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ICNAN'25

3rd International Conference on Nanoscience and Nanotechnology

16th - 19th December 2025

CONFERENCE PROCEEDINGS

Organised by
Centre for Nanotechnology Research,
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CONFERENCE PROCEEDINGS OF

ICNAN'25

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Edited by

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About VIT

The Vellore Institute of Technology (VIT), India, stands as a testament to academic excellence and visionary leadership. VIT was founded in 1984 as Vellore Engineering College by the chancellor Dr. G. Viswanathan. The institution has grown exponentially to that of having more than 40,000 students. VIT now has 1200+ international students from across 50+ countries with different nationalities represented within VIT's student body, which includes students from every state in India. There are currently five campuses of VIT, located in Vellore, Chennai, Amaravati (AP), Bangalore and Bhopal (MP). VIT adopts eco-friendly and green initiatives to promote sustainable practices in its lush and verdant campus. Established with a commitment to providing quality education, VIT has steadily risen to prominence on both the national and international stages. Its dedication to pioneering education in engineering and technology has been consistently recognized, culminating in its ranking of 142nd globally and 9th in India in the QS World University Rankings by Subject 2025. This prestigious recognition further highlights the strength of four key disciplines—Computer Science & IT, Data Science & AI, Electrical & Electronics Engineering (EEE), and Material Science—all of which were ranked among the top 200 worldwide in the same assessment

VIT's consistent high performance is also reflected in the National Institutional Ranking Framework (NIRF) by the Government of India. In 2024, VIT was recognized as the 10th best University, 13th best research institution, and 11th best engineering institution in the country. Further solidifying its global standing, the Shanghai ARWU ranking 2024 placed VIT 2nd in India and within the 501-600 band globally. Moreover, VIT's commitment to sustainable practices has been acknowledged with a rank of 396th in the world and 8th in India in the QS World University Rankings: Sustainability 2025. The institution also holds the highest NAAC Accreditation with an A++ grade, scoring 3.66 out of 4, attesting to its rigorous quality standards.

VIT offers a comprehensive array of academic programmes including 71 Undergraduate, 58 Postgraduate, 15 Integrated, and 2 M.Tech. Industrial Programmes with robust research opportunities through full-time Ph.D. programmes in Engineering and Management, Ph.D. in Science and Languages, and Direct Ph.D. programmes in engineering disciplines.

About CNR

Centre for Nanotechnology Research, VIT Vellore: Pioneering the Future of Printed and Flexible Nanotechnology for a Sustainable Future

Established in June 2008, the Centre for Nanotechnology Research (CNR) at Vellore Institute of Technology has rapidly emerged as a leading hub for cutting-edge research in nanotechnology. CNR's research philosophy is rooted in a commitment to both fundamental and applied science.

Operating at the confluence of materials science, electronics, and biomedicine, the centre's vision, "To lead as a Centre of Excellence - Integrate and deliver interdisciplinary research and provide solutions in Printed and Flexible devices for energy, sensors and healthcare," reflects its dedication to translating scientific discoveries into tangible societal benefits.

Key Scientific Strengths of CNR:

- Focused Research Domain: CNR specializes in printed and flexible electronics, a rapidly evolving field with applications in renewable energy harvesting, advanced sensor technologies, and personalized healthcare solutions.
- Interdisciplinary Expertise: The centre's unique operating model integrates expertise from various scientific disciplines, enabling the development of complex, multi-functional nanodevices.
- State-of-the-Art Infrastructure: CNR is well equipped with advanced instrumentation for nanomaterial synthesis, characterization (including microscopy, spectroscopy, and electrical measurements), and computational simulations, facilitating rigorous scientific inquiry.
- National and International Collaborations: CNR maintains strong partnerships with leading nanotechnology experts worldwide, fostering knowledge exchange and collaborative research projects.
- Emphasis on Societal Impact: The centre's research is aligned with national priorities, focusing on areas such as sustainable energy, environmental monitoring, and advanced medical diagnostics.
- Consultancy and Technical Support: CNR provides expert consultancy services in nanomaterials characterization, extending its expertise to academic institutions and industries.

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About ICNAN'25:

ICNAN 2025 - 3rd International Conference on Nanoscience and Nanotechnology, is a premier global event organized by the Centre for Nanotechnology Research at Vellore Institute of Technology, Vellore, Tamil Nadu, India. Scheduled from 16 to 19 December 2025, it brings together scientists, researchers, industry experts, and students to advance knowledge and collaboration in nanoscience and nanotechnology.

Conference Overview

This conference provides a vital platform for presenting cutting-edge research and discussing emerging trends across diverse areas. Key topics include advanced nanomaterials, nanoelectronics and quantum materials, nanomedicine, sensors and biosensors, energy materials, and sustainable nanotechnology applications. The programme features plenary lectures, invited talks by renowned experts, and parallel technical sessions held at venues like Technology Tower. These sessions enable in-depth discussions, poster presentations, and networking opportunities to foster interdisciplinary partnerships and translational research outcomes.

Main highlights

- Participation of eminent speakers from premier international and national universities and institutes: 42 from leading international institutions across more than 20 countries (such as MIT USA, University of Cambridge UK, National University of Singapore, and Monash University Australia), 23 from top national organizations (including IISc Bangalore, IITs, NITs, CSIR labs, DRDO, BARC, and TIFR), 5 from industry, and 3 from prestigious journals.
- A keynote technical lecture by Nobel Laureate in Chemistry 2023, Prof. Moungi G. Bawendi (MIT, USA), whose pioneering work in quantum dots has reshaped modern nanoscience.
- A rich scientific programme spanning plenary talks, invited lectures, and multiple parallel technical sessions covering advanced nanomaterials, nanoelectronics, quantum materials, biosensors, energy and environmental nanotechnology.
- Strong presence of industry and scientific publishers, enabling interaction on technology translation, commercialization, and publication opportunities.

Special features

- Research excellence will be recognised through multiple prestigious presentation awards supported by leading international publishers and professional societies, along with dedicated Young Researcher Awards.
- Structured opportunities for student–expert interaction, including discussions with global leaders in the field, aimed at inspiring and mentoring the next generation of researchers.
- Integration of conference activities with the facilities and initiatives of the Centre for Nanotechnology Research at VIT, including showcasing state-of-the-art laboratories and infrastructure.

Thermal and photocatalytic routes to sustainable chemicals and fuels

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The anthropogenic origin of climate change from combustible carbon, and desire to establish a global circular economy is driving the quest for new sustainable manufacturing processes.[1] Catalysis has a rich history of facilitating energy efficient, selective molecular transformations, and will play a pivotal role in overcoming the scientific and engineering barriers to sustainable and economically viable energy vectors and chemicals.

Advances in the rational design of nanoporous solid acid and base catalysts enable the fabrication of hierarchical porous architectures[2] in which different active sites are spatially compartmentalised. Synergies between nanoporous solid acids and metal nanoparticles also facilitate active and selective upgrading of phenolic components of pyrolysis bio-oils to hydrocarbon fuels, and precious metal thrifting.[3-4] Active site compartmentalization and flow chemistry facilitates chemical cascades to produce valuable chemical intermediates.[5]

Access to clean and renewable energy, and the responsible management of chemicals, are recognised by the United Nations Sustainable Development Goals and formulated in policy and legislation for almost every country on Earth. Green hydrogen, sourced from water split by solar energy is the frontrunning clean energy vector for applications where direct electrification is currently impractical, and a critical building block for sustainable chemical synthesis. Direct harnessing of solar energy for photocatalytic water splitting has been demonstrated with high efficiency using Earth abundant elements, including CdS for efficient, durable and safe solar-driven hydrogen production (**Fig. 1**).[6]

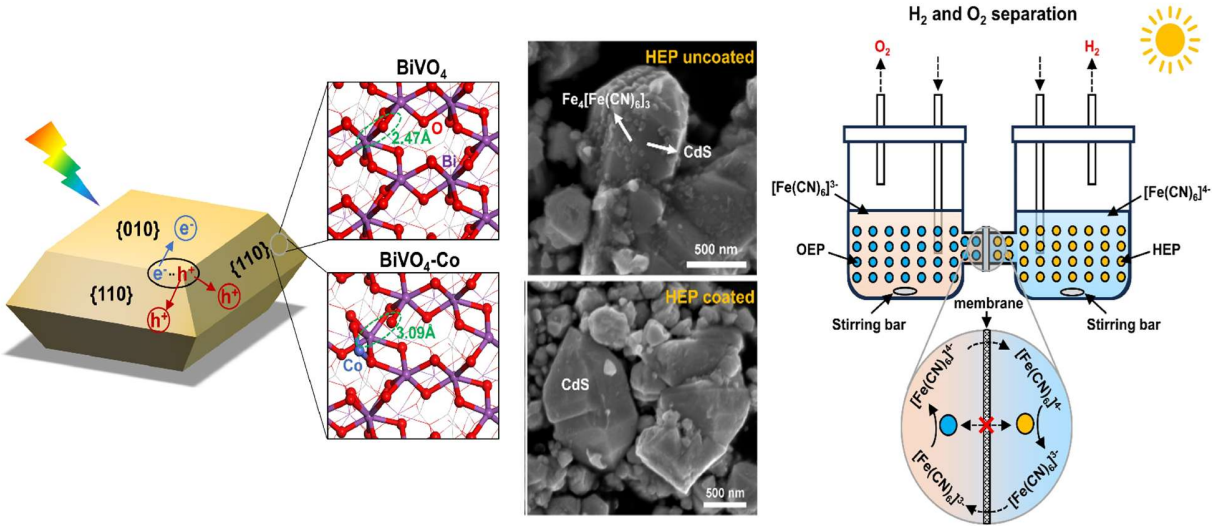

Fig. 1. (left) Facet-engineered $BiVO_4$ photocatalyst for spatial separation of photoexcited charge carriers under visible light; (middle) TiO_2-coated CdS nanoparticles suppresses Prussian blue deposition; separated H_2 and O_2 production in overall water splitting under visible light.

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Perovskites for Space Power: From Defect Physics to Mission-Ready Qualification

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Abstract:

Our expanding extraterrestrial presence and exponential growth of the space economy demand a new generation of scalable, low-cost, and space-tolerant electronics. While silicon and III-V semiconductors have long dominated space power systems, a new class of materials - metal-halide perovskites (MHPs) - is fast emerging as a promising candidate for next-generation space photovoltaics. While their legacy application is expected to be terrestrial photovoltaics, MHPs' bizarre radiation tolerance is rapidly making a case for their space power potential. *How can such delicate lattices withstand harsh radiation environments?* In this talk, I will delve into this paradox challenging existing assumptions and highlighting that lattice vibrations play a key role in healing radiation-induced displacement damage. While radiation creates significant damage, a serendipitous combination of low-frequency phonons, strong electron-phonon coupling, and low thermal conductivity enables almost instantaneous recovery via atomic reconfiguration. Nevertheless, I will caution that this ability of MHPs to self-heal could very well be their Achilles' heel when extreme thermal fluctuations are present: such as during thermal cycling and under ionizing irradiation. I will validate this hypothesis by offering fresh experimental evidence showing extensive and irrecoverable damage by electrons owing to ionization effects. I will conclude by addressing the broader challenges in assessing the full potential of MHPs for space missions and outlining critical areas for future exploration. Ultimately, I hope to motivate a broader conversation on how soft, self-adaptive semiconductors like MHPs could redefine our path toward resilient and sustainable power systems in space and other extreme frontiers.

Sustainable and Responsive Hydrogels: Wearable Energy Harvesting and Soft Microforce Sensing

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This plenary presents a materials philosophy focused on creating intelligent, functional, and environmentally sustainable soft matter through bioinspiration. We highlight two key advances: (a) Responsive Hydrogels: We introduce a halloysite nanotube-modified piezoelectric hydrogel (PVA/PVDF-HFP) that functions as a sensitive, self-powered interface. This material converts minute mechanical actions (e.g., touch, motion) into measurable electrical signals, demonstrating utility in wearable energy harvesting and soft microforce sensing for next-generation robotics and bio-integrated devices, and (b) Sustainable Composites: We detail a nacre-inspired composite reinforced by biomass-derived carbon nanomaterials (BGCNMs), a sustainable innovation that transforms agro-waste into high-performance nanofillers. This system achieves significant gains in strength and stability, demonstrating structural and environmental compatibility.

Together, these works showcase how emulating natural logic and integrating renewable nanotechnology allows us to engineer materials that are both highly responsive and fundamentally sustainable, paving the way for future neuromorphic and adaptive smart technologies.

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Nanoporous Functional Materials for Clean Energy and Environment

Dr. Ajayan Vinu
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In this plenary lecture, I will introduce a new generation of clean-energy technologies built on advanced nanoporous semiconducting and conducting materials. Our team at GICAN has developed highly stable and innovative nanostructures capable of producing clean hydrogen directly from seawater using sunlight, capturing CO_2, converting it into valuable fuels, and storing the harvested energy through next-generation supercapacitor and battery systems. This integrated approach marks a significant step toward a circular, carbon-neutral energy future. In this unique approach, clean fuels are generated from abundant natural resources while atmospheric CO_2 is simultaneously reduced. By combining photocatalysis, CO_2 capture and utilisation, and advanced electrochemical storage within a unified materials framework, this technology opens new pathways for sustainable and scalable energy solutions.

The main concept of this technology involves a series of multifunctional nanoporous semiconducting and conducting materials, including carbon nitrides and other carbon-based frameworks. These materials exhibit controlled architectures, tunable pore structures, and adjustable chemical compositions, supporting highly efficient solar-assited processes. I will provide an overview of how these tailored nanostructures are designed and fabricated, and how their properties can be modulated for targeted performance in catalysis and energy storage.[1-11] Specifically, I will highlight the preparation of novel mesoporous C_3N_5, C_3N_6, C_3N_7, and C_3N_8 materials, along with their structural characterization using advanced spectroscopic techniques. I will also demonstrate how the chemical composition, structure, porosity, and functionalization of these unique materials can be precisely tuned. This includes the fabrication of carbon nitrides from single molecular precursors containing C, N, and S elements, as well as the synthesis of mono- and bimetallic sulfides.

The second part of the talk will highlight the role of these materials in key applications such as solar-assisted seawater splitting, CO_2 capture and conversion, and next-generation batteries and supercapacitors. I will also present our progress toward large-scale production, including the establishment of pilot-scale facilities for CO_2 capture and material manufacturing. Finally, I will discuss how integrating CO_2 conversion technologies with fuel cells and electrochemical storage platforms leads to a unified, sustainable energy system capable of delivering continuous power for stationary, mobile, and automotive applications. This unique approach not only provides pathways to carbon-neutral fuel generation but also creates practical solutions to some of the world's most pressing energy and environmental challenges.

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Engineered Interfaces for Energy Harvesting

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Abstract

Composite nanostructures can be efficiently applied for Sunlight conversion and, in general, for energy harvesting and generation of solar fuels. In most of the applied systems, like excitonic solar cells, (photo)-electrochemical cells for solar fuel production, and evaporation systems for water desalination, nanomaterials can play a critical role in boosting conversion efficiency and energy use by ameliorating the processes of light management, charge photogeneration, exciton dissociation, and charge transport. A crucial role in such processes is played by the structure and quality of the interface, which needs to be properly assembled to obtain the desired functionality. Specifically, the structure of the interface determines the electronic configuration of the conduction and valence band in semiconducting composites, altering the electronic and optoelectronic properties of composite nanostructures and quantum systems. In addition, conformal interfaces inhibiting the presence of pin-holes in sub-nanometer thin films of multilayered devices are very challenging to obtain, but are critical to avoid undesired electrical short circuits. Several strategies can be pursued to modify the interface of composite systems, aiming to maximize energy harvesting and storage, including broadening light absorbance to reduce solar light losses, fastening exciton dissociation and charge injection from the photoactive medium to the charge transporting materials, reducing charge recombination during charge transport and collection at the electrodes, creation of continuous nanometer thick conformal layers to overcome issues related to the presence of pin-holes. In this lecture, a few examples of the application of nanocomposites will be discussed, including thin film solar cells, quantum dot and carbon dot fluorophores for high-efficiency luminescent solar concentrators, selective solar absorbers for solar water desalination and composite sulfides for hydrogen generation. Emphasis will be given to the role of interface engineering in improving the efficiency of energy conversion in different systems, spanning from electric power generation from Sunlight to chemical fuel production.

Zinc tailored Cobalt Prussian Blue Analogue (PBA) as a Prospective Candidate for Supercapacitor Applications

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Supercapacitors (SCs) have recently garnered plentiful consideration in energy storage due to their high-power density, incredible stability, and long operating life. Among different energy storage materials, Prussian blue analogues (PBAs) have attracted researchers' attention due to their remarkable electrochemical activity.[1] The facile modulation of their atoms without disturbing the existing lattice array and an open 3D framework that facilitates ion conduction make them an excellent choice for developing advanced electrode materials. Herein, we report the synthesis of a trimetallic PBA by tuning the concentration of one of the metals. Firstly, keeping the core ferricyanide structure intact, bimetallic Cobalt PBA (Co PBA) and Zinc (Zn PBA) were prepared, and specific capacitance of 96 F g^{-1} and 77 F g^{-1}, respectively, at 1 mA/cm^2 was obtained. But when a trimetallic PBA with both Cobalt and Zinc is introduced into the framework, the net specific capacitance plummeted to a higher value. The as-synthesized $Zn_{0.04}Co_{0.06}$-PBA achieved a specific capacitance of 203 Fg^{-1} at 1 mA/cm^2, which is an overall 211% and 263% increase compared to Co-PBA and Zn-PBA performance, respectively. An asymmetric device that achieved a specific capacitance of 23 F g^{-1} at an operational voltage of 1V was configured. It also exhibited a capacitance retention of 84.6% after 2230 cycles and with 100% coulombic efficiency. The device that powered a humidity sensor yielded an energy density of 2.13 Wh kg^{-1} and power density of 76.75 W kg^{-1}, which points out the fact that the developed material can truly revolutionize the field of energy storage.

Keywords: *Prussian blue analogues; Energy density; Power density; Specific capacitance; Operational voltage.*

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Atomistic Design and Engineering of Two-dimensional MXenes for Electrocatalysis

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Abstract

MXenes, with their $M_{n+1}X_nT_x$ chemical formula, have one of the most diverse chemical compositions and structures among the family of two-dimensional (2D) materials. This notable compositional diversity, spanning across the transition metal carbides, nitrides, and carbonitrides, positions MXenes as potential material candidates for applications ranging from energy conversion and storage to biomedicine. The rapid growth of the 2D MXenes family is driven by their tailorable surface chemistry, diverse compositions, structures, and architectures, including the transition metal and surface functional groups, non-metal X sublattice, and atomic-layer configurations. This compositional diversity controls MXenes' structure-property relationships, which tailor their functional performance in various application domains. In this talk, we will explore how variations in compositional diversity, atomic arrangement, atomistic design, and material engineering strategies enable the systematic fine-tuning of the properties of 2D MXenes and their applications in clean energy. The discussion will center around the six key factors that play a critical role in tunability and controlling MXenes' performance for electrocatalysis, including composition (M, X, and T_x), the thickness of the 2D flake (number of atomic layers), lateral flake dimensions, surface adatoms, intercalating ions, atomic defects (e.g., vacancies), and heteroatom doping. The discussion will highlight recent advances in the growing research on MXenes and offer forward-looking perspectives on leveraging MXene chemistry to develop high-performance 2D catalysts critical for achieving a carbon-neutral economy.

Pathways for the enhancement of thermoelectric efficiency in oxide materials

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Global warming due to the widespread industrial activities is a huge threat to the environment. Ever increasing domestic and industrial activities demand surplus electricity. Efficient energy generation by waste heat recovery through thermoelectrics (TE) could be the ideal solution which can address these issues. A thermoelectric generator (TEG) needs just a temperature gradient to produce electricity. Several materials like Bi/SbTe, SiGe, half heuslers, skutterudites etc have been reported as good thermoelectric materials with ZT ranging from 1 to 3. In addition, several primary and complex oxides also have been developed for thermoelectric applications. However, the ZT values of these materials are lower than other type of materials. Oxide materials have several advantages such as long term stability, low-cost, abundance, non-toxicity etc over other materials used for thermoelectric power generation.

The presentation involves the attempts to enhance the thermoelectric efficiencies of ZnO, perovskite-structured lanthanum cobalt oxide ($LaCoO_3$), and spinel ferrites of type AFe_2O_4 (A-Cu, Zn). These materials feature tunable bandgaps, enabling modulation of their carrier concentration through doping or thermal activation. Combined with a high effective mass of charge carriers, which contributes to enhanced thermopower and their robust thermal and chemical stability, these materials are capable of energy conversion in harsh environments at mid-high temperatures. Despite these favorable attributes, challenges such as low intrinsic electrical conductivity and strong carrier-phonon interactions persist, limiting their heat conversion efficiency. Therefore, it becomes imperative to explore targeted strategies such as cationic doping and composite formation to optimize their charge transport behavior and overall thermoelectric efficiency. This study is dedicated to investigating these approaches, aiming to advanceZnO, $LaCoO_3$ and AFe_2O_4 (A-Cu, Zn) based materials as viable candidates for efficient thermoelectric applications.

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Graphene Surface Engineering and Applications in Sensors, Composites and Water Purification

Dr. Aravind Vijayaraghavan

Graphene and its derivatives offer exceptional mechanical, electrical, and chemical properties, enabling transformative applications across multiple sectors. Our research focuses on engineering graphene surfaces and interfaces to exploit these properties in advanced technologies. In sensors, we develop graphene-based layered composite membranes for MEMS/NEMS devices and electronic platforms with high sensitivity and selectivity, leveraging graphene's tuneable conductivity and functionalisation for biomedical and environmental monitoring. For structural applications, we design graphene-polymer nanocomposites and elastomeric foams with enhanced mechanical strength, thermal stability, and multifunctionality, addressing challenges in aerospace and energy sectors. In water purification, we pioneer the fabrication of graphene oxide aerogels and hydrogels with hierarchical porosity and tailored surface chemistry, achieving high flux and fouling resistance in filtration membranes and adsorptive removal of contaminants. Recent work includes the creation of 3D graphene "smoke ring" aerogel particles via controlled interfacial assembly, offering efficient pollutant capture through optimised surface interactions. These studies demonstrate how surface engineering strategies, such as chemical functionalisation, dispersion control, and bottom-up assembly, unlock graphene's potential for sustainable technologies. Our findings contribute to scalable solutions for global challenges in clean water, smart sensing, and lightweight composites.

Emerging developments in organic frameworks nanocomposites for next generation membrane manufacturing and sustainable applications

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Abstract

The commercial polymeric membranes are having specific properties and prone to fouling, and reduce life. Membrane modifications are an alternative approach to enhance the membrane antifouling, self-cleaning and regeneration ability. The organic frameworks have an inherently porous nature with tunable properties and are a prospective candidate for emerging hybrid membranes. Functional membranes are used in food processing, sensor technology, medical and biomedical devices, desalination, waste water treatment, CO2 capture, energy production and energy storage, optoelectronics etc. The functional organic frameworks show positive effects on membrane performances. The modified nano-membrane is responsible for separating solutes/ions from wastewater. These modified nano-membrane are very effective in removing dyes, heavy metals, and other contaminants. Metal-Organic Frameworks (MOFs), Covalent Organic Frameworks (COFs), Polymer Organic Frameworks (POFs), and Hydrogen-Bonded Organic Frameworks (HOFs) are a class of advanced nanomaterials that have gained significant attention for their potential applications as nano-membranes in various separation, filtration, and sensing technologies. MOFs, composed of metal ions or clusters coordinated to organic ligands, offer high structural stability and can be engineered for specific gas or liquid separations. COFs, have strong covalent bonds with defined porosity and enabling precise control over pore size for molecular sieving. POFs providing robust, scalable membrane materials with potential for gas, liquid, and ion separations. HOFs, are capable of self-assembly and reversible structural changes, which applied in membarne separation applications. These materials are characterized by their highly porous, tunable structures, which offer exceptional surface area, pore volume, and chemical versatility, making them ideal candidates for selective molecular separation processes. The unique combination of high porosity, selective permeability, and mechanical stability makes these frameworks promising candidates for next-generation nano-membranes in diverse applications, including water purification, CO_2 capture, energy storage, and catalytic processes.

