved charge-transfer kinetics and overall supercapacitor performance. The plasma-treated HE electrodes exhibited improved charge-transfer efficiency, high-rate capability, and outstanding long-term durability, retaining nearly their initial capacitance after 2000 charge-discharge cycles. Overall, this study establishes a dual-plasma strategy combining thermal plasma synthesis with non-thermal plasma activation as a rapid, scalable, and eco-friendly approach for producing high-entropy nanomaterials tailored for next-generation supercapacitor applications.

Keywords: High-entropy, Supercapacitor, Thermal plasma, Surface modification, Nanoparticle

PP-49

From Charging Queues to Instant Energy: A Review on Modular Battery Swapping System for India's EV Fleets and Communities

Haridass R^{1*}, Navin Kumar P M ^{1}, Santhosh N^{1} and Dineshkumar C^{1}
^{1}Department of Mechanical Engineering, Karpagam College of Engineering, Coimbatore, India
*Email: haridass.r@kce.ac.in

Abstract

One of the largest barriers to Indian EV growth is the charging delay. Even the fastest chargers require 30 to 60 minutes for each charge, which is too long for delivery fleets, cabs & long-distance driving. There are now fewer than 20,000 installed chargers, but more than 1.3 million would be required in 2030 just to service demand. Batteries also account for nearly 40% of the price of an EV in aggregate, making them slow to deploy, inducing range anxiety, and limiting them. To address such concerns, this article proposes a modular battery swapping technique, in which slow charging is replaced with fast swapping of energy. A collection of small and light modules replaces the large battery pack in each vehicle. At the swapping station, automated robotic equipment locates, extracts, and installs just the depleted modules with fresh ones. It dynamically adjusts the number of modules exchanged to the car's or light commercial vehicle's energy requirements. This versatility makes the same infrastructure work for the prescribed vehicles. Deployments can be rapid by retrofitting conventional fueling stations with small swap bays, charging racks, and intelligent power management systems. The modular bays can operate with small sites and typical grid connections, allowing bulk rollouts to be practical and economical. A battery subscription or pay-per-swap model also reduces upfront EV costs, abolishing the economic deterrent of battery ownership. Such a modular exchange infrastructure can eliminate the time-consuming charging downtimes, scale EV penetration to the rural and semi-urban areas thereby decreasing adaptation cost considerably. By converting all the refuelling stations into clean energy exchange centres, the nation can scale the transition to sustainable mobility with an achievable cost and at a desired time.

Keywords: Cars and LCVs, retrofitting, battery swapping, swap bays, sustainable mobility.

PP-50

QHyMaEn: A Quantum–Hybrid Machine Learning Paradigm for Accelerated Discovery in Energy Materials

Sivakumar Ramu[1], Vennila Sivakumar[2*]
[1]*CSE Department, Yanbu Industrial College, Yanbu, Saudi Arabia,*
[2]*CS Department, PSGIAS, Coimbatore, India*
*Email: jknvennila77@gmail.com

Abstract

The rapid discovery of high-performance energy materials is crucial for advancing renewable technologies, while traditional methods like DFT remain computationally expensive for large-scale screening. In this work we present a new hybrid architecture incorporating a Quantum Graph Neural Network (QGNN) with a Transformer encoder to accurately predict properties that are important to the materials, such as bandgap, formation energy and ionic conductivity. Structural data from the Materials Project and OQMD were converted into graph representations with quantum circuits modeling atomic entanglement, and transformed into sequences for the Transformer to capture long-range and global atomic interactions. A multi-task property prediction used local and global features in a hybrid fusion layer. The experimental results showed that the proposed framework has better bandgap prediction MAE of 0.087 eV, formation energy MAE of 0.031 eV/atom, and ionic conductivity MAE of 0.0048 S / cm than classical ML baseliners and standalone fashions. The integration of quantum-enhanced feature extraction with global attention significantly improves existing models, demonstrating strong generalization and high accuracy across diverse and unseen material classes. This study highlights the potential of quantum-classical hybrid learning for scalable energy material screening and accelerated discovery, with applicability to catalysis, thermoelectrics, and structural alloys.

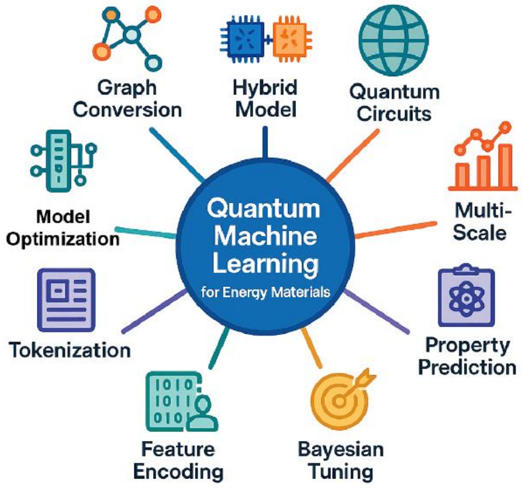


Figure 1. Features in Quantum Machine Learning for Energy Materials

Keywords: Quantum Graph Neural Network, Transformer Encoder, Hybrid Model, Energy Materials, Bandgap Prediction

PP-51

In-situ synthesis of MnO anchored Polythiophene nanocomposites: Structural and electrochemical properties

A. Sahira Banu[1], A. Christin Jenifer[1], G. Kanchana, D. Kathirvel[1*]
PG and Research Department of Physics, Government Arts College (Autonomous)
Coimbatore – 641018, Tamil Nadu, India
[*]Email: kathirvelgaccbe@gmail.com

Abstract

The growing global demand for sustainable and efficient energy storage systems has led to extensive research on advanced electrode materials for supercapacitors. Among various materials, conducting polymers and transition metal oxides have shown remarkable potential due to their high pseudocapacitive behavior and excellent charge–discharge properties. In this work, a composite of manganese oxide (MnO) anchored polythiophene (PTh) was synthesized and investigated for supercapacitor applications. The nanoscale MnO@PTh nanocomposites have been prepared by the in situ chemical oxidative polymerization method. The prepared nanocomposites were characterized by XRD, SEM-EDS, HR-TEM, and XPS. In addition, the electrochemical characteristics of the electrodes are tested by cyclic voltammetry and galvanostatic charge–discharge measurements, which revealed that the composite electrode demonstrated a high specific capacitance value of over 655 F g^{-1} at 1 A g^{-1}, with excellent cyclic stability, retaining more than 93.2% of its initial capacitance after 5000 cycles. It attributes the superior performance to the combined faradaic and non-faradaic charge storage processes due to synergistic interaction between MnO and PTh, respectively. MnO@PTh composite exhibited an enhanced specific capacitance due to improved charge transfer and reduced internal resistance. The results provide new insights into the design of efficient metal oxide-anchored polymer composite electrodes for sustainable energy technologies.

Keywords: Polythiophene; Cyclic voltammetry; Electrode; Supercapacitor; Polymerization Electrochemical impedance spectra.

PP-52

Investigation on ZIF– 67 anchored polythiophene based polymer nanocomposites for energy storage application

S. Jaipriya[1], A. Shameem[2,3*], V. Siva [1,2], A. Murugan[4]
[1]*Department of Physics, Karpagam Academy of Higher Education, Coimbatore 641021, India*
[2]*Centre for Energy and Environment, Karpagam Academy of Higher Education, Coimbatore 641021, India*
[3]*Department of Science and Humanities, Karpagam Academy of Higher Education, Coimbatore 641021, India*
[4]*Department of Science and Humanities, Karpagam College of Engineering, Coimbatore 641032, India*
*Email: shameem.abdulsamad@kahedu.edu.in

Abstract

As the world confronts an impending energy crisis, the rapid enhancement of energy storing systems is much necessity and hence led to a higher demand for materials with high specific capacitance and high stability. Conducting polymers are eminent electrode materials for developing energy efficient supercapacitors have gained significant attention. Amongst, polythiophene (PTh) stands out as a promising material due to their higher electrical conductivity, good electrochemical stability, electronic properties and thermal stabilities. Herein, combining Zeolitic Imidazolate Framework (ZIF) and PTh in electrode materials for supercapacitors as nanocomposite (ZIF-67/PTh) by mechanochemical synthesis, aiming at the structure instability of PTh caused by expansion/contraction during charging and discharging leading to the loss of capacitance after cycling, is applied to overcome the limitations and analysed by various characterization techniques. The XRD spectra confirms the formation of ZIF-67/PTh nanocomposite by the board amorphous nature of PTh with the characteristic peaks of crystalline ZIF- 67. SEM image reveals polyhedron morphology. The electrochemical analysis in three-electrode setup shows a pseudocapacitive bahaviour with extraordinary specific capacitance of 472 F g^{-1} with exceptional 91.6 % retention in a 6 M KOH electrolyte. Hence, this recent work is illustrating the possible application of the ongoing development of energy storage systems.

Keywords: Polythiophene, ZIF–67, Supercapacitor, Nanocomposite, Mechanochemical method.

PP-53

La- based Oxide Perovskites for mid-high Temperature Thermoelectric Applications

Nithya Davis[1], Anuradha M. Ashok*

[1]*Functional Materials Laboratory, PSG Institute of Advanced Studies, Coimbatore, 641004, India*

*Email: anu@psgias.ac.in

Abstract

Due to the capability of thermoelectric (TE) generators and coolers to facilitate direct conversion between heat and electricity without any emissions or moving parts, TE materials play a pivotal role in mitigating the global energy crisis. A thermoelectric device consists of both *n*- and *p*-type semiconductors (Fig.1 (a)), thus, its conversion efficiency depends on the thermoelectric performance of its constituent materials. A good thermoelectric material is judged by its dimensionless figure of merit ZT ($ZT=\sigma S^2T/(\kappa_{el}+\kappa_{lat})$) which requires high electrical conductivity σ, large Seebeck coefficient S and low thermal conductivity κ to attain high efficiency. Traditionally, Bi_2Te_3 and its alloys are used in commercial TE applications, but their optimal operation is limited to near room temperature, prompting the search for new efficient and eco-friendly thermoelectric materials capable of operating at elevated temperatures. In the present work, La- based oxide perovskites, $LaCoO_3$ (LCO) and $LaNiO_3$ (LNO) constituting the *p*- and *n*- type legs of the thermoelectric device were synthesised via sol-gel route and pressed into 13mm pellets (Fig. 1(b)). Furthermore, a systematic investigation of their structural, morphological and thermoelectric properties (Fig. 1 d) and e)) was carried out. The results indicate that LCO and LNO exhibit complementary thermoelectric behavior and compatible power-factor trends, underscoring their suitability for high-temperature TE module integration.

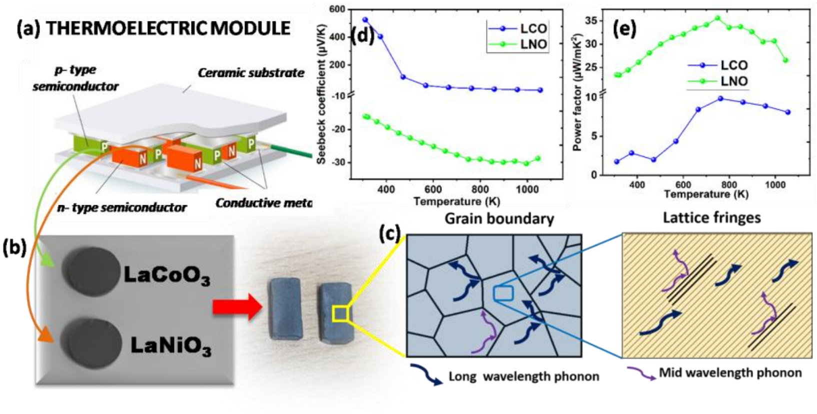


Figure 1. a) Representation of an ideal thermoelectric device, **b)** sintered and sliced pellets, **c)** presence of grain and grain boundaries within the sintered pellets, **d)** Variation of seebeck coefficient with temperature, **e)** Variation of thermoelectric power factor with temperature

Keywords: Thermoelectrics, oxides perovskites, electrical conductivity, Seebeck coefficient, power factor.

PP-54

Transition Metal-Based MXene Nanocomposite as an Efficient Electrocatalyst for Hydrogen Evolution Reaction

Mallamma Jinagi, Manav Saxena*
Centre for Nano and Material Sciences, Jain (Deemed-to-be University)
Jain Global Campus, Kanakapura, Ramanagara, Bangalore, 562112, India.
*Email: s.manav@jainuniversity.ac.in

Abstract

The ever increasing demand for energy accompanied by global warming and environmental deterioration has triggered the way towards the utilization of hydrogen, referred to as the "fuel of the future". Hydrogen (H_2) has been considered an alternative energy carrier and has generated immense interest in creating artificial catalytic systems that can efficiently produce H_2 from water. Thus, the production of hydrogen for clean energy applications has been a major area of focus. Due to their excellent catalytic activity and corrosion resistance in acidic media, noble metal nanoparticles (NPs) are considered the best hydrogen evolution reaction (HER) catalysts. Recently, Pd (Palladium) was investigated as an alternative to Pt (Platinum) due to its high abundance and enhanced catalytic activity. However, as compared to Pt, Pd displayed less electrocatalytic performance towards HER. Thus, modifying the surface properties, coupled with metal alloying, is necessary to improve the electrocatalytic properties of Pd NPs. On the other hand, efficient catalysts with minimal content of catalytically active noble metals are essential for transitioning to a clean hydrogen economy. Catalyst supports that can immobilize and stabilize catalytic nanoparticles and facilitate the supply of electrons and reactants to the catalysts are therefore needed. Being hydrophilic and more conductive compared with carbons, MXenes have shown promise as catalyst supports. In this context, attention may be shifted toward the use of alloyed NPs of Pd on MXene support, which could bring changes in the electronic and geometrical properties of pure Pd. Herein, we report a highly efficient transition metal-based MXene nanocomposite electrocatalyst with an overpotential of just 41 mV for the hydrogen evolution reaction in acidic media.

Keywords: Hydrogen evolution; Alloying; Transition Metal-Based MXene nanocomposite.

PP-55

Binder and Electrolyte Engineering on MnO_2 Cathodes for Aqueous Zn-Ion Battery Applications: A Sustainable and Cost-Effective Approach

Swapnika Suresh[1], Dhamodaran Santhanagopalan[2]*, and Sudip K. Batabyal[1]*
[1]Department of Physics, Amrita Vishwa Vidyapeetham, Ettimadai, Coimbatore, India
[2]Amrita School of Nanosciences and Molecular Medicine, Amrita Vishwa Vidyapeetham, Kochi, India
*Email: dsgopalan20710@aims.amrita.edu, s_batabyal@cb.amrita.edu

Abstract

The distinctive features of Aqueous Zinc-Ion batteries (AZIBs), such as safety, abundant zinc reserves, and low cost, have made them the emerging contenders in the field of stationary energy storage technologies. MnO_2, even though it is one of the most favorable cathode material, owing to a higher operating voltage, high capacity, and an impressive energy density is still plagued by sluggish reaction kinetics and capacity fading due to Manganese dissolution. Therefore, this work aims at minimizing the capacity fade of the MnO_2 electrode material procured from three different commercial sources exhibiting different phases (α and β-phase). In addition to that, the use of the widely employed Polyvinylidene fluoride (PVDF) binder that raises serious environmental concerns is out casted by using sustainable and cost-effective aqueous binders such as sodium salt of Carboxymethyl cellulose (Na-CMC), sodium alginate (Na-Alg), and Chitosan. Also, kinetic and capacity instability issues are alleviated by electrolyte concentration variation, additive variation, and binder engineering. With this we report β-MnO_2 with chitosan binder, electrolyte additive of 0.2 M $MnSO_4$ delivering the best performance of 374 mAh/g (upon stabilizing) at 0.05 mAh/g, good rate capability delivering 242 mAh/g at a specific current of 0.5 A/g, and exhibits 59 % retention after 500 cycles.

Keywords: Aqueous Zinc Ion Batteries, Commercial MnO_2 powder, Electrolyte Optimization, Additive Engineering, Aqueous binders

PP-56

First-Principles Insights into the Structural and Electronic Properties of a Cation-Disordered Oxy-Selenide Phase

Aswathy A. R[1], Bhagyashree. P[1], Sebin Devasia[1,2,*], Shammima Hussian[3], B. Geetha Priyadarshini[1,*]

[1]*Department of Physics, Nanotech Research Innovation and Incubation Centre, PSG Institute of Advanced Studies, Peelamedu, Coimbatore, Tamil Nadu – 641004*
[2]*Department of Physics, PSG Institute of Technology and Applied Research, Neelambur, Coimbatore, Tamil Nadu – 641004*
[3]*UGC-DAE Consortium for Scientific Research, Kalpakkam Node, Kokilamedu-603104, Tamil Nadu, India*
[*]Email: sebindevasia@gmail.com, bgp@psgias.ac.in

Abstract

Introducing multiple anion species within a single crystal lattice allows fine-tuning of structural and electronic properties of ternary compounds, particularly advantageous in thermoelectric applications. In this study, the structural and electronic properties of a cation-disordered Cu-Sn-O-Se phase is investigated using first-principles density functional theory (DFT) calculations. Initially, stable cation configurations were identified via supercell screening with the Site Occupancy Disorder (SOD) code and an MLIP-based MatterSim model, leading to selection of the most favorable structure. Detailed DFT analysis of the screened structures using Quantum ESPRESSO identified the most stable and probable structure of Cu–Sn–O–Se with a formula of $Cu_{11}Sn_5O_{10}Se_6$. Further, the density of states calculations revealed that Cu *d*, Se *p*, Sn *p, d* and O *p* orbitals contribute dominantly to the electronic states near the fermi level. Simulated X-ray diffraction (XRD) patterns yielded a *c*/*a* lattice ratio of 1.9777, compared to the experimental value of 1.9101, corresponding to an error of 3.5%. This level of agreement is consistent with values reported in published studies on complex and disordered materials. These findings provide insight into the influence of cation disorder and anion mixing on the structural and electronic transport in Cu-Sn-Se, highlighting the potential of Cu–Sn–O–Se compounds for thermoelectric applications.

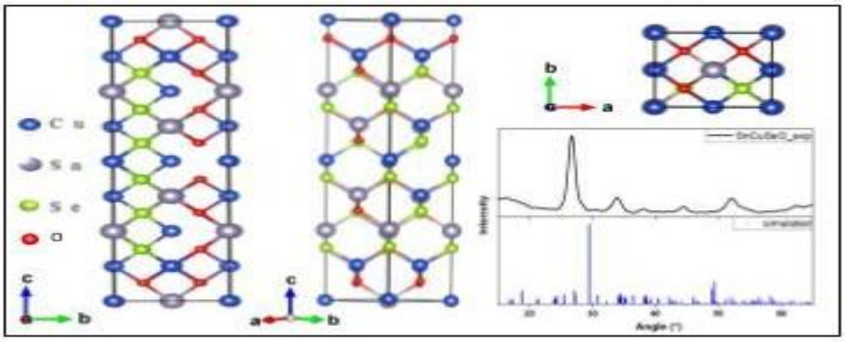


Figure 1. Structure of Cu–Sn–O–Se phase with its simulated and experimental XRD comparison.

Keywords: Oxy-selenides, Site disorder, Density functional theory, Thermoelectrics

PP-57

Enhanced photocatalytic and photoelectrochemical performance of (Nb, Ta)-doped TiO_2 modified g-C_3N_4 based Z-scheme heterojunction

Riza Paul [a,*], **Abinash Das** [a], **S. Parthiban** [a,b*]
[a] *Department of Physics, PSG Institute of Advanced Studies, Coimbatore,*
Tamil Nadu 641004, India.
[b] *Department of Physics, Centre for Research and Development, KPR Institute of*
Engineering and Technology, Coimbatore- 641407, India.
[*]Email: rizaparpukara@email.com

Abstract

The increasing demand for sustainable water treatment solutions has led to escalating interest in the development of efficient heterojunction photocatalysts that harness solar energy. Heterojunctions of metal oxides have garnered significant attention as photo(electro)catalysts due to their exceptional photoactivity. Heterojunctions can broaden the range of light by combining semiconductors with different band gaps. This study delves into the fabrication and photocatalytic performance of graphitic carbon nitride (g-C_3N_4) modified TiO_2 with Z-scheme heterojunction, for enhanced sunlight-driven photocatalytic and photo electrocatalytic activities. The doped TiO_2 nanomaterials exhibit improved charge separation and good photocatalytic activity into the UV range, while the addition of g-C_3N_4 further enhances the overall photocatalytic efficiency and extended light absorption into the visible range. When combine with TiO_2, g-C_3N_4 can form a heterojunction that enhances charge separation and extends the photo response of TiO_2 into the visible spectrum. The integration of g-C_3N_4 with TiO_2 represents a promising strategy for designing efficient, sunlight-driven photocatalysts for sustainable environmental applications. Characterization techniques, including XRD, FT-IR, TEM, PL, UV-DRS, spectroscopy, BET, LSV and EIS studies were employed to study the structural, morphological, optical, and surface properties of the composite systems. The photocatalytic performance of these composites was evaluated through water splitting experiments and degradation of organic pollutants, showcasing the developed material's ability to perform under natural sunlight conditions. An active species trapping experiment was carried out to elucidate the mechanism involved in the photocatalytic degradation of dye under light radiation.

Keywords: Photocatalysis, titanium dioxide, Z-scheme heterojunction, g-C3N4, Solar-Assisted photocatalytic applications.

PP-58

Enhanced hydrovoltaic energy conversion via optimized tubular MnO_2-activated carbon composites

Ranjithkumar Annadurai[a], Sreejith P Madhusudanan[a], Sudip K Batabyal[a,b*]
[a]*Department of Physics, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, India.*
[b]*Center of Excellence in Advanced Materials and Green Technologies, Amrita School of Engineering Coimbatore, Amrita Vishwa Vidyapeetham, India*
[*]Email: s_batabyal@cb.amrita.edu

Abstract

Recently, hydrovoltaic energy harvesting has emerged as a sustainable approach to convert water–solid interfacial interactions into usable electricity under ambient conditions. A systematic study conducted here led to the fabrication and optimization of a tubular hydrovoltaic device composed of manganese dioxide (MnO_2) and activated carbon (AC) to enhance energy conversion efficiency. New insights into the structural and morphological characterizations, adapted to the hydrovoltaic mechanism, confirmed the uniform integration of crystalline MnO_2 within the activated carbon matrix, providing both hydrophilicity and a high surface area for effective water transport and electrokinetic activity. Justifying the critical role of physical dimensions, device geometry was first optimized using silicone tubes of varying lengths (2 cm, 3.5 cm, and 5 cm), in that the 3.5 cm device exhibited the most favorable balance between capillary-driven water flow and evaporation, thereby enabling continuous hydration–evaporation cycles and stable ion migration. In-depth tuning of the MnO_2/AC ratio established that the 3:1 composition achieved the highest open-circuit voltage (1.12 V) and short-circuit current (0.19 mA), producing a peak power of 56 µW by leveraging the uniform MnO_2 dispersion within the AC framework to promote efficient electrical double layer (EDL) formation and sustained ion gradient establishment. The device demonstrated long-term operational stability over three months, scalability through series connections (up to 2.58 V with three devices), and practical utility by successfully charging capacitors of various capacitances and powering an LED. Highlighting the synergistic role of MnO_2 and AC in advancing hydrovoltaic energy harvesting, these findings bridge a critical gap in the application of composite materials, underscoring their promise for self-powered and sustainable electronic applications.

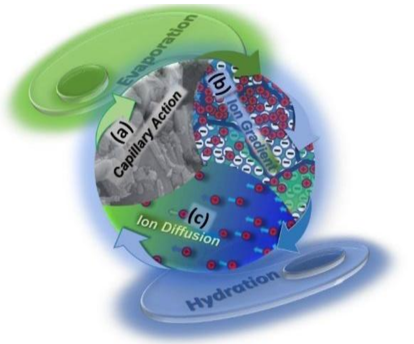


Figure 1. Working mechanism of the MnO2/Ac hydrovoltaic device.

Keywords: Hydrovoltaic, activated carbon, MnO_2, water interaction, power generation

PP-59

Kapok fruit pod-derived Activated Carbon/$ZnFe_2O_4$ Composite Nanostructures for Supercapacitor Applications

Nabeela Kader[1], **D.Vasanth Raj**[1*]
[1]*Department of Physics, PSG College of Technology, Coimbatore-641004, India*
*Email: dvr.phy@psgtech.in

Abstract

$ZnFe_2O_4$ (ZFO) rod-like nanostructure/activated carbon (Kapok shell AC) composite was prepared using the hydrothermal method. Different weight percentages of AC- 20, 30, and 40 per cent, are added to the ZFO crystal structure to investigate the influence of carbon incorporation on structural and electrochemical behaviour. SEM analysis confirmed morphological modifications upon AC addition, with enhanced structural connectivity that supports improved charge transport. Raman spectra further verified the presence of carbon in the composites, even though AC peaks were not distinguishable in the XRD patterns due to their amorphous nature. The pristine ZFO electrode delivered a specific capacitance of 385 F/g. Upon the addition of 20% of AC, the capacitance was moderately enhanced by out 7%. Further increasing the AC content to 30% produced a significant 62% improvement of capacitance, which established this composition as the most effective due to the optimised synergy between the ZFO rods and the porous carbon matrix. However, increasing the loading of AC to 40%, the enhancement was decreased to 49%, which suggests that too much carbon dilutes the pseudocapacitive contribution of the ZFO. Overall, the optimised ZFO/AC composite demonstrates superior charge-storage capability and highlights the importance of composition tuning for high-performance supercapacitor electrodes.

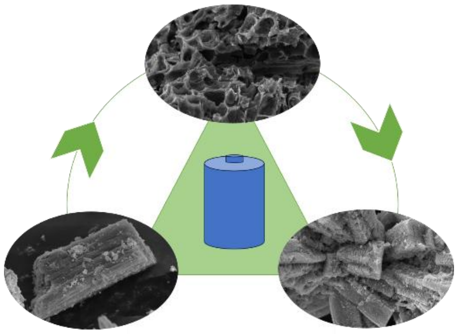


Figure 1. Graphical Abstract

Keywords: Supercapacitor, Carbon composite, Zinc Ferrite, Kapok fruit pod, Spinel ferrite

PP-60

Hydrogen embrittlement in internal combustion engine components: material challenges and selection strategies

V Magesh Kannan[1*], Rachchelle Phadvas P[1], Kesava M[1], P Karthikeyan[1], M Karthikeyan[1] and Manikandan Palanichamy[2]

[1]*Department of Automobile Engineering, PSG College of Technology, Coimbatore, India,*
[2]*Department of Engineering, Østfold University College, Fredrikstad, Norway.*
[*]Email: vmk.auto@psgtech.ac.in

Abstract

Hydrogen-enriched dual-fuel combustion offers a potential pathway for cleaner and more efficient internal combustion engine operation, but hydrogen exposure introduces durability challenges related to embrittlement and accelerated material degradation. This study investigates the influence of hydrogen enrichment on both engine performance and component integrity using a single-cylinder, 4-stroke diesel engine operated at 25-100% load conditions. Hydrogen was supplied through intake manifold injection at flow rates of 3-12 L/min, corresponding to 5–20% energy substitution. Performance testing showed that hydrogen enrichment improved brake thermal efficiency by up to 6.5% at 9 L/min, while CO and HC emissions decreased by 18–42% due to cleaner combustion. A corresponding 12–28% increase in NOx was observed, attributed to higher in-cylinder temperatures associated with hydrogen's high flame speed. Following 30 hours of dual-fuel operation, engine components including valves, valve seats, and injector-tips were examined for hydrogen-induced degradation. Material characterization revealed clear signs of damage: microcracks measuring 8–15 μm, pitting depths of 5–12 μm, surface hardness reductions of 6–11%, discoloration in regions exceeding 350°C, and an increase in surface roughness from 0.42 to 0.67 μm. These effects intensified with higher hydrogen flow rates and sustained thermal-mechanical cycling, confirming hydrogen's tendency to weaken conventional diesel engine materials. The study recommends hydrogen-compatible nickel-based alloys, ceramic thermal-barrier coatings, and improved cooling strategies to reduce susceptibility to embrittlement. Overall, the results provide evidence of material degradation in hydrogen-assisted engines and highlight engineering pathways to enhance durability and enable reliable hydrogen–diesel dual-fuel operation.

Keywords: Hydrogen internal combustion engine, material degradation, hydrogen embrittlement, surface micro cracking, material compatibility.

PP-61

Characterization and Performance Analysis of a PEM Fuel Cell under Dynamic Load Conditions

Rachchelle Phadvas P[1*], Kesava M[1], Jegathish J K[1], Elankathir E A[1], Vijay Kaarthi V[2]
P Karthikeyan[1], V Magesh Kannan[1] and Manikandan Palanichamy[3]
[1]Department of Automobile Engineering, PSG College of Technology, Coimbatore, India, [2]Department of Mechanical Engineering, PSG Institute of Technology and Applied Research, Coimbatore, India, [3]Department of Engineering, Østfold University College, Fredrikstad, Norway.
*Email: 22a233@psgtech.ac.in.

Abstract

Recent advancements in proton exchange membrane (PEM) fuel cell technology emphasize the need for efficient, durable, and responsive energy solutions in automotive applications. Existing literature highlights challenges related to dynamic load handling and transient response, which affect operational stability and long-term reliability. This study addresses ensuring robust performance when PEM fuel cell stacks encounter real-world power demands. Methods involve comprehensive characterization through polarization (I–V) curve and efficiency evaluation at steady-state, considering start/stop cycle, durability testing, and steady-state constant load. This was followed by applying controlled transient load steps and dynamic drive cycle profiles. Stack voltage, current, and temperature were continuously recorded to monitor performance under load transitions. Results demonstrate how voltage stability, current distribution, hydrogen utilization, and thermal management are influenced by dynamic conditions, revealing key factors contributing to performance degradation. The overview of the methodology is depicted in Figure 1: Fuel Cell Testing and Performance Characterization Methodology Overview. The peak power output improved by approximately 4.35%, rising from 1.15 kW to a new maximum of 1.20 kW. Under dynamic load steps, the stack exhibited rapid current responsiveness and minimal voltage fluctuation, confirming suitability for real-world automotive conditions. The results directly inform the development of robust energy management strategies and improved stack integration protocols, essential for unlocking the full potential of PEM fuel cells in advanced real-world automotive.