Experiments on low-dimensional semiconductors using light and magnetic fields

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Abstract:

Semiconductors form the hearts and brains of modern computation, optoelectronic and light wave technologies. In this talk, I will describe experiments on 2D semiconductors using light and strong magnetic fields which have provided vital tests to the theories of quantum mechanics. Classic textbook quantum phenomena such as 'particle in a 2D box' and confinement effects, quantum mechanics of artificial 2D hydrogen atoms etc. are routinely studied in the laboratory through such experiments. We will discuss the strongest magnetic fields which have been created in a laboratory. Alongside, recent progress in the area of research will be described, where every year, many fascinating discoveries are taking place setting up foundations of future quantum computation and communication technologies [1].

Towards the end, I will describe some of our latest results. For instance, I will discuss our newly invented method for performing high-precision Faraday rotation spectroscopy on 2D materials [2,3]. Using our method, we measure giant Verdet constants (Faraday rotation per unit thickness per unit magnetic field) around exciton energies in the monolayers of 2D semiconductors WSe_2 and $MoSe_2$ [3]. Such huge Verdet constants are observed for the first time in any material so far, and open pathways to ultrathin non-reciprocal device technologies.

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Rational Design and Nanoarchitectonics of Metal–Organic Frameworks for Energy Storage

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In the quest for advanced energy storage solutions, metal–organic frameworks (MOFs) offer a promising strategy to reduce reliance on fossil fuels and address the growing energy demand. The idea of nanotechnology and architectonics offers incredible opportunities for the advancement of energy, the environment, and health care. The architectonics of nanomaterials plays a pivotal role in defining their functional performance. Porous coordination polymers, specifically metal-organic frameworks (MOFs) and zeolite imidazolate frameworks (ZIFs), have garnered significant attention due to their unique and beneficial properties in the ocean of materials. These properties are highly favored due to their large surface area, porosity, structural versatility, and tailorability[1-3]. MOFs have been widely employed in the field of supercapacitors due to their promising efficiency. However, pristine MOFs exhibit limited electrical conductivity, poor stability, and inconsistent performance. To address these challenges, various strategies, including the incorporation of metal oxides or the formation of composites, have been employed to enhance their energy storage capabilities[2]. Notably, the approach of incorporating coordination modulators into the reaction medium to improve the specific capacitance of MOFs remains largely unexplored[2]. Briefly, the coordination modulators are the additives introduced during MOF synthesis to influence nucleation, crystal growth, and the overall properties of the material. This presentation will explore the fundamentals of crystal facets, the influence of surface coordination atoms, and the principles of hierarchical architectonics in directing material behavior. Particular emphasis will be placed on metal–organic frameworks (MOFs), where structural tunability and pore orientation serve as model systems for designing advanced architectures. Our focus is on how coordination modulation (CM) governs linker deprotonation, nucleation, and pH-dependent morphology in bimetallic NiCo MOFs, highlighting its critical role in controlling surface charge, structural, textural, and electrochemical properties for supercapacitor applications. NiCo MOFs synthesized at pH 6.0 demonstrated outstanding electrochemical performance, delivering a specific capacitance of 576.4 F/g at 1 A/g with balanced energy–power characteristics[1]. The corresponding asymmetric device with activated carbon achieved high efficiency, long-term stability, and excellent retention, underscoring coordination modulation and pH control as effective strategies for optimizing bimetallic MOFs in supercapacitor applications. By integrating these concepts, the talk underscores how rational design strategies can unlock new levels of efficiency and functionality in materials for targeted applications.

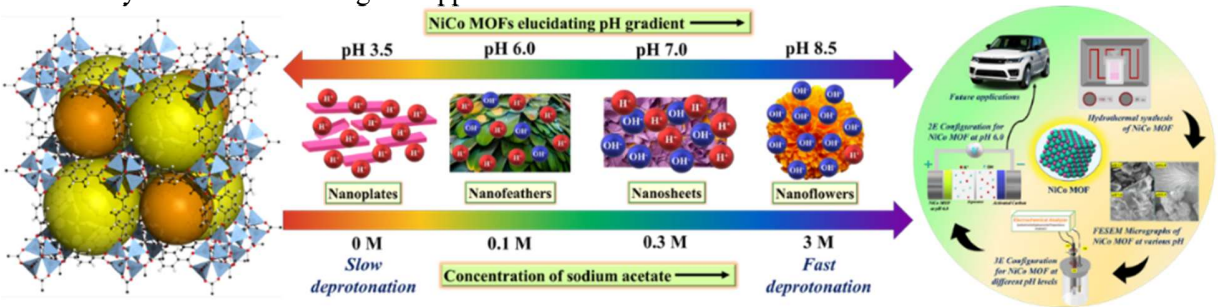

Figure 1: *Schematic representation of the effect of pH on NiCo MOFs for potential applications*

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Thermodynamic equilibrium and stability of systems with an external surface- From simulation to experimental validation

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Stable thermodynamic systems bounded by an external surface and in equilibrium with the external word are charac terized by an interface region in which all intensive thermodynamic variables, with the exception of the temperature, exhibit spatial variations. Since the origin of these variations lies in the symmetry breaking of the atomic bond struc ture in the interface region, it follows that all real systems with an external boundary are inherently non-homogeneous.. This talk aims to present a detailed analysis of the spatial variation of intensive variables in such non-homogeneous systems and to elucidate the microscopic dynamical mechanisms governing their stability and equilibrium conditions. In doing so, it departs from standard thermodynamic models which, being based on the assumption of homogeneity, neglect any spatial variation of thermodynamic variables. The first part of the talk will illustrate Molecular Dynamics (MD) simulation studies on Lennard–Jones systems spanning nano- to macroscopic length scales, in both one-phase and two-phase equilibria. The results show that one phase equilibrium arises directly from the spatial variations of intensive variables, whereas in two-phase equilibrium these variations lead to isobaric phase transitions across finite temperature intervals. Thesecond part of the talk will focus on the experimental validation of the MD approach through its application to gold nanoparticles, which have been extensively characterized experimentally. The results obtained from the simulations are in both qualitative and quantitative agreement with available experimental data, thereby validating the overall proposed methodology. More importantly, this successful validation provides a clear interpretation of experimental observations that have long been regarded as challenging. Taken together, the presented framework not only redefines the thermodynamic description of systems with an external surface but also opens avenues for more accurate interpretations of experimental data, particularly in materials science and condensed matter physics.

Synthetic to Sustainable Composites – Role of Nano and Sustainable Fillers

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Composites have become one of the key manufacturing techniques for various industrial sectors across the world due to their key benefits, such as high specific strength, ability to tailor for a given application, isotropy, durability and so on. In any type of composite, fillers/reinforcements play a major role in tailoring their properties to achieve given functionalities. In the meantime, the whole manufacturing sector is leaning towards a green future, and the introduction of sustainable materials is also a key current priority of this field. Hence, exploring the importance/benefits of existing materials while identifying possible green alternatives is timely. This work aims to explore the use of nano and sustainable fillers in industrial sectors, polymer additive manufacturing, thermal energy storage and polymeric resin-based composites.

The first part of this talk focuses on additive manufacturing. Additive manufacturing has become widely popular in various industrial sectors across the globe due to its key benefits, such as being a no-mould technique, accuracy, simplicity, adaptability, and the possible use of multiple materials/colours and so on. Regardless of the popularity, this process still heavily relies on petroleum-based materials such as polymers and their composites. Graphene oxide, graphene nanoplatlets, expanded graphite, and hexagonal boron nitrides are some of the common nano-fillers in polymer additive manufacturing with some syntactic dyes. This work explores the use of syntactic fillers, sustainable composites and natural dyes in additive manufacturing.

The second part of this talk focuses on the use of fillers with energy storage applications (with phase change materials) to enhance their thermal properties. Phase Change Materials (PCMs) have a great potential for thermal energy storage and thermal regulation applications due to their capability to store/absorb high amounts of heat in the form of latent heat. Paraffin wax and Polyethylene Glycol (PEG) are two of the commonly used organic PCMs, while there are also inorganic PCMs, such as Salt Hydrates. However, the low thermal conductivity values of PCMs limit their heat storage capacities due to low thermal propagation. Nanofillers with high intrinsic thermal conductivities can be added to PCMs to enhance their thermal propagation. Some of the commonly used nanofillers include Graphene Nanoplatelets (GNPs), Carbon Nanotubes (CNTs), Carbon Nanofibers, Graphene Oxide (GO), which are carbon-based nanofillers, and Hexagonal Boron Nitride (hBN), Silicon Dioxide, and Titanium Dioxide, which are some of the inorganic nanofillers. However, with the addition of nanofillers to a PCM, its latent heat capacity drops. The experimental data showed that with the addition of 1-15% GNPs, Graphite, Milled Carbon fibre, GO and hBN into Paraffin and PEG, the thermal conductivity of all samples was increased by over 3-fold and 2-fold compared to pristine Paraffin and PEG, respectively. However, the heat capacity decreased up to 70% and 67% for Paraffin and PEG-based composites, respectively, when the filler loading increased up to 15%. Hence, it is important to analyse the thermal behaviour of nanocomposite PCMs (NCPCMs) with the addition of nanofillers to obtain the maximum performance. Furthermore, there are more challenges, such as developing stable NCPCMs with good dispersion stability throughout the thermal cycles. Hence, further research is being carried out in the area, and numerical modelling is also conducted to develop PCMs with improved thermal performance and stability.

The final part of this work concentrates on the use of fillers in liquid resin-based polymer composites. In particular, glass/fibre reinforced composites manufactured via resin transfer moulding and braiding will be considered. Once a composite's structure is formed with long fibre, resins dispersed with nano fillers will be infused via resin transfer moulding (RTM) or vacuum resin infusion (RI). The resin infiltration of the fibres themselves is a complex process with physical phenomena occurring at multiple length scales. At the microscale, the intra-tow resin flow is primarily driven by capillary action. At the mesoscale, the rate of filling of the inter-tow and intra-tow spaces is governed by the balance of capillary and viscous forces. At the macroscale, the influence of permeability, injection conditions, and racetracking needs to be carefully evaluated during process design. Improper process parameters can lead to dry spots and void defects, which may cause the part to be scrapped or can result in long cycle times and reduced efficiencies. Nanofillers can be mixed into the resin matrix to produce composites with further enhanced and tailored properties. For example, graphene-based nanofillers can improve the electrical and thermal properties of composites. However, the introduction of nano fillers into the resin further complicates the manufacturing process by introducing additional dependencies, including proper dispersion of nanofillers within the resin and nanofiller filtration through fibres. Moreover, the presence of nanofillers affects the viscosity of the resin and the permeability of the fibrous medium, and these relations need to be experimentally determined. In line with these conditions, RTM and RI process design both can greatly benefit from numerical simulations, where the flow of resin containing nanofillers through the fibres can be modelled. It is a cost-effective and time-saving alternative to experiment-based optimisation. However, due to the complexities associated with RTM and RI, accurate simulations can be challenging to achieve. These include the multiple length scales involved, the lack of reliable parameter data such as permeability measurements and the limited amount of prior work done on nanofiller flow modelling. The work carried out so far include both experimental and numerical investigations of RTM and RI. These include visual analysis of liquid infiltration of glass fibres with and without nanofillers during RTM, fabrication of composite pipes and nanofiller dispersed natural fibre composite panels using RI, micro/ meso/ macroscale simulations of RTM mould filling and simulations of filler transport during RTM.

Eventually, a discussion will be made on the journey towards the possible replacement of synthetic fillers with sustainable alternatives in these sectors.

Design and Development of Bio-Organic Resistive Switching Memory

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Abstract:

The digital era critically demands advanced solid-state non-volatile memory. As researchers pursue technologies offering ultra-low power and reduced e-waste impact, bio-organic resistive-switching memory (ReRAM) emerges as a highly promising sustainable solution. Sourced from plants, viruses, or biological compounds and synthesized via eco-friendly processes, these materials enable biodegradable devices. Research demonstrations have surged since 2006, with exponential growth post-2020. This talk analyzes key performance/reliability factors, explores core device design principles, and outlines pathways to commercialize sustainable memory technology.

Everything you wanted to know about "Mn-dopant emission in semiconductor nanocrystal hosts", but were afraid to ask

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The highly efficient, sub-bandgap, orange emission from Mn^{2+} dopants in semiconductor quantum dot hosts has been the subject of over two thousand publications, owing to its broad scientific interest and technological potential. This emission, universally attributed to the $^4T_1 \rightarrow {}^6A_1$ transition of Mn^{2+}, is characterised by a long lifetime in the order of ms and negligible self-absorption due to the large Stokes shift, holding promises for diverse applications.

Surprisingly, the fundamental aspect of how the energy is transferred from the host to the Mn $^4T_1$ state, believed to take place extremely fast in the sub-ns scale, has not been understood so far.

In our work,[1] we address how the first excited multiplet state of Mn^{2+} ($^4T_1$) is populated from its $^6A_1$ ground state, evidently requiring non-spin-conserving processes, following the photoabsorption in the host semiconductor nanocrystals. This seemingly simple question leads to several fundamental issues: What are the energy-transfer pathways from the host excited states to Mn^{2+}? Are intermediate multiplet states of Mn^{2+} involved? How is the significant excess energy of the host excited state, compared to the energy of the Mn^{2+} $^4T_1$ state, defining the large Stokes shift, dissipated?

In this talk, I shall address these critical gaps in our understanding of Mn-emission from Mn-doped nanocrystal systems using Mn@$CsPbCl_3$ as a generic platform. Through temperature-dependent steady-state and time-gated photoluminescence experiments, we show that the initial energy transfer proceeds to a highly excited Mn^{2+} multiplet under near-resonant conditions — not directly to the $^4T_1$ state. A cascade of spin-allowed transitions within the excited multiplet manifold, assisted by multiphonon processes, subsequently populates the $^4T_1$ state. This pathway explains both the pronounced low-temperature suppression of Mn^{2+} emission (due to a phonon bottleneck) and the universal scaling of dopant photoluminescence with respect to excitonic emission that we establish experimentally. We further develop and analytically solve rate equations that quantitatively and qualitatively account for all observations.

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The Role of Nanotechnology in Early Disease Diagnostics and Disease Prevention- for Health and Well Being

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Abstract:

In this talk we shall look at the role Nanomaterials and Nanostructured devices in Health and Wellbeing. Early diagnosis of diseases are essential in so many ways, to improve the quality of life for both patients and those who provide care. The diagnosis outcome in the earlier stages of this work are to form the basis of further testing to confirm the initial pre-clinical diagnosis, ultimately using a Point-of-Care Device for rapid screening. We shall look the current state-of-the-art for the early detection of a range of diseases, from cancers to neurodegenerative diseases, such as dementia. Full testing and diagnosis can be both slow and costly, with long waiting times. Can we fast track people to enable resources to be better used and lives improved?

The second part of the talk will explore the greatest threat we may currently face – Nanoplastics! Unless nanoparticles are designed to do so, such as magnetic nanoparticles for hypothermia cancer treatment, nanoparticles should be allowed to enter the human body. Nanoparticles in 1-100 nm pose serious threat to the body as they able to disrupt human cells, leading to health issues. So why are nanoplastics so bad? The human body has an amazing blood-brain-barrier that offers us protection. Nanoplastics can circumvent this barrier, and post-mortem examinations have shown nanoplastics are deposited in the brain. It is suggested that this is linked to neurodegenerative diseases, such as Parkinson's Disease. The route to the brain is a complicated process, and can we mitigate against this? What remediation is possible to remove or reduce their levels all water sources. And can we detect them?

From Sun to Storage: Next-Gen Solar Batteries Using Earth Abundant Elements

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Abstract :

The intermittency of solar energy has long motivated diverse strategies for continuous power generation. Traditional solutions rely on coupling photovoltaic devices with batteries, but these configurations suffer from efficiency losses across multiple interfaces. An alternative route involves converting solar energy into chemical energy via photocatalysis or photoelectrocatalysis to generate solar fuels. In contrast to these indirect schemes, a growing body of research now seeks to directly capture and store solar energy within a single integrated platform: a "solar battery" that can harvest light and later release the stored energy as an electrical output.

While enabling photovoltaic systems to store charge remains challenging, integrated bifunctional architectures offer an elegant pathway forward. These systems that range from traditional multilayer assemblies to advanced photoelectrode constructs are aimed to merge light absorption, charge separation, and storage within one framework.

In this talk, I will present our recent efforts toward realizing such functionality using a non-trivial polymeric material: the ionic form of carbon nitride. I will discuss how its unique chemical composition and photophysical properties enable persistent photocharge accumulation even after illumination ceases, demonstrating how a single semiconductor can serve both as a light harvester and an energy reservoir. This, we believe, is an important step toward the realization of a true solar battery.

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Nanotechnology for Futuristic Armored Fighting Vehicles - An Overview

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Scientist G

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Nanotechnology (NT) deals with the synthesis and application of materials of size ranging from 1 to 100 nm. The quantum confinement and increased surface area-to-volume ratio at the nanoscale result in the exotic mechanical, thermal, electrical, magnetic and optical properties. NT can play a significant role in reducing the weight of next generation Armored Fighting Vehicles (AFVs), apart from enhancing the performance, stealth, and endurance. Nano-structured steel having high strength and elongation can reduce the weight of the AFV by 20 to 30%. The emerging Metal Matrix Nano Composites (MMNC) can reduce the weight of various subsystems, besides enhancing the performance. Tungsten Carbide-Cobalt nanocomposites based armor plates are expected to be as hard as diamond. Carbon nanotube (CNT) impregnated fiber reinforced plastics have high specific strength and corrosion resistant properties besides reduction in Radar Cross Section (RCS), better Electro Magnetic Interference (EMI) shielding and infrared (IR) absorbance thereby improve stealth characteristics of AFVs. Nanomaterial-based diesel, coolants, lubricants, suspension fluids, etc. reduce the heat, friction, vibration, noise and pollution remarkably. Nano-thin film p-n junction based thermo-electric devices can convert waste heat into useful electrical energy. Nanoparticles such as nano silicon dioxide, Nano titanium dioxide, Nano clay, Carbon Nano Tubes (CNTs) can be used to mitigate the corrosion in AFVs. NT can be applied in each and every sub-system of AFV for weight reduction as well as performance improvement. The paper will cover the details of these areas and their impact on futuristic AFVs.

Design and Development of Alkaline Electrolyzers for Sustainable Green Hydrogen Production

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Green hydrogen, produced by water electrolysis using renewable electricity, is emerging as a key solution for decarbonizing energy systems. Electrolyzers are central to this process, and among the various types, alkaline electrolyzers (AELs) are the most mature and widely deployed. They operate using a liquid alkaline electrolyte—typically potassium or sodium hydroxide—and non-precious metal electrodes, making them cost-effective and suitable for large-scale, continuous hydrogen production. AELs offer proven reliability and long operational lifespans, but they also face challenges such as lower current densities, slower response to power fluctuations, and the need for careful gas separation to ensure hydrogen purity. These limitations can make them less compatible with intermittent renewable energy sources without energy storage or buffering systems. In comparison, proton exchange membrane (PEM) electrolyzers provide faster dynamic response and higher purity hydrogen, while solid oxide electrolyzers (SOEs) offer high efficiencies at elevated temperatures but remain in earlier stages of development. Despite these differences, alkaline electrolyzers remain a critical technology for scaling green hydrogen in the near term. Ongoing research aims to enhance their efficiency, flexibility, and integration with renewable energy, reinforcing their role in the transition to a sustainable hydrogen economy. In this talk, we will highlight some of the important findings of our group's research in alkaline electrolyzers and their future perspective.

Sustainable Nanostructured materials for Food Security and Healthcare

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Nano/Microgels are aqueous, three dimensionally crosslinked polymeric networks. Nano/Microgels belong to a special class of colloids that exhibit various attractive features including adjustable size and size distribution, chemical functionality, surface charge, and swelling degree.1 Additionally, ease of post-modification, their large surface area, flexibility and softness, superior colloidal stability and stimuli responsive behaviour (sensitivity to T, pH, ionic strength) enable them as a versatile platform for diverse interdisciplinary applications.1,2 In our laboratory, various synthetic strategies are employed to develop multifunctional polymers and nanostructured materials with controlled chemical structure and morphology. The key objective of our research is to design smart biodegradable materials including nano/microgels and to harness their potential for societal benefit keeping sustainable development as a central point.2 In general, the presentation would encompass a few contemporary themes in the domain of biodegradable, stimuli responsive, nanostructured materials for food, agriculture, and healthcare applications.2,3,4 In keeping with the latest developments in multidisciplinary research, we have also been trying to tap the potential of self-assembled smart nanostructured materials for the given purpose. In this talk, an overview of how multifunctional nanostructured materials, built on intuitively chosen molecular/macromolecular building blocks, could be exploited for controlled release under complex conditions as a way to develop smart sustainable carriers of fertilizers or drugs will be presented.4,5 The capability of such materials to perform multiple tasks, in terms of value addition even after their degradation, will also be discussed.6 Additionally, an overview of how the nanostructured materials can be utilized for enhancing the shelf life of food items will be provided.

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Magnetoresistance study on ferromagnetic and ferroelectric materials for nonvolatile memory applications

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Non-volatile memory (NVM) is a type of computer memory that can retain stored data even though the computer power is turned off. This makes it ideal for long-term storage, unlike volatile memory, which loses data when power is lost. Electrical resistance changes with applied magnetic field and creates binary numbers, which are used for the memory storages. The magnetic dipole orientation is cause for the change in resistance. The ferroelectric polarization gives measurable charge changes and store the data as binary numbers. MRAM and FeRAM have been fabricated and studied their leakage current, endurance, fatigue, current versus voltage hysteresis loop and retention.

Engineered Nanomaterials for Selective Capture, Inactivation, And Killing of Pathogens

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Abstract:

This talk investigates a suite of stimuli responsive antimicrobial materials designed to capture, inactivate, and suppress microorganisms associated with antimicrobial resistance (AMR). Three material families were examined. First, light activated zinc oxide and copper oxide nanostructures showed strong antimicrobial photocatalysis, with irradiation intensifying reactive species flux and accelerating membrane damage in diverse pathogens. Second, graphene oxide-based composites enhanced surface interactions, improving contact driven antimicrobial activity. Third, magnetically responsive liquid metals produced mechanical and chemical stresses that fractured mature biofilms containing pathogens. This work demonstrates rapid and selective antimicrobial responses capable of countering AMR linked microorganisms in complex aqueous environments.

Keywords: antimicrobial nanomaterials, stimuli responsive, photocatalysis, liquid metals, biofilms

Structural Energy Storage: Building the Future of Electrified Mobility

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Abstract:

The future of electrified mobility and flight depends on a bold rethinking of how we store and use energy. Today's electric vehicles and aircraft carry bulky, isolated batteries that power the system but add no structural value. Imagine instead a world where the body of the car, or the fuselage of the aircraft itself, *is the battery*. This plenary talk unveils an emerging class of materials, **structural energy storage,** a system that fuses strength and energy storage into a single component. Our team has pioneered **multifunctional carbon-fiber composites** that not only sustain mechanical loads but also store and deliver electrical energy with remarkable efficiency. Using advanced simulation-driven design and precision composite fabrication, we have demonstrated **energy densities exceeding 100 Wh/kg**, **tensile strengths above 400 MPa**, and **over 1,000 stable charge–discharge cycles**, all within safe, aqueous chemistries. These **energized composites** eliminate redundant mass, reduce system complexity, and unlock entirely new design freedoms for next-generation electric vehicles, aircraft, and spacecraft. Beyond technology, this innovation redefines how we think about materials themselves, no longer passive carriers of load, but active enablers of energy. As we enter an era of sustainable aerospace and mobility, structural energy storage offers not just incremental improvement but a **paradigm shift** toward vehicles that are lighter, safer, and capable of traveling farther, powered by the very structures that hold them together.

Two Dimensional Quantum Materials For Sustainable Energy Storage Applications

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Two dimensional (2D) quantum materials are emerging futuristic materials for sustainable energy storage applications because of their unique properties with excellent functionality. The study of decorating the 2D nano sheets with inorganic functional materials such as metals, metal oxides and metal sulfides is now becoming a promising and challenging area for energy storage devices. In this study, reduced graphene metal-oxide composites with SnO_2, CeO_2, have been synthesized by homogeneous co-precipitation method. Multi-layered composite structures with 1 D carbon nanotubes integrated with 2 D graphene structures with the addition of 3 D bulk nanoparticles were prepared with improved properties. The structural properties of natural graphite, graphene oxide, graphene-metal oxide composites were studied. The prepared composite structure has been subjected to optical, electrical, and electrochemical property studies. The electrochemical properties of graphene-metal oxide composites reveal that these materials can be effectively used for supercapacitor application with improved specific capacitance, higher power density, energy density and cyclic stability. Coin cell supercapattery device using nickel cobaltite nanostructures as a cathode material has been developed for energy storage applications Heterostructures of different 2D materials have also been fabricated to improve the electrochemical performance. The results will be discussed in details.

Ion beam engineered catalytic materials for low carbon future

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The urgent global need for energy conservation and minimizing greenhouse gases has intensified interest in finding more efficient and non-polluting means of power generation. Ion beam surface engineering, pioneered by Lord Rutherford, has been applied to semiconductors, metals, and insulators to modify their electrical, piezoelectric, electrocatalytic, and magnetic properties, as well as to fabricate nanoparticles for energy applications. New Zealand has an ambitious goal of achieving a net-zero carbon emissions budget by 2050, which depends on progressively phasing out fossil fuels as an energy source. Recently, we initiated the Green Hydrogen Technology Platform aimed at delivering transformative technologies that will drive New Zealand's future as a globally connected 'green-hydrogen' economy. The Platform's focus is on technologies that sustainably produce hydrogen to replace fossil fuels for electricity generation and transportation, as well as creating smaller-scale green-hydrogen applications suitable for distributed generation. In this talk I will present an overview of our recent research activities along with our latest findings on the one-step Fabrication of Earth-Abundant Electrocatalysts for Hydrogen Evolution and Ammonia Production.

2D Semiconductors for Quantum Devices

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Van der Waals semiconductors such as 2D transition metal dichalcogenides (TMDs) are attractive for ultra-scaled and low power devices, and exploiting the novel spin-valley coupling for valleytronics [1] and quantum information processing [2, 3]. While exfoliated TMDs are expedient for quick proof-of-concept devices, the scalability for practical applications is still hindered by the lack of complete scalable processing of such materials into devices. Various traditional processes suitable for bulk semiconductors may not lend themselves directly to the fabrication of high-quality TMD devices. From electrical contacts to dielectrics for gating, the layered TMD of atomic thickness requires a near radical rethink of what are well-established rules of thumb for processing bulk semiconductors. Here, I present our efforts toward establishing scalable fabrication of valleytronic devices such as spin-valley qubits in 2D TMDs [4]. Defects inherent and induced in the TMDs can alter their performance and hence a scientific understanding of how to handle the material defects such or vacancies, unintentional dopants, grain boundaries, and imperfect interfacing with contact or dielectric materials will be critical. I will present our work towards understanding the role of defects, limiting the impact of oxidation of TMDs [5, 6], optimizing electrical contacts and dielectric interfaces related to the fabrication of TMD devices [4]. With such efforts, we have achieved gate-defined quantum dot devices [7] and electrically tunable valley polarisation [8].

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Nanoengineering Multifunctional Heterogeneous Catalysts For Biorefining

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Abstract:

Concerns over dwindling oil reserves, CO_2 emissions from fossil fuel sources and associated climate change is driving the need for renewable energy. To keep the mean global temperature rise <1.5 °C, a large proportion of crude oil, gas and coal reserves are unavailable for energy use. Biomass, derived from agricultural and forestry residues, or non-food sources of triglycerides is a sustainable source of carbon for low-cost solutions to transportation fuels and organic chemicals. Akin to petroleum refining, biorefining will integrate biomass conversion processes to produce fuels, power, and chemicals, thereby increasing the economic viability of bio-derived processes. The drive for a 'zero waste economy' also encourages a circular approach to valorize waste feedstocks.

In contrast to fossil derived hydrocarbons, that generally require selective oxidation for chemical production, highly functional bio-derived molecules will require selective deoxygenation to their target products. Such transformations may involve cascade reactions, where multicomponent catalysts containing tunable acid or base sites may act in concert with metallic sites or cooperatively to promote sequential dehydration or condensation steps and metal catalyzed hydrogenation or oxidation steps. This presentation will discuss innovations in catalyst/process design required to overcome the scientific and engineering barriers to the economic production of low carbon fuels and chemicals from sustainable feedstocks. Case studies will explore nanoengineering of bifunctional catalysts for upgrading of bio-oils to hard-to-abate fuels, and the production of platform chemicals and fuel precursors from waste derived sugars.

Keywords: Biorefining, Biofuels, Sustainability, Catalysis, Porous Materials

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Tailored Interface Engineering of Thermoelectric Materials via Atomic Layer Deposition

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Keywords: Sustainable TE materials, thermoelectric modules, atomic layer deposition, solid state cooling, metal oxide encapsulation

Thermoelectric technology has witnessed a resurgence in recent years due to increasing demands for sustainable energy sources and efficient cooling systems. Recently, the introduction of Te-free thermoelectric modules using non-toxic, abundant materials including *p*-type MgAgSb and *n*-type $Mg_3(Sb,Bi)_2$ marked [1-3] a significant breakthrough. Despite promising performance, questions persist regarding long-term robustness and stability, especially in harsh environments. In this study, a thorough exploration of thermoelectric modules is conducted, focusing on their performance degradation under various conditions. Through elemental mapping analysis, degradation mechanisms are identified within the modules during cycling in argon environments, where atomic migrations and the formation of complex oxides at contact regions are key factors. Furthermore, cycling tests in air reveal significant degradation, prompting the exploration of protective strategies. Surface coatings using atomic layer deposition (ALD) emerge as a promising solution, particularly by HfO_2, demonstrating superior protective effects. Furthermore, re-soldering effectively restores module performance is found, highlighting the importance of developing advanced soldering techniques to promote magnesium-based thermoelectric technology as a sustainable alternative to Bi_2Te_3. These findings emphasize the importance of exploring novel contact materials and demonstrate the potential of ALD as a universal approach to enhancing module reliability and robustness [4].

In a further attempt, we have coated the grains of BiSb and ZnSb powders with ALD of metal oxides. This powder based ALD coatings lead to a significant enhancement of the thermal stability of these materials and for device applications and suppresses in the case of ZnSb die formation of Zn whiskers.

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Inside the Layered Lattice: Structure–Property Rules for Next-Gen Li-Ion Cathodes

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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 increasing 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 affects oxidation states of both Ni and Co leading to defects in the structure. 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.

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Neuromorphic Photonics: From Neural Interfaces to Computing Paradigms

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Interest in Artificial Neural Networks (ANNs) has surged in recent years due to their remarkable versatility in addressing a wide range of complex problems. Today, ANNs are predominantly implemented on electronic platforms. While very-large-scale ANN models have been developed that surpass human performance in specific tasks, they do so at the cost of long training times and significant power consumption. A promising alternative lies in Photonic Neural Networks (PNNs), which leverage the inherent advantages of photonics—namely, high-speed processing, massively parallel transmission (enabled by Wavelength Division Multiplexing, WDM), and low power dissipation.

This seminar will explore a series of simple PNN prototypes implemented on a silicon photonics platform, illustrating the fundamental operating principles of silicon-based PNNs. Silicon photonics is particularly attractive due to its compatibility with electronic integration, enabling on-chip training and scalable fabrication of photonic circuits. A key example to be discussed is a basic optical neuron, in which multiple delayed versions of an optical input signal interfere before reaching the output port—demonstrating an essential mechanism for computation in photonic networks.

Finally, the hybrid approach that combines photonic neural networks with biological neurons will be discussed. It enables experiments in which optical signals are transduced into neuronal activity, activating specific neural circuits. This integration paves the way toward hybrid intelligence systems, opening new frontiers in neuromorphic computing and advanced neurological therapies.

Benefits of ultra-clean interfaces on 2D semiconductors for energy efficient electronics

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Two-dimensional transition metal dichalcogenides offer promise for high performance electronics such as complementary field effect transistors. However, to reap the benefits of 2D TMDs for CFETs and other low energy devices, high performance n- and p-type FETs must be realized.

In 2D TMDs, n- and p-type FETs can be achieved by using low and high work function metal contacts, respectively. Over the course of last 10 years, we have shown that it is possible to make clean interfaces between 2D TMDs and metals. This allows the realization of very good n- and p-type FETs. Our method for creating good contacts is to introduce a van der Waals gap between the 3D metal and the 2D semiconductor. This gap is on the order of 2-4 Angstroms. The presence of this gap creates a defect free interface, which allows FETs with high on state currents and mobility.

We have also demonstrated that the vdW can act as a vacuum tunnel barrier for efficient injection of spin polarized carriers from ferromagnetic contacts into graphene – allowing the realization spin valves with high magnetoresistance.

Finally, we have extended the vdW interface strategy to other 3D materials such as dielectrics. Our approach allows the deposition of 3D dielectrics on 2D semiconductors with very clean interfaces, which enables FETs with very low equivalent oxide thickness dielectrics.

In this talk, I will summarize our findings over the past decade and provide perspectives for the future.

Magnesium Based Nanocomposites and Relevance of Cryogenic Treatment

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Developing a high-performance material is subjected to its composition, processing methodology (primary and secondary) and thermal treatment. A judicious combination of all these factors collectively can lead to best possible properties that can possibly be realized from any given composition. Inspired by composition-processing-thermal treatment interrelationship, this study utilized magnesium-based materials, nano length scale reinforcement, environment friendly primary processing, and intriguing and less explored cryogenic treatment on the extruded materials.

Magnesium was chosen in this study primarily due to its low density (1.74 g/cc), abundance, and non-toxic nature. To note that magnesium is the lightest metal that can be used in both load and non-load bearing applications and both engineering and biomedical sectors. Nano length scale reinforcement is chosen as it avoids particle-based damage (particle fracture and interfacial debonding) on loading. Further research conducted over last two decades has validated that nano length scale ceramic reinforcements in magnesium can enhance multiple mechanical and electrochemical properties beyond what can be realized from micron length scale reinforcements. Environment friendly primary processing techniques were chosen to avoid toxicity to water, soil, or air bodies. Cryogenic treatment was chosen as there is no work conducted to study the effect of cryogenic treatment on magnesium-based nanocomposites.

The results of this study were fascinating in context of visible microstructural variation and end properties that were realized following cryogenic treatment. Results indicated clearly that cryogenic treatment has the potential to alter the characteristics (microstructure + properties) of magnesium-based nanocomposites and must be investigated critically in future.

Keywords: Magnesium, processing, nanocomposites, cryogenic treatment

Anodeless Lithium Batteries: Towards higher energy density, safer and cheaper batteries

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The anode-free lithium metal batteries (AF-LMB), eliminates the use of a host anode, and thus offer to exploit the full potential of the lithium-containing cathode system in terms of both gravimetric/volumetric energy densities. Additionally, this system becomes more safer and cheaper than the state-of-the-art lithium-ion and lithium sulfur batteries. Nevertheless, the issues such as poor interfacial contact, curtailed ion pathway, as well as the formation of dead lithium leads to the utilization Li+-ions upon repetitive cycling, which impairs the performance endurance of the practical relevance. In the present work a combination of electrolyte additives has been employed to overcome this issue. Finally, 2032-type coin cells comprising LiFePO4/ Cu were assembled and their charge-discharge performances were analysed and discussed.

Nature-Inspired Engineering Of Functional Materials Via A Systematic Design Methodology

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Abstract

Addressing global challenges in energy, water, health, and sustainable manufacturing requires transformative technologies. Inspired by nature's evolved solutions, we systematically adapt biological principles to industrial and societal contexts. A systematic nature-inspired solution methodology accelerates innovation, illustrated here with examples from fuel cells to catalysis, cancer immunotherapy, and mitigating antimicrobial resistance.

Keywords: nature-inspired, water, electrochemical, antimicrobial, catalysis.

1. Introduction

Tackling Grand Challenges in energy, water, health and sustainable manufacturing, framed by the UN Sustainable Development Goals but also economic requirements, requires transformative approaches and interdisciplinary thinking, beyond incremental variations on traditional designs (Coppens, 2021). We turn to nature for inspiration, because nature provides us with examples of solutions, perfected over the ages, to challenges that mirror those encountered in technology, such as scalability, efficiency, and resilience. However, such solutions from nature cannot be copied: the fundamental mechanisms underpinning properties of interest need to be understood, before adopting and adapting them to the different context of industrial applications. This can be achieved via a systematic, nature-inspired solution (NIS) methodology to accelerate innovation for sustainable development (Coppens, 2021).

2. Methodology

The NIS methodology is thematic, structured around ubiquitous physical mechanisms in nature. Here, we consider the following NICE themes: (T1) hierarchical transport networks; (T2) force balancing and confinement; (T3) dynamic self-organization; and (T4) ecosystems, control and modularity. The methodology is also systematic. It recognizes a suitable concept that addresses a key challenge common to nature and technology (e.g., within T1, universal fractal scaling within a certain range), then applying it to a design (e.g., a uniform, scalable fluid distributor), guided by computation and experimentation to support iterative prototyping and implementation within an applied context (e.g., gas-solid fluidization) (Coppens, 2021).

3. Results

The systematic NIS methodology makes NICE versatile: validated principles can be applied to new problems (e.g., from fluidized bed reactors to fuel cells (Trogadas et al., 2018, 2024) for energy and environmental technology (Coppens, 2021), or from catalysis (Coppens et al., 2021) to dental materials), which accelerates discovery and innovation. This approach will be illustrated with examples related to chemical engineering (NICE) in areas relevant to functional materials, supporting applications in energy and water (Bernardes et al., 2025; Liu and Coppens, 2022) required for sustainable development, as well as biomedical applications (Perera and Coppens, 2018), e.g., for cancer immunotherapy (Chin et al., 2024)

and to combat antimicrobial resistance (AMR). Iteration allows moving from proof-of-concept to practical process, product or device.

Many developments are underpinned by theory and computation-assisted optimization (Trogadas et al., 2018; Coppens et al., 2021). Molecular simulations, mesoscopic modeling, and non-equilibrium thermodynamics are tools that require further fundamental development, complemented by machine learning and data-driven approaches.

4. Conclusion

The critical challenges faced by humanity and our planet require moving beyond the status quo. Artificial intelligence is increasingly touted as an answer to our woes, with tantalizing promises to speed up discovery and innovation, but AI generally ignores fundamental understanding, and solutions rely on the data AI is trained on, which are rarely complete or properly contextualized. We advocate an approach grounded in nature itself, because nature has had to evolve solutions to problems that are at the heart of sustainability. NICE and the NIS methodology offer a fundamental mechanistic, systematic approach to address critical challenges. NICE is based on science rather than blind imitation (strict "biomimicry") and it can account for the correct design space of engineering solutions (both degrees of freedom and system constraints). Hereby, nature-inspired engineering becomes an effective pathway to the accelerated innovation we require for sustainable progress, in balance with nature.

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Atomic to Nanoscale Engineering of 2D Materials for Electrochemical Energy Applications

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Abstract:

MXenes constitute a large family (90+ phases) of two-dimensional (2D) transition metal carbides/nitrides with a composition of $M_{n+1}X_nT_x$ (M is an early transition metal, X is carbon or nitrogen, n =1-4, and T_x stands for surface terminations). Their exceptional electrical conductivity, redox activity and ion-hosting capabilities make them promising candidates for electrode materials in electrochemical energy storage and conversion. MXenes also offe

r an excellent platform for atomic and nanoscale engineering to target specific applications. In this context, we will explore examples where pre-intercalation has significantly altered MXene electrochemical behavior. In this presentation, we highlight examples where pre-intercalation has markedly altered MXene electrochemical behavior. We also discuss other atomic-level engineering strategies that enhance MXene performance in both energy storage systems and hydrogen evolution reactions (HER). Finally, we introduce a new class of 2D materials, transition metal carbo-chalcogenides (TMCCs), which share structural similarities with MXenes but feature chalcogen-terminated surfaces. TMCCs can be synthesized via a simple, acid-free solid-state route, enabling large-scale production without hazardous etching processes. This scalable and safer synthesis method opens new avenues for exploring 2D materials beyond traditional MXenes.

Development of Technologically Important Unidirectional NLO Materials for Device Applications

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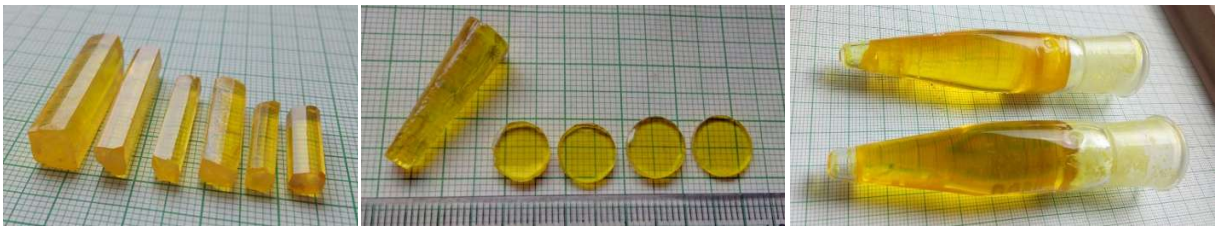
Gravity driven concentration gradient is used in the uniaxially solution-crystallization method of Sankaranarayanan-Ramasamy (SR). TGS, GPI, KAP, SSDH, DGZCD, DGBCM, benzophenone and many more crystals have been successfully grown by SR method. Longest benzophenone crystal having dimension of 1350 mm length and 55 mm diameter was grown for the first time in solution growth by SR method. Starting with a thin plate as seed a large size crystal can be grown. The physical properties and crystalline perfection of the SR method grown crystal is normally superior to the conventional method grown crystals. The quality of the SR method grown crystals has been improved by several modifications made in SR method. The impurity segregation cannot be avoided in the existing SR method. So we planned to introduce the RSR method for growing good quality, unidirectional single crystals. The effect of rotation on unidirectional crystal growth method (Rotational Sankaranarayanan - Ramasamy (RSR)) has been proposed for the first time. The organic nonlinear optical 2-Aminopyridinium 4-nitrophenolate 4-nitrophenol (2APNP) crystals have been grown by (i) conventional slow evaporation, (ii) Sankaranarayanan-Ramasamy (SR) method and Rotational SR (RSR) method. The grown 2APNP crystals were subjected to various studies like HRXRD, laser damage threshold, chemical etching, Vickers microhardness, birefringence, UV-Vis NIR, dielectrics and piezoelectrics. The Rotational Sankaranarayanan-Ramasamy (RSR) method grown crystals show excellent optical, mechanical, dielectric and piezoelectric behavior and higher laser damage threshold capability compared to the conventional and normal SR method grown crystals. HRXRD and etching studies showed that the quality of the RSR method grown crystal is better than conventional and normal SR method grown crystal. The Rotational Sankaranarayanan-Ramasamy (RSR) method can be used to grow single crystals along a specific crystallographic direction such as the phase matching direction in nonlinear optical (NLO) crystals. The unidirectional crystal growth method is ideally suited for crystal growth along this direction to obtain large size crystals required for obtaining SHG elements with minimum wastage. In addition, the unidirectional solution crystallization usually occurs at around room temperature; much lower thermal stress is expected in these crystals over those grown at high temperatures. Successful development of this unidirectional method will provide the technology to produce crystals at a yield close to 100% and easy scaling-up process.



2AP4N grown by (a) Conventional method, (b) SR method and (c) RSR method

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Micro Photosynthetic Cells For Energy Harvesting From Photosynthesis Of Algae

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Abstract:

The necessity for increased level of integration with Lab-On-a-Chip (LOC) devices have been growing for enhancing performance, functionalities, and packaging. As the fully integrated devices favour portability and disposability, they would be useful for *in-situ* biomedical diagnosis, Point-of-Care testing and energy harvesting applications. This work will present the development of microfluidics based microphotosynthetic power cell technology for energy harvesting from photosynthesis of blue green algae. The talk will cover the principles, fabrication technologies and various test results. Comparison with photovoltaic technologies will show potential to commercialize this technology for various applications in buildings and remote areas. The paper also covers the application of nanotechnology for enhancing the performance of energy harvesting from blue green algae and discussion on scaling up of the technology for commercial applications.

Lipid nanomedicine represents a cutting-edge approach in cancer theranostics, uniting therapeutic and diagnostic functions within biocompatible nanosystems.

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Lipid-based nanoparticles—such as liposomes, solid lipid nanoparticles, and lipid–polymer hybrids enable precise delivery of chemotherapeutics, nucleic acids, and imaging agents to tumor sites. Our research focuses on developing multimodal liposomes that combine chemotherapeutic agents with tumor-targeting peptides, ensuring specific localization and enhanced payload accumulation within tumors. In parallel, we are engineering advanced 3D tumor models, including spheroids, neurospheres, and organoids, to better simulate metastatic brain tumors and evaluate liposomal delivery efficiency. Additionally, we are integrating AI-driven predictive models to design and screen immunotherapeutic vaccines for metastatic cancers in conjunction with lipid nanocarriers. Beyond predictive analytics, our group has established an end-to-end pipeline that automates cell viability quantification and generates key morphological parameters for 3D multicellular tumor growth kinetics. By combining segmentation and morphological analysis, this method overcomes environmental variability and characterization challenges, providing a robust tool for drug discovery, toxicity testing, and clinical research. This integrated AI and nanomedicine approach enhances the efficiency, reproducibility, and scalability of cancer model evaluations, paving the way for intelligent, patient-specific therapeutic innovations.

Low Melting Alloy Electrodes for Flexible Electronics

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Abstract:

We explore various methods to create flexible electrodes and interconnects. using low-melting eutectic metal alloys, for large area devices. Some examples of this include free fall of the liquid metal, substrate modifications, re-formation and post-processing of films. These methods provide us various options of dimensions and shapes of the electrodes and interconnects that can be achieved. We also discuss the impact of the oxide layer formation on the surface of the films. Recent results from our laboratory in this direction will be presented.

Design of Two-dimensional MXene-Organic Hybrids for Advanced Energy Storage Devices

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Two-dimensional (2D) nanomaterials have been attractive candidates for electrical, optical, and other applications since the successful isolation and demonstration of intriguing electronic properties of graphene in 2004 by the Manchester group. The 'beyond graphene' march led to the discovery of new types of 2D materials, expanding the flatland research. MXenes, a relatively new and large family of 2D transition metal carbides, nitrides, and carbonitrides, which were discovered at Drexel in 2011, have become popular due to their diverse chemistries and unique physicochemical properties. These materials are produced by top-down wet chemical etching, resulting in surface terminations including hydroxyl, oxy, and fluorine, imparting hydrophilicity which enables solution processing. Rich surface chemistry of MXenes with engineered electrode architectures make them versatile charge storage hosts for a wide variety of ionic charge carriers. In this talk, I will discuss on our preliminary efforts in the design of MXene materials and their hybrids towards development of sustainable energy storage devices.