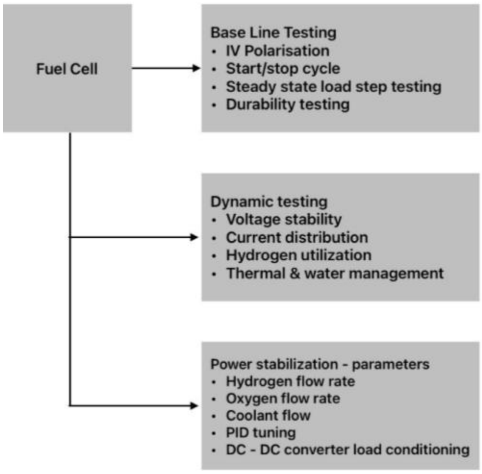


Figure 1: Fuel Cell Testing and Performance Characterization Methodology Overview

Keywords: Fuel cell, power flow, dynamic load handling, drive cycle, performance degradation

PP-62

Structural Evolution and Substrate-Driven Electrocatalytic Behaviour of Ti_3C_2 MXene for HER

Murugesan Abitha[1], Mounasamy Veena[2], Nagamony Ponpandian [1]*
[1]Department of Nanoscience and Technology, Bharathiar University, Coimbatore – 641 046.
[2]PSG Institute of Advanced Studies, Coimbatore, Tamil Nadu, India
*Email: ponpandian@buc.edu.in

Abstract

Two-dimensional transition metal carbides, known as MXenes, are in trend due to their metallic conductivity, hydrophilicity, and tunable surface functionalities, making them promising candidates for electrochemical energy conversion. These MXenes are derived from their corresponding bulk MAX phases by selectively etching A layer. Herein, a controlled time-resolved synthesis of Ti_3C_2 MXene was performed to understand the effect of exfoliation duration on its structural evolution. For which Ti_3AlC_2 was exfoliated for 24 hours monitoring its structural and morphological changes at an interval of 6 hours. Comprehensive results confirmed that at 24^{rth} hour of exfoliation, Ti_3C_2 exhibited a highly exfoliated layered structure with abundant surface terminations, favourable for electrocatalytic reactions. The as-prepared 24 h exfoliated Ti_3C_2 MXene was further investigated for substrate-dependent hydrogen evolution reaction (HER) activity using different substrates. Among these, Ti_3C_2 deposited on nickel foil demonstrated better performance, indicating rapid charge transfer and efficient hydrogen evolution kinetics owing to the strong interfacial coupling between the Nickel metal and MXene layers. The findings highlight the prominent role of both exfoliation control and substrate selection in tailoring the electrocatalytic performance of MXene-based materials for HER.

Keywords: MXene, HER, electrocatalyst, Ti_3C_2

PP-63

Electronic structure engineering of WO_3 through Fe, Co and Fe/Co co-doping for supercapacitor electrodes

Murugesan Abitha[1], Ayyamperumal Deepika[1], Nagamony Ponpandian[1]*

[1]*Department of Nanoscience and Technology, Bharathiar University, Coimbatore, India*

*Email: ponpandian@buc.edu.in

Abstract

As global energy demands accelerate, there is a critical need for sustainable energy storage devices. Supercapacitors (ultracapacitor or electrochemical capacitor) play a prominent role among the class of energy storage devices and conversion systems, as they provide greater specific capacitance, high power density, fast charge-discharge rates. Tungsten trioxide (WO_3), a transition metal oxide (TMOs) continues to gain attention for their potential advancement in electrochemical energy storage applications due to their versatile redox behaviour. However, its intrinsic low conductivity and sluggish kinetics limit their practical implications. In this study, pristine WO_3 and transition metal-doped WO_3 (Fe-WO_3, Co-WO_3, and Fe/Co-WO_3) nanostructures were synthesised via a hydrothermal method to modulate the electronic structure and enhance electrochemical activity. Structural and morphological characterisation were carried out using X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), Raman spectroscopy, UV-visible spectroscopy and scanning electron microscopy (SEM). Successful incorporation of dopants and their interaction with WO_3 matrix were confirmed by characteristic peak shift and corresponding spectral analyses. Electrochemical studies were carried out using CV, GCD, and EIS in acidic environment. Electrochemical analyses showed that the transition metals incorporated WO_3 exhibited enhanced activity than pristine WO_3 for supercapacitor electrode.

Keywords: Tungsten trioxide, Transition metals, Hydrothermal, Supercapacitor.

PP-64

Unveiling the Dual Energy Storage Mechanism in Co_3O_4/C/MoS_2 Hybrids Derived from ZIF-67 for Advanced Supercapacitor Applications

Palanivel Gayathridevi [1], Nagamony Ponpandian [1]*

[1]*Department of Nanoscience and Technology, Bharathiar University, Coimbatore – 641 046.*

*Email: ponpandian@buc.edu.in

Abstract

The increasing demand for efficient energy storage in electric vehicles and portable electronics highlights the need for devices offering both high energy and high-power density. Conventional batteries ensure high energy density but slow kinetics, whereas supercapacitors deliver high power with low energy density. Combining both systems offers a promising strategy to overcome these limitations, creating devices that deliver both high energy and power density.

In this work, A ZIF-67-derived Co_3O_4/C/MoS_2 composite was rationally designed to achieve dual energy storage behavior by merging the redox activity of Co_3O_4 with the EDLC characteristics of MoS_2. The composite was synthesized via a two-step process involving the calcination of ZIF-67 and converting the ZIF – 67 into Co_3O_4/Carbon support, followed by the in-situ growth of MoS_2 on the Co_3O_4 framework. To study the influence of electrode structure, two fabrication methods – slurry coating and free-standing polymer film formation – were employed. A comparative study of these electrodes revealed that both the fabrication and electrode structure significantly influence the charge transport, ion diffusion, and overall device performance. This study demonstrates that the hybrid charge storage with optimized electrode fabrication techniques provides a promising approach toward high-performance, flexible hybrid supercapacitor devices.

Keywords: ZIF–derived materials, MoS_2, supercapacitor, batteries, Energy storage

PP-65

Synenergic effect of synthesised g-C_3N_4/Fe_3O_4 nanocomposite and their enhanced activity in Electrochemical Watersplitting

Nithyasahayaantony Shimona[1], Murugesan Abitha[1], Nagamony Ponpandian[1]*
Department of Nanoscience and Technology, Bharathiar University, Coimbatore, India
*Email: ponpandian@buc.edu.in

Abstract

Increasing energy demands, one of the driving factors of technological development can be effectively addressed through conventional ecofriendly procedure, by incorporating electrochemical water splitting procedure with renewable energy harvesting units, that enables storage of energy in the form of secondary energy carrier, Hydrogen (H_2). Fe_3O_4 is a low cost, abundant and environmentally benign transition metal oxide, that offers multiple accessible oxidation states to promote active sites for electrochemical water splitting. Herein, g-C_3N_4, a tunable material with good chemical stability was incorporated into Fe_3O_4 lattice to form g-C_3N_4/Fe_3O_4 nanocomposite. This induces the properties of both g-C_3N_4 and Fe_3O_4, enhancing the activity of g-C_3N_4/Fe_3O_4 nanocomposite. Structural and morphological characterizations confirmed the effective formation of the material. Electrochemical studies were carried out to study the electrochemical performance of the prepared material. The resulting g-C_3N_4/Fe_3O_4 is found to show improved electrochemical activity when compared to that of individual Fe_3O_4 and g-C_3N_4.

Keywords: Hydrogen energy, g-C_3N_4/Fe_3O_4 nanocomposite, HER, OER

PP-66

Characterization of Undoped LLZO for Advanced Solid-State Electrolyte Systems

S. Mary Sharon[1*], A. Sakunthala[1]

[1]*Division of Physical sciences, Karunya Institute of Technology and Sciences, Coimbatore-641114*

[*]Email: marysharonsikiley@gmail.com

Abstract

The development of advanced solid-state energy storage devices requires materials that combine high ionic conductivity, electrochemical stability, and mechanical robustness. Lithium lanthanum zirconate ($Li_7La_3Zr_2O_{12}$, LLZO) is a promising garnet-type solid electrolyte that meets these requirements due to its stable cubic structure and wide electrochemical window. In this study, undoped LLZO was synthesized via a conventional solid-state reaction route and processed into fine powders suitable for integration into solid-state supercapacitor architectures. Structural characterization through X-ray diffraction (XRD) confirmed the formation of a phase-pure garnet structure. Electrochemical measurements electrochemical impedance spectroscopy (EIS), demonstrated stable ion transport and low interfacial resistance. The LLZO-based system exhibited promising specific capacitance, high charge–discharge reversibility, and excellent thermal and mechanical stability. These findings highlight the potential of undoped LLZO as a robust solid electrolyte material for next-generation, high-safety supercapacitors, offering an environmentally benign and thermally stable alternative to liquid or polymer-based electrolytes.

Keywords: LLZO ($Li_7La_3Zr_2O_{12}$), Solid electrolyte, Ionic conductivity, Energy storage, Garnet structure

PP-67

Influence of Inorganic Ash and Structural Defects on the Electrochemical Performance of Biomass-Derived Hard Carbon for Sodium-Ion Batteries

Desiha T S, Kalai Selvan R*

Energy Storage and Conversion Devices Laboratory, Department of Physics, Bharathiar University, Coimbatore-641046, India

[*]Email: selvankram@buc.edu.in

Abstract

Hard carbon has garnered significant attention as a sustainable anode material for sodium-ion batteries (SIBs) owing to its natural abundance, low cost, and large storage capacity. The conversion of lignocellulose biopolymers from biomass into biocarbon further enhances both economic and environmental value by utilizing renewable resources. However, intrinsic structural defects and a disordered microstructure, associated with sluggish Na^+ ion transport and low electronic conductivity, limit electrochemical performance. Moreover, the intrinsic

inorganic ash elements present in the carbon matrix, which are retained even after carbonization, pose further challenges, as these residues can strongly influence the structural integrity, surface chemistry, and sodium storage behavior of the material. Herein, we employed the catalytic effect induced in the carbon matrix using a transition metal to lower the activation energy, thereby facilitating graphitization and forming an ordered turbostratic structure at 850 °C for 2 h using the dry mixing and wet impregnation technique. The optimized electrode of Co-assisted shows a reversible specific capacity of 181 mA h g^{-1} at 20 mA g^{-1}, with an initial Coulombic efficiency (ICE) of 32%. This study suggests that selecting biomass precursors with low metallic ash content and introducing transition metal species during low-temperature carbonization can effectively optimize the microstructure of the electrode, enabling the development of efficient hard carbon anodes for high-performance sodium-ion batteries.

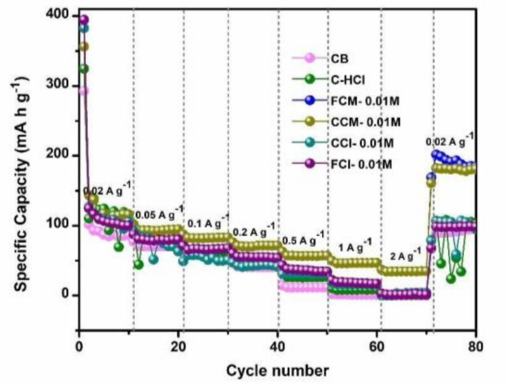


Figure 1. Rate performance of CB, C-HCl, FCM-0.01M, CCM-0.01M, CCl-0.01M, FCl-0.01M.

Keywords: Cocoa pod husk, Hard carbon, Transition metal catalyst, Catalytic graphitization, Negative electrode, Sodium ion batteries.

PP-68

Structural and Electrical Transport Properties of La-doped Li1.3Al0.3Ti1.7(PO4)3 synthesized by the Molten-Flux Method

Suba Sri Malaa R, Ganeshbabu M, Desiha T S and Kalai Selvan R*

Energy Storage and Conversion Devices Laboratory, Department of Physics, Bharathiar University, Coimbatore 641046, India

*Email: selvankram@buc.edu.in

Abstract

With the escalating need for reliable and high-performance energy storage, substantial research has been devoted to all-solid-state lithium-ion batteries, focusing on solid electrolyte materials engineered to ensure safety, high energy density, and mechanical robustness. Recently, $Li_{1.3}Al_{0.3}Ti_{1.7}(PO_4)_3$ (LATP) has attracted considerable interest as a NASICON-type solid electrolyte owing to its notable attributes, including superior ionic conductivity, low production cost, good electrochemical stability, and excellent air stability. In this work, La-doped LATP $Li_{1.3}Al_{0.3-x}La_xTi_{1.7}(PO_4)_3$ (x=0.025,0.05,0.075,0.1) was synthesized using the molten flux

method, with urea as the flux agent. The structural, morphological, and ionic conductivity of the prepared samples are characterized using various techniques. The XRD analysis revealed that LATP samples adopt a rhombohedral structure and are indexed to the R3c group. FTIR spectra confirmed the characteristic bond vibrations including Al – O and PO43-symmetric stretching modes of LATP. FESEM revealed that the particles are cubic grains with smooth surfaces. The Cole-Cole plot exhibits that x=0.05 La-doped LATP sample attained the optimum bulk conductivity of 7.33 × 10-7 S/cm at room temperature, compared to 1.62×10^{-7} S/cm of the pristine compound. Dielectric and electric modulus studies were employed to elucidate the structural properties, grain and grain boundary contributions, charge storage behavior, and the dynamical aspects of electrical transport.

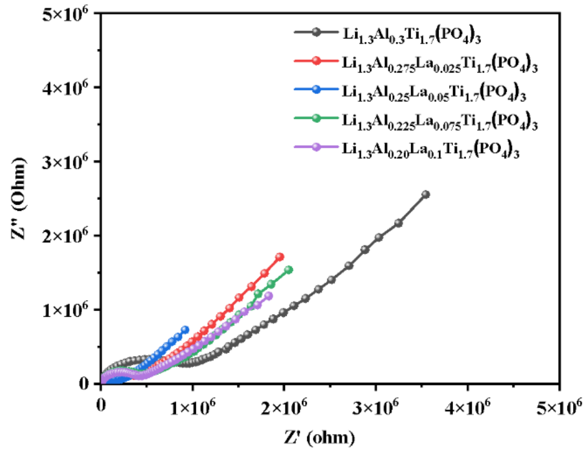


Figure 1. Impedance Spectra of La-LATP samples

Keywords: LATP solid electrolyte, Molten flux method, La3+ doping, ionic conductivity, charge transport

PP-69

Synergistic Effect of g-C_3N_4 Incorporation on the Electrochemical Behavior of NiMnCo Ternary Layered Double Hydroxides

G Sivasankari[1*] Atheek Posha[2,3] P.Puviarasu[d] D Prabha[1]
[1]*Department of Physics, PSG College of Arts & Science, Coimbatore-641014, India.*
[2]*Department of Physics, PSG Institute of Technology and Applied Research, Coimbatore-641062, India*
[3]*Department of Physics, PSG Institute of Advanced Studies, Coimbatore-641004, India.*
[4]*Ceramic Processing Lab, Department of Physics, PSG College of Technology, Coimbatore-641004, India.*
*Email: sivarudhra97@gmail.com

Abstract

The present investigation focuses on the development and electrochemical evaluation of NiMnCo layered double hydroxide (LDH) and its g-C_3N_4 based composites as advanced electrode materials for supercapacitor applications. NiMnCo LDH was synthesized via a controlled hydrothermal route, followed by the in-situ incorporation of g-C_3N_4 in varying proportions (10, 30, and 50 mg). Comprehensive structural and surface analyses using XRD, XPS, SEM, TEM, and BET confirmed the successful formation of well-crystallized LDH frameworks and effective integration of g-C_3N_4 without structural distortion. The introduction of g-C_3N_4 enhanced the surface area, electrical conductivity, and ion diffusion pathways, leading to improved electrochemical performance. Among the composites, NCM50 exhibited the highest specific capacitance of 700 F/g at 1 A/g and demonstrated excellent cyclic stability with 95% capacitance retention after 15,000 cycles. These findings emphasize the synergistic interaction between NiMnCo LDH and g-C_3N_4, establishing the composite as a promising electrode material for next-generation high-performance supercapacitors.

Keywords: Supercapacitor, Electrochemical, Graphitic carbon nitride, Layered double hydroxide, Cyclic stability.

PP-70

MXene-Based Electrode Materials for Supercapacitors: Synthesis Insights and Future Perspectives

R. Santhana Ishwarya[1] and Dr A. Bharathi Sankar[*]
[1]*School of Advanced Sciences, Vellore Institute of Technology, Chennai.*
[*]*School of Electronics Engineering, Vellore Institute of Technology, Chennai.*
[*]Email: bharathisankar.a@vit.ac.in, bharathisankar.1987@gmail.com

Abstract

Supercapacitors are considered promising energy storage devices due to their high-power density, rapid charge–discharge capability, and long cycle life. Among various electrode materials, MXenes, a novel class of two-dimensional transition metal carbides and nitrides, have attracted significant attention for their outstanding electrical conductivity, hydrophilicity, and layered morphology. In this study, the focus is on understanding the synthesis, structural characteristics, and electrochemical potential of $Ti_3C_2T_x$ MXene as an efficient electrode material for supercapacitor applications. The work reviews and compares different etching techniques, such as LiF–HCl and HF-based routes, which selectively remove the ‘A’ layer from the parent MAX phase, influencing the surface terminations and electrochemical performance of MXene. The discussion highlights how these synthesis routes affect properties like ion diffusion, capacitance, and stability. This study aims to establish a fundamental understanding of MXene processing parameters that govern capacitive behavior. In the future, MXene@$NiCo_2S_4$ hybrid nanostructures will be developed to fabricate asymmetric supercapacitors with enhanced energy and power densities. This ongoing work lays the groundwork for designing next-generation, high-performance, and durable energy storage systems based on MXene technology.

Keywords: MXene; Supercapacitor; Energy storage; $Ti_3C_2T_x$; Asymmetric device.

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Electrochemical Performance of Zifl - Graphitic Carbon Nitride Nanocomposite Electrode for Supercapacitor Application

J. Manoj[1,2], Markanthadaam Navaneeth[1,2], Ramakrishnan Vishnuraj[1,3], Murali Rangarajan[1,3,5]* and R. Sivasubramanian[4]*.

[1]*Center of Excellence in Advanced Materials and Green Technologies, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore, India*

[2]*Department of Chemistry, Amrita School of Physical Sciences, Amrita Vishwa Vidyapeetham, Coimbatore, India*

[3] *Department of Chemical Engineering and Materials Science, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore, India*

[4] *Department of Chemistry, School of Engineering, Amrita Vishwa Vidyapeetham, Amaravati campus, Andhra Pradesh, India*

5 Gurukripa Electrolyzers Private Limited, Coimbatore, India

*Email: r_murali@cb.amrita.edu and s_subramanian@av.amrita.edu

Abstract

Metal–organic frameworks (MOFs), particularly zeolitic imidazolate frameworks with linker modulation (ZIFL), have garnered significant attention as electrode materials for supercapacitors owing to their high surface area, tunable porosity, and structural diversity. Initially we synthesized ZIFL via a room-temperature method, yielding a distinctive two-dimensional leaf-like morphology. This architecture offers a high aspect ratio and promoting rapid ion diffusion and efficient charge transport, thereby enhancing pseudocapacitive behaviour. To further augment the electrochemical performance, we engineered a nano composite by integrating ZIFL with graphitic carbon nitride (g-C_3N_4), forming a ZIFL@GCN nano composite. The composite was synthesized through a sonochemical route, where in g-C_3N_4 was first dispersed in a zinc nitrate solution, followed by the addition of 2-methylimidazole to initiate in situ growth of ZIFL on the g-C_3N_4 matrix. This synergistic integration leverages the conductive and chemically stable nature of g-C_3N_4 with the high surface area and porosity of ZIFL, resulting in improved electron transport and enhanced electrochemical activity. Electrochemical characterization using a three-electrode configuration revealed a specific capacitance of 321 F/g at a current density of 1 A/g, underscoring the potential of the ZIFL@GCN nano composite as a high-performance electrode material for energy storage applications. This work highlights a scalable and efficient strategy for MOF-based composite design, paving the way for advanced supercapacitor technologies.

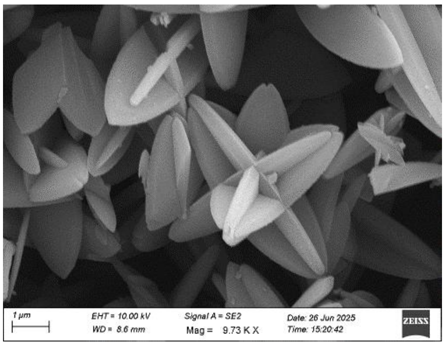

Figure 1. FESEM and EDX of ZIFL

Keywords: Metal organic frameworks (MOFs), zeolitic imidazolate frameworks layered (ZIFL), Supercapacitors, nano composite and energy storage.

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Nano-Curcumin Impregnated Wet Tissue Paper to Control Acne Bacteria

Dr. M. Poongothai, Professor and Vishal. M

Department of Biotechnology, Dr. N.G.P Arts and Science College

Nano-curcumin impregnated wet tissue paper was prepared to control acne bacteria. Curcumin extraction was done by Soxhlet extraction using ethanol as the solvent. Purification of Curcumin was done by Column chromatography using silica gel (60-120 mesh) column with Chloroform: methanol (48:2 ratio) as the solvent. Fractions obtained through column chromatography were characterized by UV visible spectrophotometric analysis and Thin layer chromatography. UV-Visible spectrophotometry showed maximum absorbance between 400nm -500 nm which confirmed the presence of Curcumin. High performance liquid chromatography further confirmed the presence of curcumin at 420 nm and the concentration was found to be 1512 mg/L. Nano-curcumin was synthesized using antisolvent precipitation method and lyophilized. Antibacterial activity of curcumin and nano-curcumin and nano-curcumin impregnated wet tissue papers were tested against Escherichia coli, Staphylococcus aureus and Propionibacterium acne. Nano-curcumin showed zone of inhibition of 1.4 cm which was equivalent to positive control which was about 1.9cm whereas for curcumin, it was about 1 cm. The study pointed out that Nano-curcumin was effective than conventional curcumin in controlling acne bacteria. The impregnation of nano-curcumin in wet tissue paper further facilitates the use of product and adds a sustainable value for the same proving the product is organic in cosmetic industry.

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Nitrogen Self-Doped Activated Carbons from Jack Bean Meal for High-Performance Supercapacitors with Redox-Active Electrolyte

Akash Sai S.M, Undavalli Venkata Gopi, Kumar Sai Smaran*

Department of Chemistry, Prasanthi Nilayam Campus, Sri Sathya Sai Institute of Higher Learning, Prasanthi Nilayam- 515134, Andhra Pradesh, INDIA

*Email: kumarsaismaran@sssihl.edu.in

Abstract

Jack bean meal (JBM), a nitrogen-rich by-product of *Canavalia ensiformis*, was utilized as a sustainable precursor to synthesize nitrogen self-doped activated carbons (NDACs) for high-performance supercapacitors. Through controlled carbonization and KOH activation, NDACs with high nitrogen content, porous morphology, and partially graphitized domains were obtained. Structural and elemental analyses using XRD, BET, SEM, HR-TEM, and EDX confirmed the development of well-defined pores and uniform nitrogen distribution. To enhance charge storage, para-phenylenediamine (PPD) was incorporated as a redox-active additive into a PVA–KOH polymer gel electrolyte. The PPD-modified system exhibited a six-fold increase in specific capacitance, reaching 835 F g^{-1} at 1 A g^{-1} in a three-electrode configuration. Dunn's analysis indicated a dominant diffusion-controlled mechanism (75.8%), emphasizing redox contributions. In a symmetric configuration, the device achieved 179.94 F g^{-1} at 1 A g^{-1}, an energy density of 35.99 Wh kg^{-1}, and a power density of 900 W kg^{-1}. This study demonstrates a sustainable route integrating nitrogen-rich biomass carbons with redox-active electrolytes for advanced energy storage applications.

Keywords: Supercapacitors, N-doped porous carbons, redox additives, activated carbon, biomass.

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Nanoscale Zinc sulfide decorated polypyrrole nanocomposites for enhanced energy storage systems

A.Loganathan[1], G. Kanchana[1*], V. Siva[2,3], A. Murugan[4]

[1]*PG and Research Department of Physics, Government Arts College (Autonomous)*
Coimbatore – 641018, Tamilnadu, India
[2]*Department of Physics, Karpagam Academy of Higher Education,*
Coimbatore 641 021, Tamilnadu, India
[3]*Centre for Energy and Environment, Karpagam Academy of Higher*
Education, Coimbatore 641 021, Tamil Nadu, India
[4]*Department of Science and Humanities, Karpagam College of Engineering,*
Coimbatore-641 032, Tamil Nadu, India
*Email: kanchanagopinath@gmail.com

Abstract

The morphology of the materials utilized greatly influences a device's energy storage capabilities. Materials having specified surface morphologies can be designed using a structure-directing agent. This research work describes a simple strategy for developing innovative hydrid nanocomposites for energy storage. A simple in-situ growing technique was used to encapsulate a hybrid Polypyrrole (PPy) with Zinc sulfide (ZnS), which was validated by HRTEM-EDS studies. The electrochemical performance was assessed using a 6M KOH electrolyte, yielding a specific capacitance of 720 Fg^{-1} at 5 mV/s. The nanocomposite electrode has good cyclic stability, with 83 % capacity retention after 10,000 cycles at a current density of 5 A/g. Furthermore, a solid-state asymmetric supercapacitor built with the designed electrode ZnS@PPy demonstrated good capacitive behavior throughout a large potential window from 0 to 5 V. In addition, the ZnS@PPy electrode has a maximum energy density of 35 W h kg^{-1} at a power density of 1260 W kg^{-1}. These findings highlight the remarkable potential of polypyrrole based nanocomposite materials for usage in next-generation energy storage systems.

Keywords: Conducting Polymers; Polypyrrole; Supercapacitor; nanocomposites; Cyclic voltammetry; Power density

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Exploring the Effect of Structural Variations on Electrocatalytic Behavior in Metal-Organic Frameworks

Anjana Chanthapally[1*], Anagha Yatheendran[2]
[1]*Assistant Professor, Mar Athanasius College of Engineering, Kothamangalam, 686666*
[2]*Inspire Fellow, MSED, NIT Calicut*
[*]Email: anjanacp@mace.ac.in

Abstract

Increasingly depleting fossil fuels and exponentially increasing energy needs of mankind won’t satisfy each other, it declares the need to device a sustainable energy source to depend on. Electrochemical water splitting offers a sustainable and environment friendly way to produce Hydrogen. Hydrogen Evolution Reaction (HER) is a renewable method of energy production by making use of the abundant resources, water and solar or electrical energy. In theory electrochemical water splitting requires 1.23 V but it's over 1.8 V practically, owing to the sluggish four electron transfer reactions. This calls for an active stable electrocatalyst, to lower the activation barrier, ease the production of Hydrogen via HER (Hydrogen Evolution Reaction) and production of oxygen via OER (Oxygen Evolution Reaction), the two core reactions of water splitting, is imperative. Metal Organic Materials or MOF derived network solids with uniformly distributed active centres are recently studied as potential catalysts for electrochemical and photochemical water splitting. Three-dimensional Metal organic frameworks was designed by tuning the metal coordination and the ligand along with the synthetic conditions. Systematic synthetic procedures were carried out to design and prepare the proposed coordination polymers. Electrocatalytic activity of coordination polymers are found to depend on a bunch of factors where the nature of metal and ligand plays the most crucial role among all. A three-dimensional cobalt coordination polymer, based on a pyridyl carboxylate ligand and exhibiting good thermal stability, was synthesized. As expected, the polymer demonstrated excellent oxygen evolution reaction (OER) activity, demonstrated superior catalytic performance with a lower overpotential value of 0.37 V at10 mA cm^{-2} and a Tafel slope of 78.9mV, outperforming other single metallic coordination polymeric structures likely due to the open metal centers and the presence of bridging hydroxo groups. Sustainable growth based on using hydrogen as fuel by water splitting can be an answer to the exponentially increasing global energy crisis. The sluggish anodic reaction evolving oxygen requires large over potential and electrocatalysts are required to increase the rate and lower the activation energy. Metal Organic frameworks can be proposed as promising OER/HER catalysts because of its inherent characteristic high surface area, cost efficiency and tuneable metal centres The copper and cobalt based metal organic materials studied in this work exhibit excellent electrocatalytic activity. These coordination polymers with tunable properties offer a huge area yet to be explored.

Keywords: Metal Organic Frameworks (MOFs), Porous Coordination Polymers (PCPs), Electrocatalysts, Hydrogen Evolution Reaction (HER), Oxygen Evolution Reaction (OER)

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Deposition and Characterization of β-Ga_2O_3 Thin Films for Photodetector Applications

Gowtham B[1], Kathirvel P[1,*] and Gopal Ram S.D[1]
[1] *GRD Centre for Materials Research, Department of Physics, PSG College of Technology, Coimbatore, Tamil Nadu – 641004, India*
[*] Email: ponkathirvel@gmail.com

Abstract

Photodetectors (PDs) are increasingly vital for a range of modern applications, including military surveillance, automated systems, and machine vision. While wide-bandgap semiconductors like gallium oxide (Ga_2O_3) are promising for ultraviolet (UV) detection, existing low-dimensional devices often face challenges such as complex fabrication and suboptimal performance. In this present study we have demonstrate the optimization of growth parameters of β-Ga_2O_3 through chemical vapor deposition (CVD) deposited over a SiO_2 and Al_2O_3 substrates. For the growth of β-Ga_2O_3 gallium oxide and carbon powders were used. From the structural analysis using X-ray diffraction (XRD) confirms the successful formation of monoclinic β-Ga_2O_3. Surface morphology was analyzed using field emission scanning electron microscope (FESEM) revealed the formation of β-Ga_2O_3 nanowires (NWs) through vapor-liquid-solid (VLS) growth mechanism. The average diameter of the NWs was ranging from ~ 80 nm to ~ 150 nm and confirms the uniform film formation. The formation of NWs is mainly driven by VLS growth mechanism and promotes the epitaxial growth of β-Ga_2O_3. The Raman spectra reveals the presence of both mid and high frequency vibration modes of the β-Ga_2O_3. The results of this study demonstrate that CVD growth is a highly promising approach for producing high-quality β-Ga_2O_3 films on both SiO_2 and sapphire substrates, offering a fast growth rate and superior material properties essential for advanced PD applications.