Emerging Light Emitting Diodes: Synthesis of Perovskite Nanocrystals and Fabrication of multicolour LED Devices

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Perovskites structured materials have attracted great interest for optoelectronics applications in the last few years. Mostly, this is thanks to the promising properties of such materials combined with low cost and solution based processing, which greatly contribute to their high potential for photovoltaic and light-emitting devices (LEDs). Recent studies have shown that these materials could also be obtained as colloidal nanocrystals exhibiting very high photoluminescence efficiency and with the possibility to emit at any desired wavelength in the visible spectrum by tuning their chemical composition and/ or by controlling their size and shape. Even though research on perovskite nanocrystals is still at the starting stage, they are expected to have a significant impact in the development of novel lighting devices in the near future thanks to their facile synthesis compared to other semiconductor nanocrystals. Here I am going to discuss the latest findings on synthesis of perovskite nanocrystals by a variety of methods to obtain high purity and narrow range emitting quantum dots. In particular, we will focus on their application in single colour LEDs (red, green and blue) and white emitting color converting layers. Finally, we will discuss what limits their application in everyday technology, such as toxicity (caused by the presence of lead in their structure and the use of organic solvent for processing), and limited functional stability.

Gold Nanocluster-Decorated WO_3/Graphene Ternary Nanocomposites: Mechanistic Insights into SMSI and Hydrogen Spillover for Enhanced HER

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The mechanistic insights on how strong metal–support interactions (SMSI) and hydrogen spillover operate at the nanoscale are fundamental to engineering high-performance HER electrocatalysts. In our work, we report a tertiary nanocomposite comprising gold nanoclusters anchored on WO_3 nanorods supported by reduced graphene layers (CC@WO_3/GR/Au), engineered to leverage both SMSI and spillover-driven proton reduction. Graphene serves as a highly conductive scaffold with rapid charge transfer pathways, while the WO_3 matrix offers tunable defect sites for efficient proton adsorption. Gold nanoclusters provide accessible catalytic centers that promote hydrogen adsorption, migration to WO_3, and desorption via the spillover mechanism.

The engineered 3D flexible electrode exhibits low overpotentials of 26 mV (acidic) and 34 mV (basic) at 10 mA cm^{-2}, along with Tafel slopes of 39–42 mV dec^{-1}. The catalyst shows strong durability with stable potentiostatic behavior over extended operation. The enhanced activity arises from the synergistic interaction between Au nanoclusters and WO_3, coupled with graphene-enabled charge migration and spillover transport. This work provides mechanistic insights into SMSI-mediated electronic reconfiguration within hybrid nanostructures and demonstrates a scalable route for designing high-performance HER catalysts for future hydrogen energy systems.

Keywords: Hydrogen evolution reaction, graphene composites, gold nanoclusters, strong metal–support interaction, hydrogen spillover, WO_3 nanorods

Advancing Power Generation in Microbial Fuel Cells Towards Practical Applications

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Biofuel cells represent a promising next-generation green energy technology for localized power generation, wastewater treatment, and self-powered sensing applications. These bioelectrochemical systems rely on enzyme-catalyzed electrode reactions, either through free enzymes or their natural cellular and subcellular hosts. Based on this, biofuel cells are broadly categorized into microbial fuel cells (MFCs) and enzymatic fuel cells (EFCs). While numerous studies have demonstrated proof-of-concept devices, their translation into commercial products remains limited, largely due to the poor performance and instability of bioelectrodes—the central components of biofuel cells. This talk focuses on strategies to enhance power generation in cyanobacteria-based MFCs (PMFCs) and sediment MFCs (SMFCs). The primary challenges are efficient channeling of metabolic electrons to the electrode and maintaining prolonged, stable operation. Improvements can be realized by promoting biofilm formation on electrodes in both PMFCs and SMFCs, augmenting photosystem efficiency in PMFCs using a FRET-guided approach, and boosting cathodic activity in SMFCs with aquatic plants. Furthermore, the use of multispecies cyanobacterial biofilms as anodic catalysts under extended dark conditions demonstrated improved stability and sustained power output in PMFCs. Overall, these findings provide critical insights into the resilience and optimization of PMFCs and SMFCs, advancing their potential for practical, real-world applications.

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Development of luminescent nanoparticles-based formulations for theragnostic applications in cancer treatment

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Cancer is a deadly disease which caused about 10 million deaths worldwide in 2022. It is the second leading cause of deaths. Hence, its early detection and treatment is essential. It is treated conventionally by chemotherapy, radiotherapy and surgery. However, the severe side effects associated with chemotherapy and radiotherapy has necessitated search for new non-invasive strategies for its treatment. Additionally, early cancer detection enhances the survival rates, hence early stage diagnosis as well as monitoring progress of treatment also need to be done with non-invasive techniques. To serve this purpose, the luminescent nanoformulations have been evaluated for diagnosis *via* real-time bioimaging and treatments because of their beneficial properties suitable for targeted drug delivery, controlled drug release, bioavailability and reduced toxicity *i.e*., theragnostic applications. In view of this, we have developed the up-conversion nanoparticles (UCNPs) and persistent luminescent nanoparticles (PLNPs), which emit especially in red region *i.e*., tissue transparency window where the biomolecules do not emit. In this effort, the $NaYF_4$ or zinc gallate ($ZnGa_2O_4$) based formulations were developed by their surface functionalization with silica coating followed by conjugation with drug molecules. The nanoparticles and formulations were characterized with powder XRD, EDS and TEM analyses and FT-IR spectroscopy. The *in-vitro* cytotoxicity of these formulations was evaluated against cancer cell lines by MTT assay and flowcytometry. The $NaYF_4$ based UCNPs functionalized with 2-deoxy-D-glucose exhibited cytotoxicity against human mammary cancer cells (MCF-7). Their luminescence property is anticipated to be helpful in precision surgery also. Hence, we have employed these nanoformulations for chemotherapy *via* drug delivery as well as imaging. Additionally, the zinc gallate based PLNPs exhibited emission even after the excitation cessation. Their formulation conjugated with pH-(low)-insertion peptise (pHLIP) exhibited utility for targeting cancer cells and their imaging also, when tracked *via* photon-imager. Further, the zinc gallate based formulations loaded with $^{10}B(OH)_3$ and tagged with pHLIP was employed to treat cancers by boron neutron capture therapy (BNCT). This formulation was found to be retained in tumors (melanoma and fibrosarcoma) developed in mice models. Later the tumor region was irradiated with neutrons which resulted in emission of alpha (α) particles that kill tumor cells, as evident from reduction in tumor volume by ~80% as compared to control tumors. These studies revealed that, the PLNPs-based formulations have potential real-time bioimaging owing to persistent luminescence as well as appropriate for therapeutic utility.

Expanding Horizons with Elastomeric 3D Graphene–Metal Nanocomposites: Multifunctional Materials for Energy Storage, Electrochemical Sensing, and Environmental Remediation

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Abstract:

Graphene, known for its superior electrical, thermal, and mechanical properties, is widely studied in materials science. To fully exploit these properties, 2D graphene sheets are often assembled into 3D architectures, such as hydrogels or aerogels, with interconnected porous microstructures. Combining 3D graphene with metal/metal oxide nanoparticles results in nanocomposites with enhanced properties, making them ideal for addressing challenges in the energy-water-environment nexus. A one-step freeze-casting method was used to fabricate 3D graphene with noble metal (Ag, Au, Pd, Pt) nanoparticles, resulting in excellent electrochemical and catalytic performance. For instance, Ag-decorated 3D-graphene showed the highest specific capacitance (845 Fg–1) and excellent cyclic retention (97% after 1000 cycles). The AgNPs/3D-graphene nanocomposite also demonstrated a strong linear relationship with Hg 2+ concentrations (0.1–40 µg L−1) and a low limit of detection (0.08 µg L−1), well below the WHO threshold. Additionally, the nanocomposites exhibited high catalytic activity in the reduction of toxic organic pollutants 4-nitrophenol and methylene blue, with Pt/3D-graphene showing the fastest reduction rates. Silver-loaded 3D-graphene displayed significant antibacterial activity, killing E. coli effectively and filtering out 37% of bacterial strains. These multifunctional 3D graphene-metal nanocomposites hold immense potential for energy storage, electrochemical sensing, and environmental remediation applications, urging further research in these areas.

Title of the talk: From Abundance to Energy: Powering Tomorrow with Sodium

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Abstract:

Environmental Sustainability in rechargeable batteries is about switching to cleaner energy sources, which requires careful consideration of how battery production affects the environment. Operations related to lithium mining have been linked to severe environmental damage that has an impact on both plants and animals. On the other hand, saltwater can be used to extract sodium, making this a more environmentally friendly source. We can lessen ecological harm by adopting sodium-ion batteries and working towards a sustainable future.

In battery technology, safety is crucial, and sodium-ion batteries perform exceptionally well in this regard. Unlike lithium-ion batteries, they are not combustible and do not experience thermal runaway, guaranteeing increased safety. Moreover, sodium-ion batteries have a longer lifespan, ensuring dependable and long-lasting energy storage for various uses. Sodium-ion batteries have become a strong contender for replacing the popular lithium-ion batteries in the search for environmentally friendly energy storage solutions. It is critical to recognise the difficulties and the current level of research in sodium-ion battery technology as we consider the potential advantages. Possible benefits of sodium-ion batteries over lithium-ion batteries include a rich source of raw materials, enhanced safety, high energy density, and extended cycle life.

Circumventing Challenges in Developing CVD Graphene on Steels for Extraordinary and Durable Corrosion Resistance

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Abstract:

Graphene has triggered unprecedented research excitement for its exceptional characteristics. The most relevant properties of graphene as corrosion resistance barrier are its remarkable chemical inertness, impermeability and toughness, i.e., the requirements of an ideal surface barrier coating for corrosion resistance. However, the extent of corrosion resistance has been found to vary considerably in different studies. The author's group has demonstrated an ultra-thin graphene coating to improve corrosion resistance of copper by two orders of magnitude in an aggressive chloride solution (i.e., similar to sea-water). In contrast, other reports suggest the graphene coating to actually enhance corrosion rate of copper, particularly during extended exposures. Authors group has investigated the reasons for such contrast in corrosion resistance due to graphene coating as reported by different researchers. On the basis of the findings, author's group has succeeded in demonstration of durable corrosion resistance as result of development of suitable graphene coating. The presentation will also assess the challenges in developing corrosion resistant graphene coating on most common engineering alloys, such as mild steel, and presents results demonstrating circumvention of these challenges.

What if we could control long-range arbitrary nanostructure alignment in polymer nanocomposites?

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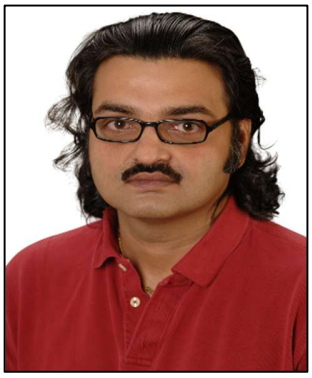
Abstract

Controlling nanostructure in polymer nanocomposites is key to unlocking their full performance potential. While achieving a high level of dispersion is a significant challenge, the alignment of nanofillers is ultimately the decisive step towards enabling multifunctional properties. The main reason is that most fillers are anisotropic and thus possess anisotropic properties. Most polymer processing operations will impart a certain level of nanostructure alignment through flow. However, local flow field gradients usually limit orientation uniformity and the orientation direction mostly in the flow direction. This is not necessarily the most optimal configuration for a broad range of applications.

Here, we present a novel nanostructure orientation technique based on a compact 1 T uniform magnetic field generated by a Halbach array. This magnetic alignment method, often enhanced by grafting iron oxide nanoparticles onto the nanofillers, enables uniform, edge-to-edge alignment with order parameters (measured via small-angle X-ray scattering) sometimes even exceeding levels characteristic of nematic liquid crystals. Crucially, the alignment direction can be arbitrarily controlled i.e. to any direction ranging from in-plane (horizontal) to perpendicular to the sample surface (vertical). We have successfully applied this method to a wide range of fillers, including reduced graphene oxide, hexagonal boron nitride, molybdenum disulfide, and cellulose nanocrystals. Notable outcomes include thermal conductivity enhancements of up to 4500%, bactericidal efficacy on par with field benchmarks but at lower filler loadings, and several other unexpected findings. Additionally, we demonstrate how this method can be used to fabricate complex nanostructure architectures, potentially opening new avenues for nanostructure design in polymer nanocomposites.

A Perspective on Emerging Nano Porous and Layered Materials & their Related Applications



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Abstract

Materials discovery and design are some of the key factors that drive technological innovations needed for substantial societal impact. Accomplishing this requires renewed materials synthesis, modification and characterization efforts. Keeping this as the central theme, this talk will focus on our ongoing investigations into understanding key fundamental properties of a variety of materials, for example, carbon-based nano-porous structures, atomically thin two-dimensional (2D) layered materials well as magnetocaloric compounds for specific applications. Specifically, (a) results of investigation on surface adsorptive properties of high specific surface area carbon based structures and their viability as efficient adsorbents for function specific applications, (b) light-matter interactions in atomically thin 2D layered semiconductors, and (c) magnetocaloric effect seen in compounds strategically processed using high energy ball milling technique, will be presented. The results of these investigation, as it relates for developing potential future applications pertaining to environment, optoelectronics and energy will be discussed.

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Advances in 2D Materials: From Nanoelectronics to Energy Applications

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Abstract

Recent advancements in atomically thin two-dimensional (2D) materials have unlocked a range of promising applications in post-CMOS nanoelectronics, as well as efficient energy generation, and storage. Over the past decade, graphene and other layered 2D transition metal dichalcogenides (TMDs) have sparked significant research interest. This work explores the scalable synthesis, functionalization, and structural, electrical, and electrochemical properties of various 2D materials.

A key focus of this discussion is the nanoscale engineering of 2D-hybrid materials by tailoring their structure, surface, and interface to achieve customized properties. Additionally, the current status and future potential of 0D-1D-2D hybrid materials are examined, highlighting their synergistic applications in next-generation electronics and energy devices. For instance, ceramic ferrite–polymer nanocomposites on metallic substrates have been developed for broadband microwave absorption in the 4–15 GHz range. Similarly, an in-situ gel-combustion method was used to synthesize a 2D graphene oxide (GO)–ferrite nanoparticle hybrid framework, followed by the fabrication of homogeneous, structurally stable thin (~100–120 μm) hybrid polyurethane films on metallic substrates for broadband microwave absorption.

Another crucial topic in this discussion is the metallic polymorph of 2D-MoS_2 (1T-MoS_2), a highly promising electrocatalyst due to its exceptional intrinsic conductivity, large interlayer spacing, hydrophilic surface, high specific surface area, rapid in-plane charge transfer, and low energy barrier for hydrogen adsorption and desorption. This work provides an overview of the electrocatalytic property evolution of 1T-MoS_2, particularly in hydrogen production via water splitting.

Furthermore, the use of plasmonic nanocrystals (NCs) to facilitate phase transformation in 2D-MoS_2 presents exciting opportunities for energy harvesting through electrocatalysis and photoelectrocatalysis. Enhancements such as increased electronic conductivity, greater catalytic active sites, and reduced Gibbs free energy for hydrogen adsorption and desorption are discussed. Lastly, the synthesis of faceted gold pentagonal bipyramidal (Au-PBP) nanocrystals for plasmon-induced phase transition (from 2H to 1T phase) in chemical vapor deposited 2D-MoS_2 is explored, along with their applications in electrocatalytic hydrogen generation.

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Grazing Incidence Small Angle X-Ray Scattering study of Thin Films on Self-Organized Nanopatterned Templates: An in situ Growth Investigation

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Grazing incidence small angle x-ray scattering (GISAXS) is a sophisticated method used to investigate surfaces, interfaces, and subsurface structures in thin films, owing to its sensitivity to surface features [1,2]. This technique allows for non-destructive, contact-free measurements of sample structures with dimensions ranging from 1 nm to 1 μm, providing statistical data about the entire illuminated volume of the sample. In-situ real-time GISAXS plays a vital role in examining the growth mechanisms of materials, especially regarding thin films. This method enables researchers to monitor the growth process within its natural environment, yielding valuable insights into the kinetics and dynamics involved in the growth by conducting GISAXS measurements in real-time, researchers can enhance their understanding of growth parameters, including substrate temperature, growth rate, and substrate interactions, which are essential for optimizing material properties. Furthermore, GISAXS can disclose the effects of templating and other control parameters on the film structure, providing unprecedented control over the nanostructure of innovative thin film materials.

In this talk, a detailed in situ GISAXS investigation of the growth of thin films of metallic and alloy thin films on self-organized nanopatterned templates prepared by low energy ion beam erosion has been done. GISAXS experiments were performed at the P03/MiNaXS beamline of the PETRA III storage ring at DESY (Hamburg, Germany). A highly automated sputter chamber (known as HASE) specially designed for in-situ GISAXS measurements has been used for growing thin films [3]. Two different kind of nanopatterned templates, (i) GaSb nanocones and (ii) nanorippled Si prepared by low energy ion beam erosion under two different experimental geometry have been used as templates to grow thin films. Thus, two different cases and experimental results will be discussed in detail:

I. Nanocone patterns exhibiting long-range order were created on a GaSb (001) substrate through the process of normal incidence low-energy ion beam sputtering. The experimental results clarify the fundamental mechanism that governs the growth of nanostructures on the GaSb (001) surface. During the deposition of Ag film, four distinct growth phases were identified: surface replication, cluster formation, coalescence into a continuous film, and the transformation of the nanoclusters' shape from hemi-ellipsoids to cylinders following percolation [4].
II. A real-time investigation into the growth of permalloy (Py) thin films deposited on ion beam sculptured nanorippled silicon templates has been conducted. During the deposition process, different growth regimes were identified: Template-guided conformal growth transitions into strain-induced roughening, which is then followed by structural reordering, culminating in bulk-like rough film growth. The growth characteristics of the film, encompassing its shape and spatial configurations, have been derived through simulations and models. Studies on magnetic anisotropy and anisotropic magnetoresistance (AMR) have been carried out to examine the magnetic and

magneto-transport properties related to the thickness dependence of Py films on nanorippled templates. As the thickness of the film increases, the influence of surface ripples on its magnetic properties diminishes, leading to a reduction in the AMR response.

The GISAXS data, along with their simulations, offered significant insights into the structural evolution, shape, and distribution of the film throughout the deposition process.

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Interfacial Engineering of Sm-Co Magnetic Thin Films on Si(100) for MEMS Applications

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Abstract:

The formation and evolution of the interfacial layer in ~240-nm-thick Sm-Co films deposited on bare Si(100) substrates were investigated as a function of deposition temperature ($T_{d,Sm\text{-}Co}$ = 400, 450 and 500°C) with respect to the structural and magnetic properties of the films. X-ray diffraction analysis revealed the crystallization of both Sm_2Co_{17}(R) and $SmCo_5$(H) magnetic phases. Rutherford backscattering spectrometry indicated that surface diffusion reactions between the Sm-Co layer and the Si substrate were accompanied by the quasi-layered growth of a $CoSi_2$ phase and the concurrent formation of a $SmCoSi_2$ phase. Cross-sectional transmission electron microscopy showed an irregular interface characterized by a deeply developed $CoSi_2$ layer and localized Moiré fringes at certain regions of the Co/Si interface. Magnetic measurements exhibited a square hysteresis loop with maximum coercivity (11.6 kOe) and remanence ratio (0.99) for films deposited at 500°C. Magnetic force microscopy images displayed patch-like domains with increasing phase contrast at higher $T_{d,Sm\text{-}Co}$. Furthermore, changes in magnetization reversal processes and the corresponding enhancement in coercivity with increasing $T_{d,Sm\text{-}Co}$ were interpreted in terms of domain morphology and first-order reversal curve characteristics. An important outcome of this study is the rapid evolution of a $CoSi_2$ interfacial layer between the as-deposited Sm-Co film and the Si substrate, which has significant implications for the design and integration of micromagnetic devices.

Keywords: Magnetic films; Sm-Co; $CoSi_2$; Sputtering.

Plasma Printing of 2D materials

Satheesh Krishnamurthy,
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We developed an innovative approach to print 2D heterostructures with promising applications in photocatalysis. Leveraging a low-powered atmospheric pressure plasma jet (APPJ) for in situ oxidation of 2D systems provides a controlled and energy-efficient route to forming TiO_2 layers with tailored electronic and structural properties. The in-situ oxidation method using APPJ promotes the formation of defect-rich oxides on the different substrates, which can enhance photocatalytic performance due to improved light
absorption and charge separation. The creation of vacancies and mixed oxidation states of metal and C likely contributes to a broadening of the absorption spectrum and facilitates electron mobility, crucial for efficient photocatalysis. The introduction of vacancies and the variation in valence states of titanium and carbon enhances the electronic density of states near the Fermi level. This modification may improve the 2D materials catalytic efficiency by reducing electron-hole recombination rates and enabling more effective charge transfer.

The use of APPJ not only enables in situ oxidation but also offers flexibility for surface functionalization, which is advantageous for tailoring the photocatalytic properties to specific applications. Additionally, APPJ's potential in printing and depositing these materials on diverse substrates can open new avenues in device integration and scalability. These 2D heterostructure shows promise for thin-film photocatalytic electrodes, which could be useful in environmental and energy-related applications, such as wastewater treatment and hydrogen production. Its deployment versatility could also extend to other photocatalytic and optoelectronic uses.

The last part of my talk I will demonstrate TRL8 demonstrator that was implemented at Denim factory in Turkey

Soft ultrasound imager toward wearable hospital grade diagnostic tools

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Abstract:

This study explores the development of hospital-grade wearable medical devices capable of home diagnosis and treatment. By integrating ultrasonic chips and other medical components onto textile substrates, we aim to enable deep tissue monitoring. Additive manufacturing and low-temperature soldering techniques were employed to fabricate flexible medical devices with reliable performance.

1.Introduction

Wearable medical devices are increasingly important for enabling continuous monitoring and diagnosis outside the hospital. To achieve hospital-grade wearable healthcare monitoring at home, devices must integrate solid medical chips with flexible substrates such as textiles. This integration requires careful consideration of both mechanical properties.

2.Materials And Methodology

We applied additive manufacturing techniques, including inkjet printing, screen printing, and aerosol printing to fabricate flexible medical devices on textile substrates. In addition, low-temperature soldering methods were developed to attach solid electronic components. Mechanical properties, rectifier performance, and acoustic phenomena were evaluated to assess device reliability.

3.Results

A 16-channel ultrasonic sensor array was successfully fabricated on textile substrates. The devices demonstrated sufficient mechanical strength and flexibility, maintaining stable performance under deformation. Experimental evaluation confirmed the ability to monitor blood vessel.

4.Conclusion

This research demonstrates that additive manufacturing combined with low-temperature bonding enables the creation of flexible, textile-based medical devices with hospital-grade diagnostic capabilities. These findings provide a foundation for future wearable systems that can deliver advanced monitoring and treatment at home, bridging the gap between hospital care and everyday life.