Keywords: β-Ga_2O_3, Nanowires, CVD, Photodetector

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Bio-Inspired Layered Vanadyl Foams for Polar-Solvent Energy Harvesting via Dipole-Driven Coulombic Drag

Hridya C Prakash[1], Neethu.M[1], Sudip K Batabyal[1*]
[1] *Department of physics, Amrita Vishwa Vidyapeetham, Coimbatore, India*
[*] Email: s_batabyal@cb.amrita.ed

Abstract

The principle of molecular self-assembly in living systems, where the aligned dipoles guide charge flow, can be applied to hybrid organic-inorganic materials for energy harvesting. Here, we demonstrate dipole-induced power generation using polar solvents on a Vanadyl HDA foam. Structural characterisations confirm the enhancement in the interplanar spacing, verifying the successful formation of vanadyl HDA foam. When a polar solvents penetrate into the form, its dipoles align with the internal electric field of the foam. This ordered aligned dipoles creates an interfacial dipole gradient, exerting a coulombic dipole-carrier drag coupling and generating reversible current and voltage signals without any mechanical flow or redox reactions. The vanadyl foam devices show significantly higher current and voltage generation than commercial V2O5 upon the addition of acetone, confirming the importance of the dipole architecture in energy generation. Solvent properties govern the electrical response such that IPA creates slower, wider signals. At the same time, acetone produces sharp, high-amplitude current spikes, and ethanol produces the most stable voltage and current signals due to ideal adsorption kinetics and dipole alignment. This study establishes vanadyl HDA foams as a promising platform for solvent-induced dipole-driven molecular energy conversion applications.

Keywords: Coulombic drag, Dipole moment, Power generation, Self-assembly, Vanadyl foam

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Simulation studies on the influence of different buffer layers for CFTS solar cell applications

M K Jyolsna Raj [1], Kallol Mohanta[2], B. Geetha Priyadarshini [1*]
[1]Nanotechnology-Research Innovation and Incubation Centre (NRIIC), PSG Institute of Advanced Studies, Coimbatore, Tamil Nadu, India – 641004
[2]Wiley APAC Services LLP, Noida, Uttar Pradesh - 201301
*Email: bgp@psgias.ac.in

Abstract

Quaternary chalcogenide CFTS is a promising material for various applications, including solar cells and photocatalytic activities. CFTS, composed of earth-abundant and non-toxic elements, is low-cost and has an optimal bandgap of around 1.5 eV. It belongs to the group of materials such as CIGSSe, CdTe, and CZTS, with suitable element substitutions based on similar atomic radii. To enhance device performance, CdS has commonly been used as the n-type layer in many photovoltaic devices. However, the toxicity of cadmium is a significant drawback. Consequently, alternative binary chalcogenides are being considered as potential n-type buffer layers to improve device performance. Several studies report device performance using n-type layers, mostly with CdS as the standard buffer layer. Comparative investigations between CdS and other buffer materials have been conducted to identify more efficient buffer layer. These materials include CdS, Bi_2S_3, and Ag_2S, as referenced in a literature and the work focuses on a detailed study of efficiency losses and performance drops associated with different buffer layers using SCAPS-1D simulationsoftware. The solar cell structure studied is Mo/CFTS/Bi2S3/Al, designed to analyze the performance of the p-n junction compared to reference data having the maximum efficiency of 2.9%. In this structure, molybdenum (Mo) serves as the back contact, CFTS as the absorber layer, bismuth sulfide as the buffer layer, and aluminum (Al) as the front electrode. The influence of each layer, particularly the n-type buffer, on device efficiency has been examined. Efficiency drain caused by various defects like bulk defect density and interface defect density within the device have also been investigated. Other device configurations studied include Mo/CFTS/CdS/Al and Mo/CFTS/Ag_2S/Al.

Keywords: Chalcogenides, CFTS, SCAPS-1D, buffer layer, Solar cell

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Carbon fiber/Alumina fiber reinforced Boron Nitride Composites for High-Temperature Applications

Shiva Subramani M[1], Anuradha M. Ashok[1*]

[1]*Functional Materials Laboratory, PSG Institute of Advanced Studies, Coimbatore, India 641004*

*Email: anu@psgias.ac.in

Abstract

In the defence sector, the emergence of precision strike weapons has prompted the development of stealth technology. This anti-detection technology makes objects less visible under radar, sonar, IR, or other radiation. Among the possible anti-detection technologies, radar-absorbing stealth technology has emerged as one of the most advantageous technologies in defence applications. Radar absorbing materials (RAM) should be capable of effectively absorbing the electromagnetic (EM) radiation, converting it into heat, to minimise detection by radar systems, unlike general electromagnetic interference (EMI) shielding materials, where the EM radiation is reflected to prevent interference with electronic systems. Good RAMs generally have a strong absorption capacity of electromagnetic waves over a wide range of frequencies. An effective EM absorbent material should possess moderate electrical conductivity, so that the charge carriers can interact with the electromagnetic signals and cause reflection on the front surface, along with ohmic heating in its interior. In addition, it should possess magnetic and/or electric dipoles, which help in absorbing the radiation. This work involves the development of Boron Nitride (BN) based composites with carbon and alumina fabrics for high-temperature and radar-absorbing applications.

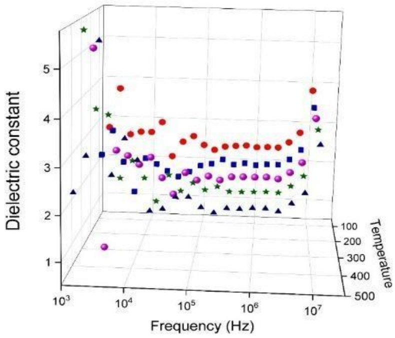


Figure 1: Temperature-dependent dielectric studies of BN Composite

Keywords: Alumina, Boron Nitride, Carbon, Electromagnetic shielding

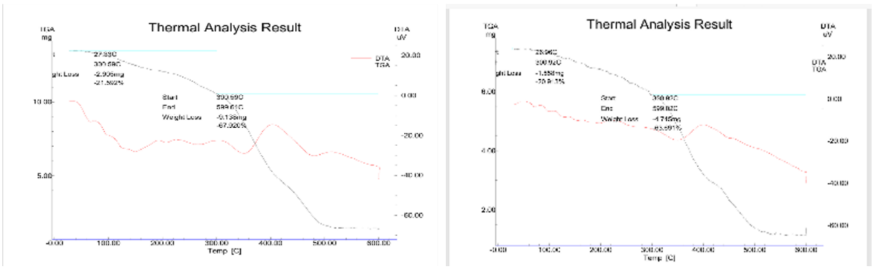
PP- 80

A Structurally Enhanced Next-Generation Proton Exchange Membrane with Promising Electrochemical Potential for PEM Water Electrolysis

Arthipriscilla ganesan[1], sharmila chandran[2]
*[1]*Department of Physics, PSGR Krishnammal College for Women, Coimbatore, India*
*Email: sharmilac@psgrkcw.ac.in, arthipriscilla22@gmail.com

Abstract

Polymer electrolyte membrane (PEM) water electrolysis requires membranes that possess high proton conductivity, excellent mechanical stability and improved water retention. In this work, polyvinyl alcohol (PVA) based composite membranes incorporated with imidazole and titanium dioxide (TiO_2) nanoparticles were synthesized to achieve a cost-effective and high-performance alternative to commercial membranes. Membranes with 5 wt% and 10 wt% TiO_2 loadings were prepared through solution casting and citric acid crosslinking. Structural and morphological analyses confirm enhanced crystallinity and uniform filler dispersion in the 10 wt% membrane. SEM reveals a denser microstructure with fewer defects, while contact-angle measurements show significantly improved hydrophilicity for 10 wt% loading. XRD, FTIR and thermal studies indicate strong polymer–filler interactions contributing to improved stability. Overall, the 10 wt% TiO_2 membrane demonstrates superior properties, making it a promising candidate for low-cost, durable PEMWE applications.



a)5wt% TiO_2 b) 10 wt% TiO_2

Figure 1. SEM micrographs of PVA–Imidazole membranes with (a) 5 wt% TiO_2 and (b) 10 wt% TiO_2 showing improved filler dispersion and denser morphology at higher loading**.**

Keywords: PVA membrane; TiO_2 filler; Imidazole; Proton conductivity; PEM water electrolysis.

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Development of Zn_3N_2/Cu_3N All-Nitride Heterojunction Photodetectors via RF Magnetron Sputtering

G. Akshaya Devi[1], A. Siva[1], P. Atheek[1*]
Dept. of Physics, PSG Institute of Advanced Studies, Peelamedu, Coimbatore– 641004.
[*]Email: pak@psgias.ac.in

Abstract

The demand for eco-friendly optoelectronic devices has driven research toward earth-abundant semiconductors such as copper nitride (Cu_3N) and zinc nitride (Zn_3N_2). All-nitride heterojunctions offer improved interface quality compared to oxide-nitride systems, making them promising for photodetector applications. We report the synthesis and characterization of *p*-type Cu_3N thin films via RF magnetron sputtering on glass substrates at room temperature. Crystalline of Cu_3N was confirmed by X-ray diffraction. UV-Visible spectroscopy confirms the bandgap of 1.839 eV, suitable for visible-light detection. Hall measurements confirmed *p*-type conductivity with a carrier concentration of 8.09×10^{14} cm^{-3} and mobility of 7.75 $cm^2/V\cdot s$. Current-voltage characteristics with Ag contacts further showed linear ohmic behaviour in the range -2 to +2 V with minimal contact resistance. AFM analysis showed uniform 20 nm thick films with smooth surface quality. Further n-type Zn_3N_2 was then deposited for the *p-n* junction photodetector for visible-light detection in applications such as optical communication and environmental monitoring.

Keywords: Cu_3N thin films, Zn_3N_2, RF magnetron sputtering, photodetector, all-nitride semiconductors.

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Structural and Morphological studies of rGO-biopolymer nanocomposites For Fuel Cell Applications

Sharvasri S[1], J. Balavijayalakshmi[1*],
[1] *Department of physics, PSGR Krishnammal College for women, Coimbatore, India,*
[*]Email: balavijayalakshmiroopa@gmail.com

Abstract

Graphene and its derivatives are thin layered 2D materials. The reduced Graphene oxide (rGO) derived from Graphene oxide is well known with high surface area, sharp edges with hydroxyl and carbonyl groups present in it. Reduced graphene oxide-biopolymer nanocomposites are prepared artificially by novel and simple method. Biopolymer nanocomposites are abundant in nature and eco-friendly. Graphene oxide (GO) is closely packed honey comb structured, non-toxic nanomaterials. The synthesized nanocomposites are characterized by X-ray diffraction (XRD) analysis that shows the amorphous nature. The Fourier transform infrared spectroscopy (FTIR) refers the presence of hydroxyl, epoxy groups of nanocomposites. The Field Emission Scanning electron microscopy (FESEM) shows the uniform distribution of rGO over biopolymer nanocomposites. These nanocomposites may be used for fuel cell applications.

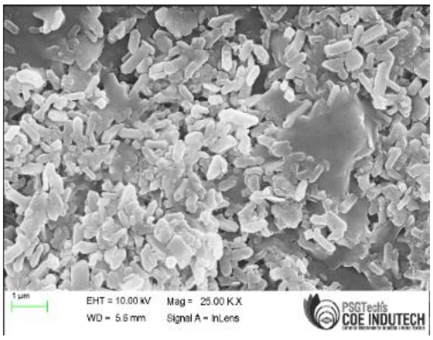

Figure 1. FESEM Analysis of rGO- biopolymer nanocomposites

Keywords: XRD, FESEM, Reduced graphene oxide, thin films, nanocomposites.

PP- 83

Fabrication of an Asymmetric capacitor from Bio-waste activated carbon: Enhanced electrodes for energy storage applications

R. Priyadharsini[1], J. Balavijayalakshmi[1*],
[1]*Department of physics, PSGR Krishnammal College for women, Coimbatore, India,*
[*]Email: balavijayalakshmiroopa@gmail.com

Abstract

Researchers seeking to develop an easy-to-use and ecologically friendly process have long been interested in the production of activated carbon. For this investigation, activated carbon is made from various types of biowaste, including corn cobs, waste from sugarcane, and groundnut shells. Through the use of KOH, the prepared carbon is activated. In an aqueous electrolyte, the activation of activated carbon by potassium hydroxide (KOH) results in a considerable increase in surface area, reaching around 3000 m^2g^{-1}. This leads to an increase in specific capacitance, energy density, and power density. According to the electrochemical findings, activated carbon that is generated from maize cobs demonstrates an exceptional capacitance of around 496 Fg^{-1} when subjected to a current density of 1 Ag^{-1}. Within the context of long-term cycling applications, the activated carbon has a capacity retention rate of 87% after 10,000 cycles. Based on the data, it appears that the common maize cob has the potential to be utilised as an essential raw material for energy storage applications.

Keywords: Activated Carbon, maize cobs, KOH, Energy storage device

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$Co_2(OH)_3Cl/Nb_2CT_x$ MXene Composite for High-Energy Aqueous Asymmetric Supercapacitors

Abhishek K[1], Elma Elizaba Mathew[2], M. Ulaganathan[1]*,

[1]Research Scholar, Department of Physics, Amrita Vishwa Vidyapeetham, Coimbatore, TN – 641112

[2]Post-Doctoral Fellow, Department of Physics, Amrita Vishwa Vidyapeetham, Coimbatore, TN – 641112

[1]Associate Professor, Department of Physics, Amrita Vishwa Vidyapeetham, Coimbatore, TN – 641112*

*Email: m_ulaganathan@cb.amrita.edu

Abstract

MXenes are increasingly explored as conductive platforms to boost charge transport in hybrid electrode materials. In this work, a $Co_2(OH)_3Cl/Nb_2CT_x$ composite was developed to harness this synergy. Nb_2CT_x MXene was first prepared by HF-etching of the Nb_2AlC MAX phase, followed by ultrasonic delamination to obtain few-layer nanosheets. The required MXene content was then dispersed in a DI water–ethanol (9:1, 200 mL) solution containing 0.1 mol $CoCl_2·6H_2O$ and 60 mmol HMT, maintained at 90 °C for 1 h under vigorous stirring. The resulting composites—CN-1, CN-2, and CN-3, corresponding to 1, 3, and 5 wt % MXene, respectively—were compared with the bare $Co_2(OH)_3Cl$ (CN-0) sample. While CN-0 exhibited a discharge time of 65 s at 1 A g^{-1}, the optimized CN-1 extended this to 220 s, achieving a specific capacitance of 366 F g^{-1} within a 0.6 V window. In an asymmetric configuration (AC‖PVA–KOH‖CN-1) operating up to 1.6 V, the device delivered an energy density of 45 Wh kg^{-1} at a power density of 1.5 kW kg^{-1}, with excellent rate performance. The strong interfacial coupling between redox-active $Co_2(OH)_3Cl$ and conductive Nb_2CT_x MXene enhances both electron transport and ion diffusion, demonstrating clear promise for high-energy aqueous supercapacitors.

Keywords: MXene, Cobalt hydroxide chloride, Asymmetric Supercapacitor, Aqueous Electrolyte, Energy Storage.

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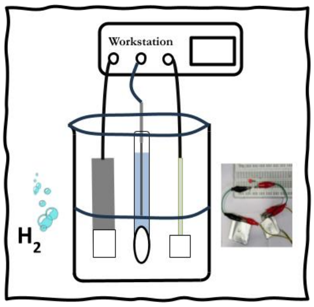
Few-layer graphene and Fluorine as stabilizing agents for improved pseudocapacitive cycling of β-Ni(OH)2 and water electrolysis

Eeswar Unnikrishnan[1,3], Abhishek Krishnamoorthi[2,3] and Dr. Mani Ulaganathan[2,3*]
[1]*Departmen of Chemistry, Amrita School of Physical Sciences, Amrita Vishwa Vidyapeetham-Coimbatore, India-641112,* [2]*Departmen of Physics, Amrita School of Physical Sciences, Amrita Vishwa Vidyapeetham-Coimbatore, India-641112,*
[3]*Functional Materials Laboratory, Amrita School of Engineering, Amrita Vishwa Vidyapeetham-Coimbatore, India-641112*
[*]Email: nathanphysics@gmail.com

Abstract

The growing energy demand and global warming could only be tackled by the development of alternative fuel sources as well as sustainable energy storage pathways. Hence, in this study, the prime focus is on improving the cycle life and energy density of battery type β-Ni(OH)2 by modifying it with fluorine and few-layer graphene. Different concentrations of few-layer graphene modified F-doped β-Ni (OH)2 were synthesized (0.5, 1, and 2 wt.%). The materials were tested for energy storage and conversion applications in alkaline medium. The optimized composite showed exceptional capacitance retention and coulombic efficiency even beyond 20’000 cycles. And, the bare β-Ni(OH)2 material showed good catalytic activity towards alkaline HER with a minimum overpotential at 10 mA cm-2. Hence, it is evident that the 0.5 wt% few-layer graphene into the F-doped β-Ni (OH)2 will be an efficient positive electrode for an asymmetric supercapacitor device, and bare β-Ni(OH)2 will also be an excellent cathode for alkaline hydrogen evolution reaction.



Keywords: Catalysis, Cycle life, Asymmetric capacitor, Water electrolysis, Alkaline medium.

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Investigation of Zinc-Vanadium (Zn-V) Hybrid Redox Flow Cell

Sokkalingam Subash[1,3], Moothedath Aparnasree[2,3], Mani Ulaganathan[1,3] *
[1]*Department of Physics, Amrita School of Physical Sciences, Coimbatore, Amrita Vishwa Vidyapeetham, Coimbatore, 641 112, India*
[2]*Department of Chemistry, Amrita School of Physical Sciences, Coimbatore, Amrita Vishwa Vidyapeetham, Coimbatore, 641 112, India*
[3]*Functional Materials Laboratory, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, Coimbatore, 641 112, India*
*Email: m_ulaganathan@cb.amrita.edu

Abstract

The world is rapidly transitioning to renewable energy resources, such as solar and wind, which necessitate secure, efficient, and large-scale energy storage systems. Among various technologies, the redox flow battery (RFB) stands out due to its flexibility in design, high energy density, excellent rate capability, and use of non-flammable aqueous electrolytes. Unlike conventional batteries, such as lithium-ion, which store energy in electrode materials, RFBs store energy in electrolytes containing redox-active species. However, during operation, redox ions can diffuse through the membrane due to concentration or potential gradients, leading to capacity loss, electrolyte imbalance, reduced coulombic efficiency, and side reactions. In this work, Zinc–Vanadium (Zn–V) redox flow cell was constructed. Additives were used in the anolyte to maintain pH and enhance the reversibility of zinc redox kinetics. Incorporating additive in the negative electrolyte reduced side reactions, improved ionic conductivity, stabilized cycling performance, and slightly decreased electrolyte crossover. The system exhibited an open-circuit voltage (OCV) of 1.84 V. Zinc precursor along with additive electrolyte is used as the anolyte, while vanadium ($V^{3.5+}$) was used as the catholyte. The cell with optimized additive concentration achieved over 100 stable cycles with a coulombic efficiency above 75%.

Keywords: Zn-V redox flow cell, additive electrolyte, enhancing cycle stability, balancing pH, enhancing conductivity.

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PCL/BI Composite electrospun nanofibrous membrane as a separator in Energy storage devices

Velmurugan Sriram [1,2,3], Shanmugasundaram Lakshana[1,2,3], Mani Karthega[1,3*], Mani Ulaganathan[1,2*]

[1]Department of Physics, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, India,

[2]Functional Materials Laboratory, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, India,

[3]Bio-materials Laboratory, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, India

*Email: m_karthega@cb.amrita.edu, m_ulaganathan@cb.amrita.edu

Abstract

The rapidly increasing demand for sustainable energy has integrally increased the need for safe and, long-lasting energy storage technologies. Aqueous Zinc-ion batteries have emerged as a safe and sustainable energy storage due to their abundant zinc anode, environmental sustainability and non-flammability in aqueous electrolyte. Despite their potential, zinc-ion cells suffer from dendrite growth during charging and discharging, which severely affects their stability and lifespan. Moreover, the limited thermal stability, poor ionic conductivity, and poor wettability of commercial separators further hinder their practical applications. In this work, we fabricated a composite electrospun nanofiber membrane of PCL with varying benzimidazole concentrations. The prepared membrane is subjected to various physical, chemical, thermal, mechanical and electrochemical studies with an optimised electrolyte in a Zn//CS//-MnO_2 cell to analyse the performance of the membrane as a separator. The fabricated membrane shows an enhanced thermal stability, wettability and ionic conductivity, inhibiting the growth during the Zinc plating and stripping process. This work signifies improved electrochemical performance of AZIBs, validating a suitable potential for practical large-scale energy storage applications.

Keywords: Electrospinning, Separator, Specific capacity.

PP- 88

Role of supporting electrolyte on Zinc Iodide Redox Flow Battery

Moothedath Aparnasree[1,3], Mani Ulaganathan[2,3]*

[1]Department of Chemistry, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, Coimbatore - 641 112, India

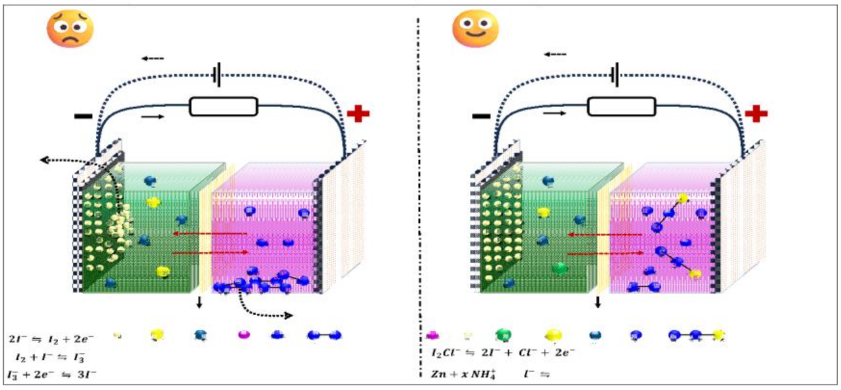
[2]Department of Physics, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, Coimbatore - 641 112, India

[3]Functional Materials Laboratory, Amrita School of Engineering Coimbatore, Amrita Vishwa Vidyapeetham, Coimbatore - 641 112, India.

*Email: *m_ulaganathan@cb.amrita.edu,*

Abstract

Redox Flow Batteries (RFBs) are regarded as one of the most promising large-scale energy storage systems due to their decoupled power and energy configuration, sustainability, and environmentally friendly characteristics. In this work, the Zinc–Iodide (Zn–I_2) RFB has been investigated because of its high energy density, low cost, non-corrosive nature, high solubility, and the high redox potentials of the Zn^{2+}/Zn ($E^0 = -0.76$ V vs. SHE) anolyte and I_2/I^- ($E^0 = 0.536$ V vs. SHE) catholyte, along with inherent safety advantages. However, challenges such as low iodine utilization, shuttle effects, zinc dendrite formation, and unbalanced reaction kinetics have limited their long-term cycling stability. In this study, the Zn–I_2 flow cell performance was enhanced by incorporating a safe, low-cost, and neutral supporting electrolyte—ammonium chloride (NH_4Cl)—on both sides of the cell. The optimized flow cell configuration, comprising KI + NH_4Cl as the catholyte and $ZnCl_2$ + NH_4Cl as the anolyte, exhibited excellent cycling stability over ~1000 cycles, achieving a coulombic efficiency (CE) of 90% and an energy efficiency (EE) of ~70%. Furthermore, the cell delivered a maximum power density of ~70 mW cm^{-2}, outperforming the baseline system utilizing bare KI (catholyte) and $ZnCl_2$ (anolyte) electrolytes.



Scheme 1: Schematic representation of the constructed redox flow battery. Case-1 RFB without NH_4Cl additive, and Case- 2 RFB with NH_4Cl additive.

Keywords: Redox Flow cell; Dendrite suppression; Polyhalide electrolyte; Bifunctional electrolyte; long life cycle;

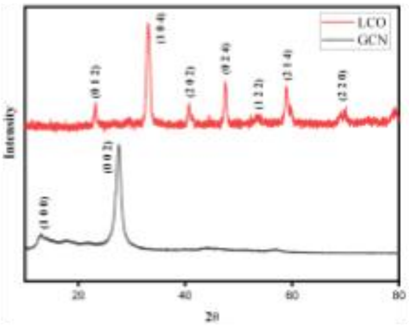
PP- 89

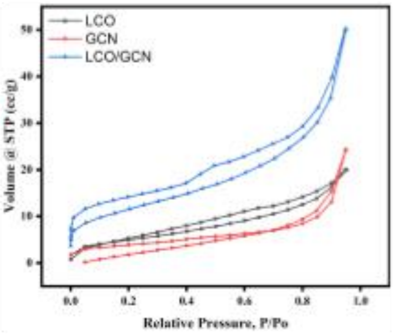
Strategic Manganese Doping and Composite Engineering of Lanthanum cobalt oxide with Graphitic Carbon Nitride for Enhanced ORR Catalysis for Aluminium-Air Batteries.

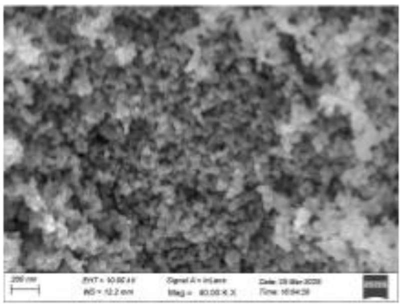
Markamthadam Navaneeth[1,2], J. Manoj[1,2], Ramakrishnan Vishnuraj[1,3], R. Sivasubramanian[4], Murali Rangarajan[1,3,5]
[1]*Centre of Excellence in Advanced Materials and Green Technology, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, India.*
[2]*Department of Chemistry, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, India.*
[3]*Department of Chemical Engineering and Material Science, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, India.*
[4]*Department of Chemistry, Amrita School of Engineering, Amaravati, Amrita Vishwa Vidyapeetham, India*
[5]*Gurukripa Electrolysers Pvt Ltd, India.*
*Email: r_murali@cb.amrita.edu & s_subramanian@av.amrita.edu

Abstract

The Oxygen reduction reaction plays an important role in energy conversion systems like Metal-air batteries and fuel cells. In this study, we explore the ORR behaviour of five materials: pure Lanthanum cobalt oxide (LCO), Manganese doped Lanthanum cobalt oxide (LCMO), graphitic carbon nitride (GCN), and two hybrid composites- LCO/GCN and LCMO/GCN. The electrochemical studies show that introducing Manganese into the LCO lattice improves its catalytic properties by tuning the electronic properties and increasing the oxygen vacancies. GCN, while moderately active on its own, contributes significantly when paired with perovskite oxides, which gives better conductivity and surface area. Out of all the samples, LCMO/GCN stands out giving the better results, with lesser overpotential, more favourable onset potential, lesser Tafel slope, and greater stability. The improved ORR performance comes from the combined effect of Manganese doping and addition of GCN. The Open circuit voltage (OCV) is found to be 1.4V and with an energy density of 1820 $mAhg^{-1}$ and the power density was calculated to be 10.04 mWs cm-2 at 0.6 V vs. RHE. Together, they help expose more active sites and make it easier for charges to move across the material, which boosts the overall catalytic efficiency.This work highlights how thoughtful material design through doping and composite engineering, which leads to more efficient, cost-effective ORR catalyst for next generation energy devices.







Keywords: ORR, Aluminum-air battery, Electrocatalyst, Rotating disc electrode, Perovskite, composite.

PP- 90

Design and development of electron channelizer and surface vacancy integrated with Bi2WO6 with high indexed polar facets for elevated photocatalytic ORR

Shreya B Hiremath, Akshaya K Samal*
Centre for Nano and Material Sciences, Jain (Deemed-to-be University)
Jain Global Campus, Kanakapura, Ramanagara, Bangalore, 562112, India.
*Email: s.akshaya@jainuniversity.ac.in

Abstract

The development of highly efficient photocatalysts for Oxygen reduction reaction (ORR) remains crucial for sustainable energy conversion and selective H2O2 Production. The synthesis strategy couples anisotropic facet engineering with controlled defect creation and interfacial electronic modulation to synergistically improve charge separation and surface reaction kinetics. High-polar facets were selectively exposed during solvothermal growth, providing intrinsically strong internal electric fields to promote directional charge migration. To further accelerate carrier transport, a conductive electron-channelizer network was incorporated, forming continuous pathways that suppress electron–hole recombination and deliver electrons directly to vacancy sites. Comprehensive structural, optical, and photoelectrochemical analyses confirm the coexistence and functional cooperation of these three design elements. As a result, the optimized material exhibits markedly elevated photocatalytic ORR activity, showing earlier onset potential, higher electron-transfer efficiency, and significantly enhanced H_2O_2 (or ORR product) yield under visible-light irradiation. This integrated approach demonstrates an effective and modular route for constructing next-generation Bi_2WO_6-based photocatalysts and highlights the critical role of facet polarity, defect chemistry, and electron-transport architecture in governing ORR performance.

Keywords: Electron channelizer, Facet engineering, Charge-transport modulation.

PP- 91

Light-Driven Active Site Evolution in CuO/C Photocathodes during Photoelectrochemical Nitrate Reduction

Manish Verma[1,2], Pravisha V.P.[3], Nikhil. N Rao[1], V. Ramakrishnan[3], Neena S. John[1*]

[1] Centre for Nano and Soft Matter Sciences (CeNS), Bengaluru,562162, India.

[2] Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, 201002, India.

[3] Sree Sankara College, Kalady, 683574, India.