Powering India's Green Hydrogen Future: The Journey to the Nation's First Indigenous AEM Electrolyser Technology

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CSIR National Chemical Laboratory

Abstract:

India's green hydrogen ambitions face a significant technology gap in Anion Exchange Membrane (AEM) electrolysis, particularly due to the lack of indigenous technologies like catalysts, membranes, and stack engineering. This presentation highlights the CSIR–NCL Pune team's groundbreaking work in developing the country's first fully indigenous AEM electrolyzer technology. It showcases advancements in non-platinum group metal catalysts and high-performance MEAs, along with innovative engineering strategies for multi-cell stacks. Case studies from prototypes demonstrate improvements in stability, efficiency, and manufacturability, suited to Indian conditions. This journey illustrates how home-grown AEM technology can reduce import dependence, lower hydrogen production costs, and enhance India's position in next-generation electrolyzer innovation.

From Water Splitting to Sustainable Solutions: Expanding the Horizons of Photoelectrocatalysis

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ABSTRACT

Artificial photosynthesis provides an excellent platform to explore semiconductor-based catalysts for water splitting reactions, enabling the production of clean fuels such as hydrogen and oxygen. This light-driven catalysis approach offers an energy-efficient alternative to conventional chemical and electrocatalytic processes. The pioneering demonstration by Fujishima and Honda[1], using a TiO_2 single-crystal photoelectrode, served as a proof-of-concept for photoelectrocatalysis (PEC) water splitting. Since then, advancements in nanostructured semiconductor materials have revolutionized the field. Modern nanoscale semiconductor electrodes-both photoanodes and photocathodes-exhibit superior charge separation and transfer properties, extended visible-light absorption through multilayer architectures, and excellent integration potential with renewable power sources such as concentrated solar systems, photovoltaic modules, and hybrid energy setups [2]. Despite significant progress, misconceptions persist in distinguishing photoelectrocatalysis from electrocatalysis, particularly at higher applied potentials where electrochemical processes often dominate. Moreover, inaccuracies in interpreting characterization data-including J–V plots, chronoamperometry, incident photon-to-current efficiency (IPCE) measurements, and overall water-splitting efficiencies-remain common due to an incomplete understanding of the fundamental principles governing photoelectrochemical (PEC) systems.

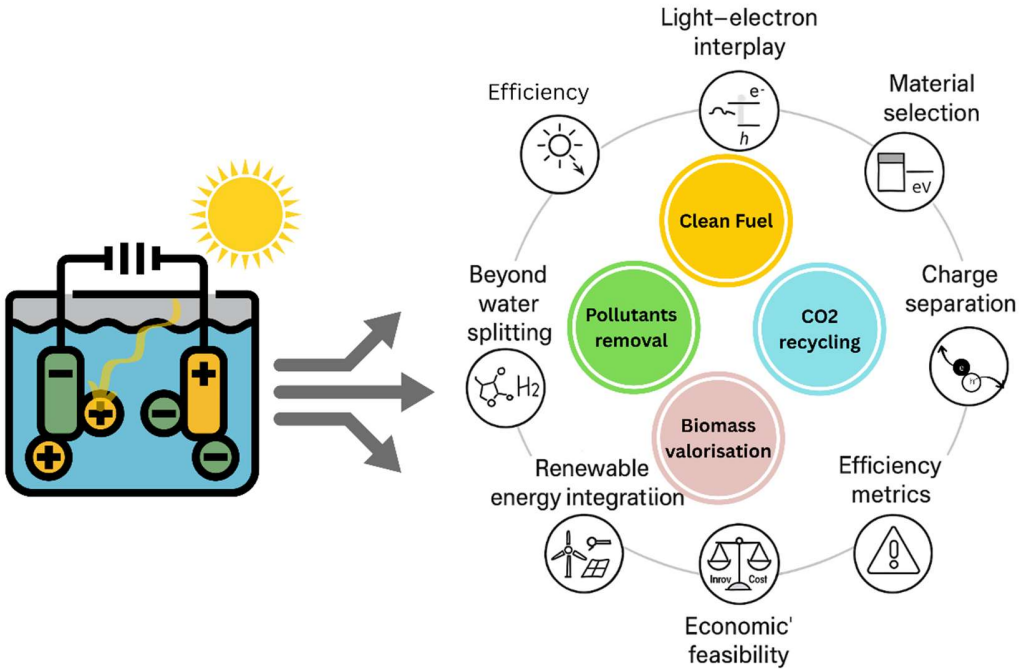

Figure. Key influencing factors in photoelectrocatalysis governing the overall performance of clean hydrogen generation, CO_2 recycling, biomass valorisation and pollutants removal.

This talk will clarify the core principles of photoelectrocatalysis, delineating its fundamental differences from purely electrochemical water-splitting mechanisms, and provide practical guidance to avoid common pitfalls in PEC cell operation and efficiency analysis.

An often-overlooked aspect of PEC system design is the choice between photoanode and photocathode configurations. This selection is not arbitrary but rather a hypothesis-driven decision that must align with the energetic requirements of the oxidation and reduction reactions involved. Understanding these distinctions is crucial for advancing PEC technology beyond conventional hydrogen and oxygen generation. Finally, the presentation will highlight recent advances in value-added PEC reactions, including the anodic valorisation of small organic molecules and the cathodic removal of heavy metals, and carbon dioxide removal at cathode showcasing how photoelectrocatalysis extends "beyond water splitting" toward sustainable and multifunctional chemical transformations [3-6].

Keywords: Solar Energy, Photoelectrocatalysis, Nanomaterials, Water Splitting, Hydrogen, Clean Chemicals.

Acknowledgement

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Nano-Bio Inspired Biosensing Technologies

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Abstract:

Nano-inspired biosensing technologies represent a paradigm shift in analytical chemistry, offering unprecedented sensitivity, selectivity, and real-time detection capabilities for complex biological, environmental, and food matrices. By integrating nanomaterials such as nanoparticles, nanowires, and nanotubes, these biosensors offer enhanced electrical, optical, and magnetic properties that enable rapid, highly sensitive, and often label-free detection of biological molecules. This advancement has paved the way for miniaturized, high-throughput systems capable of analyzing multiple analytes simultaneously, which is critical for applications ranging from early disease diagnosis to environmental monitoring and food safety. With these advancements, now researchers are succeeding in bringing these nano-inspired biosensing technologies from lab to lap, farm to fork, waste to wealth to see the light of commericialisation.

Keywords: Biosensors, Nanotechnology. Point of Care devices, Food and Water Quality Monitoring.

From materials design to system implementation: glimpses from sustainability research

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Abstract:

The maturation of materials engineering now facilitates rigorous computational materials design, particularly via multiscale modelling paradigms and emerging data science approaches. These are a means to expediting the discovery and deployment of functional materials of relevance to the UN Sustainable Development Goals (UN SDGs). We shall specifically look at case studies involving energy conversion, storage, and water treatment and water quality assurance. This presentation systematically examines data-driven and theory-grounded approaches that synergise with advanced experimental methodologies, ultimately reducing innovation latency from concept to implementation. Highlighting interdisciplinary collaborations in research areas such as photocatalytic remediation and high-capacitance energy storage materials in device and systems implementation, this talk will feature selected outcomes from our group. We shall further elucidate how an integrated system testing approach, bridging materials science, electronics, environmental sciences, and instrumentation engineering, allows industrially and socially impactful research. Focus will be placed on the dynamic relationship between computational modelling, synthetic and multi-disciplinary innovation, and empirical validation in advancing next-generation functional materials.

Wearable Electronics for Practical Uses by Printing

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Tactile sensors have taking increasing attention for the use in wearable healthcare devices and electronic skins for robots. In fabrication of the deformable tactile sensors, there have been two approaches; electronic sensor and iontronic sensor. Electronic tactile sensors monitor the electrical changes (resistance, capacitance, inductance, voltage, current) resulting from temperature change and mechanical deformation, either with/without selectors (diodes, transistors) and signal modulators (ring oscillator, analog-to-digital converter). Iontronic tactile sensors detect the electrical changes (voltage, capacitance, current) caused by charge distribution and ion transport in an electrolyte-containing medium, either with or without synaptic units used for signal modulation. In both approaches, several technological trends are emerging and competing; time-division multiple access (TDMA) versus event-driven parallel collection, passive sensing versus active sensing, and having multifunctions with clear decoupling between the functions. In this talk, I discuss some of the achievements in both the electronic and iontronic tactile sensors and compare the pros and cons of the approaches in the type of data collection, power supply, structural simplicity, and multifunctionality.

Droplet-based deposition of Organic Light Emitting Diodes: Applying Ultrasonic Spray Coating and Spray on-Screen for large-area ultra-thin coatings and devices

Prof. Dr. ir. Wim Deferme

The primary purposes of lighting remain visibility and safety. Our quality of life however can be improved by creating a complete visual environment that includes needs like health and communication.

Therefore, it's indispensable to go passed rigid, planar lighting towards flexible lighting. This also implies the use of inexpensive application techniques suitable for continuous manufacturing like printing. Ultrasonic Spray Coating is a droplet-based technology that is studied in this research to deposit all layers in an Organic Light Emitting Diode. The hole transport layer, PEDOT:PSS; the emissive layer composed out of a PPV-derivative SuperYellow, and the electron transport/hole blocking layer consisting out of a ZnO:PEIE blend will be discussed and the morphological properties of the deposited layers and the opto electronic properties of the OLEDs will be compared with spin coating. Further, to achieve extremely thin coatings – as needed for an optimized performance of the devices – the newly invented Spray-on-Screen is discussed and its application to deposit layers as this as 10nm on large area (10x10cm²) is discussed. The combination of Ultrasonic Spray Coating and Spray-on Screen sheds a light on the future generation of Organic Light Emitting Diodes and its potential application in other fields such as battery research, energy harvesting and biomedical coatings.

Abstract ID: 13

Multilayer Piezo-Triboelectric Hybrid Harvester for Clean Electricity And E-Skin Based Tactile Sensor

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High-performance multilayer-structured piezoelectric-triboelectric hybrid harvester (MS-PTH) was designed to generate a clean electricity with a gentle mechanical force. Sequential spin-coating deposition was used to develop a reliable (Ca, Sn)-doped $BaTiO_3$0.01Cu_2O (BCST)/PDMS multilayer structures. The BCST fillers exhibits a higher d_{33} value of 394 pC/N and minimized leakage losses. The MS-PTH generates a power density of 238 mW/m^2, is greater than the single-layered individual harvesters. Furthermore, the MS-PTHs (4×4 matrix) are used as an E-Skin for the prosthetic arm, with machine learning (ML) assistance to detect tactile location, action, and pressure with impeccable accuracy.
Keywords: Multilayers, piezoelectric, triboelectric, hybrid harvester, E-skin for prosthetic arm

Abstract ID: 14

Improved Resistive Switching Ratio in A Metal Oxide Polymer Matrix for Artificial Synaptic Device

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Back-to back Schottky barrier memristor fabricated with functionalising active layer using NiO+PVA matrix showed enhanced switching performance. Device showed a bipolar resistive switching with a low bias of +0.4V for SET and -0.5 V for RESET process. A ON/OFF ratio of 10^5 order with a retention time of 10^3 secs were achieved on the device. It's even interesting to study the underlying device mechanism, as the device has been fabricated with a conducting polymer for top electrode instead a metal electrode. Synaptic measurements were also performed for emulating the brain like artificial synaptic performance.
Keywords: Memristor, artificial synapses, Nickel oxide, Nanoparticles, Schottky barrier

Abstract ID: 17

Sulfur Incorporation Boosts Alkaline Water Splitting Performance of $Co_2mn_1s_x$/Nf Electrocatalyst

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Large-scale green hydrogen generation necessitates the development of efficient and durable electrocatalysts capable of producing high current densities at low overpotentials. In the present study, a $Co_2Mn_1S_x$ electrocatalyst was synthesized over nickel foam via the solvothermal method. Sulfur was introduced into the electrocatalyst by varying the aqueous solvent with DMSO, which resulted in the observable improved HER activity for an H_2O:DMSO ratio of 1:1. These results highlight that the solvent engineering approach effectively optimizes the activity and durability of the $Co_2Mn_1S_x$/NF electrocatalyst for sustainable hydrogen production.
Keywords: Hydrogen evolution reaction, solvent engineering, alkaline water splitting

Abstract ID: 18

Controlled Synthesis of Super Carbonate Apatite for In Vivo Delivery of Nucleic Acid

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Efficient delivery of nucleic acid remains as one of the challenges to be addressed for regenerative therapeutics. In order to address this issue, we have successfully synthesized biomimetic carriers i.e. nanoparticles (NaP) made of super carbonate apatite (sCA). The synthesis was performed via controlled precipitation to obtained a spherical shape nanoparticle. The internal morphology seemed ideal for cellular internalization and charge of particles also seemed optimal for the uptake of nucleic acids. Furthermore, the nucleic acid uptake capacity also seemed high. This study gives a future scope for in vivo delivery applications in regenerative medicine.
Keywords: Super carbonate apatite, nanoparticle, nucleic acid, tissue regeneration, in vivo delivery.

Abstract ID: 21

Textile Dye Degradation Using Magnesium Oxide Nanoparticles Via Green And Chemical Synthesis

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This study investigates magnesium oxide (MgO) nanoparticles as eco-friendly catalysts for dye degradation. MgO was synthesised via chemical precipitation and planned green synthesis using *Nerium oleander* flower extract. The chemical route yielded nanoparticles that, when added to Reactive Orange dye solutions of 2, 4, 6, 8, 10 ppm, show visible adsorption within 60 minutes and a significant reduction in UV–Vis maximum absorbance at 400 - 450 nm, with degradation efficiencies up to 94% at 10 ppm [Table 1]. The chemical route confirmed effective dye removal, and green synthesis is expected to enhance stability and surface activity. Further characterisation using UV–Vis, FTIR, XRD, and SEM is planned to assess morphology, structure, and functional groups. These results highlight MgO nanoparticles as a cost-effective and sustainable material for textile wastewater treatment.
Keywords: *Textile dyes, MgO nanoparticles, green synthesis, Wastewater treatment, Dye Degradation*

Abstract ID: 22

Synthesis And Characterization Of B-Ga_2O_3/G-C_3N_4 Nanocomposite for Visible-Light-Activated Room-Temperature Hydrogen Detection

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Hydrogen is a clean energy carrier, but its safe detection is challenging. We developed a visible-light-driven hydrogen sensor based on a β-Ga_2O_3/g-C_3N_4 nanocomposite operating at room temperature. The heterojunction structure enhances charge separation and visible light absorption, improving sensing performance. Synthesized nanocomposites showed reduced bandgap and strong interfacial stability, confirmed by XRD and UV-visible spectroscopy. These features enabled fast, sensitive, and selective hydrogen detection without external heating. This work demonstrates a promising approach toward low-power, efficient hydrogen sensors for clean energy applications, with future work focusing on device integration and real-time monitoring.
Keywords: hydrogen sensing, β-Ga_2O_3, g-C_3N_4, nanocomposite, visible light

Abstract ID: 23

Understanding The Effect of Nitio$_x$/Nf Electrocatalyst in Enhancing Alkaline Water Splitting

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Nickel-based catalysts hold the potential to enhance active sites, conductivity, and electronic structure through various modifications, which can facilitate electron transfer and reactions occurring at the electrocatalyst surface. Herein, a bifunctional $NiTiO_x$ catalyst was developed on nickel foam via a facile hydrothermal method. The influence of incorporating titanium was studied by varying the precursor ratios to optimize the best combination that leverages a superior activity in alkaline water splitting. The as-synthesized catalyst delivered good catalytic activity towards hydrogen evolution and oxygen evolution reactions with lower overpotentials.
Keywords: Nickel-based electrocatalyst, hydrothermal, nanosheets, water splitting

Abstract ID: 24

Effects Of Stack Dielcetric Layers and Scaled Channel Length on the Electrical Properties of An Extended Gate Field Effect Transistor

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The tuning ability of stack dielectrics tends to exhibit much impact on microelectronic device performance. Here, we investigate the electrical characteristics of extended gate field effect transistor (EG-FET) with varying channel length (CL) from 2 to 100 µm and different dielectric layers of SiO_2/SiO_2 and HfO_2/SiO_2. These two dielectric layers can provide more passivation layer which is more preferable for perfect field effect transistor. The EG-FET with stack dielectrics of SiO_2/SiO_2 exhibits high electrical performance at short CL 2 µm than others ranging from 10-100 µm.
Keywords: EG-FET, Channel length, dielectric, I-V measurement, current saturation

Abstract ID: 25

Ion Beam Sputtered Cuprous Sulfide Thin Films for Low-Temperature Thermoelectric Applications

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Cuprous sulfide (Cu_2S) is an earth-abundant and a promising thermoelectric material for low-temperature energy harvesting. We investigated ion beam sputtered and thermally treated Cu_2S films exhibiting mixed-phase structures, with γ-Cu_2S and β-Cu_2S below 200°C and α-Cu_2S above 300°C. Rutherford backscattering spectrometry (RBS) and Hall results confirmed p-type conductivity in Cu-deficient films. The electrical conductivity and Seebeck coefficients were 653-2416 $\Omega^{-1}cm^{-1}$ and 20-49 μVK^{-1}, respectively. The mixed-phase films annealed at 100°C showed energy filtering of charge carriers which yield the highest power factor of 308.5 $\mu Wm^{-1}K^{-2}$, and figure-of-merit of 0.049. Phase-engineered Cu_2S thin films show strong potential for low-temperature thermoelectric applications.
Keywords: Thermoelectric; cuprous sulfide; copper vacancy; phase transition; power factor.

Abstract ID: 26

Energy Transfer Dynamics in Tb^{3+} Doped 2d $Cspb(Br/Cl)_3$ Nanoplatelets

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This research investigates thickness-dependent energy transfer dynamics in quantum-confined Tb^{3+}-doped $CsPbX_3$ (X=Br/Cl) perovskite nanoplatelets (NPL). We elucidate the influence of quantum confinement on energy transfer efficiency from the perovskite host to lanthanide dopants. $CsPbBr_3$ NPL as the host material, provides tunable optical band gap. Besides, precise control over the NPL thickness leads to distinct excitonic transitions in the NPL. Incorporation of Tb^{3+} ions enhance the higher order excitonic transitions in the host NPL, unobserved otherwise in undoped NPL. Excitation of these excitonic transitions results in varying emission strength from Tb^{3+} ions. These changes suggest a potential interaction between the host excitons and dopant ions, opening a path for energy transfer dependent optoelectronic and sensing applications.
Keywords: Quantum confinement, Nanoplatelets, Energy transfer

Abstract ID: 27

Facile Synthesis of Copper Modified Γ-Al_2o_3 and Cuo/$Cual_2o_4$ for Photocatalytic Remediation of Toxic Hexavalent Chromium

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Remediation of noxious hexavalent chromium (Cr(VI) was achieved using low-cost γ-Al_2O_3 and Copper-modified derivatives prepared by simple combustion method. Materials were characterized by P-XRD, FT-IR and UV-DRS. 1% Cu dopant incorporated into the γ-Al_2O_3 lattice enhanced UV-driven adsorptive reduction, yielding 93% remediation of 25 mg/L Cr(VI) at pH 2 using 30 mg catalyst. Higher Cu concentrations produced visible light active CuO/$CuAl_2O_4$ which reduced Cr(VI) under 150-300 W visible light in 6-4h.
Keywords: Hexavalent Chromium, Adsorptive-Reduction of Cr(VI), Visible Light Cr(VI) Photoreduction, Alumina

Abstract ID: 28

Modeling And Simulation of Hzao-Based Fefets

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This work presents TCAD-based modeling and simulation of HZAO-based ferroelectric field effect transistors (FeFETs) to evaluate their potential for non-volatile memory applications. The polarization characteristics were first calibrated using metal–ferroelectric–metal (MFM) capacitors and subsequently transferred to MISFET structures for device-level analysis. The simulated transfer characteristics showed a good agreement with experimental data, achieving more than 70% accuracy. The developed simulation framework provides valuable insights for optimizing material parameters and guiding the design of reliable ferroelectric memory device
Keywords: TCAD, FeFET, HZO, polarization, and hysteresis

Abstract ID: 29

Ball Milling-Assisted Homogenization of Incinerated Copper and Zinc Oxides For Traditional Medicine Applications

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Indian traditional medicine uses incinerated metal particles as internal medicines. Their synthesis process mostly involves wet grinding the metal foils with plant extract, followed by conventional incineration, resulting in heterogeneous micro/nano particles. Their therapeutic activities are evaluated through *in vitro* and *in vivo* studies; however, it is challenging to assess their intercellular pathways and other subcellular interactions due to their heterogeneous morphology. Here, incinerated zinc (InZn) was ball-milled. Its crystallite size and hydrodynamic radius were measured using XRD and DLS. The crystallite size was reduced from 42.1–59.2 nm to ~20.9 nm, the hydrodynamic radius was 505 nm, and the polydisperse index was 0.16. These results demonstrate that ball milling is a scalable method for homogenizing incinerated metals used in traditional Indian medicine.
Keywords: *InZn, Ball milling, XRD, DLS, PDI.*

Abstract ID :30

Phytotherapeutic Incorporated 45s5 Bioactive Glass for Enhanced Bone Regeneration

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45S5 bioactive glass (45S5BG) is recognized for its osteoconductivity and the ability to bond with bone, yet its regenerative efficacy can be enhanced through phyto-therapeutic incorporation. In this study, extracts from *Cissus quadrangularis* and *Blepharis maderaspatensis* were integrated into the nano 45S5 BG, yielding a composite that retained apatite-forming ability. The incorporation of the phytochemicals was physiochemically confirmed. The biocompatibility assay revealed that the nanoparticles are non-toxic. Hence, this material has the potential to be used for advanced bone-healing applications.
Keywords: bioactive glass, 45S5BG, phyto-therapeutic, apatite formation.

Abstract ID: 31

Modeling And Simulation of Cucro2 Based TFT

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In this paper, a comprehensive parameter profile of CuCrO2 based thin film transistor using TCAD –Sentaurus is presented to understand the origin of conductivity and performance of ptype TFTs. To validate the profile the simulated I-V characteristics were fitted with an experimentally extracted transfer characteristic of thin film transistor. It is observed that both acceptor-donor band tail states and Gaussian states plays a major role in the defect profile of CuCrO2.
Keywords: TCAD, Thin Film Transistors (TFTs), $CuCrO_2$, Density of states (DOS) and oxide semiconductors (OSs).

Abstract ID: 32

Tio_2 – Sio_2 Hybrid Metal Oxide Nanomaterial Composites for Advanced Triboelectric Nanogenerator-Based Self-Powered Sensing Applications.

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Hybrid TiO_2–SiO_2 nanocomposites can significantly enhance triboelectric nanogenerators for self-powered sensing. This work explores how TiO_2, SiO_2, and their binary composites improve surface chemistry, dielectric response, charge density, and stability. Using the sol–gel method, a simple and scalable route, allows fine control of stoichiometry, morphology, and interfacial bonding. Devices show that TiO_2 increases dielectric permittivity and charge retention, producing higher voltages and power, while SiO_2 enhances mechanical strength, charge trapping, and thermal/chemical stability. These synergies boost TENG performance for motion, humidity, UV, gas, and pressure sensing in wearables. Future directions involve addressing nanoparticle dispersion, interface engineering, long-term durability, and scalable fabrication for advanced hybrid TENG sensors.
Keywords: Metal Oxides Nanomaterials, TENG, Self Power Sensor, TiO2 and SiO2.

Abstract ID: 33

Kitchen Waste-Derived Functional Materials for EcofriendlyTriboelectric Nanogenerators and Selfpowered Sensors.