*Email: jsneena@cens.res.in

Abstract

The Haber–Bosch process is energy-intensive and CO_2-emissive, whereas the photoelectrochemical nitrate reduction reaction PEC-NTRR offers a sustainable route to produce NH_3 from wastewater nitrates using water as a hydrogen source under ambient conditions.(Ren et al., 2024) In this study, a highly stable CuO/C photocathode is demonstrated for the photoelectrochemical nitrate reduction reaction (PEC-NTRR), providing a sustainable pathway to ~~close~~ the artificial nitrogen cycle. The optimized photocathode achieves an ammonia yield of **37.5 µmol h^{-1} cm^{-2} at −1.4 V vs. Ag/AgCl under illumination**, representing a 2.6-fold enhancement compared to dark conditions. Meanwhile, the **nitrite yield increases to 32.2 µmol h^{-1} cm^{-2},** nearly **240 times higher** than in the dark. In situ XAS and EXAFS analyses reveal that the application of a negative potential induces a CuO → Cu^0 transformation, more pronounced under illumination, resulting in an increase in the coordination number of Cu–Cu in Cu^0 from 6.34 (dark) to 10.6 (light) at −1.3 V vs. Ag/AgCl. This structural evolution modifies ammonia-favouring active sites and promotes selectivity towards nitrite formation. These findings elucidate how light influences the evolution of active sites in CuO and demonstrate that their dynamic structural rearrangement directly govern product selectivity. The study establishes a strong correlation between light-driven active site evolution in CuO, local structural dynamics, and the selectivity and kinetics of photoelectrochemical nitrate-to-ammonia conversion.

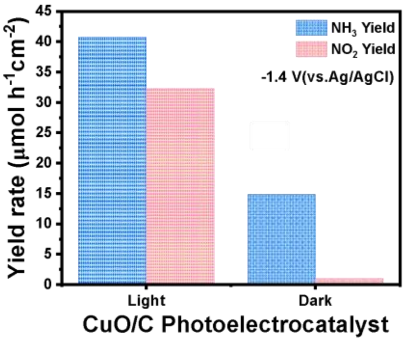


Figure 1: Yield rate of NH_3 and NO_2 at −1.4 V vs. Ag/AgCl of CuO/C in both light and dark conditions.

Keywords: Photoelectrocatalyst, nitrate reduction, *in-situ* Spectro electrochemistry, coper oxide, ammonia.

PP- 92

Adsorption of Diclofenac Using Zinc-Modified carbon from Chicken Feathers

Cindhu B[1] and Saritha E[1*]
[1] *Research Scholar, Department of Biotechnology, PSG College of Arts & Science, Coimbatore-14.*
[*]Email: sarithasenthikumar@gmail.com

Abstract

Water contamination harms both humans and the environment, causing health problems and disrupting aquatic ecosystems. In recent years, growing awareness has emerged about the presence of PPCPs in aquatic environments, where their accumulation in water, sediments, and organisms can harm aquatic life. Their widespread use in human and veterinary medicine leads to continuous environmental release, making this a major concern. Many PPCPs resist removal by conventional water treatment due to their physicochemical properties, leading to their detection in drinking water. Their incomplete elimination in wastewater treatment poses risks to aquatic life and public health. Activated carbon is widely used to adsorb PPCPs due to its high efficiency and favorable properties. Poultry consumption in this country produces over five million tonnes of feathers annually, with limited utilization of this by-product. The removal of micro-pollutants has been achieved using various adsorbents, and chicken feathers have emerged as a promising alternative resource for the preparation of carbon due to their abundant availability, renewability, and low cost. In this study, carbon prepared from chicken feather waste was activated with zinc (ZnCFC) and used as an adsorbent for the removal of the non-steroidal anti-inflammatory drug (NSAID) diclofenac. The ZnCFC, both before and after activation, was characterized using FTIR, XRD, and SEM. Various experimental parameters-such as agitation time, adsorbate concentration, adsorbent dose, and pH—were studied to optimize diclofenac adsorption. The experimental data were fitted to the Langmuir and Freundlich adsorption isotherms. To better understand the adsorption mechanism, the Lagergren first-order and pseudo-second-order kinetic models were applied.

Keywords: Adsorption, PPCP's, Chicken Feather Carbon, Diclofenac.

PP- 93

Green engineered Ag-activated carbon nanocomposite: A novel safe material for cosmetic application

Helen Rose J[1], Nidhin M[1*]
[1]*Department of Chemistry, CHRIST (Deemed to be University), Bangalore.*
[*]Email: nidhin.m@christuniversity.in

Abstract

The green synthesis of activated carbon from biowaste materials introduces an eco-friendly approach that converts waste into wealth. In this work, activated carbon was synthesised from coconut shell through the pyrolysis method, followed by activation using NaOH to achieve a high surface area and porosity. This activated carbon was further functionalized with Ag nanoparticles to get a multifunctional composite combining the unique properties of both activated carbon and the Ag nanoparticles. The properties of the synthesised material were evaluated using different characterisation techniques like XRD, BET, SEM, EDX, FTIR and Raman Spectroscopy. The particle size analysis was done using DLS analysis before incorporation of the nanoparticle into the activated carbon. The synthesised material showed excellent antimicrobial activity, adsorption capacity, and better stability and biocompatibility with the skin. Plant growth and seed germination studies examined the material's biological compatibility, nontoxicity and environmental safety. The antioxidant activity was tested using the DPPH assay. Overall, the study brings up a safe, stable, high-performance raw material with multifunctional activity for different cosmetic applications.

Keywords: Ag-activated carbon nanocomposite, characterisation, cosmetic application, green synthesis, eco-friendly.

PP-94

Seaweed (*Kappaphycus Alvarezii*) as Membrane and its Applications

Smilee Benita S.H[1], Dr. Kavitha S[1*]

[1]*Department of Biotechnology, School of Agricultural and Biosciences, Karunya Institute of Technology and Sciences, Coimbatore – 641114.*

[*]Email: kavibiotech@karunya.edu.in

Abstract

Seaweeds, abundant in marine ecosystems, have gained attention for their unique properties, including biodegradability, renewability, and low environmental impact. This abstract explores the potential of seaweed-derived materials as membranes for different applications. The utilisation of seaweed biomaterials presents a promising avenue for addressing sustainability challenges while advancing membrane technology. Seaweeds, such as *Kappaphycus alvarezii,* have garnered interest as potential materials for the fabrication of novel membranes with unique properties. This study focuses on the utilization of seaweed-mediated membranes derived from *K. alvarezii* and their characterization through microbial fuel cell (MFC) applications. First, seaweed components, including polysaccharides, proteins, and bioactive compounds, are extracted from *K. alvarezii* and incorporated into membrane fabrication processes. The membranes are prepared using techniques such as casting or electrospinning to form thin films or fibers. The physicochemical properties of the seaweed- mediated membranes are characterised, including surface morphology, porosity, hydrophilicity, and mechanical strength. The seaweed-mediated membranes are then integrated into MFC systems, which harness the power of microorganisms to generate electricity from organic matter. The performance of the membranes in MFCs is evaluated, with a focus on parameters such as power output, current density, and electrochemical characteristics. The influence of the membrane properties on the MFC performance is investigated, providing insights into the role of seaweed components in enhancing electrochemical activity and ion transport within the MFC system.

Key Words: Seaweed (Kappaphycus alvarezii), membrane, microbial fuel cell MFC.

PP-95

Development of Eco-Friendly CaO Adsorbents from Eggshell Waste for Carbon Capture Applications

Gopika P K[1], B. Vidhya[1*]

[1]Division of Physical Sciences, Karunya Institute of Technology and Sciences, Coimbatore-641114.

*Email: gopikap24@karunya.edu.in

Abstract

The continuous increase in atmospheric CO_2 concentration driven by industrialization and fossil fuel utilization has emerged as a major contributor to global warming and climate change. Carbon capture and storage (CCS) is recognized as a viable strategy to mitigate these emissions; however, the search for cost-effective, sustainable, and eco-friendly sorbents remains a critical challenge. In this study, waste-derived eggshells were utilized as renewable precursors for developing efficient CO_2 adsorbents. Eggshell waste, rich in calcium carbonate, was converted to calcium oxide (CaO) through controlled calcination. The presence of CaO has been confirmed by X-ray diffraction peaks corresponding to CaO which is in agreement with the JCPDS file no.77–2376. The morphology and composition of the prepared samples were tested using SEM and EDAX, respectively. The samples were subjected to BET surface analysis to estimate the pore size, surface area, and adsorption capacity. These samples will be further tested for CO_2 uptake using GC-MS. Scope for further improvement will be based on composite formation with complementary materials.

Key words: CaO, Egg shell, XRD, SEM-EDAX, BET.

PP-96

Development of 2D Material Based g-C_3N_4/TiO_2/CeO_2 Ternary Heterojunction for Visible-light-assisted Photocatalysis

Abimanyu R[1], Rathish S[1] and Abinash Das[1*]

[1]Solar Fuel Research Group (SFRG), PSG Institute of Advanced Studies, Coimbatore, Tamil Nadu 641004, India.

*Email: abinashnitsmsc@gmail.com

Abstract

A novel heterojunction photocatalyst composed of 2D-layered graphitic carbon nitride (g-C_3N_4), titanium dioxide (TiO_2), and cerium oxide (CeO_2) was developed using a simple route. In this study, g-C_3N_4 was modified using TiO_2 and CeO_2 as a supporting catalyst. It is identified that g-C_3N_4 is widely utilised in the photocatalytic degradation of organic pollutants due to its low band gap energy. However, some of its inherent limitations restrict the application in large scale. g-C_3N_4/TiO_2/CeO_2 ternary composite was prepared and the structure, morphology, and optical properties were characterised using X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), and photoluminescence spectroscopy (PL). When compared to the pristine and g-C_3N_4/TiO_2 binary catalyst, the g-$C_3N_4/TiO_2/CeO_2$ ternary composite demonstrated significantly enhanced photocatalytic activity in the degradation of Rhodamine B (RhB). The performance of ternary composite was found to be superior than the remaining samples and it could achieve high dye removal efficiency of 90% within 60 minutes.

Keywords: Dye-degradation, Photocatalyst, Heterojunction, 2D materials.

PP-97

Preparation of g-$C_3N_4/BiVO_4/MoS_2$ Ternary Composite for Visible-light-driven Photocatalysis

Rathish S[1], Abimanyu R[1] and Abinash Das[1*]
[1]Solar Fuel Research Group (SFRG), PSG Institute of Advanced Studies, Coimbatore, Tamil Nadu 641004, India.
[*]Email: abinashnitsmsc@gmail.com

Abstract

Graphitic carbon nitride (g-C_3N_4) is an emerging photocatalyst that provides innovative solutions to critical environmental and energy challenges. This metal-free 2D material is well-known for its applications in photocatalytic processes, such as water splitting for hydrogen production and the degradation of pollutants. Bismuth vanadate ($BiVO_4$) is another versatile material that has been extensively studied as a counterpart of 2D materials. Additionally, molybdenum disulfide (MoS_2) is an inorganic compound that demonstrates high absorption capabilities in the visible spectrum. Therefore, in this work, we presented a sandwich heterostructure of both $BiVO_4$ and MoS_2 with g-C_3N_4 for enhancing its photocatalytic performance and efficiency under visible light irradiation. The performance of the catalyst for the Rhodamine B dye degradation was studied, and the ternary photocatalyst could outperform other samples in terms of rate constant and dye degradation efficiency. The modified properties of the catalyst were studied using XRD, SEM, TEM, and PL characterization techniques to provide insight about their properties for photocatalytic applications. This work aims to provide a simple idea to design an efficient catalyst with improved light absorption capacity, low charge carrier recombination, and increase surface reactivity.

Keywords: Photocatalysis, Dye-degradation, Solar Fuel, 2D materials.

PP-98

Flower derived carbon quantum dot/silver nanoparticle nanogel for sensor and coating applications

N.S. Akshaya[1] and D. Ravi Shankaran[1*]
[1]Nano-Bio Materials and Sensors Laboratory, National Centre for Nanoscience and Nanotechnology, University of Madras, Guindy Campus, Chennai, India.
[*]Email: dravishankaran@hotmail.com

Abstract

There is an increasing interest in the development of functional nanomaterials for high-performance sensors and coatings applications. The employment of hybrid nanomaterials is gaining importance for their potential in coating and multimodal sensor applications. In the present work, we have developed Carbon quantum dots (CQDs) and silver nanoparticle (AgNP) hybrid nanomaterials. Here, we prepared AgNPs using CQDs derived from Hibiscus rosa-sinensis flower extract, which act as both reducing and stabilizing agents. The optical studies confirm the formation of CQD@AgNPs, where the λmax exhibits a red shift from 263nm to 430nm, accompanied by a hydrodynamic diameter of 95nm and a zeta potential of -72.3 mV. The PL studies reveal an increase in intensity, accompanied by a red shift, indicating plasmon-enhanced fluorescence. The prepared hybrid nanomaterial has been evaluated for the sensing of metal ions for its suitability for environmental analysis. A cellulose-based hydrogel embedded with the CQD@AgNPs have been prepared and evaluated for sensing. Further, the functional nanogel has been coated over different substrates, such as textiles, glass, for their fluorescence and plasmonic properties towards sensing and antimicrobial resistance. The results are highly promising for the application of the proposed nanogel for sensing and coating applications.

Keywords: Carbon Quantum Dots, Silver Nanoparticles, functional Nanomaterials, multimodal sensing.

PP-99

Plasma-Enhanced Pomegranate Peel Fibers for Eco-Friendly Textile Production

Sanjana. R[1], Jeevitha.P[1], Dr J Banu Priya[1*]
[1]Department of Costume Design and Fashion PSG College of Arts & Science, Coimbatore.
[*]Email: 25pcdf02@psgcas.ac.in

Abstract:

The growing demand for sustainable textile production has driven the innovative use of plasma technology combined with fibers derived from agro-waste, particularly pomegranate peel, to advance a circular textile economy. Pomegranate peel, rich in polyphenols and natural tannins, acts as a natural bio-mordant that enhances dye absorption, color durability, and imparts antimicrobial and UV-protection properties to cellulosic textiles. This study presents a life cycle assessment (LCA) of textiles made from pomegranate peel fiber subjected to eco-friendly, low-temperature plasma treatment. The plasma process effectively alters textile surfaces without significant water or chemical use, boosting wettability and dye fixation while preserving fiber strength. The LCA indicates notable decreases in water consumption, chemical waste, and energy use compared to traditional wet processing. Utilizing pomegranate peel supports circular bioeconomy objectives by closing resource loops and lessening environmental impact. The results demonstrate the combined potential of plasma technology and pomegranate peel agro-waste to create multifunctional, sustainable textiles and encourage the adoption of greener manufacturing methods that add value to agricultural by-products.

Keywords: Plasma technology, Pomegranate peel fiber, Sustainable textiles and Circular textile economy.

PP-100

Design optimization of adsorbent structures fabricated from fly ash derived zeolites for enhanced heavy metal removal

Hareesh Padayath[1], Srudhi Sankar[2], Murali Rangarajan[1*]
[1]Centre of Excellence in Advanced Materials and Green Technologies, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore, Tamil Nadu, India.
[2]Department of Chemical Engineering and Materials Science, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore, Tamil Nadu, India.
[*]Email: r_murali@cb.amrita.edu

Abstract

Advancement and growth of the industrial sector have led to increased heavy metal concentrations in water bodies, posing a growing environmental concern. Even at parts per billion level, they can lead to a variety of diseases such as kidney damage, neurological disorders and cardiovascular problems. The low concentration of heavy metals (typically in the ppm levels) in the contaminated water and the resulting low concentration gradient pose a challenge in the design of a large-scale continuous adsorption process. Zeolites with its strong adsorption capacity has gained attention as a promising candidate for heavy metal removal due to its strong adsorption capacity. Here, fly ash obtained from cement industry (a by-product) is used to synthesize high quality zeolite. The synthesis technique is developed with due considerations to the need for a large-scale production of zeolite. In addition, as a step towards the deployment of zeolites in a continuous process for heavy metal removal, the synthesized zeolite is used for the fabrication of an adsorbent structure optimized for enhanced continuous heavy metal removal.

Keywords: Zeolite, Heavy metal removal, fly ash, Modelling.

PP-101

N-Aminophthalimide based Schiff base: characterization and applications as chemo sensor and anti-tumour activity

Paustin Asha Arockiamathan[1], **S. Sheeba Thavamani**[1*]

[1]*PG and Research Department of Chemistry, V.O.Chidambaram College, Tuticorin, India.*

[*]Email: sheeb.che@voccollege.ac.in

Abstract

Heterocyclic compounds possessing phthalimide moiety have attracted tremendous interest in the field of medicinal chemistry due to their diverse and a wide range of biological properties. Schiff's base ligand was synthesized via the condensation of N-aminophthalimide and 6-bromo-2-pyridinecarboxaldehyde was characterised using different analytical techniques, and its potential for use in metal ion sensing, DNA binding and cytotoxic effect was investigated. UV-Visible absorption spectrum of the ligand showed a distinct absorption band centered at 295 nm that corresponds to n-π* transition of the azomethine group signifying the creation of >C=N- bond of the imine. The band centered at 245 nm is attributed to π-π* transitions. With a donor group, conjugate bridge, and acceptor group, these ligands are part of the D-π-A System (donor-π-acceptor), which facilitates and amplifies intramolecular electron transfer and results in fluorescence emission. The fluorescence spectrum of the ligand exhibited remarkable emission intensity at 387 nm at an excitation wavelength of 365 nm. The change in fluorescence behaviour of the ligand was investigated with different metal ions. Selectivity studies indicated maximum enhancement with barium ions. The significant fluorescent turn-on behaviour was studied towards chemosensing of barium ions. Because of the significant interest garnered by the phthalimide group in medicinal chemistry due to its diverse biological properties, such as anti-tumor and DNA binding and cleavage ability, *in vitro* antiproliferative efficacy of the ligand was assessed against various cell lines: MCF7, NHDF. IC_{50} value against MCF7 cell lines was estimated to be 30.32 μM/mL confirming significant activity. Furthermore, DNA binding studies were also carried out to investigate the biological potential of the test compound.

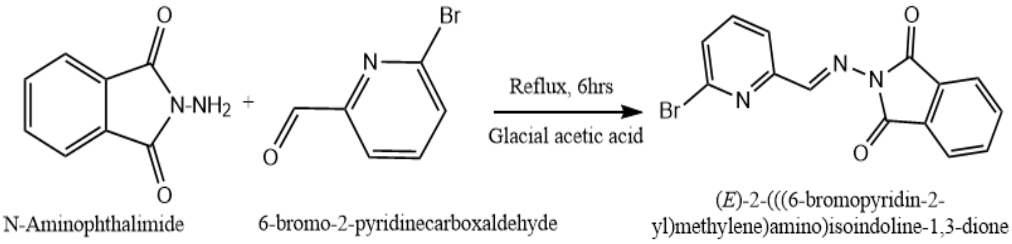


Figure 1: Synthesis of Schiff base ligand

Keywords: N-Aminophthalimide, Schiff base, Chemo sensor, DNA binding, Anti-cancer.

PP-102

Ultrasound-assisted preparation of Nickel tungstate/Activated charcoal/Graphene Nanoplatelet composite and its Electrochemical performance

Leena V S[1†], Mathan Kumar P[2†], Muthuraaman B[2*], and Ramathilagam C[1*]

[1]*PG Department of Physics, Dwaraka Doss Goverdhan Doss Vaishnav College, Chennai, India.*

[2]*Electrochemical Energy Devices Laboratory, Department of Energy, University of Madras, Guindy Campus, Chennai-600025, India.*

*Email: bm.raaman@gmail.com, ramathilagam@dgvaishnavcollege.edu.com

Abstract

Dye-sensitized solar cells (DSSCs) have emerged as one of the promising photovoltaic technologies for the near future, owing to their simpler fabrication and cost-effectiveness. However, using Platinum, which is much expensive and rarer; as the counter electrode (CE) hinders the large-scale applications of DSSCs. Transition metal oxides have drawn the attention of researchers over the years due to their unique electronic, mechanical and optical properties. This work explored the use of Nickel tungstate/ Activated Charcoal/ Graphene Nanoplatelets composite as a low-cost alternative for platinum CE. The material was prepared by a simple ultrasound–assisted synthesis by varying the ratio of activated charcoal and graphene nanoplatelets. The structure and morphology were studied with XRD and FESEM. Electrochemical behaviour was investigated from cyclic voltammetry, cyclic stability, and Electrochemical Impedance Spectroscopy (EIS) in I_3^-/I^- redox couple-based electrolyte. The device fabrication and characterization for cell efficiency are in progress. These findings suggested that this transition metal oxide composited with carbon nanoparticles, exhibits good electrocatalytic activity, along with enhanced surface area and conductivity, can be a potential alternative to platinum in DSSC applications.

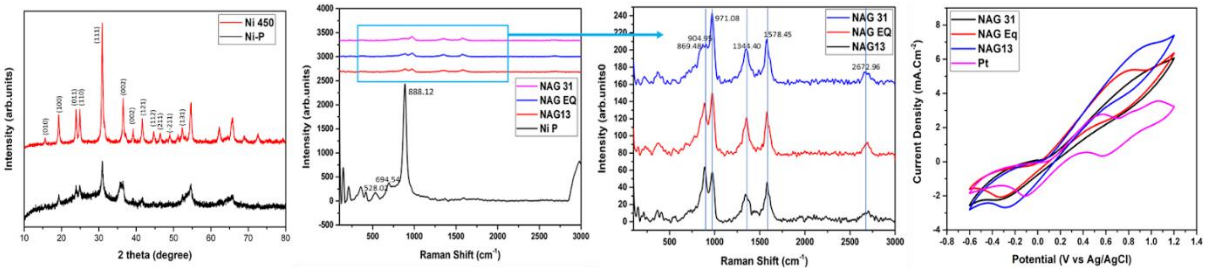


Figure 1. XRD, Raman studies and Cyclic Voltammetry graphs of Nickel Tungstate/AC/GNP.

Keywords: Nickel Tungstate, DSSC, Counter Electrode, Activated Carbon, Graphene Nanoplatelets.

PP-103

Hermetia illucens–mediated bioconversion of municipal sewage sludge: Nutrient recovery, pathogen risk reduction, and frass microbiome characterization for soil amendment

Rachana Sharma[1*], Agalya. M[1], and Prabhu Thangadurai[2]
[1]*Department of Biotechnology, PSGR Krishnammal College for Women, Peelamedu, Coimbatore, Tamil Nadu, India.*
[2]*Center for Sustainability, PSGR Krishnammal College for Women, Peelamedu, Coimbatore, Tamil Nadu, India.*
[*]Email: rachanasharma@psgrkcw.ac.in

Abstract

Municipal sewage sludge requires treatment that stabilizes organic matter, recovers nutrients, and assures biosafety. We optimized *Hermetia illucens* (black soldier fly (BSF)) larval bioconversion of dewatered sludge under controlled conditions. Pre-conditioned sludge with 70 ± 2 % moisture was co-processed with pre-treated food waste at a 3:1 dry-weight ratio for 14 d at 28 ± 1 °C and 65 ± 3 % relative humidity. The process achieved 62.7 % reduction in volatile solids and 56.2 % reduction in total solids, indicating effective stabilization. The resulting frass contained 4.3 % N, 2.9 % P_2O_5, and 2.1 % K_2O, which supports agronomic value. Pathogen monitoring showed greater than 4.5 $\log_{10}$ reduction of *Escherichia coli* with *Salmonella* not detected, which meets USEPA Class A requirements, and concentrations of Cd, Pb, and Cr were below regulatory limits. A cress bioassay yielded a germination index of 92 %, which indicates no acute phytotoxicity. Amplicon based characterization of frass indicated bacterial classes Bacilli 30 %, Gammaproteobacteria 25 %, Bacteroidia and Sphingobacteriia 25 %, Actinobacteria 12 %, and Alphaproteobacteria 5 %. Fungal classes were Saccharomycetes 25 %, Tremellomycetes 20 %, Eurotiomycetes 20 %, Sordariomycetes 15 %, and Dothideomycetes 10 %. Functional inference with PICRUSt2 and FUNGuild predicted enrichment of carbohydrate and nitrogen metabolism, glycan biosynthesis, cofactor and vitamin metabolism, and secondary metabolite pathways. Guild composition was dominated by saprotrophs 60 % with pathotroph saprotroph 25 % and symbiotroph 15 %. Together these outcomes show that black soldier fly bioconversion reduces sludge mass, ensures biosafety, and yields functionally active soil ready frass for circular wastewater resource recovery.

Keywords: Black soldier fly, sewage sludge, resource recovery, pathogen control, frass microbiome.

PP-104

Sustainable Wastewater Treatment: A study on Pineapple Peel as a Biosorbent for Textile Dye Removal

Movunika C[1], Arcchana S[1] and Pradeepa D[1*]

[1]*Department of Biochemistry, Dr. N.G.P. Arts and Science College, Coimbatore – 641048, Tamil Nadu, India.*

Abstract

The rapid expansion of the textile industry has led to the generation of large volumes of dye-laden wastewater, which poses serious environmental hazards to soil and aquatic ecosystems. Conventional treatment methods for textile effluents are often costly, energy-intensive, and generate secondary pollutants. This study explores the use of pineapple (*Ananas comosus*) peel, an agro-industrial waste, as a low-cost and sustainable biosorbent for wastewater treatment and resource recovery. Pineapple peels were processed through washing, drying, grinding, and sieving to different particle sizes (100 µm, 200 µm, and 300 µm). Batch adsorption experiments were conducted to determine the influence of particle size, adsorbent dose, contact time, and pH on dye removal efficiency. The results indicated that the smallest particle size (100 µm) achieved the highest removal rate of 70%, attributed to greater surface area and more active binding sites. The optimum conditions were found at an adsorbent dose of 0.1 g, contact time of 150 minutes, and neutral pH (7), resulting in a maximum dye removal efficiency of 89.2%. The adsorption mechanism was mainly driven by electrostatic interactions and hydrogen bonding between dye molecules and functional groups on the peel surface. The study establishes pineapple peel as an efficient biosorbent for textile dye removal, turning agricultural waste into a valuable resource for pollution control. This approach supports sustainable wastewater management and circular economy principles by integrating waste valorization with eco-friendly remediation technologies.

Keywords: Pineapple peel, Biosorption, Wastewater treatment, Resource recovery, Textile dyes, Sustainable remediation.

PP-105

Advanced Oxidation and Sand Filtration Techniques: Sustainable Treatment of Textile Dye Effluents to Prevent Soil Pollution

Pavithra K[1], Devavarnini K[1], Jishani K[1] and Pradeepa D[1*]
[1]*Department of Biochemistry, Dr. N.G.P. Arts and Science College, Coimbatore – 641048, Tamil Nadu, India.*
[*]Email: pradeepa@drngpasc.ac.in

Abstract

Industrial textile effluents are major contributors to soil and water pollution due to the presence of toxic dyes, heavy metals, and complex organic compounds that resist biodegradation. This study focuses on developing an eco-friendly and sustainable approach for treating textile dye wastewater using Advanced Oxidation Processes (AOPs) and sand filtration. Azo dyes, particularly yellow dyes, were selected as the model pollutant owing to their persistence and environmental toxicity. The UV/O_3 oxidation method was optimized by varying parameters such as dye concentration, pH, and salt levels to enhance decolorization and degradation efficiency. Results revealed that ozonation at alkaline pH significantly improved color removal up to 73.7%, demonstrating effective breakdown of dye molecules through hydroxyl radical generation. The subsequent sand filtration process further improved purification efficiency, achieving over 95% color removal while reducing chemical oxygen demand (COD) and total suspended solids (TSS). Treated water was successfully reused for plant growth experiments using *Vigna radiata* (green gram), confirming its non-toxic nature and suitability for irrigation. This integrated UV/O_3 and sand filtration system not only reduces the environmental load of textile effluents but also provides a sustainable solution for minimizing soil contamination. The study highlights that combining advanced oxidation with low-cost physical filtration can transform hazardous industrial waste into reusable water, supporting cleaner production practices and soil conservation. This approach contributes significantly toward achieving Sustainable Development Goals related to clean water, soil protection, and responsible industrial waste management.

Keywords: Textile effluents, Advanced Oxidation Process (AOP), Ozonation, Sand filtration, Soil pollution, Sustainable wastewater treatment.

PP-106

Purity Analysis of Milk Protein by Sds-Page

Rohan Christopher.A[1], Dharsini.T.K[1], Sridevika.M[1], Aarthi Chinnaswamy Ravi[1]*
[1]PG and Research Department of Biotechnology, Dr. N.G.P. Arts and Science College,
Coimbatore – 48, Tamil Nadu, India.
*Email: aarthi.cr@drngpasc.ac.in

Abstract

Milk is a nutritionally rich fluid containing variety of proteins that contribute to its functional and nutritional properties. Major proteins present in milk include caseins and whey proteins such as β-lactoglobulin and α-lactalbumin. The objective of this experiment was analysing the purity and molecular weight distribution of protein(milk) using Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis (SDS-PAGE) under denaturing conditions. SDS-PAGE is a powerful analytical technique used for the separation and characterization of proteins based on the molecular weight. Milk proteins were first extracted and treated with SDS and β-mercaptoethanol to disrupt non-covalent bonds and denature the polypeptide chains. The denatured protein were separated by using Polyacrylamide Gel Electrophoresis based on their molecular weights. After electrophoresis, the gel was stained with Coomassie Brilliant Blue dye to visualize the bands. Bands corresponding to casein, α-lactalbumin, and β-lactoglobulin were observed, confirming presence of milk proteins. The molecular weight of this protein compared with standard protein marker. The specificity and sharpness of these band were high sample purity and unexpected bands indicated contaminants or sample adulteration. The SDS-PAGE result showed that both purity assessment and identification of protein in raw milk, pasteurized milk and powdered milk samples. In conclusion, SDS-PAGE proved to be an indispensable technique for confirming the purity and molecular weight of milk protein under denaturing conditions. This method proves essential for food quality control, biochemical characterization and protein research.

Keywords: Protein, SDS-PAGE, Coomassie Brilliant Blue dye, Adult.

PP-107

Decentralized Bio-composting Systems as Sustainable Solutions for Soil and Air Pollution

Elakiya A[1], Swathi G[1], Godlin sharmi x[1] and Pradeepa D[1]*
[1]Department of Biochemistry, Dr. N.G.P. Arts and Science College, Coimbatore – 641048,
Tamil Nadu, India.
*Email: pradeepa@drngpasc.ac.in

Abstract

Rapid urbanization and population growth have led to a significant increase in solid waste generation, posing major challenges to soil and air quality. Conventional waste disposal practices, such as landfilling and incineration, release greenhouse gases and toxic residues that degrade environmental health. This study explores decentralized biocomposting as a sustainable alternative for managing household organic waste and mitigating pollution. Various biocomposter bins—Samata, Geebin, Omega, Trust, and Bokashi—were evaluated to determine their efficiency in converting organic waste into nutrient-rich compost. Different microbial inocula were tested to enhance the composting process, focusing on parameters such as decomposition rate, odor control, leachate production, and compost quality. Among the tested systems, the Geebin and Samata bins demonstrated superior composting efficiency with minimal odor and balanced moisture retention. The resulting composts were analyzed for physicochemical properties, including pH, moisture, ash content, organic carbon, and NPK composition. In-vitro plant growth assays using *Capsicum annuum* validated the biofertilizer potential of the compost, revealing that a 75% compost-soil mix yielded optimal plant growth. The study concludes that decentralized biocomposting provides an eco-friendly and cost-effective method to recycle organic waste, reduce landfill dependency, lower methane emissions, and enrich soil fertility. By integrating microbial technology and user-friendly biocomposter designs, this approach promotes circular waste management and supports sustainable agriculture. The findings underscore the potential of community-level composting to serve as a scalable model for soil rejuvenation and air pollution reduction, aligning with global sustainability goals.

Keywords: Biocomposting, Decentralized waste management, Soil fertility, Air pollution reduction, Sustainable agriculture.

PP-108

Preparation, Characterization and Biological Activity of Persea americana Leaf Extract Chitosan–Fucoidan Complex Coated with Silver Nanoparticles

Adithya Kumarasamy LV[1], S. Divyapriya[1], Srinivi. S[1]

[1]*Department of Biochemistry, Dr. N.G.P. Arts and Science College, Coimbatore, India.*

*Email: 231bc001@drngpasc.ac.in

Abstract

Polycystic Ovary Syndrome (PCOS) involves oxidative stress, metabolic imbalance, and chronic inflammation. This study presents a chitosan–fucoidan biopolymer complex coated with silver nanoparticles (AgNPs) synthesized using Persea americana leaf aqueous extract and evaluates its therapeutic potential. Phytochemical screening confirmed flavonoids, phenols, tannins, terpenoids, and alkaloids. GC–MS analysis identified key bioactive compounds including thymol, estragole, and long-chain alkanes. Antioxidant assays (DPPH, FRAP, H_2O_2 scavenging, and phosphomolybdate) revealed strong concentration-dependent radical-scavenging activity. Antifungal evaluation showed inhibition zones of 9 mm for Candida albicans and 5 mm for Candida tropicalis. The complex also demonstrated metabolic activity through pancreatic lipase inhibition (86.40%) and α-amylase inhibition (72.56%). Anti-inflammatory assays, including albumin denaturation and heat-induced hemolysis, indicated significant protein stabilization and membrane protection. The combined effects arise from the synergistic interaction of phytochemicals, chitosan, fucoidan, and AgNPs. These results suggest that Persea americana–based nanoparticle formulations are natural, biocompatible candidates for managing oxidative stress, inflammation, metabolic disorders, and PCOS.

Keywords: PCOS; Persea americana; Chitosan–Fucoidan Complex; Silver Nanoparticles; Antioxidant Activity.

PP-109

Synthesis and Characterization of Starch Based Bioplastic from Elephant Foot Yam

Vimal. P[1], Rajathi. K[1]
[1]*Department of Biochemistry, Dr. N. G. P. Arts and Science College, Coimbatore, India.*
*Email: vimalramani98@gmail.com

Abstract

The word plastic derives from the Greek word 'plastikos,' which implies fitted for being shaped or moulded. Plastic has become a catch-all word relating to the wide range of materials made utilizing polymers and additional chemicals that may be moulded and projected into diverse shapes. Polymers can be natural or synthetic; natural polymers include cellulose, protein fibre (silk, wool), and starch. This article describes the production of bioplastics from elephant foot yam using a casting technique and glycerol.

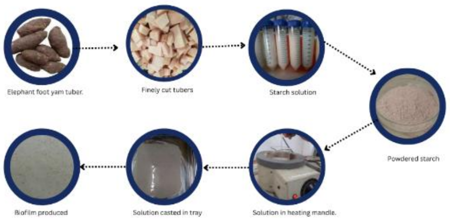


Figure.1 Workflow of synthesis of Bioplastic from "Elephant foot yam"

Keywords: Elephant foot yam, bioplastics, biofilm.

PP-110

Efficacy of Hand Hygiene agents against Resistant Microorganisms (*Streptococcus Aureus* and *Aspergillus niger*)

Madhumitha A[1]* and Lalitha G[1]
[1]*Department of Biochemistry, Dr.N.G.P Arts and Science college, Coimbatore -641048*

Abstract

Our research work is focused for assessing and comparing the Disinfectant efficiency of Ethanol, Dettol handwash, Lifebuoy handwash, Patanjali anti-bacterial handwash and Microbat handwash against Bacteria (*Streptococcus Aureus)* and fungus (*Aspergillus niger)* which can be commonly identified in the Environment. Pathogenic samples obtained were allowed to grow on their respective media and subsequently subjected to Anti-Bacterial and Anti-Fungal tests. The most used disinfectants in labs are ethanol and hand Bleach which has a main constituent of sodium hypochlorite, oxidizes the cell of microorganisms, and attacks the essential components of cells including lipid, protein, and DNA. All the test hand wash displayed observable zones of inhibition of the Pathogens that can cause as Abscesses (boils), furuncles, Respiratory tract infections, etc. hence four of the test hand wash i.e Dettol handwash, Ethanol, patanjali anti-bacterial handwash, microbat handwashes and Ethanol produced zones of inhibition against the microorganisms used in this study. Lifebuoy hand wash does not show inhibitory zones for those microorganisms. This study sheds light on the Inhibitory function of Handwashes against bacterial strains and Fungus growth.

Keywords: Disinfectant, *Streptococcus Aureus*, *Aspergillus niger*, zone of Inhibition.

PP-111

Natural Nano Colorant-Infused Eco-Safe Diapers: A Sustainable Solution for Menopausal Women

Harini. P. H[1], Dr. K. Rajathi[1]*
[1]*Department of Biochemistry, Dr. N. G. P. Arts and Science College, Coimbatore, India.*
*Email: hariniharipprabu@gmail.com

Abstract

According to NCBI, about 36.8% of women aged 50 and above are menopausal, and nearly 75% of them experience hot flashes as a major symptom. This study focuses on developing a safe, eco-friendly, and rash-free diaper specifically for menopausal women using natural and biodegradable materials like *Neem, Turmeric, Orange peel,* and *Banana fiber*. Conventional products often contain chemicals that cause rashes and irritation, so this research aims to create a chemical-free alternative enriched with natural nano colorants and copper nanoparticles to provide antibacterial protection, odor control, and comfort. The diaper's absorbency, skin compatibility, and antimicrobial activity were evaluated to ensure safety and performance. The study highlights the potential of herbal nano components to improve hygiene comfort and promote sustainability, offering a healthier and eco-conscious solution for menopausal women.

Layer view of Diaper **Final view of Diaper**

Keywords: Menopausal women, Eco-friendly diaper, Natural nano colorant, Antibacterial properties, Biodegradable materials.

PP-112

PHYTOGENIC AND BIOCHAR BASED FILTRATION SYSTEMS FOR SUSTAINABLE WATER TREATMENT

Dr.T.Indhumathi[1]*, M.Punithaprincy[1], S.Renugadevi[1]
[1]PG and Research Department of Biochemistry, Dr.N.G.P Arts and Science College, Coimbatore, TamilNadu, India.
*Email: indhumathi@drngpasc.ac.in

Abstract

The present study focuses on the physicochemical analysis and treatment efficiency of dye-contaminated wastewater collected from a textile industry in Tiruppur, Tamil Nadu. The untreated effluent exhibited high levels of pollutants, including elevated total dissolved solids (13,616 mg/L), total suspended solids (568 mg/L), hardness (230 mg/L), turbidity (211 NTU), and an alkaline pH (11.3), rendering it unsuitable for discharge or reuse. To address this issue, a natural, multi-layered filtration unit was developed using eco-friendly and locally available materials such as cotton, coconut shell biochar, vetiver grass, and Canna indica plants. Cotton served as the preliminary filter for coarse particles, while biochar adsorbed dyes and heavy metals. Vetiver roots and Canna indica contributed to phytoremediation, absorbing residual contaminants and stabilizing water quality parameters.Post-treatment analysis showed a remarkable improvement in water quality: total dissolved solids reduced to 4913 mg/L, total suspended solids to 232 mg/L, hardness to 140 mg/L, turbidity to 90.6 NTU, and pH was neutralized to 6.8. Concentrations of iron, calcium, and magnesium also decreased significantly, confirming the system's efficiency. These results demonstrate that the integrated natural filtration system effectively combines physical filtration, chemical adsorption, and biological remediation processes.

In conclusion, this study highlights the potential of using biodegradable and low-cost materials for sustainable wastewater treatment. The developed filtration unit offers an environmentally friendly and economically feasible alternative for managing textile effluents, promoting cleaner production practices and contributing to sustainable water resource management.

Figure1: Filtration bed

Keywords: Wastewater treatment, coconut shell biochar, Vetiver grass, and *Canna indica*.

PP-113

Metal-integrated Hydroxyapatite Nanocomposite: A Sustainable Approach for Wastewater Treatment

Aabeedunnisa[1], Shankara G Radhakrishnan[2*], Ramakanth Illa[1*]
[1]*Department of Chemistry, School of Advanced Sciences, VIT-AP University 522241, AP, India.*
[2]*Department of Chemistry, University of Pretoria, 0002, Pretoria, South Africa.*
*Email: shankara.radhakrishnan@up.ac.za; ramakanth.illa@vitap.ac.in

Abstract

Naturally occurring calcium and potassium-rich materials such as bones, sea shells, egg shells are sustainable means to synthetic hydroxyapatite (HAp). These offer eco-friendly and cheaper means to HAp production while also mitigating the bio-waste into useful materials. While, HAp is known for its extensive biological application, it has also equally important material in environmental remediation [1]. In this, wastewater from industries is a major concern as they release heavy metals, synthetic dyes and other pollutants and often dumped into open drains, lakes, river stream to name a few [2-3]. In particular, effluent from textile industries contain azo dye, the common one being Congo red (CR), a carcinogenic and mutagenic dye, highly water soluble, which poses a significant challenge in its removal from wastewater. HAp being highly porous as well as its unique ion exchange ability makes it a suitable adsorbent for CR.

In this study, biomass-derived Fe/Al-integrated hydroxyapatite nanocomposite was synthesized and characterized using standard techniques such as Fourier transform infrared spectroscopy, Xray diffraction followed by the use of scanning electron microscopy to decipher its morphology. The overall adsorption performance of this nanocomposite on CR was performed and the results indicated an overall efficiency of 83%.

Keywords: hydroxyapatite, adsorption, active sites, impregnation, nanocomposite.

PP-114

Decentralized Bio-composting Systems as Sustainable Solutions for Soil and Air Pollution

Godlin Sharmi. X[1], Pradeepa D[1], Yamuneshwari M[1] and Lalitha G[1*]
[1]*Department of Biochemistry, Dr. N.G.P. Arts and Science College, Coimbatore – 641048, Tamil Nadu, India.*

Abstract

Rapid urbanization and population growth have led to a significant increase in solid waste generation, posing major challenges to soil and air quality. Conventional waste disposal practices, such as landfilling and incineration, release greenhouse gases and toxic residues that degrade environmental health. This study explores decentralized biocomposting as a sustainable alternative for managing household organic waste and mitigating pollution. Various biocomposter bins—Samata, Geebin, Omega, Trust, and Bokashi—were evaluated to determine their efficiency in converting organic waste into nutrient-rich compost. Different microbial inocula were tested to enhance the composting process, focusing on parameters such as decomposition rate, odor control, leachate production, and compost quality. Among the tested systems, the Geebin and Samata bins demonstrated superior composting efficiency with minimal odor and balanced moisture retention. The resulting composts were analyzed for physicochemical properties, including pH, moisture, ash content, organic carbon, and NPK composition. In-vitro plant growth assays using *Capsicum annuum* validated the biofertilizer potential of the compost, revealing that a 75% compost-soil mix yielded optimal plant growth. The study concludes that decentralized biocomposting provides an eco-friendly and cost-effective method to recycle organic waste, reduce landfill dependency, lower methane emissions, and enrich soil fertility. By integrating microbial technology and user-friendly biocomposter designs, this approach promotes circular waste management and supports sustainable agriculture. The findings underscore the potential of community-level composting to serve as a scalable model for soil rejuvenation and air pollution reduction, aligning with global sustainability goals.

Keywords: Biocomposting, Decentralized waste management, Soil fertility, Air pollution reduction, Sustainable agriculture.

PP-115

Removal of dye from effluent by using synthesized composite liquid membrane adsorbent from petroleum waste present in the soil contaminated regions.

Aswaththaman T R[1], Sivagami K[1*]
[1]*School of Chemical Engineering, Vellore Institute pf Technology, Vellore, India.*
[*]Email: sivagami.k@vit.ac.in

Abstract

Leakage of fossil fuels and lubricating oil spills during disposal of waste materials during storage distribution and refining operations can cause major environmental pollution. A series of physio chemical techniques is needed to drastically reduce the magnitude of damage provoked by these pollutants. The objective of this study is to use the adsorption process from composite material obtained from petroleum waste, for effective removal of contaminants from dye contaminated waste water discarded into the ecosystem. Moisture content was removed from the contaminants at 105 degrees for 48 hours by adsorbing into calcium carbonate. Also, it was observed that moisture was able to separate from the contaminated soil, however, CaCO3 was not an effective way to treat lube contaminated soil its hydro phobic properties says otherwise, It can be improved of its oleophilic properties. Moreover, the FTIR analysis of lube oil proved to have aliphatic compounds and poly-cyclic contamination due to continuous use of lube oil in the automobile. Using the TGA, BET, SEM the characterization can be done for composite its effective use in adsorption of PAH dyes from waste water from the dye industry. Particle characterization is done using the Particle size and Zeta potential (DLS) analysis of the composite materials synthesised relates to surface properties of the adsorption. A film layer generated on the micro/meso-porous carbon black synthesized by using waste lube oil.

Meanwhile, adsorption studies revealed effective adsorption and desorption capabilities were analyzed using UV-Vis spectrometry analysis for different concentrations (ppm) of PAH dye compared to carbon black without film layer.

Keywords: PAH, micro/meso-porous carbon black, waste lube oil, poly aromatic Dye adsorption, desorption.

PP-116

g/CeMnO$_3$ Nanozyme as a Dual-Functional Catalyst and Colorimetric Sensor for Lead Ion Detection

A. Koushalya[1], K. Anitha[1*]
[1]*School of Physics, Madurai Kamaraj University, Madurai-625021, India.*
*Email: singlecrystalxrd@gmail.com

This study presents a facile and sensitive colorimetric sensor for the detection of lead (Pb^{2+}) ions based on the oxidase-like activity of Ag/CeMnO$_3$ nanozyme. The synthesized nanozyme was studied with the characterization techniques such as powder X-ray diffraction, UV-Vis spectroscopy, high-resolution transmission electron microscopy, Fourier transform infrared spectroscopy, and field emission scanning electron microscopy. The analysis of the oxidase-like activity reveals enhanced catalytic oxidation of 3,3',5,5'-tetramethylbenzidine (TMB) for Ag/CeMnO$_3$ when compared to CeMnO$_3$ due to the improvement in the production of superoxide radicals. The integration of Ag nanoparticles with CeMnO$_3$ perovskite enhances catalytic activity by efficient electron transfer. Further, the sensing studies show the selective detection of Pb^{2+} ions using Ag/CeMnO$_3$, by the inhibition of its oxidase-like activity. This sensor demonstrates high sensitivity, selectivity, and rapid response toward Pb^{2+}, with a low detection limit of 76 nM. The practical application was done in real water samples from the tap, river and well.

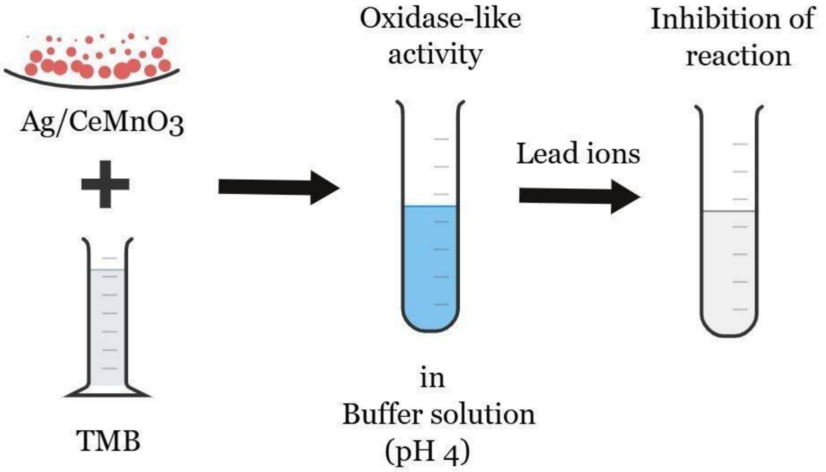


Figure 1. Schematic representation of Pb^{2+} detection by Ag/CeMnO$_3$

Keywords: Ag/CeMnO$_3$, Heavy metals, oxidase mimic, lead, colorimetry.

PP- 117

First-Principles Investigation of a Cost-Effective and Non-Toxic Transition Metal-Based Direct Band Gap Compound for Solar Cell Applications

Gowri Sankar S[1], and Biji Pullithadathil[1*]

[1]Nanosensors & Clean Energy Laboratory, Department of Chemistry & Nanoscience and Technology, PSG Institute of Advanced Studies, Coimbatore-641004, India.

*Email: bijuja123@yahoo.co.in, pbm@psgias.ac.in

Abstract

The search for cost-effective, non-toxic, and earth-abundant materials has become a critical priority in the development of next-generation solar cell technologies. Transition metal-based compounds are particularly attractive due to their tunable electronic structures, chemical stability, and low production costs compared to traditional lead- or cadmium-based materials. In this study, we present a comprehensive first-principles investigation of the direct band gap compound $Ti_{0.75}NiP$ to evaluate its suitability for photovoltaic applications. The calculated solar cell parameters, including a power conversion efficiency (PCE) of 15.35% and a spectroscopic limited maximum efficiency (SLME) of 24%, demonstrate its strong potential for solar energy conversion. The elastic constant analysis confirms its mechanical stability, while phonon dispersion results exhibit only positive frequencies, indicating excellent lattice dynamical stability. Additionally, optical absorption coefficient calculations reveal strong absorption in the visible region and noticeable optical anisotropy, further supporting its suitability for use in optoelectronic devices. These findings suggest that $Ti_{0.75}NiP$, as a cost-effective and non-toxic transition metal-based compound, is a highly promising material for efficient and stable solar cell applications.

Keywords: Density functional theory, Solar cell, Lattice dynamic stability, SLME.

PP- 118

Analyze the Efficacy of *Pennisetum glaucum* Plant Growth Using Organic Biofertilizer

Dr. T. Indhumathi[1],Anisha. T[2], Nethrashree . S[2]

[1]Dr.N.G.P Arts and Science College, Coimbatore, TamilNadu, India.

*Email: indhumathi@drngpasc.ac.in

Abstract

The present study investigates the efficacy of organic biofertilizers on the growth and yield of Pennisetum glaucum (pearl millet), a drought-tolerant cereal crop cultivated widely in arid and semi-arid regions. The overuse of chemical fertilizers in modern agriculture has led to serious environmental concerns such as soil degradation, nutrient imbalance, and reduced microbial diversity. Hence, organic biofertilizers offer an eco-friendly alternative to enhance crop productivity while maintaining soil health. In this research, *Pennisetum glaucum* plants were treated with various organic biofertilizers, including vermicompost, decompost, and panchagavya, either alone or in combination. Growth parameters such as germination rate, plant height, leaf number, and biomass accumulation were recorded and compared with control and chemically fertilized plants. The findings revealed that the use of organic biofertilizers significantly improved soil fertility, microbial activity, and overall plant growth performance. Among the treatments, the combination of vermicompost and panchagavya showed the most promising results in enhancing nutrient uptake and yield. This study concludes that organic biofertilizers are effective, sustainable, and environmentally safe alternatives to chemical fertilizers for promoting *Pennisetum glaucum* growth and supporting long-term agricultural productivity.

Key Words: *Pennisetum glaucum,* organic farming, biofertilizers, vermicompost, decompost, panchagavya, soil fertility, sustainable agriculture.

PP- 119

Functionalized MXene-integrated Thin Films for Efficient Microplastic Removal from Aqueous Systems

Madhubala Kothapalli[1], Ramakanth Illa[1*], and Shankara G. Radhakrishnan[2*]
[1]Department of Chemistry, School of Advanced Sciences, VIT-AP University, Amaravati 522 241 AP, India.
[2]Department of Chemistry, University of Pretoria, Pretoria, 0002, South Africa.

[*]Email: ramakanth.illa@vitap.ac.in, shankara.radhakrishnan@up.ac.za

Abstract

Microplastics (MPs), classified as emerging contaminants, are small plastic fragments less than 5 mm. These emerging contaminants are difficult to manage because they are still unregulated under environmental laws. Thus, they have dispersed into aqueous media, recognised as a potential biohazard, emphasising the need for regulatory and efficient removal approaches. MPs removal from water systems requires the creation of advanced, selective, and durable adsorptive materials. To this end, research has grown significantly, and numerous methods for removing MPs have been proposed. In this study, a flexible and responsive polymer-based nanocomposite thin film integrated with MXene was developed. The structural and thermal characteristics of the film were investigated using XRD, TGA, and FTIR analyses. The viability of this nanocomposite film for its use in MP removal shall be presented and discussed.

Keywords: microplastics, adsorption mechanism, Mxene films, environmental remediation.

PP- 120

Evaluation of Fresh Properties of Geopolymer Concrete using Eco Friendly Bio-Based Foaming Agent

Adithya.K, Renuka S M
Department of Civil Engineering, CEG, Anna University, Chennai, Tamil Nadu, India 600025.
*Email: aadi.rajasekaran@gmail.com

Abstract

This study explores the use of soap nut (Sapindus mukorossi) extract as a natural foaming agent for the development of lightweight geopolymer paste. The binder such as fly ash(FA), ground granulated blast furnace slag (GGBFS), and lime were activated by a combination of sodium hydroxide and sodium silicate solutions. The incorporation of soap nut(Natural Foaming Agent), rich in saponins, developed a stable foam thereby reducing the bulk density of the hardened paste. Preliminary tests were carried out to assess the fresh properties (flowability, foam stability, setting behaviour of the paste). The study emphasizes that natural foaming agent using soap nut has a wide range of applications due to its unique properties and adaptability. By providing this comparative analysis with synthetic foaming agent the research offers valuable insights for both researchers and industry professionals on the effectiveness and sustainability of natural foaming agents as viable alternatives to achieve best construction practices. The results indicated that soap nut-based foam produced a uniform pore distribution, leading to significant reductions in density compared to control mixes. Although the compressive strength decreased with increasing foam content, the produced material showed promising characteristics for lightweight construction applications. The findings highlight soap nut as a sustainable and bio-based alternative to synthetic foaming agents in geopolymer technology, supporting the development of eco-friendly lightweight construction materials.

Key Words: soap nut, geopolymer, sustainable, lightweight.

PP- 121

Green Synthesis of Zinc Oxide Nanoparticles Using *Prosopis juliflora* for Antibacterial and Wound Healing Textile Applications

Muneeswaran A.[1], Dr. K. Rajathi[1] and Elna Bijo Kuriappuram[1]*
[1]Department of Biochemistry, Dr. N.G.P. Arts and Science College, Coimbatore, India.
*Email: 24pgbch0004@drngpasc.ac.in, rajathi@drngpasc.ac.in

Abstract

This study focuses on the eco-friendly synthesis of zinc oxide nanoparticles (ZnO NPs) using aqueous leaf extract of *Prosopis juliflora*, an invasive plant rich in bioactive phytochemicals. The synthesized ZnO NPs were characterized by SEM, XRD, and FTIR analyses, confirming their hexagonal wurtzite structure and stable morphology. Cotton fabric treated with these nanoparticles via the pad-dry-cure method exhibited significant antibacterial activity against

Escherichia coli and Staphylococcus aureus, demonstrating zones of inhibition comparable to standard antibiotics. An in-vitro scratch assay revealed enhanced fibroblast migration and accelerated wound closure, indicating superior wound healing potential. The use of *P. juliflora* not only provides a sustainable route for nanoparticle synthesis but also aids in valorizing an invasive species. This green approach offers a cost-effective and biocompatible strategy for developing multifunctional biomedical textiles suitable for wound dressings and antimicrobial healthcare materials.

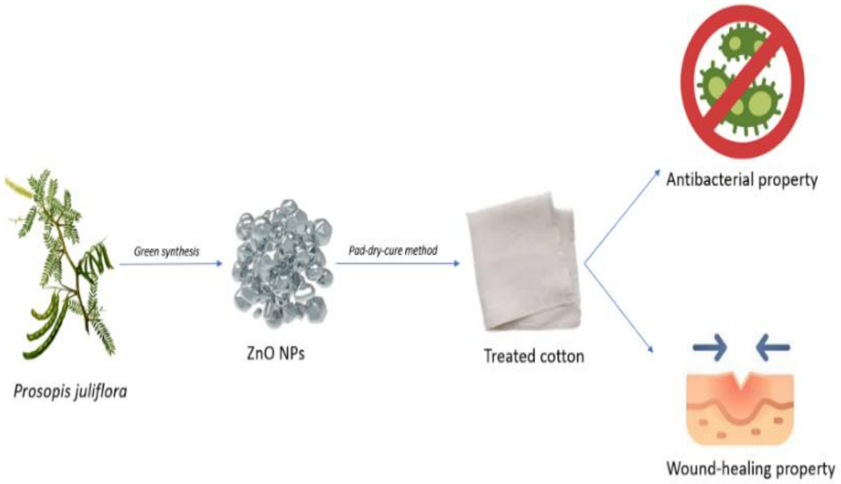


Figure 1. Schematic illustration of the green synthesis of zinc oxide nanoparticles (ZnO NPs) using *Prosopis juliflora* leaf extract, their incorporation into cotton fabric via the pad-dry-cure method, and the resulting antibacterial and wound-healing properties of the treated textile.

Keywords: Zinc oxide nanoparticles, *Prosopis juliflora*, Green synthesis, Antibacterial textiles, Wound healing.

PP- 122

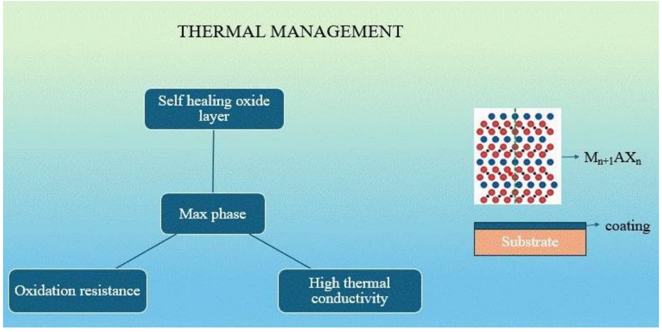
Next - Generation Thermal Management: The Role of Max Phase Coatings

Aruna Devi M[1] and B. Geetha Priyadarshini[1*]
[1]*Nanostructured Surfaces and Thin Films Lab, PSG Institute of Advanced Studies, Coimbatore, Tamil Nadu 641004, India.*
*Email: bgp@psgias.ac.in

Abstract

Efficient thermal management has become a critical requirement in advanced technologies such as aerospace, energy conversion systems and high-power electronics, where materials are often exposed to extreme temperatures and oxidative environments. Traditional coating materials including oxides and carbides, often face thermal shock resistance and structural degradation under prolonged exposure. MAX phase materials have recently gained attention as a promising material for next generation thermal management coatings. MAX phases are represented by general formula $M_{n+1}AX_n$ (n = 1,2,3). These phases are family of nano

laminated ternary nitrides and carbides, where M is an early transition metal, A is an A- group element and X either carbon or nitrogen. MAX phase exhibits a unique combination of metallic and ceramic properties. These materials are resistant to oxidation and corrosion, stiff, high thermal and electrical conductivity and machinable. This combination of properties makes MAX phase very interesting for high temperature applications. Coatings based on MAX phases such as Ti_2AlN, Ti_3SiC_2, have demonstrated the ability to form stable, self-healing oxide layers that protect substrates from thermal degradation. This study focuses on understanding the role of MAX phase coatings in enhancing heat resistance and oxidation protection and performance in harsh thermal environments.



Key words: Role of MAX phase, self-healing oxide layer, high thermal conductivity.

PP-123

Piezo, Photo and piezo-photocatalytic properties of triazine carbon nitride towards the degradation of ciprofloxacin

E.V. Anjana[1], Anjali Vinay[1], P. Haripriya[1] and Darbha V. Ravi Kumar[1,2*]
[1]Department of Chemistry, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, India.
[2]Biosensor Research Lab, Amrita School of Engineering Coimbatore, Amrita Vishwa Vidyapeetham, India.
[*]Email: vrk_darbha@cb.amrita.edu, darbhavravikumar@gmail.com

Abstract

$g-C_3N_4$ (g-CN) exhibits variable photocatalytic activity depending on its structural and compositional modifications. These modifications include elemental doping, changes in crystallinity, surface area, and more recently, alterations involving triazine and heptazine ring structures. Among these, carbon nitride containing triazine rings, known as poly (triazine imide) (PTI), has emerged as a new class of carbon nitride material. This study investigates the photo-, piezo-, and piezo-photocatalytic activities of PTI for ciprofloxacin degradation, with results compared to those of unmodified g-CN. PTI demonstrates higher piezocatalytic activity than g-CN, while g-CN shows superior photocatalytic performance. These contrasting behaviors highlight the potential for constructing homojunctions with enhanced catalytic efficiency.