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Every day, large amounts of kitchen waste are generated, creating environmental concerns. Meanwhile, the rising use of sensors and electronics demands renewable and sustainable energy options. This work suggests converting kitchen waste into eco-friendly materials for making triboelectric nanogenerators. Biowaste-derived materials show excellent dielectric and surface properties, enabling strong triboelectric charge generation. In TENG devices, they capture energy efficiently from mechanical actions like pressing, sliding, and tapping. These devices also function as self-powered sensors for gas, humidity, and human activity, proving their versatility. The findings confirm that kitchen waste materials are lowcost, green, and effective substitutes for synthetics, supporting waste reduction and clean energy. This approach promotes circular economy concepts and connects environmental stewardship with renewable energy technologies.
Keywords: Kitchen waste, Triboelectric Nanogenerator, Self Powered Sensor.

Abstract ID: 34

Nanoparticle-Enhanced 3D Bioprinting for Neural Tissue Engineering

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Nanoparticle-enhanced 3D bioprinting has emerged as a transformative approach for neural tissue engineering by improving bioink properties, cellular viability, and functional integration. Nanoparticles enable controlled delivery of biomolecules, enhance mechanical stability, and modulate neural regeneration pathways. This review highlights recent advances in combining nanotechnology with 3D bioprinting to fabricate neural tissue constructs, emphasizing strategies for neuroregeneration and treatment of neurological disorders. Challenges such as long-term biocompatibility and clinical translation are discussed, alongside future directions

that integrate smart nanomaterials and biofabrication technologies to advance personalized neurosurgical therapies.

Keywords: nanoparticles, 3D bioprinting, neural tissue, neuroregeneration, biofabrication

Abstract ID: 35

Tio_2-Rgo Support for Pt Electrocatalysts In Proton Exchange Membrane Fuel Cells

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This study investigates the performance of titanium dioxide-reduced graphene oxide (TiO_2-rGO)-supported Pt nanoparticles (NPs) as a cathode catalyst in proton-exchange membrane fuel cells (PEMFCs). TiO_2-rGO composites were fabricated by the hydrothermal method, followed by the loading of Pt nanoparticles via chemical reduction. The resulting Pt/TiO_2-rGO catalyst displayed 5× and 4× higher mass and specific activities, respectively, compared to that of Pt/C catalyst. These findings demonstrate that the Pt/TiO_2-rGO catalyst offers a promising alternative to conventional Pt/C catalyst for durable PEMFC cathode.

Keywords: TiO_2-rGO support, Pt catalyst, oxygen reduction reaction, acidic electrolyte

Abstract ID: 37

Comparative Study of Binder-Free Taurine-Doped Polyaniline and Its Graphene Composite for Bioactive Supercapacitors.

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Taurine-doped polyaniline (T-PANI) and its graphene composite (T-PANI/Gr) were synthesized via low-temperature oxidative polymerization to evaluate graphene's role in morphology, electrochemical behavior, and cytocompatibility. AFM showed increased surface roughness (48 → 72 nm) with graphene, while XPS confirmed taurine doping and graphene–polymer interactions. T-PANI/Gr exhibited lower charge-transfer resistance (92 Ω vs. 215 Ω), higher capacitance (412 vs. 265 F g^{-1} at 1 A g^{-1}), and superior stability (91 % retention after 2000 cycles). MTT assays confirmed > 85 % fibroblast viability, with slightly improved cytocompatibility for T-PANI/Gr, underscoring its potential in bioactive supercapacitor and bioelectronic applications.

Keywords: Taurine-doped PANI, Graphene composite, AFM, Electrochemical studies, Cytocompatibility.

Abstract ID: 40

Fabrication Of G-C_3n_4-Mnv_2o_6-Zro_2 Ternary Nanocomposite on Porous Polymer Scaffold for the Efficient Photoreduction of Chromium and Photodegradation of Bisphenol A

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In recent years, the accumulation of hazardous pollutants has become a primary ecological concern, prompting the exploration of advanced oxidation technologies, including photocatalysis for water purification. Graphitic carbon nitride (g-C_3N_4), a metal-free, visible-light-responsive conjugated polymer, has attracted significant attention due to its suitable band structure, high physicochemical stability, and earth-abundant nature [1]. In this work, g-C_3N_4 and metal oxide nanostructures (MnV_2O_6-ZrO_2) were synthesized and combined to form a ternary heterojunction, which was further embedded in a polymer scaffold, to enhance practical applicability and minimize environmental impact. This photocatalyst was employed to study the photoreduction of chromium and photodegradation of bisphenol A under visible light illumination.
Keywords: Graphitic carbon nitride, metal oxide, Z-scheme, photocatalysis, environmental remediation.

Abstract ID: 44

Design And Characterization of Bio-Inspired Super Wetting Multifunctional Nano Composite Membranes for Oil Removal

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This study presents the development of sustainable polysulfone-based nanocomposite membranes for efficient oil removal from waste stream. Two sets of membranes were prepared one incorporated with TiO_2-ZnO nanoparticles and the other with a bio-extract containing phenolic and fatty acid groups. Both membranes were cross-linked for improving stability. The bio-inspired membrane demonstrated superior Hydrophilicity and antifouling characteristics Further, showed 97% oil rejection from an emulsion under vacuum filtration. Surface analyses of the membrane confirm uniform particle distribution across membrane surfaces. Repeatable eco-friendly synthesis route and high oil rejection performance show that the bio-based membranes are sustainable alternatives to inorganic nanocomposites membranes for oil–water separation applications.
Keywords: Polysulfone membrane, Nanocomposites, Bio-extract, Phenolic compounds, Wastewater treatment.

Abstract ID: 45

Characterizing the nanocomposite and MOF membranes using super wettability theory

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The super wettability behaviour of nanocomposite and MOF-embedded polysulfone membranes was evaluated using Young's, Wenzel's, and Cassie–Baxter models. The MOF-modified membranes exhibited a water contact angle (WCA) of 30° and an oil contact angle (OCA) of 170°, indicating superior hydrophilicity and underwater superoleophobicity. FTIR and SEM analyses confirmed hierarchical roughness and hydrophilic functional groups consistent with theoretical models. These results demonstrate Wenzel-type superhydrophilicity and Cassie-Baxter type superoleophobicity, influenced by surface chemistry and texture. The findings offer mechanistic insight into wettability tuning and advance the design of next-generation membranes for efficient oil-water separation and wastewater treatment.
***Keywords**:* Super wettability, Water contact angle, MOF-embedded membranes, Wenzel model, Cassie-Baxter model.

Abstract ID: 46

Surface-Engineered Amorphous Zirconia Aerogels for Energy Storage Applications

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As a chemically inert and thermally stable ceramic, zirconia is considered a promising material for energy storage when processed as aerogels owing to its high porosity and surface area. Amorphous zirconia aerogels were synthesised via the sol-gel method with controlled ageing, solvent exchange, and ambient-pressure drying using the eco-friendly multifunctional agent, hexamethylenetetramine. Ageing and drying conditions were tuned to preserve high surface area and porosity, mitigating pore shrinkage and densification. Characterisation by BET, XRD, Raman, FTIR, and SEM-EDS confirmed a porous nanostructure and amorphous framework of zirconia aerogels. Electrochemical analysis of the high surface area samples demonstrated superior energy storage behaviour, highlighting their potential as efficient supercapacitor electrodes.
Keywords: Zirconia aerogel, Amorphous, Surface area, porosity, Electrochemical performance.

Abstract ID: 47

A Free-Standing Nanofibrous Nanocomposite Membrane for The Sensitive, Selective, And Rapid Detection of Breast Cancer

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Breast cancer remains one of the leading causes of mortality among women, emphasizing the need for rapid and reliable diagnostic strategies. Here, we report a free-standing nanofibrous nanocomposite membrane composed of polyvinyl alcohol (PVA) and gold nanoclusters (AuNCs) for the selective and sensitive detection of breast cancer biomarkers. The PVA-AuNCs membrane displayed strong orangish-red fluorescence at 647 nm, which decreased linearly with increasing hydrogen peroxide (H_2O_2) concentration, achieving a low detection limit (LOD) of 47 pM. Since elevated H_2O_2 levels are closely associated with oxidative stress and cancer progression, the developed membrane effectively distinguishes cancerous (MCF7) and normal (L929) cells, highlighting its potential for early breast cancer detection.
Keywords: Electrospinning, Photoluminescence, Cancer detection, Activator, Inhibitor.

Abstract ID: 50

Electrochemcial evaluation of Phase pure Lithium Cobalt Oxide ($LiCoO_2$) synthesized from end of life (EoL) batteries for cathode applications

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Lithium cobalt oxide ($LiCoO_2$, LCO) has long been preferred as a cathode material for lithium-ion batteries due to its high discharge capacity, excellent cycle life, and stable shelf life. In this study, we investigate the synthesis of $LiCoO_2$ using secondary raw materials recovered from discarded lithium-ion batteries, with a purity exceeding 99%. Lithium carbonate (Li_2CO_3) and cobalt oxalate (CoC_2O_4), recovered from end-of-life batteries, were used as starting precursors. A stoichiometric composition of $LiCoO_2$ was synthesized via the solid-state reaction method. The resulting samples were characterized through physico-chemical and electrochemical investigations to evaluate their structural, morphological, and electrochemical performance.
Keywords: Recycling, Solid state synthesis, Lithium cobalt oxide, XRD, SEM, Discharge capacity, Cycle life

Abstract ID: 51

State-of-Charge-Dependent Charge Transport in a Nickel-Rich Cathode: An *in-Operando* Study Using an Ion-Gated Transistor Configuration

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Understanding the coupling between ionic and electronic transport in lithium-ion battery (LiB) cathodes is essential for improving their cycle life and stability. This work investigates the charge transport behaviour of a nickel-rich layered oxide cathode, Lithium Nickel Manganese Cobalt Oxide ($LiNi_{0.85}Mn_{0.05}Co_{0.10}O_2$ or NMC85), using an in-operando Ion-Gated Transistor (IGT) configuration. Morphological and compositional characterizations, including Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDX), were combined with electrochemical and electrical measurements. The results show that electronic conductivity increases with delithiation, confirming the strong dependence of transport on State of Charge (SoC). The study highlights the potential of IGT as an in operando electrochemical engineering tool to probe the charge transport mechanisms in LiB cathode materials. Further, the work contributes to the advancement of iontronic and neuromorphic devices.
Keywords: Lithium-ion battery, Nickel-rich cathode, In operando, Ion-gated transistor, electronic transport.

Abstract ID: 52

$Ti_3C_2t_x$ Mxene Bonded Perylene Diimide as A Robust Charge Host for Seawater Electrolytes

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Organic materials represent a new class of redox charge hosts for the creation of sustainable metal ion-based electrochemical energy storage systems. These materials are affordable and easy to process. Seawater is an abundant natural resource which creates a way to design sustainable and economical large-scale energy storage systems. However, when potential is applied to organic materials in the electrolyte medium, they experience dissolving effects, poor

electrical conductivity, and mechanical instability. To prevent this, some modification is needed. Here, we reported $Ti_3C_2T_x$ MXene bonded with cationic perylene diimide (*c*PDI) as a redox-active charge storage material for seawater-based electrolytes such as NaCl, KCl and $MgCl_2$. By integrating $Ti_3C_2T_x$ MXene, it regulates and promotes the interaction of cations with the carbonyl groups of *c*PDI and plays the role of conductive and mechanical support for stabilizing the organic electrodes.

Keywords: $Ti_3C_2T_x$ MXene, cationic perylene diimide (*c*PDI), energy storage, organic materials.

Abstract ID: 54

Photolithographically Patterned Ion Gated Transistor to Probe Electronic and Ionic Transport in Lithium Cobalt Oxide Cathode.

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Ion-gated transistors (IGTs) are powerful platforms to study charge transport in battery materials such as Lithium Cobalt Oxide ($LiCoO_2$). Previous IGT studies have shown clear gate-induced changes in conductivity, but the use of an unpatterned LCO channel makes it difficult to distinguish intrinsic electronic transport from parasitic electrochemical processes at electrolyte/metal interfaces. Building on these results, we focus on introducing photolithographic patterning of the LCO channel to better control the active gating region and suppress unwanted parasitic currents. This approach improves reproducibility and provides clearer insight into how charge transport happens through the LCO composite electrode, correlating fundamental battery studies with solving device-level limitations in advanced applications in iontronics and synaptic transistors.

Keywords: Ion-gated transistor, Li-ion battery cathodes, Patterning, Parasitic Capacitance, Leakage current, electronic transport.

Abstract ID: 55

Unconventional Synthesis of Phase Pure Ti_3AlC_2 MAX Phase and $Ti_3C_2T_x$ MXene Ink for Flexible EMI Shielding Application

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Electromagnetic Interference (EMI) shielding has become one of the major research interests due to the rapid growth of electronics and telecommunication field. Herein, we report the EMI shielding effectiveness of layered and flexible $Ti_3C_2T_x$ MXene film with different thickness. The $Ti_3C_2T_x$ MXene inks were obtained through LiF/HCl etching of lab prepared Ti_3AlC_2

MAX phase. Pristine MXene inks were coated on a flexible substrate with different thickness of 2, 5, and10 µm exhibits a total EMI shielding effectiveness (SE_T) value of 28, 34, and 39 dB respectively at 8-12 GHz. We estimate the EMI shielding efficiency of 14000 dB/mm for 2 µm thick MXene layer.

Keywords: EMI shielding, 2D material, MXene, Thickness, Flexible

Abstract ID: 56

Rapid Synthesis of Potent Silver Nanoparticles Using *Peltophorum Pterocarpum* Bark Extract with Enhanced Antibacterial and Anticancer Activities

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Silver nanoparticles (AgNPs) were synthesized using *Peltophorum pterocarpum* bark extract as an efficient reducing and capping agent. The AgNPs formation was confirmed by UV–visible spectroscopy, with a SPR peak at 420 nm. TEM images showed uniformly distributed spherical AgNPs (3–27nm). AgNPs exhibited potent antibacterial activity against both Gram-positive and Gram-negative bacteria. MTT assay revealed dose and time dependent AgNPs cytotoxicity on human breast cancer (MCF 7) and lung cancer (A549) cells, while fluorescence microscopy confirmed AgNPs-induced cell death through nuclear staining methods (AO/EB and DAPI).

Keywords*: Peltophorum pterocarpum*, Silver Nanoparticles, Antibacterial, MCF 7, A 549

Abstract ID: 57

DNA Tetrahedron-Mediated Nano-Delivery Potentiates Cisplatin Delivery In Oral Cancer Cells

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Oral Squamous Cell Carcinoma (OSCC) exhibits pronounced therapeutic refractoriness arising from intrinsic and acquired chemoresistance, inadequate intratumoral drug bioavailability, and dose-limiting systemic toxicities associated with cisplatin. To address these pharmacological constraints, a cisplatin-encapsulated DNA tetrahedron nanoplatform (TDs:Cis) was rationally engineered, leveraging the nanoscale structural fidelity, molecular programmability, and biocompatibility of DNA nanotechnology. The TDs:Cis construct demonstrated enhanced cellular internalization, sustained intracellular drug retention, and augmented DNA adduct formation, culminating in apoptosis-mediated tumour cytotoxicity. Comparative analyses

revealed superior therapeutic indices and attenuated off-target effects relative to free cisplatin, underscoring the translational potential of TDs:Cis for precision nano-chemotherapy in OSCC.
Keywords: Oral Squamous Cell Carcinoma, DNA Tetrahedrons, Cisplatin

Abstract ID: 58

Eco-Friendly Silver Nanoparticles: A Comparative Study of Green and Chemical Synthesis Approaches Towards Biocompatibility and Conductivity

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In this paper, silver nanoparticles were synthesised using two methods: a traditional chemical method and a green method that used extract from *Jasminum Multiflorum*. The results highlight the trade-off between conductivity and biocompatibility by showing that chemically synthesized AgNPs exhibit greater electrical conductivity, while green-synthesised AgNPs are more effective against Gram-negative bacteria than Gram-positive bacteria and ecologically safe. The antibacterial efficacy of green-synthesized AgNPs was consistently higher than that of their chemically synthesized counterparts due to their wider inhibition zones. These results highlight the possibility of ecologically safe, plant-mediated synthesis pathways that yield AgNPs with improved antibacterial activity.
Keywords: Chemical Synthesis, Green Synthesis, *Jasminum Multiflorum*, Conductivity, Biocompatibility

Abstract ID: 59

Energy-Dependent Neutron Attenuation and Interaction Analysis in Gd_2O_3 and B_4C Modified Concrete Using Monte Carlo Simulation

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Understanding the energy-dependent behaviour of neutron interactions in shielding materials is essential for optimizing protection in nuclear and research environments. In this study,150 × 150 × 50 mm^3 concrete slabs with varied nano-Gd_2O_3 and B_4C were analysed using the OpenMC Monte Carlo code to evaluate neutron moderation, attenuation, and reaction behaviour across a wide energy spectrum. The slab was discretized into ten layers of 0.5 cm thickness to capture the spatial evolution of neutron flux and reaction rates. Monoenergetic neutron sources covering 10^{-4} eV to 10^7 eV were simulated to investigate elastic, inelastic, absorption, and radiative-capture processes.
Keywords: Neutron, Concrete, Gadolinium Oxide, Boron Carbide, Monte Carlo

Abstract ID: 60

Multifunctional natural rubber-few layer graphene-hexagonal boron nitride hybrid nanocomposites with superior mechanical and antimicrobial properties for biomedical devices

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Thin-film nanocomposites of natural rubber (NR) reinforced with few-layer graphene (FLG), hexagonal boron nitride (h-BN), and their hybrid (h-BN/FLG) were developed to advance biomedical elastomer technology. The optimized hybrid system exhibited exceptional tensile strength (35.1 MPa), thermal stability (T_{10}=359 °C), and superior biological performances. Antibacterial studies showed inhibition zones up to 29 mm, ~100% contact killing, and 55% biofilm reduction against *S. aureus* and *P. aeruginosa*, while >95% fibroblast viability confirmed outstanding cytocompatibility. These multifunctional nanocomposites were successfully fabricated into finger cots, condoms, and gloves, demonstrating strong potential for next-generation biofunctional and protective medical applications.
Keywords: Natural rubber, nanocomposites, graphene, boron nitride, antibacterial.

Abstract ID: 63

Silver Oxide Nanoparticles Through Melia Dubia Comprehensive Study of Structural Characterization and Antibacterial Activity

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Silver nanoparticles (AgNPs) are potent antimicrobial agents capable of in vitro and in vivo killing of pathogenic bacteria. The current research compares chemical synthesis (AgO) and green synthesis (AgM) by *Melia Dubia* extract. Particle formation was verified by X-ray diffraction, Fourier-transform infrared spectroscopy, and scanning electron microscopy, verifying spherical particles of average diameter 3 µm for AgO and 2 µm for AgM. The antibacterial efficacy against *Klebsiella, Pseudomonas, Staphylococcus, and Escherichia coli* was screened, with higher activity by green-synthesized AgM, which was 96% against *Klebsiella* and 65% against *Escherichia coli.* These results provide the advantage of green synthesis for biomedical applications**.**
Keywords: Silver Oxide Nanoparticles, *Melia Dubia***,** Sol gel method**,** Antibacterial efficiency.

Abstract ID: 65

Electrochemical study of Tungsten-Based Electrode Material for High-performance supercapacitors

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The development of high-performance electrode materials is crucial for advancing supercapacitor technologies. In this work, $WS_2/WO_{2.9}$ synthesized using atmospheric pressure chemical vapor deposition technique (APCVD) and systematically investigated for their electrochemical supercapacitor application using two electrode system – Swagelok cell. The APCVD technique enabled the growth WS_2 petal like structure along with the rod like morphology of $WO_{2.9}$. Structural, morphological, and compositional analyses using XRD, SEM and HRTEM confirmed the formation of mixed phases $WS_2/WO_{2.9}$, exhibiting the high surface area and interconnected rod-like structure. Galvanometric charge discharge (GCD) cycle revealed a specific capacitance of 380 F/g at a current density of 0.08 A/g. These findings highlight the potential of APCVD- grown tungsten-based electrodes as promising candidate for the next generation energy storage devices.

Abstract ID: 66

Beyond Global Averages: A Scalable Country-Resolved CO_2–Temperature Analytics Framework for Forecasting and Policy Design

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This study presents a reproducible *Emission Intelligence Framework (EIF)* that integrates carbon- emission analytics, causality testing, and forecasting to evaluate national climate dynamics. By aligning country-level CO_2 emissions with temperature anomalies from multiple datasets, EIF identifies temporal lags, causal directions, and predictive patterns. Using hybrid econometric and machine-learning models to transforms environmental data into actionable insights for emission accountability and policy formulation. The results highlight national-scale variability and confirm that reproducible forecasting frameworks can serve as foundations for data-driven climate governance.

Keywords: CO2 emissions, temperature anomaly, causality, forecasting, emission intelligence

Abstract ID: 68

2D WS_2/rGO coated Nickel Foam Hybrid Electrode for Seawater Splitting

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Electrochemical seawater splitting provides a sustainable approach for large-scale hydrogen production, utilizing abundant solar energy and seawater resources. However, conventional electrodes suffer from corrosion in natural seawater electrolyte. Here, we report a hybrid electrocatalyst composed of two-dimensional (2D) tungsten disulfide (WS_2) nanosheets integrated with rGO coated nickel foam (NF). This synergistic hybrid heterointerface provides abundant active sites, enhanced charge transport, and a corrosion resistant WS_2 layer, enabling long-term stability and efficient hydrogen production in seawater. Our findings demonstrate that the WS_2/rGO-NF hybrid serves as a robust, high-performance electrocatalyst for sustainable green hydrogen fuel production.
Keywords: seawater splitting, hydrothermal method, solid state reaction, tungsten disulfide, nickel foam.

Abstract ID: 69

Enhanced Electrochemical Properties of Selenium-Doped Zirconium Oxide Quantum Dots with Controlled Crystallinity and Particle Size

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Selenium-doped zirconium oxide quantum dots were synthesized through microwave combustion approach. The powder diffraction patterns exhibited broad peaks, indicative of quantum dots, which correspond to the tetragonal crystal structure of zirconia. The morphology of the synthesised quantum dots were found using HRTEM analysis. Further, the entry of selenium into the crystal lattice of the zirconium oxide quantum dots were confirmed by analyzing the Energy Dispersive X-ray (EDX) spectroscopy. The electrochemical analyses were done using cyclic voltammetry, galvanostatic charge- discharge and Electrochemical Impedance Analysis for the synthesised quantum dots and the specific capacitance were found to be 525.3 Fg^{-1}.
Keywords: quantumdots, zirconia, TEM, CV, GCD

Abstract ID: 71

Observation of Spin Electrons in Undoped and Fe doped Cadmium Telluride Nanostructures for Quantum Bit Applications

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The research work discussed here explains the observation of spin electrons in Undoped and Fe doped cadmium telluride (CdTe) nanostructures for quantum bit (QuBit) applications. The nanostructures are synthesized by single injection hydrothermal method. The fundamental characterizations are carried out to know the structural, elemental composition, optical properties of the as synthesized CdTe nanostructures. The Hall parameters employing van der Pauw method reveals the n-type conductivity and increased number electrons. SQUID measurement is used to observe the ferromagnetic nature of CdTe nanostructures which evidences the existence of spin electrons. Such kind of CdTe nanostructures can be used for the quantum bit applications.
Keywords: CdTe nanostructures, van der Pauw, SQUID, Quantum Bits

Abstract ID: 72

Higher Manganese Silicide by Molten Salt Shielded Synthesis Method

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Silicides are considered as one of the potential candidates for commercial thermoelectric applications, as they are non-toxic, stable and made up of earth abundant elements. Mg_2Si, $MnSi_x$, $CrSi_2$, and β-$FeSi_2$, are some of the silicides studied for thermoelectric applications. Among these silicides, $MnSi_x$ show good thermoelectric performance at mid-temperature range with good mechanical stability. In this work we have synthesized $MnSi_x$ with excellent thermoelectric properties by a cost-efficient molten salt shielded synthesis method in ambient air atmosphere. This method overcomes the difficulties in the conventional methods that requires high temperature and vacuum or inert gas atmosphere. The phase, morphology and elemental composition of the synthesized materials have been characterized through X-ray diffraction, Field emission scanning electron microscopy and EDX. The Rietveld refinement of diffraction pattern confirms the formation of higher manganese silicide along with a minimal MnSi impurity phase.
Keywords:Thermoelectric material, Transition metal silicide, Higher manganese silicide, Molten salt shielded synthesis.