PP-124

Synthesis of MoO_3 nanostructures for ammonia sensing applications

D. Sudha[1], K. Uthayarani[*1], N. Neelakandeswari[2], M. Chitra[1], K. Jeyadheepan[3] and E. K. Girija[4]
[1]*Department of Physics, Sri Ramakrishna Engineering College, Vattamalaipalayam, Coimbatore, 641022, India.*
[2]*PG Department of Chemistry, Nallamuthu Gounder Mahalingam College, Pollachi, 642001, India.*
[3]*School of Electrical and Electronics Engineering, SASTRA University, Tirumalaisamudram, Thanjavur 613401, India.*
[4]*Department of Physics, Periyar University, Salem - 636011, Tamilnadu, India.*
[*]Email: uthayarani.karunakaran@srec.ac.in

Abstract

Ammonia (NH_3) detection is essential and vital for industrial safety and environmental protection. Molybdenum trioxide (MoO_3) is one of the most promising semiconducting metal oxides, particularly for gas sensing applications. In this work, orthorhombic molybdenum oxide (α-MoO_3) nanostructures are prepared by hydrothermal technique using urea surfactant. The prepared sample is characterized by XRD, FESEM, EDAX, UV-vis DRS and FTIR. The gas sensing properties of MoO_3 sensor is investigated in the presence of 25 ppm of various analytes such as ethanol (C_2H_5OH), trichloroethylene (C_2HCL_3), formaldehyde (HCHO), ammonia (NH_3), toluene ($C_6H_5CH_3$) in vapour form. The sensing responses measured at different concentration levels of NH_3 ranging from 1 ppm to 75 ppm at room temperature. Moreover, the MoO_3 sensor shows highest sensing responses towards ammonia NH_3 (9.02 towards 4 ppm) with response and recovery times of 77 and 144 s, respectively at room temperature. The sensing mechanism of α-MoO_3 to ammonia is also discussed.

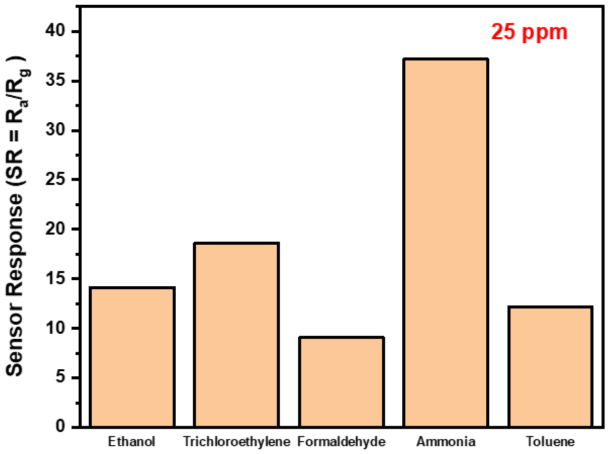


Figure 1. Selectivity plot of MoO_3 Sensor

Keywords: α-MoO_3, hydrothermal, chemiresistive sensor, ammonia sensing, gas sensing.

PP-125

Thin-film hydrovoltaic device with surface charge engineering based on an activated carbon-PVDF composite

Athulya Ravindran[1], Sreejith P Madhusudanan[2], Sudip K Batabya[1,2]*

[1] *Department of Physics, Amrita School of Physical Sciences, Coimbatore, Amrita Vishwa Vidyapeetham, India.*

[2] *Center of Excellence in Advanced Materials and Green Technologies, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, India.*

*Email: batabyal@cb.amrita.edu

Abstract

In the realm of sustainable and eco-friendly power technology, energy harvesting from hydrovoltaic devices for power generation has garnered a lot of attention. In this work, a thin-film hydrovoltaic power generator with low mass loading operating in ambient circumstances is shown. The creation of a low-cost, high-performance hydrovoltaic power generator using a composite material made of polyvinylidene fluoride (PVDF) and activated carbon (AC) obtained from bio-derived sources has led to the proposal of a revolutionary design. Despite being hydrophobic, the PVDF was added to take advantage of its capacity to increase the material's electronegativity when it interacts with solvents and functions as a binder, producing hydrovoltaic effect. A peak output of more than 1 V and an average output were effectively generated by the device that resulted from optimising the weight ratio of PVDF with AC. The device that resulted from optimising the weight ratio of PVDF with AC was able to generate a maximum power output of 14 µW/cm2, an average current of 50 µA, and a peak output exceeding 1 V. Dropping a single drop of water on top of the device after a predetermined length of time can simultaneously sustain the generated electricity. The device demonstrated its potential for real-time and practical applications by presenting the critical capacity to resume power output after 30 days of inactivity.

Keywords: Hydrovoltaics, surface charge engineering, sustainable electricity generator, water evaporation, supercapacitor, reusability.

PP-126

Universal-MLIP-Guided Design of Cu_2ZnSnS_4 (CZTS) Functionalized -Carbon Nanofibers Based Electrochemical sensor for Ammonium Ion Detection for Water Quality Monitoring

Divya Sreetha Murugan[1], Athira Suresh[1], Gowri Sankar Saju[1], Biji Pullithadathil[1]*
[1]Nano sensors & Clean energy Laboratory, Department of Chemistry & Nanoscience and Technology, PSG Institute of Advanced Studies, Coimbatore-641004, India.
*Email: pbm@psgias.ac.in

Abstract

Electrochemical methods for detecting ammonium ions are crucial for assessing the environmental impacts of water pollution and for elucidating nitrogen cycling processes within ecosystems. In this investigation, porous Cu_2ZnSnS_4 (CZTS) functionalized carbon nanofibers (CNFs) have been synthesized and demonstrated its potential in detecting ammonium (NH_4^+) ions in water. Hydrothermally grown CZTS nanoparticles on the surface of electrospun carbon nanofibers were characterized by Raman, XRD, SEM, and TEM. Prior to experimental analysis, four MLIP-based computational models were employed to evaluate the CZTS-NH_4^+ interaction, all consistently predicting favourable binding energy. This U-MLIP prediction was further corroborated by experimental verification confirming the favourable interaction between CZTS and ammonium ions. The porous nanostructures of CZTS-decorated CNFs possess abundant active sites for NH_4^+ ion adsorption. The CZTS@CNFs is expected to be one of the promising sensing elements for the electrochemical detection of NH_4^+ ions for water quality monitoring applications.

Keywords: Ammonium ions, carbon nanofibers, Aquaculture, Electrochemical sensor, U-MLIP.

PP-127

Pigmented, Self-Cleaning Superhydrophobic Coatings for Environmental Applications

Athira Suresh[1], Navami Sunil[1], Shalini.H.Jogee[1], Raghavi M[2], Biji Pullithadathil[1]*
[1]Department of Chemistry & Nanoscience and Technology, PSG Institute of Advanced Studies, Coimbatore-641004.
[2]PSGR Krishnammal College for women, Peelamedu, Coimbatore-641004.
*Email: pbm@psgias.ac.in, bijuja123@yahoo.co.in

Abstract

Superhydrophobic surfaces exhibit a contact angle greater than 150°, which significantly reduces water adhesion, leading to self-cleaning effects. The superhydrophobic property was achieved by creating optimum surface roughness and modifying surface with low surface energy material. Moreover, various metallic pigments were used for imparting colours to the superhydrophobic coatings on various substrates adapting simple spray coating method. These protective coatings, produce micro- and nanoscale surface patterns that trap air and reduce the amount of water contact with the underlying surface and thereby significantly reduces the dust particles stick onto the surface. Polyurethane (PU) materials have gained significant attention for their potential in superhydrophobic applications due to their exceptional water-repellent properties. The versatility of functionalized polyurethane allows for tailoring surface characteristics, such as roughness and chemical composition, to achieve optimal superhydrophobic performance the incorporation of PU derivatives can enhance the compatibility of PU with various substrates, broadening its application range. Furthermore, pigmented formulations offer UV-resistant, heat-reflective, or infrared-selective surfaces, which enhance building thermal management and reduce the need for cooling energy. Additionally, these coatings prolong material life and reduce resource consumption by lowering surface fouling and corrosion in industrial equipment, which helps to create a more sustainable and clean built environment.

Keywords: Superhydrophobic, Polyurethane, Surface modification, Self-Cleaning, Pigmented Coatings.

PP-128

Integrated Polymeric Nanocarrier for Drug Delivery and Bioimaging Application

Jofel Jose J[1], Chandirasekar S [1,2*]
[1] Functional Polymers and Nanophotonics Lab, Department of Nanoscience and Technology, PSG Institute of Advanced Studies, Coimbatore-641004, Tamil Nadu, India.
[2] Department of Chemistry, PSG Institute of Technology and Applied Research, Neelambur, Coimbatore - 641 062, Tamil Nadu, India.
*Email: scs@psgias.ac.in

Abstract

A hybrid polymeric micelle- fluorescent gold nanocluster system is reliable for both the encapsulation of drug and tracking of drug delivery processes. Polymeric micelles are typically formed from amphiphilic block copolymers, which consist of hydrophilic and hydrophobic segments. The hydrophobic segments aggregate to form a core, while the hydrophilic segments form a shell that stabilizes the micelle in aqueous environments. These micelles self-assemble in aqueous solutions when the concentration exceeds the critical micelle concentration (CMC), allowing for encapsulation of hydrophobic drugs within the core. Noble Metal nanoclusters (NCs) consist of tens of atoms possessing size <2 nm, which is comparable to the Fermi wavelength of electrons. In this aspect, we have synthesized chitosan-poly (DL-lactide) amphiphilic block copolymer through ring-opening polymerization of DL-lactide and fluorescent gold nanoclusters (AuNCs) were synthesized using chitosan-poly (DL-lactide) as stabilizing agent. The synthesized polymers were characterized using FT-IR spectroscopy. The optical properties of the chitosan-poly (DL-lactide) templated gold nanoclusters (AuNCs) were characterized using UV-visible and fluorescence spectroscopy. The sizes and oxidation state of the AuNCs were measured using High-resolution transmission electron microscopy (HR-TEM) and X-ray photoelectron spectroscopy (XPS) respectively.

Keywords: Micelles, Nanoclusters, CMC, Fluorescence.

PP-129

Crystal facet isotype junctions over tetragonal (010)/(001)-BiOBr: Deciphering the polar functional facet exposure factor towards photo exciton transfer dynamics

Samrat[1], Basudev Baral[1], and Akshaya K Samal[1*]

[1]Centre for Nano and Material Sciences, Jain University, Jain Global Campus, Ramanagara, Bangalore, 562112, India.

[*]Email: s.akshaya@jainuniversity.ac.in

Abstract

Scrupulous architecture of functional catalyst with tweaked polar redox facets alongside tuned phase crystallinity, active surface area and microstructural hierarchy evidenced to alter photo-exciton migration dynamics owing to altered opto-electronic attributes. Core studies on the mechanistic insight of the nature of exciton channelization cum separation over polar facets have opened a novel, unmapped realm of crystal facet engineering. (Mi et al., 2018) In this regard, diverse synthetic tactics, incorporating co-precipitation (BiOBr-CP), calcination (BiOBr-Cal) and hydrothermal treatment (BiOBr-HT1 and BiOBr-HT2), have been employed to fabricate assorted hierarchical morphologies of highly crystalline tetragonal Bismuth Oxybromide (BiOBr) with varying redox facet exposure factors and altered surface atomic configuration. The findings have been impeccably demonstrated via employing transmission electron microscopy analysis, X-ray diffraction, Fourier transform infrared spectroscopy, field emission scanning electron microscopy analysis and DFT studies. (Meng et al., 2021) The analytical upshots revealed superior photocatalytic proficiency of the BiOBr-HT2 {010/001} facet isotype heterojunction (Figure 1) toward norfloxacin (NFC) detoxification (66.3%, 120min) relative to the contemporary counterparts. Nevertheless, photoelectrochemical inferences have well validated such constructive outcome to be solely a consequence of elevated exciton generation, injection and separation owing to deteriorated charge transfer resistance and increased relative hole-free time owing to an elevated exciton anti-recombination. (Shi et al., 2020) The current research proliferates through a labyrinth of scientific insights, unfolding the role of controlled redox facet exposed nanostructures towards altered photoexciton-separation promoted catalytic activity and unfolds a new dominion for impending fundamental research.

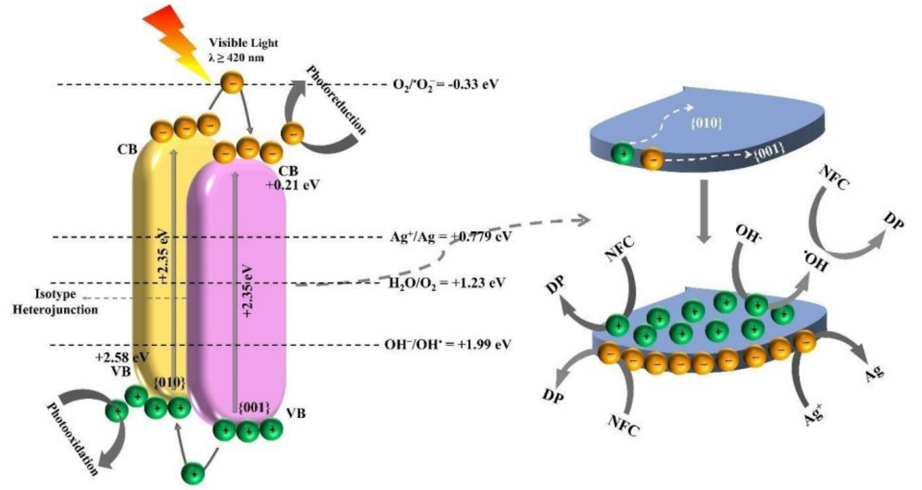


Figure 1. Graphical Illustration of Exciton Transfer Dynamics over a {010/001}-BiOBr Crystal Facet Isotype Junction.

Keywords: {010/001}-BiOBr, Crytal Facet Engineering, Exciton Transfer Dynamics, Photocatalysis.

PP-130

Dual-Functional ZnO Quantum Dot Modified Graphitic Carbon Nitride for Efficient Photoelectrochemical Water Splitting and Dye Degradation

Gayathri K[1], G. Sathiyan[1,2*]

[1] *Department of Chemistry, PSG Institute of Advanced Studies, Coimbatore-641 004, Tamil Nadu, India.*

[2] *Department of Chemistry, PSG Institute of Technology and Applied Research, Coimbatore-641062, Tamil Nadu, India.*

*Email: gsn@psgias.ac.in

Abstract

The development of efficient photocatalysts for solar energy conversion is crucial for addressing energy and environmental challenges. In this study, graphitic carbon nitride (GCN) was modified with zinc oxide quantum dots (ZnO-QDs) to construct a heterojunction photocatalyst for dye degradation and photoelectrochemical (PEC) water splitting. The ZnO-QDs were synthesized by the traditional sol-gel method, and GCN/ZnO-QDs heterojunctions were prepared through physical mixing of ZnO-QDs in three different weight percentages (10%, 20%, and 30%). The resulting heterojunctions were subjected to detailed structural, morphological, optical, and photoelectrochemical characterizations. The XRD and XPS analyses confirmed the successful formation of GCN/ZnO-QDs heterojunctions, while microscopic observations revealed uniform dispersion of ZnO-QDs on the GCN surface. The photocatalytic performance was evaluated using Rhodamine-B dye degradation, and the GCN/ZnO-QDs (20%) composite exhibited the highest photocatalytic efficiency (88.42%), outperforming pristine GCN (36.9%) and ZnO-QDs (60.9%). The enhanced photocatalytic activity can be attributed to increased light absorption and efficient charge separation that suppress electron-hole recombination. The electrochemical impedance spectroscopy further indicated a lower charge transfer resistance (500 Ω) for the heterojunction compared to pristine GCN (800 Ω), signifying improved electron-hole separation. Moreover, linear sweep voltammetry revealed a photocurrent density of 2.25 mA cm^{-2} for the GCN/ZnO (20%) heterojunction, demonstrating rapid carrier transfer and strong photoresponse. These results suggest that the optimized GCN/ZnO heterojunction exhibits enhanced photocatalytic and photoelectrochemical properties, making it a promising material for wastewater treatment and other photocatalytic applications.

Keywords: Quantum dots, Graphitic carbon nitride, Photocatalyst, Photoelectrode, Heterojunction.

PP-131

Hydrogen valleys as a new paradigm for holistic piloting of green hydrogen ecosystem

Prashant Kumar Singh[1*], **Saroj Kumar Nayak**[1*]
[1]*Odisha Hydrogen Valley Foundation (as applicable), India Institute of Technology Bhubaneswar, Khordha, Odisha, India.*
*Email: prashantksingh@iitbbs.ac.in, nayaks@iitbbs.ac.in

Abstract

The Hydrogen Valley Innovation Cluster (HVIC) is a first-of-its-kind concept in India, developed and monitored by the Department of Science and Technology, and funded by the Ministry of New and Renewable Energy under National Green Hydrogen Mission. HVICs are established to demonstrate the complete Green Hydrogen value chain-encompassing production, storage, transportation, and applications. Odisha Hydrogen Valley Foundation (OHVF), set up by Indian Institute of Technology Bhubaneswar, is the unique HVIC under this Scheme in Eastern India and is focused on piloting the complete green hydrogen value chain at ~100 ton/annum scale. One among ~100 hydrogen valleys across globe, the facility, infrastructure, and technical expertise of Odisha Hydrogen Valley shall act as demonstration platform for potential gH2 ecosystem adopters, benchmarking for newer technologies, as well as techno-commercial feasibility analysis. Importantly, our specific application focus area is mining and metallurgy including iron production. As the country is taking a giant leap and is poised towards being a developed nation by 2047, there will be accelerated requirement of iron to develop necessary infrastructure to drive fast paced development. Considering Iron production is a hard to abate sector for decarbonization, linking various methodologies of green hydrogen production in conjunction with CO_2 free 'iron production innovation' will have a positive impact on net CO_2 emission reduction.

Keywords: Hydrogen Valley, Green Hydrogen, green DRI, hard to abate sectors, decarbonization.

PP-132

Geospatial and Biomass-Based Assessment of Carbon Sequestration Potential in an Urban Academic Campus

Liketha S[1], Chandran R[1*], and Nandhika N[1].

[1]Department of Environmental Science, PSG College of Arts & Science,
Coimbatore 641-014, Tamil Nadu, India.
[*]Email: chandran@psgcas.ac.in

Abstract

Urban campuses play a crucial role in mitigating climate change by enhancing green cover and promoting sustainable carbon management. This study quantifies carbon storage in the trees of PSG College of Arts & Science, Coimbatore, through species identification, block-wise geospatial mapping, and biomass-based carbon estimation. A total of over 2,500 trees representing 34 plant families were assessed using standard biomass equations incorporating above-ground and below-ground components. Statistical analysis using SPSS (Version 21) revealed a strong positive correlation ($r = 0.726$, $p < 0.01$) between species diversity and CO_2 sequestration potential. Independent samples tests showed significant differences in carbon storage between edible and non-edible tree groups, while native and non-native species exhibited no statistically significant variation. Age-wise analysis indicated that trees aged 5–40 years contributed maximally to carbon capture. Block-wise evaluation identified the G Hostel and Academic Blocks as key carbon-rich zones, whereas the STP and Hall areas require prioritized afforestation. The study highlights the substantial carbon sequestration capacity of the campus (2,397.80 tons of CO_2) and emphasizes the need for enhanced native species planting, green hotspot conservation, and continuous carbon monitoring. The findings position educational institutions as critical contributors to urban climate resilience and sustainable ecosystem management.

Keywords: Carbon sequestration, Species diversity, Urban campus ecology, Biomass estimation, Sustainability strategies.

PP-133

Acetonitrile-degrading halophilic aerobic granular sludge: de novo granulation, biodegradation, nitrogen and phosphate removal pathways

Anuroop Singh[1,2], Y.V. Nancharaiah[1,2*]

[1]Biofouling and Biofilm Processes Section, Water & Steam Chemistry Division, Bhabha Atomic Research Centre, Chemistry Group, Kalpakkam – 603 102, India.
[2]Homi Bhabha National Institute, Anushakti Nagar, Mumbai – 400 094, India.
[*]Email: yvn@igcar.gov.in

Abstract

Aerobic granular sludge offers an emerging superior technology compared to the existing biological wastewater treatment systems, given its larger particle size, dense microbial

structure, superior settling properties, biodegradation capabilities, and higher tolerance to emerging pollutants (Nancharaiah and Sarvajith 2019). Granules are commonly cultivated from preexisting activated sludge as inoculum; however, they can be grown using waterborne microbes, a technique which is less explored (Sarvajith & Nancharaiah, 2020). In this study, halophilic aerobic granules are cultivated from seawater-borne microbes by feeding acetonitrile as the sole source of carbon and nitrogen. Granulation was achieved with particle sizes of about 1.2 mm, and SVI_5 71±2.7 ml/g. TOC removal was stabilized at 93.3±3% [Fig.1]. Release of ammonium accompanied acetonitrile biodegradation and TOC removal. Partial nitrification-denitrification pathway removed the released ammonium; however, incomplete removal of ammonium led to its accumulation up to 120 mg/L. Phosphate fed as inorganic phosphate (15.7±0.6 mg/L PO_4^{3-}-P) was removed through enhanced biological phosphate removal pathway with removal of 78±7.1 %. Alpha diversity index indicated a reduction and moderation of bacterial community during granulation. Stable granules were dominated by *Proteobacteria* (64%). This study provided first evidence on de no granulation of seawater-borne microbes and acetonitrile (emerging pollutant) biodegradation.

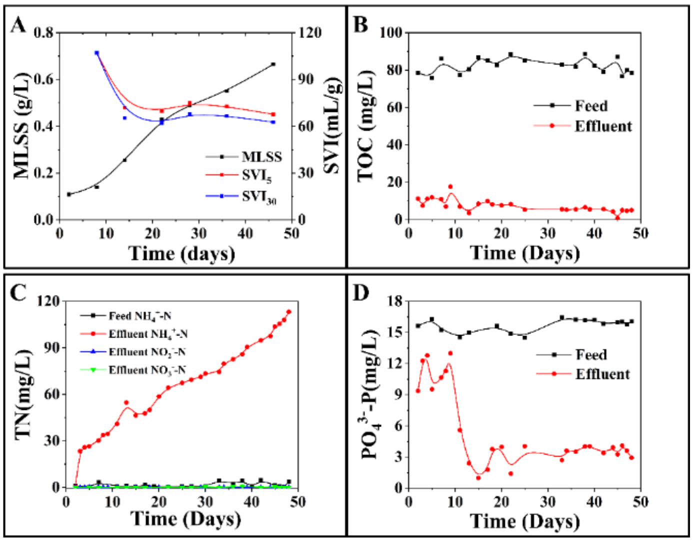


Figure 1. Experimental results from a 3-litre bioreactor operated in sequencing batch reactor mode with a 6 h cycle time and fed with acetonitrile as the sole C and N source. A) Granulation, B) TOC removal, C) Nitrogen release, D) Phosphate removal.

Keywords: Aerobic Granules, Bioremediation, Emerging Pollutants, Microbial Granulation, Wastewater Treatment.

PP-134

Sustainable Valorization of Fly Ash through Green Acid Leaching for Synthetic Mullite Production

Vinayak Arun Sankar Vijayasankar [1*], Vinopaul Kirubhagaran B[1], Shahid Karna M[1] and Mohana Shrihari S[1]

[1]*Karpagam College of Engineering, Coimbatore, India.*

[*]Email: arunsankar@kce.ac.in

Abstract

Coal-based thermal power plants generate a massive amount of fly ash as by product, which is usually dumped in landfills and disposed in ocean, causing serious environmental issues like air and water pollution and reduce the quality of soil. Even though fly ash contains valuable materials such as alumina (Al_2O_3) and silica (SiO_2), it is mostly treated as waste. This paper deals with converting waste into useful product by using a green and sustainable process. To extract alumina and silica, citric acid and oxalic acid that are categorised as green acids are used instead of conventional mineral acids like sulphuric and nitric acid. These green acids are biodegradable, safe to handle and ecofriendly. The process starts with treating and sieving fly ash to get fine particles, followed by green acid leaching to dissolve the useful components. By changing the pH value of green acid, the silica gel and aluminium hydroxide are separated from fine particles, which are then purified, and heated to form pure silica and alumina powders. Pure silica and alumina powders are mixed in a 3:1 ratio and heated again around 1500°C to produce synthetic mullite. Synthetic mullite are strong ceramic material that can be used as refractories and as heat resisting shield in aerospace applications. This process offers a simple and eco-friendly solution for small scale industries. This will help to manage or to reduce industrial waste into valuable product with real market potential. This process will reduce pollution by reusing industrial by product in a sustainable and efficient manner.

Keywords: fly ash, green acid leaching, sustainability, alumina, silica.

PP-135

Low-Cost Sponge-Based Moving Bed Bioreactor (MBBR) for Treatment of Landfill Leachate: A Case Study

Devika Venu[1*], Roumi Bhattacharya[2], and Tanya Sonker[2]

[1]*Civil Engineering Department, Mar Athanasius College of Engineering,* [2]*Civil Engineering Department, Indian Institute of Technology Delhi, India.*

[*]Email: devikavenu.phd@gmail.com

Abstract

Treatment of landfill leachate through low-cost and environmentally sustainable technology is still a challenging issue. Moving Bed Bioreactor (MBBR) offers a promising approach in this regard with reduced inhibitory effect of toxic contaminants in leachate on microorganisms. The study evaluates the application of a sponge-based MBBR for treating landfill leachate collected from Brahmapuram Solid Waste Management Facility located in Kerala, India. Characterization study was conducted to establish baseline pollutant profiles, including chemical oxygen demand (COD), ammoniacal nitrogen (NH_4-N), pH, and total suspended solids (TSS). Elevated levels of COD (4590 mg/L), TSS (24950 mg/L), and NH_4-N (1530 mg/L) confirm the highly polluted nature of the leachate. Sponge as bio-carrier material provides high biofilm attachment surface due to its porous structure along with buoyancy for effective mixing and significantly reduced material costs and reusability potential. The lab-scale sponge-based MBBR was monitored over a period of 2 months. Under stable operating conditions, removal efficiency of 62%, 53% and 37% were observed for COD, TSS, and NH_4-N, respectively. The study confirms the effectiveness of MBBR as a promising technology in resource-constrained settings with no secondary pollution although it cannot be used as a standalone reactor to reduce the pollutants within safe disposal limits.

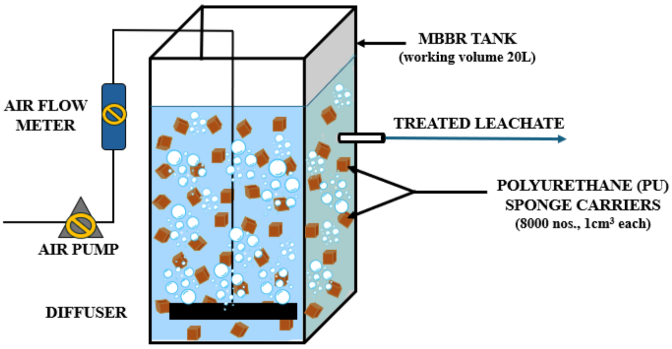


Figure 1. Schematic Representation of the lab-scale Moving Bed Bioreactor with PU sponge carriers.

Keywords: landfill leachate, moving bed bioreactor, attached growth system, COD removal, NH_4-N removal.

PP-136

Ruthenium-based macromolecular complexes for application in organic photovoltaics

Srikanth Bhuvanagiri[1], Rajarshi Sarkar, Natasha Kotzé[2], Supriyo Halder[3], Henrietta W. Langmi[2], Shankara G. Radhakrishnan[2*], Dripta De Joarder[1*]
[1]*Department of Chemistry, School of Advanced Sciences, VIT-AP University, Amaravati 522 241 AP, India.*
[2]*Department of Chemistry, University of Pretoria, Pretoria, 0002, South Africa.*
[3]*Department of Chemistry, Jadavpur University, Kolkata 700106, India.*
[*]Email: shankara.radhakrishnan@up.ac.za, dripta.joarder@vitap.ac.in

Abstract

In order to cope with the ever-growing energy demand and in mitigating the dependence on the fossil fuels have seen a global shift towards renewable energy resources and storage forms. In this, solar energy harvesting has been one of the key research areas however the only silicon-based single crystalline solar cells have made their way into the end-user market. On the other hand, organic photovoltaic (OPV) systems have posed a significant potential in replacing the

single crystalline systems and have their footprint as third generation solar cells which are aimed at reducing costs and efficiency of the solar energy harvesting. In this dye sensitized solar cells (DSSCs) are heavily researched systems since its original invention owing to their versatility in preparation, stability and as a cheaper alternative to the 1st and 2nd generation of OPVs.

The heart of a of dye-sensitized solar cell is a photosensitizer that usually comprises of macromolecular dye which and in this ruthenium-based dyes are most investigated owing to their exceptional redox and photophysical behavior. Further, the ligands that can be used to form these dyes are myriad allowing for the finetuning of their absorption into required wavelength range of the visible spectrum thus influencing their charge transfer behavior and hence the power conversion efficiencies of a DSSC device.

In this study, terpyridine-based ruthenium complexes were prepared and characterized. Their redox behavior and a plausible application into as a sensitizer in DSSCs have been explored. The findings of this work will be discussed in the presentation.

Keywords: organic photovoltaics, ruthenium complexes.

PP-137

Synthesis and characterization of bio-based low cure chalcone based polybenzoxazines for UV light shielding and hydrophobic coating

Praba Nagarajan[1], Latha Govindaraj[1], Balaji Krishnaswamy[1]

[1]*Department of Chemistry, PSG Institute of Technology and Applied Research, Coimbatore, India.*

*Email: latha@psgitech.ac.in

Abstract

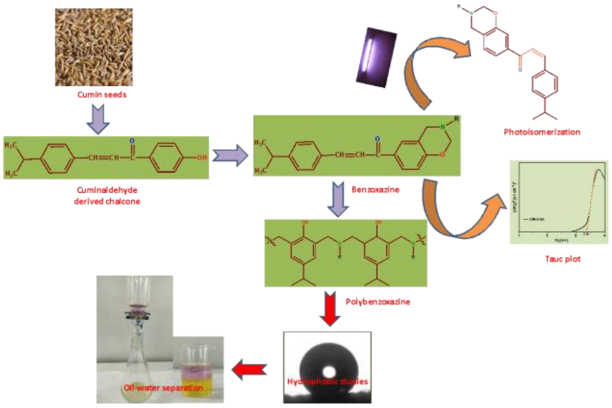
A bio-based chalcone containing phenol, 1-(4-hydroxyphenyl)-3-(4-isopropylphenyl)prop-2-en-1-one (HIP) was synthesized through Claisen-Schmidt condensation using precursors cuminaldehyde and p-hydroxyacetophenone. Using HIP, four benzoxazine monomers were developed using different amines namely, aniline, octadecyl amine, dodecyl amine and furfuryl amine through Mannich condensation reaction and were assigned as CM-AN, CM-ODA, CM-DDA and CM-FFA. The structural confirmation of the HIP, benzoxazine monomer and polymer was done using High resolution mass spectroscopy, Attenuated total reflection-fourier transform infrared spectroscopy and proton nuclear magnetic resonance spectroscopy. The UV-

Abstract

Visible spectroscopy was used to study the optical properties and it confirms that the photo reactive moiety (α,β-unsaturated ketone) present in developed HIP undergoes photoisomerization upon UV exposure. The tauc plot was employed to assess the optical band gap. These findings were helpful in determining the electrical properties and found that the synthesized monomers lie under the category of wide gap semiconductor. The evaluated band gap for corresponding monomers are 3.47ev, 3.37ev, 3.43 ev and 3.41ev. The hydrophobic study was carried out through water contact angle measurements. Among the four developed polymers, poly(CM-ODA) obtained the higher water contact angle value of 145°. The

hydrophobic behaviour of poly(CM-ODA) suggested for utilizing in oil-water separation process and the separation efficiency was found to be 96 %.

Graphical abstract



Keywords: Benzoxazine, Chalcone, UV-Visible spectroscopy, Tauc plot, Hydrophobic studies.

PP-138

Metabolic Engineering of Lachancea Kluyveri Using Cre Loxp Method

Harinitha sri. P[1], Shalini. K[1], Shruthi. S[1], Saranya. S[1*]
[1]PG and Research Department of Biotechnology Dr. N.G.P. Arts and Science College, Coimbatore – 48, Tamil Nadu, India.
[*]Email: Ssaranya@drngpasc.ac.in

Abstract

Lachancea Kluyveri is an ascomycetous yeast associated with fruit flies, slime fluxes, soils and foods. The habitat of *L.Kluyveri* is not well known because only about 30 isolates have been recorded. It is, however, thought to be environmentally widespread. First described as *Saccharomyces Kluyveri* in 1956 from fruit flies in California, this species has been isolated from slime fluxes on tree, soils in North America and Europe. This species is thought to have diverged from the *Saccharomyces* lineage and has an 11.3 Mb genome organized into 8 chromosomes. *L.Kluyveri* makes a more efficient use of glucose for energy production. However, for efficient utilization of xylose from lignocellulosic biomass, this work attempts to integrate heterologous Xylose utilizing genes. In this work, the XYL-1 gene from the xylose utilization pathway of S. stipilus is inserted into the URA3 locus of *L.* kluyveri using the cre-*loxP* system. The initial steps involved the amplification of the Xyl-1 gene fragment of S.stiplilus, 1kb upstream and downstream region of the URA3 gene locus and the high expression promoter along with the loxp region with hygromycin and kanamycin antibiotic markers. Since L.kluuyveri is a diploid organism so both the alleles were targeted for XYL-1 gene integration. After the amplification of all the fragments, the electroporation method was performed to transform these fragments inside the organism. The cells were revived for 3 hours after transformation and then plated into respective selective plates. The colonies appeared in the selective plates after 2-3 days; correct transformants were analyzed using colony PCR, for which one primer was taken from the antibiotic cassette and the other primer was taken from the genomic region of L.kluvyveri. In the positive colonies, another transformation was attempted in a similar way but using different antibiotic cassette to target 2nd allele of the organism. After colony PCR 3 colonies came positive, which indicates that in these 3 colonies XYL-1 gene was integrated in both the alleles. Further marker removal transformation was done result was formed. The same process of XYL 2 was done and the result was examined. Marker was removed.

Keywords: *Lachancea Kluyveri,* Kanamycin, cre-*loxP,* Colony PCR, Marker.

PP-139

Photocatalytic Decontamination of Endosulfan Using La-Doped ZnO Nanofibers: A Sustainable Approach to Mitigate Soil Pollution

Arul Meena S[1], Nivetha G[1] and Pradeepa D[1*]
Department of Biochemistry, Dr. N.G.P. Arts and Science College, Coimbatore – 641048, Tamil Nadu, India.
[*]Email: pradeepa@drngpasc.ac.in

Abstract

Soil pollution caused by persistent organochlorine pesticides such as endosulfan poses a severe threat to environmental and agricultural sustainability. This study focuses on the synthesis and application of lanthanum (La)-doped zinc oxide (ZnO) nanorods immobilized on polyacrylonitrile (PAN) nanofibers for the photocatalytic degradation of endosulfan. The PAN nanofibers were fabricated using the electrospinning technique, and La-doped ZnO nanorods were synthesized via a hydrothermal method. The structural and morphological features of the nanocomposites were characterized using FTIR, XRD, SEM, and EDX analyses, confirming uniform coating and rod-like morphology of the catalyst. Photocatalytic experiments were conducted under UV irradiation to evaluate degradation efficiency, with parameters such as catalyst concentration, pH, and pesticide dosage optimized for maximum performance. The results indicated a 98% degradation efficiency of endosulfan within one hour, as confirmed by UV-Vis spectrophotometry and HPLC analyses. Phytotoxicity assays demonstrated reduced toxicity of the degradation products, validating the environmental safety of the treated samples. The free radical scavenging studies further confirmed the role of hydroxyl radicals in the mineralization process. The findings establish that La-doped ZnO-PAN nanofiber composites are highly efficient, reusable, and eco-friendly photocatalysts capable of decomposing hazardous pesticides under mild conditions. This sustainable nanotechnology-based approach provides a promising solution to remediate pesticide-contaminated soils and protect ecosystems, aligning with the goals of green chemistry and sustainable soil management.

Keywords: Endosulfan degradation, Photocatalysis, La-doped ZnO nanofibers, Soil pollution, Sustainable remediation, Nanotechnology.

PP-140

Phytoremediation of Mercury Using the Aquatic Fern *Azolla Microphylla*

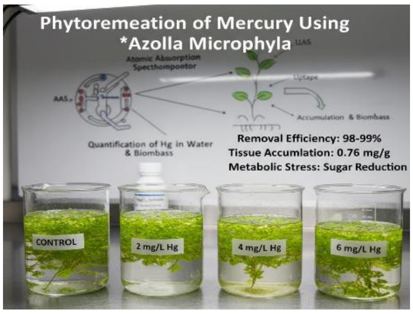
M. Roshini jenshiya[1], Vimal. C[1], Dr. N. Kannikaparameswari[1] *

[1]Department of Biochemistry, Dr. N. G. P. Arts and Science College, Coimbatore, India

*Email: roshininilla@gmail.com

Abstract

Heavy metal contamination by mercury (Hg) represents a major ecological and health concern due to its persistence and bioaccumulation. The aquatic fern *Azolla microphylla* was evaluated for its phytoremediation efficiency in mercury-contaminated water under concentrations of 2, 4, and 6 mg/L $HgCl_2$ for seven days. Mercury levels in water and plant biomass were quantified using Atomic Absorption Spectrophotometry (AAS). A. microphylla exhibited a removal efficiency of 98–99% with tissue accumulation reaching 0.76 mg/L. Biochemical analyses indicated marked reductions in total soluble sugars, reducing sugars, non-reducing sugars, and starch, reflecting mercury-induced metabolic stress. The results demonstrate the high potential of A. microphylla as a bio accumulator for mercury remediation. Appropriate disposal of heavy-metal biomass is necessary to avoid secondary contamination.



Keywords: Phytoremediation, Mercury contamination, Azolla Microphylla, Bioaccumulation, Heavy metals.

PP-141

Bio-functional Ellagic Acid–Zr MOF/Bacterial Cellulose Hybrid Matrix for Environmental Detoxification of p-Nitrophenol

Harikrishnan M[1], R. Kumar[2], and K. Kadirvelu*[1]

[1]DRDO Industry Academia Centre of Excellence, Bharathiar University, Coimbatore, India

[2]Defence Institute of Biodefence Technologies, Mysore, India.

*Email: kadirvelukrishna@yahoo.com

Abstract

The development of sustainable hybrid materials for environmental detoxification is of increasing significance. In this study, an ellagic acid-based zirconium metal organic framework (EA–Zr-MOF) was synthesized v hydrothermal route using zirconium dioxide as the metal node and ellagic acid as the organic linker, with acetic acid employed to regulate pore architecture. The bacterial cellulose (BC) matrix used for hybrid fabrication was biosynthesized by *Acetobacter xylinum* under static fermentation conditions, yielding a highly pure, nanofibrous cellulose pellicle. To improve mechanical integrity and dispersibility, the MOF was embedded into a BC matrix, forming a bio-functional EA-Zr-MOF@BC hybrid. The physicochemical characterization of the materials using XRD, FTIR, SEM, TGA, and BET confirmed the three-dimensional porous network, abundant hydroxyl functionalities, high surface area, tuneable porosity, good thermal stability. SEM imaging revealed the presence of columnar MOF crystal aggregates uniformly distributed across the BC nanofibers resulting hybrid composite. Adsorption and catalytic reduction revealed that the EA–Zr-MOF@BC hybrid matrix efficiently reduced to p-nitrophenol (PNP), a hazardous organophosphorus contaminant, into less toxic p-aminophenol and was validated through UV-Vis spectral shifts. These findings establish the EA–Zr MOF@BC composite as a robust, sustainable, and catalytically active platform for advanced environmental detoxification and water purification technologies.

Keywords: Ellagic acid–Zr-MOF, Bacterial cellulose hybrid, p-Nitrophenol reduction, Environmental remediation, detoxification.

PP-142

Low temperature Ammonia gas sensing based on MoS_2 nano structures on Si/SiO_2

Suvarna Ganesh[1], Alex Mathew[1], Asha A S[2], Siril V S[3] and Reshmi R[1*]

[1] *Optoelectronicand Nanomaterials Research Laboratory (ONRL), Department of Physics, Union Christian College, Aluva, Kerala India- 683102.*

[2] *Nanomaterials for Emerging Solid State Technology Laboratory (NEST), Department of Physics, Cochin University of Science and technology, Kochi, Kerala, India -682022.*

[3] *Departtment of Instrumentation, Cochin University of Science and Technology, Kochi, Kerala, India -682022.*

[*]Email: rrreshmi@gmail.com

Abstract

The increasing population and industrial expansion had witnessed a drastic threat to environment due to release of toxic gases like NH_3 ,NO_2, CO etc results in high air pollution. The main cause of pollutants are industrial emissions, vehicle exhaust and open burning of garbage waste. There is an urgent need to address this issue of monitoring the environment pollution. Hence a low temperature, stable and sensitive sensor with sub ppm detection level is the need of the hour.2D TMDs like MoS_2 WS_2 have attracted tremendous interest for sensing applications due to their high surface to volume ratio, wide range of chemical compositions and their unique thickness - dependent physical and chemical properties.Here we demonstrates the development of a low temperature NH_3 gas sensor using MoS_2 thin film on Si/SiO_2 by Chemical Vapour Deposition (CVD). The surface morphology and elemental composition of the MoS_2 thin film were characterized by FESEM, XRD and Raman. The sensing was tested for 60 ppm of NH_3 at 30^0C and 60^0C. An increase in response from 15% to 64% was found to

correspond with a rise in operating temperature. A relative response of 49% was obtained at 60^0C for 100 ppm of NH_3 with a response and recovery time of 3 s and 225 s respectively.

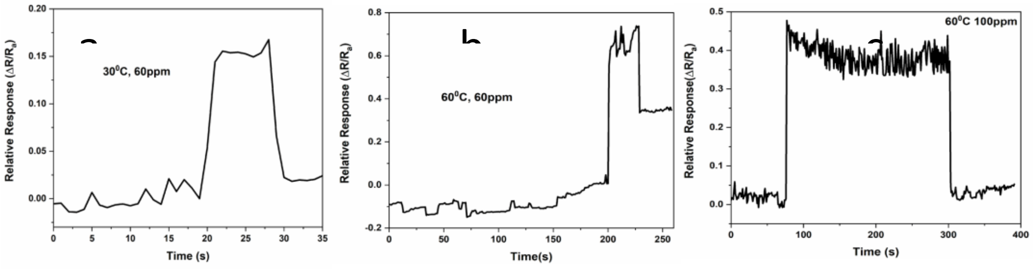


Figure 1. Response of MoS_2 for 60 ppm NH_3 gas at a) 30^0C b) 60^0C and c)100 ppm NH_3 gas at 60^0C.

Keywords: 2D TMDs, Thin film, Chemical Vapour Deposition, NH_3 gas sensor.

PP-143

A comparative study on the photocatalytic performance of g-C_3N_4 synthesized using various exfoliation methods for visible-light-driven organic dye degradation

Freddy Solomon S[1], Abinash Das[1]
[1]*Department of Physics, PSG Institute of Advanced Studies, Coimbatore, India.*
*Email: abinashnitsmsc@gmail.com

Abstract

Globally, water pollution is one of the major concerns. As per CNN's 2023 report, textile industry alone accounts for 20% of industrial waste water globally. Photocatalytic degradation of dyes is one of the methods to treat waste water in which the reaction takes place under room temperature and pressure. Graphitic carbon nitride (g-C_3N_4) is a two dimensional, visible light active, low cost and eco-friendly photocatalyst [1]. Bulk g-C_3N_4 has low photocatalytic performance due to low surface area and faster recombination of electron-hole pairs. Exfoliation of bulk g-C_3N_4 into thin sheets is one of the strategies to improve the photocatalytic performance of g-C_3N_4 [2]. In this work, we present a comparative study about the photocatalytic performance of bulk g-C_3N_4 and g-C_3N_4 exfoliated using different methods like acid exfoliation, sonication assisted exfoliation, microwave assisted exfoliation and thermal exfoliation for waste water treatment using Rhodamine B as probe pollutant. Among the samples examined, the photocatalytic performance of thermally exfoliated g-C_3N_4 was found to be better than the other samples.

Keywords: Exfoliation.

PP-144

Metal Ferrite composite for Non-Photonic Degradation of Azo dye

Hepzibah Anto[1], Rajakani Paramasivam*

[1]Research Department of Chemistry, V.O.Chidambaram College, Tuticorin – 628008, Tamil Nadu.

*Email: prkvoc@gmail.com

Abstract

A Metal ferrite (MFe_2O_4) nanocomposite was synthesized via coprecipitation method and investigated as an efficient catalyst for the non-photonic degradation of azo dyes under simple stirring conditions. Unlike conventional photocatalysts that require external light sources, the MFe_2O_4 composite exhibited remarkable degradation activity in the absence of irradiation, demonstrating its potential for ambient wastewater treatment. The structural and optical properties of the material were characterized, confirming the formation of a stable spinel structure with strong dye–catalyst interaction. UV analysis for degradation of azo dye using MFe_2O_4 composite on its own achieves nearly complete removal of Azo dye within about minutes when operated under stirring. Such behavior mirrors observations which have demonstrated fast azo-dye degradation within minutes under mild conditions. The composite achieved high degradation efficiency, highlighting its effectiveness, energy-saving operation, and environmental compatibility. This study establishes metal ferrite composites as a promising, sustainable route for the remediation of dye-contaminated wastewater.

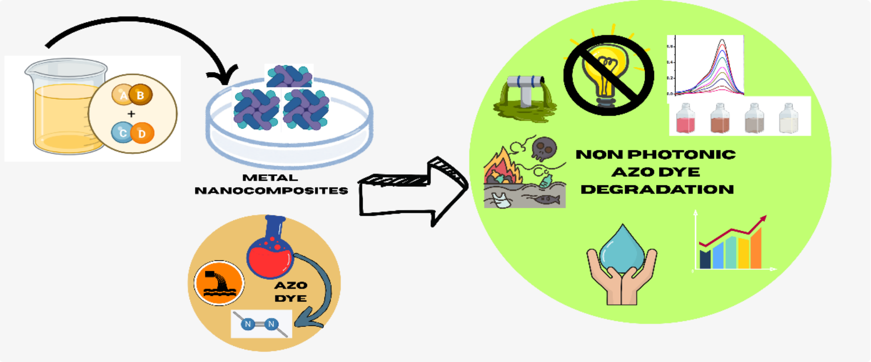


Figure. 1 Graphical representation of azo dye degradation using metal ferrite nanocomposites

Keywords: Metal ferrite, Azo dye, Nonphotonic degradation, Wastewater remediation, Spinel nanocomposite.

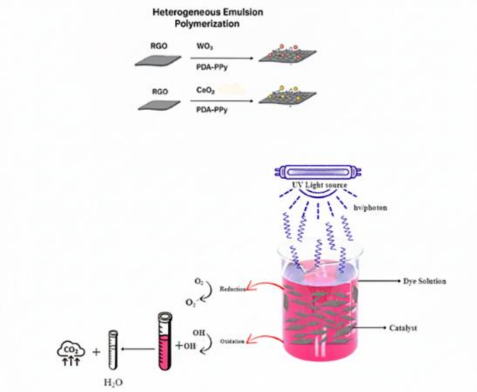
PP-145

Photocatalytic degradation using RGO based nanocomposite

T. JeyaSri[1] and P. Rajakani[1]
[1]PG and Research Department of Chemistry, V.O.Chidambaram College,
Tuticorin-628008, Tamil Nadu.
*Email: prkvoc@gmail.com

Abstract

Surface area and surface-active sites is important in the improvement of the photocatalytic activity of the semiconductor nanomaterials. Incorporation of reduced graphene oxide (RGO) is synthesized by the Hummer's method which enhances the separation of charges, adsorption, and transportation of electrons. Previous research found that RGO/WO_3 nanostructures degraded 94% of Rhodamine B dye in 210 minutes in the sunlight [1], and WO_3/CuO/RGO composites degraded 93.1% in 90 minutes in the UV-visible light [2]. Comparatively, hydrothermal synthesized RGO/CeO_2 composites exhibited almost 99% degradation of dye because of inhibited recombination of electrons and holes and shorter band gaps [3,4,5]. Based on these results, novel PDA-PPy, RGO/WO_3/PDA-PPy and RGO/CeO_2/PDA-PPy were synthesized using heterogeneous emulsion polymerization and extensive physicochemical characterization was used to verify the synthesized material. Photocatalytic activities were tested using RhB dye under UV-visible light irradiation, the optimal operational factors were catalyst dose, initial dye concentration and pH. RGO/WO_3/PDA-PPy demonstrated 94.3% RhB degradation in 40 minutes under UV-visible light, and RGO/CeO_2/PDA-PPy demonstrated complete 100% RhB degradation in just 25 minutes. These findings prove that RGO-incorporated metal oxide/PDA-PPy nanocomposites are potential photocatalysts in efficient dye degradation, non-toxic wastewater purification and textile dye pollution.



Keywords: Metal oxide, RGO, dye degradation, physiochemical characterization, heterogeneous emulsion polymerization.

PP-146

Exploring the Potential of Bi-Directional Charging for EV Cars in India: Consumer Perceptions, Challenges and Awareness

Vijaya Vardhan Manchala[1*], Sooryaprakash M[1]
[1] PSG Institute of Management, PSG College of Technology, Coimbatore, India.
[*]Email: vmanchala@psgim.ac.in

Abstract

The objective of this study is to evaluate the feasibility of its implementation in India through understanding the consumer perceptions, awareness, key challenges in implementation and the benefits. This study follows the quantitative approach to understanding EV and non-EV user's consumer perceptions of V2X technology and their underlying motivation to accept or reject it. The Unified Theory of Acceptance and Use of Technology (UTAUT) model is used in this study to understand how people accept and use technology. The data is collected through structured questionnaire; a total of 261 valid responses were used to perform the analysis. SEM analysis along with correlation, mediation and T test are performed to analyze the responses. The findings of the study concluded that BDC adoption is achievable in India through collaboration between various stakeholders along with awareness initiatives and incentives from Government. Bi-Directional charging is a technology with which an electric vehicle can receive electricity from the grid and send it back if needed. It is not an entirely new concept to the world as Western countries already have this technology in their electric cars but not in India.

Keywords: Bi-Directional charging, V2X, V2H, V2G, Electric Vehicles (EVs), SEM, Consumer perceptions, Adoption intent, Awareness, Financial compensation, UTAUT model.

PP-147

Investigation of Photocatalytic Performance by Glycine-Assisted Synthesized La_2FeCoO_6 for Environmental Remediation

Harithalakshmi R[1] and Dr. Y .Vidyalakshmi[1*]
Department of Physics, CEG, Anna University, Chennai, Tamil Nadu, India 600 025.
[*]Email: yvlakshmi69@yahoo.com

Abstract

Photocatalysis, a sustainable and energy-efficient technique of water treatment, may break down resistant organic pollutants such as colors when exposed to light. Rapid recombination of photo-generated electron-hole pairs is a typical constraint in photocatalysis, lowering photocatalytic effectiveness and restricting the use of visible light. La2FeCoO6's double perovskite structure allows for a tunable bandgap and excellent stability, making it perfect for absorbing visible light. The double perovskite was synthesized in this study utilizing a glycine-assisted auto-combustion process, and its photocatalytic potential in environmental remediation was then studied. X-ray diffraction (XRD) structure and phase analysis revealed the emergence of a monoclinic P21/c perovskite phase. Fourier-transform infrared spectroscopy (FTIR) revealed unique vibrational bands indicating metal-oxygen bonding, confirming the effective development of the perovskite phase. UV-Vis spectroscopy exhibited strong absorption in the visible spectrum and yielded a band gap energy of 1.97 eV, indicating possible activation under visible light. The breakdown of malachite green dye was assessed using both natural sunlight and a controlled laboratory photo reactor to determine La2FeCoO6's photocatalytic efficiency. The material demonstrated excellent degradation performance, reaching full dye degradation in 60 minutes under sunlight and 90 minutes in the photo-reactor. This study confirms that La2FeCoO6 double perovskite is a potential photocatalyst activated by visible light for dye removal in wastewater treatment applications.

Key Words: Double perovskite, Photocatalysis, Malachite green, Glycine-assisted auto combustion.

PP-148

2D Nanostructured NiCo Layered Double Hydroxide Based Electrochemical Sensor for Trace Level Detection of Pb(II) in Complex Water Matrix

Shankar Ram Ramakrishnan[1,2,3], Ramakrishnan Vishnuraj [2,3], Tilesh Sanjay Chaudhari[2,3,5], Kannankuzhiyil Surjith [2,4], G. S. Amal[2,3], Murali Rangarajan [2,3,6*]
[1]*Research Group Applied Electrochemistry and Catalysis (ELCAT), University of Antwerp, Universiteitsplein 1, Wilrijk 2610, Antwerp, Belgium.*
[2]*Center of Excellence in Advanced Materials and Green Technologies, Amrita School of Engineering Coimbatore, Amrita Vishwa Vidyapeetham, India.*
[3]*Department of Chemical Engineering and Materials Science, Amrita School of Engineering Coimbatore, Amrita Vishwa Vidyapeetham, India.*
[4]*Department of Chemistry, Amrita School of Physical Sciences Coimbatore, Amrita Vishwa Vidyapeetham, India.*
[5]*Creative and Advanced Research Based on Nanomaterials (CARBON Lab), Department of Chemical Engineering, Indian Institute of Technology, Hyderabad – 502285, India.*
[6]*Gurukripa Electrolyzers Private Limited, Coimbatore 641046, India.*
*Email: r_murali@cb.amrita.edu

Abstract

The presence of heavy metal ions in water resources is highly pernicious and makes the water unfit for human consumption. The water needs to be monitored for over-exposure to such contaminants, especially Pb (II). A reliable electrochemical sensor based on transition metal-based bimetallic layered double hydroxide, NiCo-LDH modified on a copper substrate, has been developed for ultra-trace detection of Pb(II) ions in water. The formation of NiCo LDH was confirmed using various characterisation techniques to deduce the morphology, composition, structural, thermal, and electronic properties. This material with hexagonal structure and an equiatomic mixture of Ni and Co ions distributed between both the divalent and trivalent forms of the ions was drop-cast on a copper substrate to sense Pb(II) by means of Square Wave Anodic Stripping Voltammetry (SWASV). The sensor exhibited a linear range of 0.3ppb-10ppb, a sensitivity of 0.461 μA/ppb, with a limit of detection of 101.6 ppt and the relative standard deviation of 1.29% during reproducibility studies. In the presence of other interferents, the current deviation was within 4.5% of the original current and tap water samples showed a recovery close to 100%, suggesting that NiCo LDH is a promising sensor material for detecting Pb (II) in complex water matrices.

Keywords: Heavy metal ions, Layered Double Hydroxide, NiCo LDH, Square Wave Anodic Stripping Voltammetry, Pb (II) sensing.

PP-149

Electrochemical Oxidative Degradation of Acetaminophen using Nanostructured α-Fe_2O_3 on Nickel Foam: Optimization and Comparative Framework with g-C_3N_4 Composites

G S Amal[1,2], Murali Rangarajan[1,2 *]
[1]*Department of Chemical Engineering and Materials Science, Amrita School of Engineering, Amrita Viswa Vidyapeetham, Ettimadai, Coimbatore, Tamilnadu, India.*
2 Center of Excellence in Advanced Materials and Green Technologies, Amrita Viswa Vidyapeetham, Ettimadai, Coimbatore, Tamilnadu, India.
*Email: r_murali@cb.amrita.edu

Abstract

Acetaminophen (paracetamol) has emerged as a widespread pharmaceutical pollutant in aquatic ecosystems, necessitating development of innovative treatment technologies. This investigation examined the electrochemical removal of acetaminophen using nanostructured iron(III) oxide (α-Fe_2O_3) electrocatalysts that were uniformly coated onto nickel foam substrates. The α-Fe_2O_3 nanoparticles were prepared through hydrothermal methodology and subsequently immobilized on pretreated nickel foam via dip-coating to produce high surface area electrodes. Electrochemical characterization involved linear sweep voltammetry and chronoamperometric measurements conducted in a three-electrode setup with silver/silver chloride reference, platinum counter electrode, and the coated foam as working electrode. Pharmaceutical concentration quantification was performed through ultraviolet-visible spectrophotometry at 254 nanometers. Systematic optimization experiments independently varied pH (range: 2.0–8.0), applied potential (range: 100–300 millivolts vs. Ag/AgCl), and treatment duration (range: 0–240 minutes) maintaining 100 milligrams per liter acetaminophen feed. Optimized operational parameters were determined: 300 mV vs. Ag/AgCl, pH 3.0, and 2.5 minute duration, achieving 99.5% removal efficiency. Investigation of concentration-dependent behavior across concentrations from 10–100 milligrams per liter revealed inverse relationships: removal efficiency decreased proportionally to initial concentration reductions, while required treatment time increased accordingly. Triplicate experimental runs confirmed excellent reproducibility. The α-Fe_2O_3/g-C_3N_4 nanocomposite has been successfully synthesized and fully characterized. Planned investigations include direct comparative studies between pristine and composite electrocatalysts operating under identical conditions to establish whether composite formulations provide superior performance.

Keywords: Acetaminophen; Electrochemical oxidation; α-Fe_2O_3; Nickel foam; Nanocomposites; g-C_3N_4; Wastewater treatment.

PP-150

A First Principles Study on Ti_3 Cluster Substituted 2D-Goldene for the Detection of Respiratory Biomarkers

Surya Nagarathinam Senthilkumar[1]**, and Senthilkumar Lakshmipathi**[1*]
[1]*Department of Physics, Bharathiar University, Coimbatore 641 046, Tamil Nadu, India.*
[*]Email: lsenthilkumar@buc.edu.in

Abstract

Respiratory diseases, such as COVID-19, influenza, and dengue, are highly contagious and spread rapidly. These diseases are associated with volatile organic compound (VOC) biomarkers, such as heptanal, toluene, acetaldehyde, butanal, and ethyl butyrate. Therefore, early diagnosis is crucial to prevent disease progression and control transmission. In this study, the sensing mechanism of monolayer (ML) two-dimensional Goldene and a Ti_3 cluster-substituted Goldene was systematically explored using Density Functional Theory (DFT) to evaluate their potential as noninvasive VOC sensor materials. The optimized structure of the sensing material is shown in Fig. 1. The biomarkers used are CO, NO, and Acetaldehyde, which are associated with distinct respiratory diseases [4,5]. Both MLs exhibit a metallic nature and remain stable at T=300 K, as studied from AIMD (ab initio Molecular Dynamics (AIMD) analysis. The adsorption energy (Eads) ranged from -2 to -4 eV for the biomarkers that exhibited chemisorption over the MLs. The overall sensitivity of the biomarkers increased after doping 2D-goldene with Ti_3 clusters. Therefore, we anticipate that Ti_3 cluster-engineered 2D-Goldene will be an efficient sensing material for respiratory disease biomarkers.

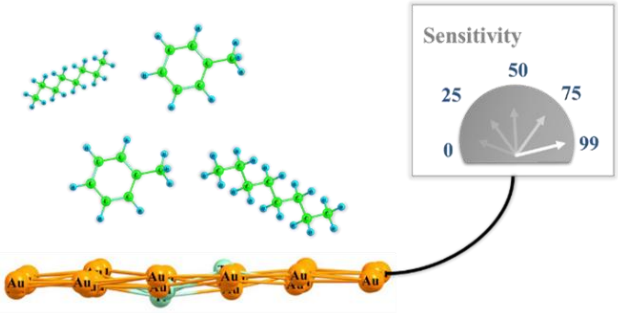


Figure 1. Schematic Representation of Sensing Mechanism.