Abstract ID: 73

Development of a Borophene-Biopolymer Composite for the Detection of Tetracycline and Oxytetracycline

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Abstract: Borophene is a recently developed two-dimensional nanomaterial known for its remarkable physicochemical features. Incorporating borophene into polymers, particularly biopolymers, can enhance its stability, dispersibility, biocompatibility, and sensing performance, making such composites suitable for biosensing and environmental analysis. However, research on borophene–biopolymer material remains limited. In this work, borophene nanosheets were exfoliated in an H_2O-DMSO medium and combined with sericin to form a borophene-sericin composite. This composite displayed high biocompatibility and functioned as a ratiometric fluorescent sensor for detecting tetracycline (TC) and oxytetracycline (OTC) in water and milk. Detection limits reached 1.25 μM for TC and 0.93 μM for OTC, demonstrating strong sensitivity and selectivity even in complex real samples. Additionally, MTT assays using Caco-2 cells confirmed the enhanced biocompatibility and the composite.
KEYWORDS: borophene; sericin; composite; biocompatible; real media; tetracycline; oxytetracycline.

Abstract ID: 74

Conducting bimetallic MOF derived nitride: A unique pathway for the transformation of amorphous to metallic MOF

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Bimetallic metal organic frameworks (MOFs) are considered as effective materials with abundant active metal sites and thus offers selective determination of target analytes. However, bimetallic MOF exhibited poor conductivity. Herein, in the present work a new pathway for the transformation of bimetallic MOF obtained via terephthalic acid as an organic linker has been transformed into conducting MOF. CoNi-MOF derived nitride (CoNiN) enhances electrical conductivity, surface area, and electrocatalytic activity and the obtained CoNiN coated on screen printed electrode (SPE) demonstrates exceptional performance for adenine and guanine oxidation, achieving high sensitivity (0.4 μA/μM/cm²) & (0.51 μA/μM/cm²), a low detection limit (0.02 μM & 0.03 μM) with a broad linear range (0.1–180 μM).

Additionally, CoNiN exhibits excellent selectivity, stability, reproducibility, and practical applicability in detecting purines in real paracetamol tablet samples.
Keywords: CoNi-Bimetallic MOF, CoNiN bimetallic nitride, electrochemical sensor, adenine and guanine.

Abstract ID: 75

A Comparative Analysis Of NiO Nanoparticles Synthesized Using Sol-Gel, Co-Precipitation and Modified Hydrothermal Methods

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This study follows the synthesis of NiO nanoparticles prepared via modified hydrothermal, co-precipitation and sol-gel methods. Structure studies of NiO were explored by XRD, with further characterization carried out by FTIR, SEM, BET, BJH, UV-DRS and Mott-Schottky Analysis. Shape, size and morphology of the synthesized samples were studied using SEM analysis. The energy band gaps for the samples prepared via modified hydrothermal, co-precipitation and sol-gel methods were calculated using Tauc plots and found to be 3.56, 3.64, and 3.67 eV, respectively. The synthesized samples have shown promising results towards photocatalytic degradation of RR35 dye for waste water treatment.
Keywords: NiO, hydrothermal, co-precipitation, sol-gel, photocatalysis

Abstract ID: 76

Surface Layer-Assisted Piezoelectricity On Centro-Non-Centrosymmetric Heterostructure: Application In Human Breath Sensing

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Flexible electronics are currently prominent platforms for mechanical energy harvesting and sensing. Beyond classical piezoelectric constraints, both centrosymmetric and non-centrosymmetric materials exhibit effective electromechanical conversion when integrated into flexible device architectures. Using plasma-deposition techniques, we synthesized a centro-non-centrosymmetric heterostructure of PANI (polyaniline)-Rubrene|ZnO on flexible devices.

Using ellipsometry and piezoresponse force microscopy, the crystal symmetry breaking on centrosymmetric rubrene is well studied. By pressure and bending, the piezo-electrical performance is studied. The entire device is well integrated with a human face mask, thus enabling a piezoelectric human breath pressure-sensor. This work signifies the possibility of broadening the scope of piezoelectric and related effects to any crystalline structure where the effect of inversion symmetry would otherwise pose a bottleneck for smart technologies.
Keywords: centrosymmetric, piezoelectricity, polyaniline, ZnO, pressure-sensor.

Abstract ID: 77

Reactive Milling Agent-Assisted In-Situ Ball-Milling of Graphite into Mn_xo_y/N-Doped Graphene for Highperformance Flexible Supercapacitors

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Supercapacitors are promising for flexible and wearable energy devices due to their high-power density and durability. An eco-friendly in-situ ball-milling route was used to synthesize Mn_xO_y/N-doped graphene (MnNG) nanocomposites by milling graphite with urea and $Mn(OH)_2/MnO_2$, followed by mild calcination. The process achieved simultaneous exfoliation, N-doping, and Mn_xO_y deposition. Characterizations confirmed α-Mn_2O_3/Mn_3O_4 phases on Nfunctionalized graphene. The MnNG electrode exhibited 119.8 Fg^{-1} at 0.1 A g^{-1} with 88.7% retention after 1750 cycles and delivered 16.6 Wh kg^{-1} energy density. The flexible device maintained stable performance under bending, highlighting a scalable green strategy for highperformance supercapacitor electrodes.
Keywords: Ball-milling, MnxOy/N-doped graphene, flexiblesupercapacitors, pseudocapacitance, high cycling stability

Abstract ID: 78

Influence Of Physical Dimensions on GAA-CNTFET Performance

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With CMOS technology reducing to less than 22 nm, leakage and quantum tunnelling problems lower the performance of the devices. Gate-All-Around Carbon-Nanotube FETs (GAA-CNTFETs) offer much better electrostatic control and near-ballistic transport, and are good competitors to nanoscale logic circuits. This paper discusses the effect of CNT diameter (CNT_d), gate-oxide thickness (tox), and gate length (Lg) on Drain-Induced Barrier Lowering

(DIBL), Subthreshold Swing (SS) and current ratio (Ion/Ioff) on the Stanford VS-CNTFET model in Cadence Virtuoso. Under optimal design constraints, CNT_d = 1.2-1.6 nm, tox = 1-5 nm, and Lg = 10-14 nm, the device in question has DIBL = 0.13 mV/V, SS = 60-65 mV/dec, and Ion/Ioff $\geq 10^3$, significantly better than CMOS counterparts.

Keywords: GAA-CNTFET, CMOS, DIBL, SS, Ion/Ioff ratio.

Abstract ID: 80

Systematically Engineered Enzyme-Mimicking Nanoceria for Electrochemical Detection of H_2O_2

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Herein, we propose an electrochemical sensor towards the detection of hydrogen peroxide (H_2O_2) using a structurally engineered nanozyme with peroxidase-mimicking activity. Cerium-based metal organic framework (Ce-BTC MOF) was synthesized and utilized as a precursor for the synthesis of nanoceria (CeO_2 NPs) with enzyme-mimicking activity. Thus synthesized CeO_2 NPs exhibited unique properties like high surface area which facilitates increased active sites and abundant oxygen vacancies enhancing their catalytic efficiency and capability to scavenge reactive oxygen species. The CeO_2 NPs as nanozyme was utilized for the amperometric detection of H_2O_2, where it demonstrated good linear range and very low detection limit.

Keywords: enzyme-mimicking, Ce-BTC MOF, CeO_2 Nanoparticles, H_2O_2

Abstract ID: 82

Nanoscale Electronic and Morphological Insights into Trimetallic NiFeMo Bifunctional Electrocatalysts for High-Efficiency Alkaline Water Electrolysis

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The global pursuit of carbon neutrality urgently drives the transition to sustainable hydrogen (H_2) fuel. Alkaline water electrolysis (AWE) is a critical, cost-effective technology for large-scale (H_2) production, offering the advantage of using abundant, non-precious electrocatalysts instead of scarce Pt and IrO_2. However, commercial viability remains limited by the high energy consumption needed to overcome the sluggish kinetics of both the hydrogen evolution reaction (HER) and the oxygen evolution reaction (OER). Nickel (Ni) is the traditional AWE electrode base, but its practical use is hampered by insufficient catalytic activity. While incorporating Iron (Fe) significantly boosts OER by optimizing the electronic structure, this often compromises HER activity by leading to weak hydrogen adsorption. This challenge necessitates the design of a highly effective bifunctional electrocatalyst. The incorporation of a high-valence third metal, Molybdenum (Mo), is a highly promising strategy, as Mo is known

to improve HER activity by tuning hydrogen-metal interactions and enhance OER via increased electrical conductivity [1].

Building on this research, we hydrothermally synthesized five distinct trimetallic NiFeMo electrocatalysts directly on Ni felt substrates to systematically investigate the effect of the Fe:Mo ratio on bifunctional performance. Electrochemical screening confirmed that the NiFeMo_1:1:1 catalyst, with an equal molar ratio, exhibited the optimal activity for simultaneous HER and OER. To establish a direct structure-property correlation, we employed atomic force microscopy (AFM) and Kelvin probe force microscopy (KPFM). These nanoscale techniques enable mapping of surface morphology, characterization of grain boundary properties, and probe local electronic properties via the contact potential difference (CPD). KPFM measurements revealed that, while the average CPD across all samples corresponds to a surface work function of ~5.1 eV, Mo-containing catalysts display pronounced CPD variations of 40–50 mV at grain boundaries compared with Mo-free counterparts. These results offer critical, fundamental insights into how compositional changes in ternary alloys influence the surface work function and the formation of active sites, ultimately explaining the enhanced bifunctional performance of the optimal NiFeMo_1:1:1 composition.

Abstract ID: 83

Portable Electrochemical Sensors For Clinical Diagonistics Using Modified Screen-Printed Electrodes

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Carbon based nanomaterials have been widely used to modify electrodes to improve the sensitivity of electrochemical systems. In this study, we synthesized cerium oxide/multi-walled carbon nanotubes (CeO_2@MWCNT) nanoparticles composite via a hydrothermal method, for creatinine determination. MWCNT provides more active sites due to its high surface area for the actual electroactive species to react, and enhances the sensitivity of the sensor while CeO_2 offers an active catalytic sites and favorable adsorption for creatinine oxidation. Cyclic voltammetry confirmed an increase in peak current at 0.12V for the modified screen-printed electrode (SPE) compared to bare SPE. The sensor shows linear response in the range 9×10^{-8} to 7.5×10^{-6} M.

Keywords: CeO_2@MWCNT, Electrochemical sensor, SPE, Cyclic Voltammetry, Enzyme less Diagnosis.

Abstract ID: 87

Developing Biocompatible Benserazide-Stabilized Gold Nanoparticles with Anticancer Properties: An Experimental Approach

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Cancer remains a major global health challenge, demanding innovative therapeutic strategies. In this study, benserazide, a marine bacterial metabolite analogue, was conjugated with gold nanoparticles (BEN–AuNPs) to develop a novel nanodrug for lung cancer treatment. The synthesized BEN–AuNPs exhibited excellent stability, controlled drug release, and selective cytotoxicity toward lung cancer cells through reactive oxygen species–mediated apoptosis, while sparing normal cells. This is the first report of benserazide-conjugated gold nanoparticles demonstrating potent anticancer efficacy, highlighting their promise as a safe, targeted, and efficient nanoplatform for future lung cancer therapeutics.
Keywords: Benserazide, Gold nanoparticles, Marine bacterial metabolite analogue, Lung cancer, Nanodrug delivery

Abstract ID: 90

Biodegradable Guar Gum-Based Triboelectric Nanogenerator for Intelligent Self-Powered Sensing and Energy Harvesting

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A compact and ecofriendly guar gum based triboelectric nanogenerator (G-TENG) was designed for sustainable energy harvesting and intelligent biomechanical motion sensing. The device employs guar gum and bentonite clay composite film as a novel triboelectric positive material coated with graphite-guar gum ink as the conductive electrode. The addition of bentonite not only improved the surface charge but also enhanced the mechanical strength of the composite film compared to pristine guar gum, indicating robustness and durability. The TENG achieved an open-circuit voltage of ~110 V, current of 7.5 μA, power density of 110 μW, maintaining consistent performance for more than a month. Further the biomechanical signals acquired from neck, walking, and jumping motions were processed through deep learning algorithms, enabling 99% classification accuracy and demonstrating its potential for self-powered, wearable, and sustainable electronic systems.
Keywords*:* Biopolymer, Triboelectric nanogenerator, Deep learning, flexible device, self-powered sensing.

Abstract ID: 91

A Novel Co_2O_3/MWCNT Electrochemical Platform for Atenolol Detection in Pharmaceutical and Biological Samples

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A novel electrochemical sensor for the selective and sensitive detection of Atenolol (ATN) using transition metal oxides integrated with MWCNTs has been established. GCE modified with solvo-thermally produced 3d-transition metal oxides and MWCNTs exhibit high surface area and conductivity. Due to synergistic effects Co_2O_3/MWCNT displayed superior electrocatalytic activity. DPV revealed a linear response from 0.1- 40 μM with 2.53 μA/μM sensitivity, LOD =10×10^{-8} M, and LOQ = 34×10^{-8} M. The sensor showed 97–101% recovery in pharmaceutical and urine samples.
Keywords: Atenolol, Co_2O_3/MWCNT composite, Electrocatalysis, Electro-oxidation.

Abstract ID: 92

Asymmetric Growth Of 1D MoO_x Nanostructures for Enhanced Ethanol Sensing

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One-dimensional molybdenum oxide (MoO_x) nanostructures were grown via a simple controlled thermal oxidation process. A 250 nm MoO_3 film deposited on glass by vacuum evaporation was oxidized under optimized conditions to form nanorods and nanowires. Structural, chemical and optical characterizations confirmed phase formation and morphology control with oxidation parameters. Both nanostructures exhibited strong and selective ethanol sensing, highlighting their potential for VOC detection applications.
Keywords: Molybdenum oxide, 1D Nanostructures, Thin films, Gas sensor

Abstract ID: 93

Harnessing Solar Energy via Niobate-based Photocatalyst: A Step Towards Sustainable Green Hydrogen Production

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Sustainable development goals emphasise the urgent need to reduce the dependence on fossil fuels by promoting environmentally friendly and renewable energy technologies. Fossil fuels, which currently account for the majority of the global energy supply, are not only finite but also significant contributors to greenhouse gas emissions and climate change. To address these challenges, the scientific community is increasingly focused on harvesting solar energy, which is both abundant and inexhaustible. Currently, only a small fraction of the vast solar energy available is harnessed for human use. A portion of this solar energy can be utilized to convert water into green hydrogen by a suitable photocatalyst. However, its practical deployment remains limited due to low quantum efficiency, rapid charge carrier recombination, poor stability, and difficulties in large-scale implementation. To address these limitations, we developed a ternary Niobate-based composite photocatalyst system, where visible light absorption, improved charge separation and stability were taken care through the formation of a Z-scheme heterostructure. The prepared ternary Niobate-based composite photocatalyst system delivered a high photocatalytic hydrogen evolution rate of ~80 mmol/h/$g_{cat.}$. The enhanced stability, charge carrier dynamics, broadened solar light utilization and increase in the hydrogen production efficiency were optimized by systematic variation of composition and experimental conditions. The strategic synthesis, structural, optical characterization, and photocatalytic evaluation and mechanism of the heterostructure will be discussed in detail during the presentation.

Keywords: Photocatalysis, CdS/WO_3, Visible active, $CoNb_2O_6$, Hydrogen production

Abstract ID: 96

Facile Synthesis of High-Quality Mos_2 Nanosheets Using a Thermally Decomposable Surfactant at Low-Temperature

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The liquid-phase exfoliation of semiconducting transition metal dichalcogenides (TMDs) into 2D nanosheets offers a scalable route for high-performance applications. Achieving network conductivity close to that of individual nanosheets remains challenging due to surfactant-induced degradation. Although thermal annealing effectively removes surfactants, residual

molecules on MoS_2 nanosheets can introduce doping and defects, deteriorating electronic performance. To address this issue, a low-temperature decomposable is proposed in liquid-phase exfoliation and stabilization of MoS_2 nanosheets in water, providing an environmentally sustainable approach for producing high-quality nanosheets suitable for next-generation electronic and optoelectronic device applications.

Keywords: MoS_2 nanosheets, surfactant, exfoliation, low-temperature, high-quality.

Abstract ID: 97

Pfas-Free Robust Slippery Surfaces Via Lubricant Intercalation in Reticular Frameworks

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Slippery lubricant infused porous surfaces (SLIPS) have the potential to address daunting challenges such as undesirable surface fouling/biofouling, icing, corrosion, etc. However, depletion of lubricants hampers their practical utility. Here, we introduce a rational strategy exploiting sub-nanometer reticular structures that generate ultra-high capillary pressure to intercalate and lock lubricant chains within pores. The resulting PFAS-free SLIPS maintain strong lubricant retention through geometric compatibility and tailored pore-lubricant interactions. They withstand high-speed water jet impacts up to 110 m/s, continuous water shedding (50 hours), exhibit low ice adhesion strength (<10 kPa), and show excellent corrosion resistance, ensuring durable performance under extreme conditions.

Keywords: reticular frameworks, nanoporous, slippery surface, lubricant retention, fouling/biofouling

Abstract ID: 99

Thermal Characteristics and Nanoscale Interactions in A Multi-Functional Peek Nanocomposite for Fused Filament Fabrication

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Polyether ether ketone (PEEK) offers bone-like stiffness and radiolucency but remains bio-inert. This work reports a solvent-assisted, ultrasonic dispersion route for synthesizing a multi-functional PEEK nanocomposite containing 15 wt% of a tri-component filler system that enhances bioactivity, reinforcement, and wear resistance. Thermogravimetric (TGA) and Differential Scanning Calorimetry (DSC) confirmed precise filler incorporation, excellent thermal stability (>557 °C onset), and increased crystallinity (33 % to 47 %). These findings confirm heterogeneous nucleation and high processing stability, demonstrating the composite's thermal viability for Fused Filament Fabrication (FFF) of biomedical feedstocks.

Keywords: PEEK; Bioactive Nanocomposite; Thermal Stability; Nanomaterials; Heterogeneous Nucleation

Abstract ID: 102

Engineering the morphology of ZnCo2O4 through different synthetic approaches for enhanced OER performance

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Renewable energy research focutts on developing efficient electrocatalysts for the oxygen evolution reaction (OER) to enhance water splitting. Factors such as morphology and active sites, which govern intrinsic OER activity, can be tuned via synthesis methods. Here. ZnCo:O. electrocatalysts were synthesized by solution combustion (ZCO-C), sol-gel (ZCO-SG), and hydrothermal (ZCO-H) routes to study their effect on OER performance. In 1 M KOH. ZCO-C showed outstanding OER activity with a low overpotential of 330 mV at 10 mA cm² and a Tafel slope of 59.7 mV dec-superior to reported pristine ZnCo:O.. The enhanced activity of ZCO-C is attributed to its higher crystallinity, greater electrochemically active surface area, increased Co /Co ratio, and lower charge-transfer resistance. This study underscores the critical influence of synthesis routes in optimizing electrocatalyst properties for OER.

Abstract ID: 103

An Ultra-Sensitive Ratiometric Fluorescent Sensor Based on Halogen Doped Boron Nitride Quantum Dots for The Selective Detection of Riboflavin

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Chlorine doped boron nitride quantum dots were utilized as a ratiometric fluorescence sensor probe for the detection of riboflavin. Structural and spectroscopic analyses confirmed the successful doping of halogen in the boron nitride quantum dots. Here, the sensor probe emitted blue fluorescence whereas riboflavin fluoresces in yellow region. When they were in the same matrix, the yellow emission from riboflavin increased while sensor probe's blue emission decreased enabling ratiometric quantification. This inverse fluorescence response enabled detection with high selectivity and sensitivity. The dual-emission system offers a reliable platform for riboflavin sensing, with potential applications in biomedical diagnostics.
Keywords: Quantum dots, Halogen, Boron Nitride, Ratiometric Fluorescence, Riboflavin

Abstract ID:104

Techno-Economic Assessment and Life Cycle Analysis of Graphene

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The proposed study aims to conduct a comprehensive techno-economic assessment (TEA) and life cycle analysis (LCA) of graphene production. We have calculated the energy requirement on a lab scale and scaled up graphene to evaluate the economic viability by analysing capital and operational costs, market potential, and the scalability of emerging graphene synthesis methods. Simultaneously, the life cycle analysis assesses environmental impacts, resource consumption, and sustainability aspects across the graphene supply chain. This integrated approach provides critical insights to optimise graphene manufacturing for cost-effectiveness and eco-friendliness, supporting its commercial adoption and sustainable development.
Keywords: Graphene manufacturing, Techno-Economic Assessment, Life Cycle Analysis, Cost Analysis.

Abstract ID: 105

Techniques For Measuring Thermal Conductivity: A Comparative State of the Art Study

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Thermal conductivity is a fundamental material property that governs the rate at which heat energy is transferred through a material. Accurately measuring thermal conductivity is essential for assessing heat management performance in various applications such as electronics, insulation, and thermal energy storage. Current work reviews the principal measurement techniques, including steady-state and transient methods, highlighting their applicability, advantages, and limitations across different material classes from liquids and solids to thin films (micro and nano) and phase change materials. Understanding these methods enables better selection of characterization techniques tailored to specific material properties and conditions. The discussion aims to provide a clear framework for researchers and engineers to optimize thermal characterization strategies in advanced material systems
Keywords: Heat-transfer, thermal conductivity, interfaces, high-k materials and measurements.

Abstract ID:106

Femtosecond Laser-Assisted Direct Patterning of Highly Crystalline α-V_2O_5 Nanobelts

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This work demonstrates a femtosecond laser-assisted direct patterning method for the fabrication of crystalline α-V_2O_5 nanobelts with precise spatial control. Conventional synthesis techniques lack the ability to deposit vanadium oxide structures at targeted locations for on-chip applications. Using a two-photon photo-reduction process, localized laser exposure induces chemical reduction in a photoactive vanadium resin, followed by thermal treatment at 550 °C to form phase-pure α-V_2O_5. The resulting nanobelts exhibit cross-sections of ~300 nm × 100 nm and lengths up to 2 μm. This maskless approach enables targeted oxide patterning suitable for micro/nano energy storage, sensing, and electrochromic devices.
Keywords: Two-Photon Reduction (TPR), Vanadium pentoxide (V_2O_5), Micro-Fabrication, Nanobelts, Direct Patterning.

Abstract ID:107

Super-Hydrophobic Zno Thin Films for Self-Cleaning Application

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Hydrophobic ZnO nanorod arrays were grown on glass substrates using vacuum evaporation of Zn thin film followed by controlled thermal oxidation. The ZnO nanorods oxidized at 700 °C exhibited high surface roughness with a water contact angle of 127°. Spin coating of these ZnO nanorods with 1 wt% polystyrene further increases the contact angle towards super-hydrophobicity. This eco-friendly, fluorine-free ZnO + PS hybrid surface effectively combines nanoscale roughness with reduced surface free energy, offering potential for self-cleaning, anti-corrosion, and biomedical applications.
Keywords: Hydrophobic surface, ZnO nanorods, Polystyrene, Thermal oxidation.