Keywords: DFT, 2D materials, biomarkers, NEGF, optical properties, gas sensors.

PP-151

Air quality and impact of physiological and Biochemical parameters of tree species

Rupa. P
Department of Chemistry, Coimbatore Institute of Technology, Coimbatore-14.
*Email: rupa@cit.edu.in

Abstract

Industrial activity is also responsible for the release of various pollutants into the environment, especially to the atmosphere. Trees play an important role to monitor and control pollutants present in the air and improve the quality of air. Plants response to air pollution load vary between species. The present study aimed at the determination of Air pollution tolerance index of different plants in the industrial area by computing the physiological and biochemical parameters namely, relative water content, leaf extract pH, ascorbic acid content, and leaf chlorophyll content of different trees in the SIDCO industrial area. Based on the air pollution tolerance index grade results Tabernaemontana divaricata,Magnolia champaca were the tolerant species.Jasminium sambac,Syzygium cumini,Hibiscus rosa sinensis,Annona squamosa and Phyllanthus emblica were identified as sensitive species to air pollution. The tolerant species during the study were identified as the indicators of pollution acting as a sink to dangerous disease causing pollutants. By the way of plantation of tolerant native species with good APTI value,recommendation to develop a good and effective green belt around the industrial area is possible to monitor the prevailing air quality and minimize air pollution.

Key words: Industrial area, Monitor, Air pollution, APTI value, Green belt.

PP-152

The Green Shift in Leather: Environmental Evaluations of Plant-Based Innovations

Jeevitha.P[1], Sanjana. R[1] and Dr J Banu Priya[1]
[1]Department of Costume Design and Fashion, PSG College of Arts & Science, Coimbatore.
*Email: jeevithaponnuswamy@gmail.com

Abstract

Increasing environmental concerns have propelled the development of plant-based leather alternatives as sustainable substitutes for conventional animal leather. Lifecycle analyses indicate that plant-based leathers considerably reduce greenhouse gas emissions, water usage, and land demand. Unlike traditional leather, which results from resource-intensive livestock farming and employs environmentally harmful chromium-based tanning, plant-based leathers utilize renewable agricultural byproducts such as pineapple leaves, mushroom mycelium, cactus, and fruit residues. These materials offer improved biodegradability, lower carbon footprints, and reduced landfill waste. The avoidance of animal agriculture also curtails methane emissions and biodiversity loss. Nevertheless, challenges persist in sustainable scale-up, ensuring product durability, and minimizing the use of synthetic polymers that can compromise biodegradability. Ongoing advancements in bio-fabrication and chemical transparency are critical to surmounting these barriers and fostering circular production models. Overall, plant-based leathers present a promising avenue to mitigate the environmental impacts of the leather industry. Their increasing integration into fashion, automotive, and lifestyle sectors signifies a pivotal shift towards environmentally responsible materials aligned with global climate objectives.

Keywords: Plant-based leather, Environmental sustainability, Biodegradability, Greenhouse gas emissions.

PP-153

A novel way to tune the shape and boosting the Cu nano/microstructures.

A. S. Diya[1], Niyatha Venugopal[1], Darbha V Ravi Kumar[1,2*]
[1]*Department of Chemistry, Amrita School of Physical Sciences, Coimbatore, Amrita Vishwa Vidyapeetham, India.*
[2]*Biosensor Research Lab, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, India.*
*Email: vrk_darbha@cb.amrita.edu, darbhavravikumar@gmail.com

Abstract

Anisotropic copper nano/microstructures exhibit direction-dependent growth, enabling unique shapes and structures with tuneable physicochemical properties useful in electronics, optics, and catalysis. In particular, Cu nanowires are promising materials for transparent conductive and flexible optoelectronic devices, and controlling their morphology is critical for tailoring performance. Halide ions act as shape-directing agents, with iodide known to transform 1D Cu nanowires into 2D microplates. In this study, the effect of different halide sources on the morphology of Cu nano/microstructures was systematically investigated. The resulting structures were further evaluated as catalysts for $NaBH_4$ hydrolysis, selected due to its high hydrogen storage capacity (10.8 wt%) and low toxicity. Distinct Cu morphologies obtained in different halide media exhibited markedly different catalytic efficiencies, attributed to variations in surface area and exposed facets. These findings provide insight into halide-mediated shape control and offer a pathway toward designing cost-effective copper-based catalysts for efficient hydrogen generation.

PP-154

Graphene Oxide Based Delivery of Phloridzin Enhances Cytotoxicity and Apoptosis in MCF-7 Breast Cancer Cells

Poongodi Thirumoorthy[1], Sharmila Chandran [1*]

[1] Department of Physics, PSGR Krishnammal College for Women, Coimbatore, TN, India.

[*]Email: sharmilac@psgrkcw.ac.in

Abstract

Breast cancer remains a major global health concern, and current therapies are often limited by toxicity, poor drug bioavailability, and resistance. Nanocarrier systems such as graphene oxide (GO) offer high surface area, tunable functional groups, and strong drug-loading capacity. Phloridzin, a natural flavonoid with anticancer potential, suffers from low stability and solubility. This study investigates GO-based nanoparticles as an improved delivery platform for phloridzin in MCF-7 breast cancer cells. Phloridzin-loaded GO nanoparticles (GO-PHL NPs), with and without chitosan coating, were synthesized and characterized using SEM, FTIR, particle size analysis, and zeta potential measurements. In vitro drug release behavior, cytotoxicity, and cellular uptake were evaluated. Apoptosis induction was confirmed through DAPI/PI fluorescent dual staining. GO-PHL NPs exhibited uniform nanoscale morphology, stable surface charge, and sustained release of phloridzin. Compared to free phloridzin, GO-PHL NPs significantly enhanced cytotoxicity and cellular internalization in MCF-7 cells. Chitosan-functionalized nanoparticles further improved uptake and antiproliferative activity. Fluorescence imaging demonstrated distinct apoptotic features, including nuclear condensation and fragmentation. Phloridzin-loaded GO nanoparticles especially chitosan-modified formulations shows improved delivery efficiency and stronger anticancer activity against MCF-7 cells. These findings highlight GO-based nanocarriers as a promising platform for breast cancer therapy, warranting further preclinical investigation.

Keywords: GO, Phloridzin, Breast Cancer, MCF-7.

PP-155

Engineering Biochar Briquettes from Agricultural Waste and Invasive Species: Production, Characterization, and Sustainable Applications

Aiswarya A[1], Sabariswaran Kandasamy[1*]

[*]Department of Biotechnology, PSGR Krishnammal College for Women, Peelamedu, Coimbatore, 641 004, India.

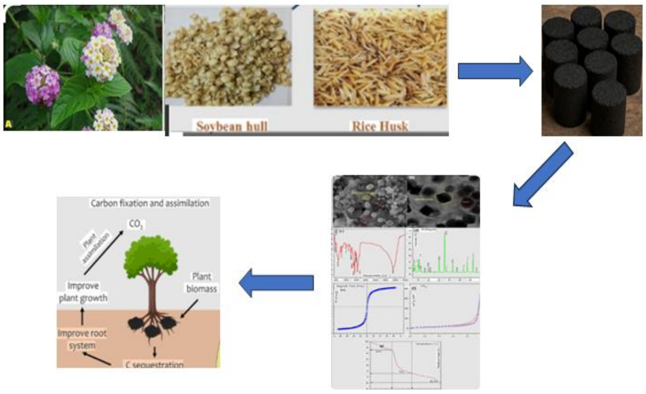
[*]Email: sabariswaran@psgrkcw.ac.in, sabariswaran14@gmail.com

Abstract

Biochar briquettes are an environmentally friendly alternative to conventional solid fuels, providing both renewable energy and ecological restoration. These value-added briquettes, prepared by pyrolysis of agricultural and invasive species, have high carbon stability and calorific values and emit lower amounts of gases than charcoal or firewood. Biochar briquettes

reduce open biomass burning, decrease GHG emissions, and valorize waste in rural communities.

When applied to soils after combustion or degradation, residual biochar enhances soil fertility, water retention, and microbial activity, thus contributing to the restoration of ecosystem functions and climate resilience. The use of biochar briquette technology is in line with the concept of circular bioeconomies by integrating waste management, clean energy generation, and environmental conservation. This paper reviews advances in the current perspectives on feedstock selection, briquetting techniques, and performance optimization, and highlights the potential role of biochar briquettes in achieving sustainable energy access and ecological restoration goals in line with global sustainability frameworks.



Keywords: Biochar briquettes, Sustainable energy, Pyrolysis, Waste valorization, Soil restoration.

PP-156

Facile synthesis of folic acid modified NiO/g-C_3N_4 nanocomposite & its anti-cancer activity studies

Nikhil S[1], Arathy S[1], Renjusha S[1]*
[1]*PG Department of Chemistry N.S.S. College Pandalam- 689501, India.*
*Email: renjushsasatish@gmail.com

Abstract

In this study, a cost-effective method was employed to synthesise a novel g-C_3N_4 based nanocomposite. Folic acid & NiO nanoparticles were effectively incorporated on to g-C_3N_4 sheets by co-precipitation method. The synthesised Folic Acid/NiO/g-C_3N_4 (FNG) nanocomposite was confirmed using characterisation techniques such as XRD, FTIR, SEM, EDAX, TEM & SAED. Molecular platform-based assay test was conducted on MDA MB SCAT3 NLS cells using the nanocomposite prepared in two different proportions (FNG-1 & FNG-2), confirmed the anti-cancer activity of the nanocomposites. The results showed that FNG-2 displayed a better performance.

Keywords: Nanocomposite, Anti-cancer, Folic Acid/NiO/g-C_3N_4, Molecular platform-based assay test, MDA MB SCAT3 NLS cells.

PP-157

Hybrid Learning Approach for Earthquake Prediction in South-Western China

Ramya Jeyaraman[1*], Rahul M[2], Pathmavathy S[3], Saravanan M[4], Venkatanathan Natarajan[5]

[1,2,3]School of Computing, SASTRA Deemed to be University, Thanjavur, Tamil Nadu, India.
[4]K. Ramakrishnan college of technology, India.
[5]School of Electrical and Electronics Engineering SASTRA Deemed to be University, Thanjavur, Tamil Nadu, India.
[*]Email: jramyasastra@gmail.com

Abstract

Earth quake prediction is an interesting and growing area of study in seismology. Despite decades of research into the physical mechanisms behind seismic activity, traditional physical and statistical models have struggled to provide accurate and reliable forecasts, particularly for large earthquakes. The Chuandian region of Southwestern China (98.0°E–106.0°E, 24.0°N–32.0°N) was selected due to its high seismic activity. Hence, A Hybrid learning approach is used such that the machine learning and Deep learning technique is integrated to the prediction of large earthquake using small earthquake. The project explores specifically Random Forest and Long Short-Term Memory (LSTM) neural networks to determine whether patterns in small earthquakes can be used to predict larger seismic events (magnitude ≥ 6.0) is likely in the study region within the next year and to estimate the maximum possible magnitude in that period. The Random Forest model is used for classification to assess the probability of a large earthquake were as for time-series analysis LSTM model is applied to estimate the maximum future magnitude. As a result, small earthquakes provide valuable predictive signals that, when analyzed through a combined machine learning and deep learning framework, can lead to more reliable and insightful earthquake predictions.

Keywords: Earthquake Prediction, Machine Learning, Deep Learning, Random Forest, LSTM, Seismology.

PP-158

Design and Characterization of $CuFe_2O_4$: Mn^{2+} nanomaterials for efficient oil spill cleanup and Multifunctional Applications

Sk. Munimasthani[1*], S. Sarathkumar[1*], J. Jayarubi[2] and S. Sundaranayagi[2]

[1]Department of Physics, Rajiv Gandhi University of Knowledge Technologies, Nuzvid, Andhra Pradesh, India-521202.

[2]Department of Physics, Periyar Maniammai Institute of Science & Technology (Deemed to be University), Thanjavur, Tamil Nadu, India-613403.

[*]Email: allushaik999@gmail.com, sarathsigireddy371@gmail.com

Abstract

In this study, $CuFe_2O_4$: Mn^{2+} nanoparticles were prepared via a solid-state reaction method and analyzed the characteristics like structural, morphological, and adsorption. The substitution of Mn^{2+} ions in the CuFe2O4 spinel lattice was confirmed through X-ray diffraction (XRD), revealing the shift in the lattice parameters and found the crystallite size in nanometers range. This spinel formation was further supported by Fourier-Transform infrared spectroscopy (FTIR) spectrum analysis through which one observed the characteristic metal-oxygen vibrations. SEM illustrated morphology revealed Agglomerates. The energy-dispersive x-ray spectroscopy (EDX) confirmed qualitative analysis on elemental analysis. Adsorption studies showed high efficiency on the removal of oil content and suggesting the possibility of oil slicks cleanup. In this paper also discusses the materials ability to remove oil spill from water through adsorption processes. These results provide evidence that Mn^{2+} doped $CuFe_2O_4$ has the potential to be a multifunctional material for environmental applications.

Keywords: X-ray diffraction, FE-SEM, Oil Spill remediation, copper ferrite.

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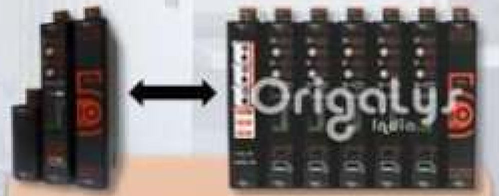

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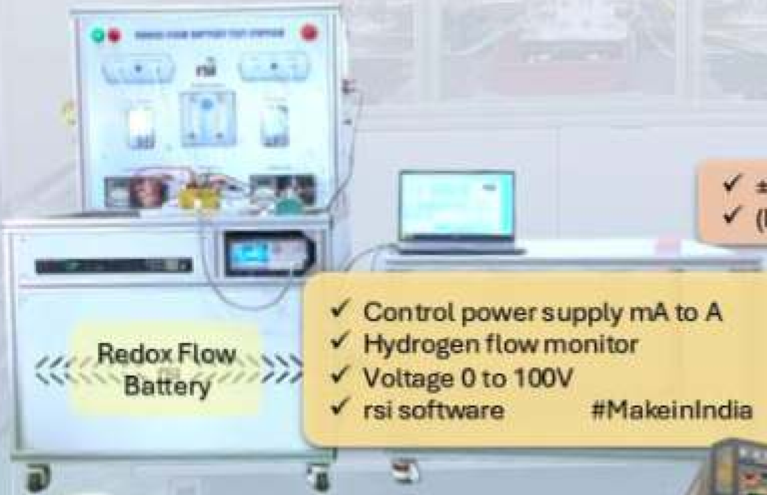

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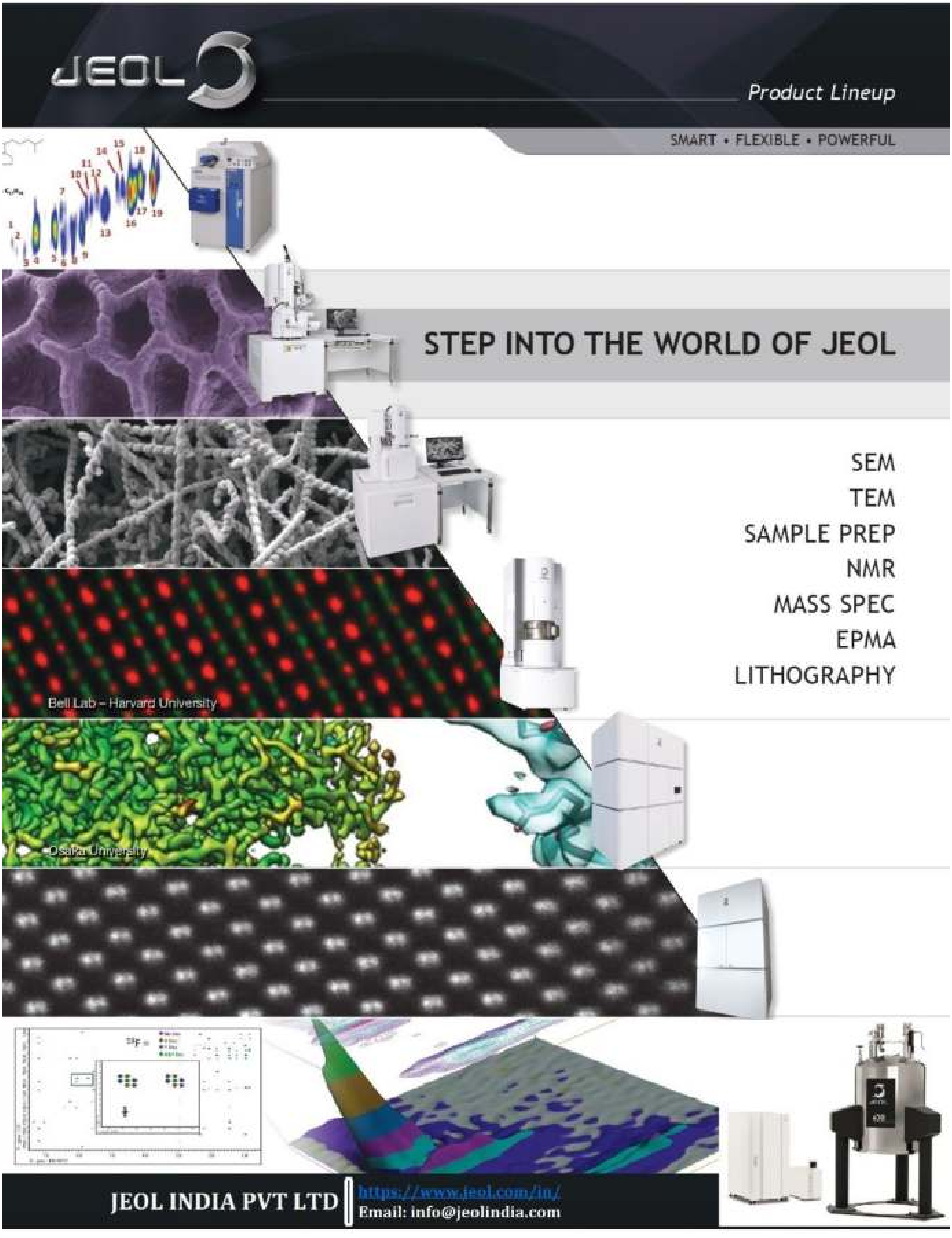
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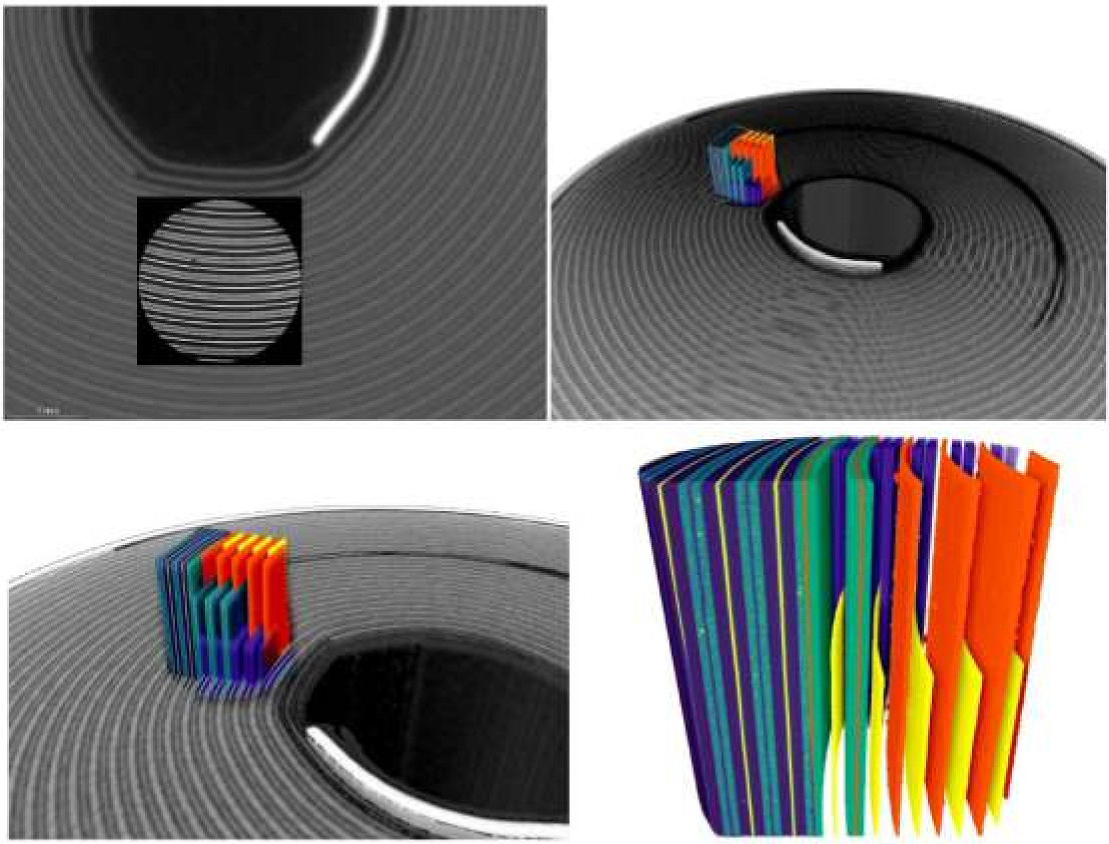

Research facilities in PSGIAS

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Applications for Research Internship

PSG Institute of Advanced Studies (PSGIAS), is an approved research center of Anna University and Bharathiar University to carry-out research in Mechanical engineering, Nanoscience and Technology, Material Science, Biotechnology, Nanobiotechnology, Physics and Chemistry with state-of-the-art research infrastructure to translate research from lab-scale to industry.

Major Research Areas

Energy
- Fuel cells
- Thermoelectrics
- Batteries
- Supercapacitors
- Solar cells
- Green Hydrogen

Sensors
- Gas sensors
- Electrochemical sensors
- SERS
- Fluorometric Sensor

Environment
- Water Remediation
- Bio-hydrogen
- CO_2 Remediation
- Antibiofilm Materials
- Carbon capture
- Toxicology

Polymer
- Bio-polymer
- High-Performance polymer
- Polymer Micelles
- Polymer coating
- Microplastics

Electronics
- FET
- Photodetectors
- Memristors
- Photonics
- Semiconductors

Healthcare
- Neurophysiology
- Tissue engineering
- 3D Bio-Printing
- Anti-infective biomaterials
- Antimicrobial resistance

Thin Films & Coatings
- High-Temperature
- Adhesive
- Superhydrophobic
- Smart Textiles

Materials
- Plasmonics
- Nanoclusters
- Computational Materials
- Fluorescent materials

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Are you a student, scholar, or aspiring researcher with a passion for discovery?

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- ✓ Access high-end research facilities including clean room and advanced microscopic techniques
- ✓ Collaborate with top researchers
- ✓ Flexible internship duration
- ✓ Boost your academic and professional profile

Location: PSG Institute of Advanced Studies, Peelamedu, Coimbatore
Duration: 2–6 Months
Fields: All Major Research Areas

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Fees Structure

Internship fee

- **Rs. 6,000/-** + 18% GST as applicable (for 3 months)
- **Rs. 12,000/-** + 18% GST as applicable (for 6 months)

Caution deposit

- **Rs. 3,000/-** (Refundable)
- Caution deposit will be refunded after the completion of the project undertaken.
- The cost of breakage/damage if any, will be accounted from the caution deposit, plus, additional cost as applicable.

After the acceptance from PSGIAS, the fees are to be remitted. as DD in favor of **"PSG Institute of Advanced Studies"** payable at Coimbatore.

Application Procedure

- Candidates must review the research areas of the respective supervisor, as detailed on the website.
- An application indicating the proposed work and the supervisor from PSGIAS should be submitted with approval from the Head of the institution/ Department of the candidate, where, the time duration for which the candidate is available is clearly indicated.

- Certificates will be issued upon successful completion of the internship.

Interested students should furnish the application, forwarding letter from principal/director/hod, resume and copies of mark lists and certificates to

The Director, PSG Institute of Advanced Studies,
Coimbatore-641004, Tamil Nadu, India
Call: 0422 434 4541
E-mail: **internship@psgias.ac.in** by post or by email.

For further details and to download application form, visit **https://www.psgias.ac.in/**

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- Specialized coursework in nanotechnology, cleanroom practices, and advanced materials.
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- Apply engineering principles to solve real-world industrial and systems challenges.
- Develop strong analytical skills through experimentation, data analysis, and sound engineering judgment.

Northern Illinois University

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- Strong foundation through fundamentals, experimentation, and mini project.
- Reinforces materials science curriculum at LU for diverse academic backgrounds.
- Builds academic aptitude and ensures smooth transition to international education.
- Guaranteed admission for eligible candidates
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Loughborough University

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- Dual-campus model (1+1) with opportunities to work on real-world, industry-relevant projects as a team.
- Build strong skills in machine learning, data mining, parallel programming, and network science.
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- Learn to design and develop computer programs and algorithms to handle and analyze large data sets.

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Let's build your future – one DM (or call) away!

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Director-Global Engagement
PSG Institute of Advanced Studies
Avinashi Road, Peelamedu,
Coimbatore – 641004

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ABOUT THE EDITORS

Dr. P. Biji is currently working as Professor & Head, Department of Chemistry & Nanoscience and Technology at PSG Institute of Advanced Studies, Coimbatore. She completed her PhD from IIT Madras and further joined with PSGIAS in 2009. Dr. P. Biji specializes in the interdisciplinary fields of clean energy materials and sensors, with a strong focus on developing advanced materials for sustainable technologies. Her expertise lies in engineering durable, less-platinum electrocatalysts and support materials for PEM fuel cells and AEM electrolyzers and fabrication of large-area superhydrophobic coatings for photovoltaic and non-photovoltaic applications. She also has strong expertise in designing high-performance sensors for environmental and water quality monitoring, such as Hydrogen sensors and other hazardous gas sensors. She has also developed microfluidic sensors for water quality monitoring and SERS biosensors for cancer diagnosis. Over the years, she has successfully led and contributed to 11 nationally funded research projects supported by premier agencies such as DST, CHT/MoP&NG, ONGC Energy Centre, DRDO etc. and multiple consultancy projects. With more than 90 peer-reviewed publications in reputed journals, 5 patents, and multiple recognitions including the prestigious SMC Bronze Medal-2024 and MILIR Best Scientist Award-2024, Dr. Biji's work significantly advances the frontiers of material science for energy and environmental sustainability.

Dr. R. Selvakumar, Professor and Head, Department of NanoBiotechnology and Biotechnology, PSG Institute of Advanced Studies, Coimbatore, has more than 15 years of experience with expertise in nanobiotechnology with specialization in Environmental biotechnology and Bio-nanomaterials. He did his Ph.D. at Bharathiar University, Coimbatore and Postdoctoral Fellowships at the University of Newcastle, Australia and University of Nebraska, USA. He is a recipient of various prestigious awards like the Water Advanced Research and Innovative (WARI) fellowship from IUSSTF, Endeavour Research Fellow from Government of Australia, Blaustein postdoctoral fellowship awarded at Zuckerburg Institute for Water Research, Israel, CSIR-SRF from Govt. of India, etc. He has completed several funded research projects sanctioned by DST-Water Technology Initiative (WTI), DRDO, ICMR, ONGC, IGCAR etc. As on date, he has 100+ publications with H index of 36 and 3284 citations, 9 book chapters, 2 patents and 2 technology transfers to industry. He has supervised 8 Ph.D, 4 M.Phil and 2 National post-doctoral fellows (NPDF) so far.

Dr. Anuradha M Ashok is Professor and Head of Dept. of Physics, PSG Institute of Advanced studies (PSG IAS), Coimbatore, Tamilnadu. She did her Masters' in Materials Science from Mangalore University Karnataka and PhD in Physics from University of Oslo, Norway. Her research interests are Functional oxides for clean energy applications such as Solid oxide Fuel cells, thermoelectrics, photocatalytic hydrogen generation, solar photovoltaics, transparent conductors etc. She also has the expertise in Transmission Electron Microscopy, crystallography, structural analysis, analysis of structure-property relationships. She established research facilities such as XRD, electron microscopy thermoelectrics etc at PSG IAS. So far she has carried out Research projects funded by DST (SERB, International cooperation), DRDO (NRB, ARDB, CARS) UGC DAE-CSR on various clean energy applications. She is the Life member of Materials Research Society of India, Electron Microscopy Society of India, and Institute for Smart Structures and Systems. So far she has published more than 50 research articles in peer reviewed international journals, 13 book chapters, 52 invited lectures and more than 65 presentations in national and international conferences. She has conducted several workshops conferences and symposiums on clean energy including Indo US bilateral workshop funded by IUSSTF. She has guided 7 PhD, 3 M.Phil and more than 50 Master's students and currently guiding 7 PhD students.

Dr.. Kothandaraman Ramanujam a professor at IIT Madras (Since 2021), completed his Ph.D. from IISc Bangalore in 2006 and joined the Department of Chemistry-IITM in March 2011as an assistant professor. Since May 2025, he has been an Adjunct Professor at the Center for Future Materials, University of Southern Queensland, Australia. He is actively involved in the ECS IITM student chapter as a Faculty Advisor, which has completed nearly 25 workshop/conference since 2022. He was bestowed with Masila-Vijaya award by the Academy of Sciences in 2024 for innovative patents. He is the recipient of the CRSI 2023 Bronze Medal and recipient of the SMC-BARC Bronze Medal 2023, Amara raja Award 2021 by ECSI and IESA Researcher of the Year award in 2024 from Indian Energy Storage Alliance. His research focuses on contributing to realizing India-centric solutions for the ever-growing need of energy storage and conversion. He has done two technology transfers on vanadium redox flow battery and zinc-bromine redox flow battery. Recently, he has commissioned a 10kW/0.1MWh Vanadium Redox Flow system at Trichy, at TRL 7 level. His area of interest broadly includes Flow batteries, Lithium/Sodium/Zinc ion-based batteries, electro organic synthesis and electrocatalysis. He published over 170 research articles, obtained ten patents, completed two technology transfers, and completed 28 sponsored & 16 consultancy projects.

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