Abstract ID:108

Innovative Advances In Fet-Based Biosensors: Shaping The Future Of Biomedical Sensing

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Field-effect transistor-based biosensors have attracted significant attention as advanced platforms for biomolecular detection, offering high sensitivity, excellent selectivity, and the advantages of real-time, label-free analysis with quick response times. These biosensors leverage the principle of modulating the electrical properties of a semiconductor channel through the interaction of target biomolecules with a functionalized gate electrode. The inclusion of nanomaterials such as silicon nanowires, carbon nanotubes and graphene has substantially enhanced both the sensitivity and miniaturization of these biosensors. FET-based biosensors are increasingly employed in fields such as biomedical diagnostics, environmental surveillance, and analysis of food safety, enabling the identification of biomarkers, pathogens, and toxic agents even at trace levels. However, several challenges particularly related to device reliability, reproducibility, and biocompatibility still need to be addressed to achieve consistent performance. This paper reviews recent advancements in FET-based biosensor design, fabrication, and potential applications, highlighting their role in next-generation point-of-care diagnostic systems. Over the past few decades, remarkable progress has been achieved in the design and development of FET-based devices, particularly for applications in biomedical diagnostics and cell-based assays. The exceptional electrical characteristics, combined with miniaturized dimensions and scalability, make them ideal candidates for rapid, label-free, and high-throughput biomolecular detection. Recent research has emphasized the technological advancements in FET-based biosensors, focusing on attributes such as low power consumption, real-time monitoring, and label-free operation. Nanomaterial-based Bio-FETs have emerged as significant platforms for biosensing applications. In recent years, label-free FET biosensors have drawn widespread interest due to the incorporation of various biocompatible nanomaterials onto their exposed gate surfaces, leading to remarkable improvements in both sensitivity and selectivity. The integration of nanomaterials such as adding nanoparticles, nanowires, nanofibers into label-free field effect transistor architectures significantly contributes to enhancing their overall sensing performance. This review explains about the various types of FET based biosensor such as Junction Field-Effect transistor, Metal Oxide Semiconductor Field-Effect Transistor and Ion Selective Field effect Transistor. JFETbased biosensors exhibit low noise and high thermal stability, making them suitable for sensitive biochemical analysis. The incorporation of an open-gate structure in Junction field effect transistor enhances the sensor's overall sensitivity and operational efficiency. Likewise, the primary benefit of Metal Oxide Semiconductor FET lies in their high input impedance, which minimizes the loading effect on preceding circuits. Their energy efficiency arises from the gate's negligible current consumption. Additionally, their compact structure enables highspeed switching and ensures reliable operation, making them indispensable in contemporary electronic and biosensing applications. In addition to, n-type junctionless double gate Metal oxide semiconductor FET biosensors have implemented to enhance the sensitivity. As proposed, it shows higher sensitivity compared to conventional Metal Oxide Semiconductor FET. Similarly, it shown Dielectric Modulated triple surrounding gate developed for higher efficiency and sensitivity. In the same way, the Ion sensitive field effect transistor can function as both a transducer and a sensor, depending on its underlying operating principle. Recently, Ion sensitive have been developed to detect various biological analytes such as DNA, glucose, and cholesterol. Significant advancements explore over Ion sensitive FET, technology have enabled its application in the medical field for the sensitive and label-free detection of

biomolecules with enhanced sensitivity. For instance, it shown excellent potential in pH sensing, drug monitoring, and biochemical analysis due to their compactness, stability, and ability to operate in liquid environments. Recently, nanomaterial-based FET biosensors have been extensively developed for the detection and measurement of various biomolecules along with utilizing nanowires, nanotubes and nanofibers. These nanostructures and nanomaterial exhibit exceptional properties including high carrier mobility, large surface-to-volume ratios, and superior biocompatibility, which facilitate improved signal amplification and molecular recognition at ultra-low concentrations. Similarly, nanowire FETs fabricated from materials such as silicon, copper oxide, or zinc oxide have exhibited outstanding performance in the detection of glucose, cholesterol and other clinically relevant molecules. Such devices have opened new possibilities for point-of-care diagnostics, personalized medicine, and wearable health monitoring platforms. Especially, graphene-based FET sensors primarily detect extracellular potentials and conductance signals. Reduced graphene oxide FET have been using to monitor the enzymatic interaction between biomolecules. Despite these achievements, several technical challenges remain, including surface charge screening in high-ionic-strength environments, limited long-term stability, and difficulties in achieving large-area fabrication. Addressing these issues requires interdisciplinary approaches involving advanced surface chemistry, novel dielectric engineering, and improved encapsulation methods to maintain device reliability under physiological conditions. Moreover, the exploration of organic and hybrid FETs provides opportunities to enhance flexibility and environmental compatibility while maintaining high detection accuracy. The convergence of flexible electronics, nanotechnology, and bioengineering will facilitate the creation of intelligent, multifunctional FET biosensors capable of multiplexed detection, wireless communication, and real-time physiological analysis. Continued innovations in surface functionalization, noise reduction, and signal processing are crucial to achieving reliable large-scale production. Despite ongoing challenges in device stability and biocompatibility, advancements in material engineering and fabrication techniques continue to enhance their performance. In future perspective, the convergence of FET-based biosensors with artificial intelligence, machine learning and Internet of Things technologies is expected to transform biosensing into intelligent diagnostic systems capable of autonomous data analysis, decision-making and detecting various biomolecules. In addition to rigid devices, recent research has shifted toward developing flexible and wearable FET biosensors for non-invasive health monitoring. The ability of these biosensors to function at low operating voltages and deliver rapid response times offers a practical pathway toward miniaturized, portable health monitoring systems. These sensors function by modulating the channel current in response to variations in surface charge or ionic concentration caused by the binding of target biomolecules. Furthermore, material engineering innovations, particularly the embedding of graphene and other nanomaterials, have greatly enhanced the sensing performance, enabling ultrasensitive detection of biomolecules at trace levels. However, challenges related to stability and selectivity remain, requiring further research to unlock their full potential. This review emphasizes the working principles, recent progress, sweat based and non-invasive concepts and future directions of FET-based biosensors in biomedical fields.

Keywords: Field effect transistor, Biosensors, Biomolecules, Nanomaterials, Fabrication, Reliability, Biocompatibility, Biomedical.

Abstract ID: 109

Preparation of MoS_2 Carbon Composite Nanoflowers and Their Application in High-Performance Photodetector Fabrication

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MoS_2 Carbon composite (MoS_2@C) have emerged as promising materials for ultraviolet (UV) photodetection. MoS_2@C nanosheets were synthesized via microwave irradiation method. MoS_2 sites and the conductive carbon support, which facilitates electron transfer and stability. In UV photodetection, MoS_2@C composites show excellent sensitivity due to MoS_2's inherent optical properties and the efficient charge separation and transport provided by the carbon matrix. Key performance metrics include photosensitivity (PS) is 58045, responsivity (R) is 111 mA/W, detectivity (D) on the order of 1.3×10^{12} Jones, and a rapid response, as evidenced by I-T curves with rise time 6.24 s and fall times 6.27 s.
Keywords: Microwave irradiation, MoS_2 carbon composite, heterojunction UV-Photodetector, high photosensitivity

Abstract ID: 110

Two Dimensional Multilayered $Ti_3C_2T_x$ MXene for Electrically Driven Desalination Application

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The idea of exploring unconventional water resources to fix the water demand have given birth to various desalination and waste water treatment technologies. Among emerging non-traditional desalination technologies Capacitive Deionization (CDI) has attracts stage due its low energy consumption, cost effectiveness and ion selective removal capacity. CDI system has been further developed into categories depending on their cell architectures, but in common all such systems are greatly dependent on their electrode for continuous and long-term functioning. Carefully engineered nanomaterial, MXene (M_{n+1} X_nTx) offer distinct advantage as CDI electrodes, including high conductivity, hydrophilicity, and tuneable interlayer spacing for rapid ion adsorption. To enhance the performance, engineering MXene composite based electrodes solve certain issues like stability, restacking to an extent. Such electrodes pave way for next generation sustainable and scalable units. This research study focuses on the electrochemical behaviour, stability, salt adsorption capacity and ion adsorption capacity of developed MXene composite electrodes for convenient CDI cell architecture.
Keywords: MXene, Capacitive deionization, HCDI, Desalination

Abstract ID: 111

Growth And Characterization Of 1D CuO Nanorods

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High-quality one-dimensional CuO nanowires were synthesized through controlled thermal oxidation of vacuum-deposited Cu thin films on glass substrates under an oxygen-rich environment. The oxidation temperature and duration were optimized to achieve uniform, vertically aligned CuO nanowires with tunable length and diameter. Structural, morphological, and compositional analyses using XRD, FESEM, and XPS confirmed the formation of singlephase CuO. With increasing oxidation duration at 500°C, nanowire length increased while diameter decreased, accompanied by a rise in surface resistance. The simple, scalable oxidation process demonstrates an effective route for fabricating high-quality CuO nanowires suitable for sensing and optoelectronic applications.
Keywords: Copper oxide (CuO), 1D Nanostructures, Thin films.

Abstract ID: 112

Self-Powered and Flexible Energy Devices of Polyvinylidene Fluoride Piezoelectric Nanogenerators

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The increasing global need for reliable, eco-friendly, and portable power sources has driven significant research toward flexible piezoelectric nanogenerators, which are emerging as potential substitutes for traditional battery systems. Piezoelectric nanogenerators convert ambient mechanical energy such as human motion and environmental vibration for wearable applications. PVDF and its composites have emerged as dominant materials owing to their flexibility, process-ability, and strong piezoelectric β-phase formation strategies such as electrospinning, nanofiller incorporation and enhance piezoelectric performance, output stability and biocompatibility. It highlights multi-function PENGs integrated with energy storage, sensing and therapeutic systems indicating their potential for applications in healthcare, robotics, and the IoT. Ongoing advancements in material development and structural design are expected to accelerate the practical adoption and market commercialization of piezoelectric nanogenerator technologies for sustainable energy harvesting applications.
Keywords: Piezoelectric Nanogenerators, Wearable devices, Energy harvesting.

Abstract ID: 113

Amine-functionalized $Ti_3C_2T_x$ MXene as a generic immobilization platform towards enzymatic electrochemical detection of H_2O_2

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The development of reliable and cost-effective electrochemical sensors for hydrogen peroxide (H_2O_2) monitoring is crucial in biomedical diagnostics, especially in early disease diagnosis. Herein, we prudently synthesized an amin-functionalized NH_2-$Ti_3C_2T_x$ MXene, onto which a horseradish peroxidase (HP_x) was covalently immobilized and employed for the distinctive determination of H_2O_2. The synthesized NH_2-$Ti_3C_2T_x$ MXene is coated over a glassy carbon electrode (GCE), followed by the covalent immobilization of the electroactive HP_x enzyme through the glutaraldehyde (GA) coupling reaction. This in turn results in the firm anchoring of the HP_x by establishing a stable imine linkage between the -NH_2 group of NH_2-$Ti_3C_2T_x$ MXene and the free -COOH group of HP_x. Thus, the obtained HP_x/NH_2-$Ti_3C_2T_x$/GCE sensor demonstrates an excellent electrocatalytic response for H_2O_2 determination over a broad linear range with a high sensitivity and a low detection limit.
Keywords: Amine functionalization, MXene, Horseradish peroxidase, Biosensor, H_2O_2 detection.

Abstract ID:114

Integrating Density Functional Theory Simulations, Material Engineering, and Device Fabrication of Zirconium based Metal–Organic Frameworks for High-Efficiency Photo Electrochemical Water Splitting

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A viable method for producing hydrogen sustainably is photoelectrochemical (PEC) water splitting, which transforms solar energy directly into chemical fuels. In this work, we report the design and simulation of the previously reported Zr-MOF based composite material using the first principle calculations. Density Functional Theory (DFT) calculations were carried out in order to study the band structure, density of states (DOS), partial density of states (PDOS) and band edge alignment with respect to water oxidation and reduction potentials. Zr-MOF and Zr-MOF/$BiVO_4$ materials were synthesized using Solvothermal and characterized using XRD, SEM, UV-Vis spectroscopy and Raman spectroscopy to confirm their formation, phase purity and their light absorption properties. The electrochemical studies such as Linear sweep

voltammetry (LSV) and electrochemical impedance spectroscopy (EIS) to study their electrochemical properties and charge transport kinetics. This optimized material was integrated into a proton exchange membrane-based PEC electrolyzer to hydrogen production capability of the material under simulated sunlight. The distinctive feature of this study is the custom-designed PEC device, which is assembled internally to maximize electrolyte flow, electrode arrangement, and light consumption. Under simulated sunlight, the constructed system allowed for an accurate assessment of photocurrent density, stability, and solar-to-hydrogen (STH) efficiency. This integrated approach shows a scalable and economical way to advance PEC water splitting technologies by combining material synthesis, DFT-guided understanding, and tailored device production. A flexible platform for testing novel photo electrode materials and advancing the development of effective solar hydrogen production is offered by the in-house PEC system.

Keywords: Zr-MOF/BiVO4, Photo-Electrochemical (PEC), Water Splitting, DFT simulation, Hydrogen Evolution Reaction (HER)

Abstract ID: 115

Piezo-Supercapacitors in IoT Devices & Smart Grids

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Supercapacitor is a promising electrochemical energy storage device which possessing very high-power density, rapid charge and discharge rates with a very long lifecycle. Supercapacitors hold high energy density as compared to common electrolytic capacitors and hence supercapacitors are extensively utilized not only for powering several portable electronic devices but also plug-in hybrid electric vehicles. Supercapacitor can deliver a huge power within a very short time and hence it has the potential to contribute toward the rapid growth of power electronics such as portable and wearable electronic devices. In this context, the present chapter describes on the design and fabrication of various supercapacitor cells and their potential applications in several sectors like flexible and portable electronics, automobiles and transport, implantable healthcare, biomedical sensor, etc. Besides, the design and development of a bidirectional DC-DC converter by using a battery-supercapacitor hybrid system for electric vehicle applications and hybrid energy management system are briefly explained and highlighted.

Keywords: Supercapacitors; Energy storage and conversion; Energy harvesting; Electric vehicles; Flexible electronics

Abstract ID: 116

Green-Synthesized Multilayered nZVI-Chitosan-CQDs Nanocomposite for Sustainable and Efficient Biofilm Inhibition In Nuclear Power Plant

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Biofilm formation poses a major challenge in industrial and medical systems due to microbial resistance and ineffective conventional treatments. This study presents a sustainable multilayered nanocomposite (nZVI-Chitosan-CQDs) synthesized from guava leaves, prawn shells, and sugarcane bagasse for efficient biofilm inhibition. The composite demonstrated over 90% inhibition of *Bacillus subtilis*, *E. coli*, and biofilm consortia within 3–4 hours. Characterization confirmed successful integration and stability of components. The synergistic effects of reactive oxygen species generation, membrane disruption, and photodynamic activity make this eco-friendly nanocomposite a promising, cost-effective solution for long-term biofilm control in environmental and biomedical applications.
Keywords: Biofilm, Nanocomposite, Antibacterial, Chitosan, Sustainability

Abstract ID: 117

Facile Single Step Room Temperature Synthesis of Printable Carbon Quantum Dot Ink Synthesis for Visual Encryption and High-Performance Photodetectors

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Carbon quantum dots (CQDs) are emerging as eco-friendly, cost-effective alternatives to traditional semiconductor quantum dots for optoelectronics, owing to their superior stability. We present a facile, one-step, room temperature synthesis of printable fluorescent CQD ink, enabling invisible fingerprint stamping, inkjet micropatterning, and soft lithography with 1.5 μm resolution. This as-synesized functional CQD ink was also used as photo active layer to fabricate a high-performance CQD-ZnO heterojunction ultraviolet photodetector with responsivity of 3.85 A/W, detectivity of 6.78×10^{10} Jones, and EQE of 15.3%. This scalable approach promises advancements in flexible optoelectronics, printing, imaging, forensics, and security applications.
Keywords*:* Fluorescent quantum dot ink, Room temperature synthesis, Micro-patterning, Anti-counterfeiting applications, Hetero-junction UV-Photodetector.

Abstract ID: 119

A Low-Loss and Phase-Stable Photonic Hadamard Gate

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Our work shows a systematic improvement of a planar light wave circuit to implement a Hadamard gate, starting from a conventional Y-junction towards a low-loss, phase-stable design. By employing adiabatic tapering and the inverse design method, we attained a low insertion loss of < 1 dB. Further, the phase-injected inverse design is incorporated to achieve reciprocity with desired output phases, which ensures phase difference (0 or π) is upheld while keeping minimal loss. The mode-encoded Hadamard gate is implemented with a high process fidelity of 0.974 and a high extinction ratio of >20 dB.
Keywords: Hadamard gate, inverse design, adiabatic-tapers, phase-injected topology optimization.

Abstract ID: 120

Leveraging Data-Driven Design of Triboelectric Nanogenerators for Enhanced Support in Paralysed Patient Care

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Triboelectric nanogenerator converts mechanical energy to electrical energy, which can serve as a renewable source of energy in this era of energy deficiency. Herein, a TENG is proposed for paralysed person care which can predict the different touch pattern of a paralysed patient. FZ-TENG consist of Aluminium as the positive layer and MOF functionalised composite film as negative layer, in contact separation mode. The output voltage was fed into a random forest model and it predicted the patient needs according to different touch pattern. MOF functionalised composite film is a novel candidate in the data driven approach of MOF based TENG.
Keywords: TENG, MOF, Energy harvesting, Friction, Random Forest

Abstract ID: 121

Microwave-Assisted Synthesis and Investigation of Optical and Structural Properties of Pure and Mn^{2+}-Doped ZnS Quantum Dots:A Study on Doping-Driven Behavior

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The synthesis and investigation of semiconductor quantum dots (QDs) have revolutionized nanoscience, particularly for applications in optoelectronics, photonics, and biomedicine. Among various II–VI semiconductors, zinc sulphide (ZnS) stands out as a non-toxic, wide-bandgap material with excellent optical tunability. However, pure ZnS exhibits limited visible light emission, restricting its performance in device and energy applications. Doping ZnS with transition metal ions such as Mn^{2+} effectively tailors its band structure, photoluminescence, and electronic behavior. The present research focuses on the "Microwave-Assisted Synthesis and Investigation of Optical and Structural Properties of Pure and Mn^{2+}-Doped ZnS Quantum Dots: A Study on Doping-Driven Behavior". This work is motivated by the urgent need to develop environmentally safe, highluminescence nanomaterials for next-generation optoelectronic and sensing technologies. While numerous studies have explored Mn doping in ZnS, the novelty of this work lies in the **microwave-assisted, surfactant-free synthesis**, which ensures rapid volumetric heating, uniform dopant distribution, and enhanced crystallinity at reduced reaction times. This approach eliminates the requirement for toxic surfactants or high-temperature conditions used in conventional wet-chemical or hydrothermal methods. Furthermore, the present study provides a **systematic correlation between Mn concentration and structural, morphological, and optical evolution**, highlighting how precise doping modulates the energy gap and emission properties. The findings not only deepen understanding of dopant-induced quantum confinement in ZnS QDs but also demonstrate a scalable, eco-friendly synthesis technique suitable for flexible electronics, photonic materials, and nanocatalysis.

The experimental methodology employs a simple, rapid microwave-assisted synthesis route using zinc acetate dihydrate (98%- extra pure), thiourea, and manganese (II) acetate tetrahydrate (98.5%-extra pure) as precursors in deionized water. The precursor solutions were magnetically stirred for one hour to achieve complete homogeneity and irradiated in a domestic microwave oven at 400 W for 27–45 minutes. This irradiation promotes instantaneous nucleation and uniform particle growth. Pure ZnS was first synthesized and later doped with varying Mn^{2+} concentrations (1%, 3%, and 5%) by substituting a fraction of Zn^{2+} ions with Mn^{2+} in the host lattice. The resulting QDs were subjected to comprehensive characterization using X-ray diffraction (XRD) for structural analysis, Fourier-transform infrared spectroscopy (FTIR) for bonding verification, field emission scanning electron microscopy (FESEM) and energy-dispersive X-ray spectroscopy (EDX) for morphology and compositional confirmation, and UV–Visible and photoluminescence (PL) spectroscopy for optical evaluation. The microwave process offered remarkable advantages—short synthesis time, low energy consumption, and high yield—while maintaining nanoscale uniformity.

The synthesized pure and Mn-doped ZnS quantum dots exhibited significant changes in optical and structural features with increasing dopant concentration. XRD analysis confirmed the formation of a **single-phase cubic zinc blende structure** for all samples with no impurity peaks, indicating successful substitutional doping of Mn^{2+} into Zn^{2+} lattice sites. A slight peak shift and broadening with higher Mn content revealed lattice strain and microstructural distortions, consistent with dopant incorporation. The crystallite sizes, calculated using the Debye–Scherrer formula, ranged between **2.31 and 2.40 nm**, well below the ZnS excitonic Bohr radius (2.5 nm), confirming strong quantum confinement effects. FTIR spectra showed prominent Zn–S stretching vibrations around 775 cm^{-1} and emerging Mn–S modes in doped samples, validating lattice substitution. FESEM images revealed a morphological transition from flower-like nanostructures in pure ZnS to aggregated nanoclusters in Mn-doped QDs, while EDX spectra verified the elemental composition and gradual Mn inclusion. Optical absorption measurements exhibited a red shift in the band edge, with the bandgap decreasing from **5.40 eV (undoped)** to **4.67 eV (5% Mn)** due to dopant-induced energy levels. Photoluminescence spectra revealed dual emission bands—a blue emission near 491 nm (sulphur vacancy-related) and a characteristic orange-red emission at 662 nm due to the $^4T_1 \rightarrow {}^6A_1$ transition of Mn^{2+} ions. The emission intensity peaked at 3% Mn doping, indicating optimal energy transfer between host and dopant. These findings confirm that **controlled Mn doping effectively tailors the photonic and electronic response** of ZnS QDs, enhancing their suitability for optoelectronic and sensing devices.

The conclusions derived from this investigation establish the microwave-assisted route as a powerful, eco-efficient method for synthesizing high-purity $Zn_{(1-x)}Mn_xS$ (x=0, 0.01, 0.03, 0.05) quantum dots. The structural and optical analyses reveal that Mn doping enhances luminescence behavior while maintaining crystal integrity and phase purity. The reduction in bandgap energy with increased Mn concentration signifies the creation of intermediate states that facilitate radiative recombination. Moreover, the strong and stable orange-red emission suggests potential application in **LED phosphors, display technologies, and optical sensors.** The uniform dopant distribution achieved through microwave processing ensures reproducibility, scalability, and cost-effectiveness—critical parameters for industrial nanomaterial fabrication. This research provides new insights into the doping dynamics of transition metal ions in II–VI semiconductors and paves the way for engineering luminescent nanomaterials for multifunctional applications such as light harvesting, photocatalysis, and biomedical imaging. The work also highlights how fine control of doping concentration can optimize emission efficiency and tailor energylevel transitions, offering a design platform for next-generation nanoscale devices.

As this work finds scope in **Advanced Nanomaterials and Characterization**, **Semiconducting Materials and Devices**, and **Energy Harvesting and Environmental Applications**, the study will be extended in the future to explore advanced applications of such nanomaterials. Future exploration could involve expanding Mn doping levels beyond 5% to examine the critical limit for maintaining structural stability and emission efficiency. Integrating these Mn:ZnS QDs into **thin-film or flexible substrates** could enable their use in **flexible optoelectronics and printed nanodevices**. Additionally, incorporating artificial intelligence and density functional theory (DFT) simulations can aid in predicting dopant behavior and optimizing synthesis parameters. Investigating Mn:ZnS QDs as photocatalysts for

water purification and CO_2 reduction aligns with sustainable nanotechnology goals. Further, surface passivation with biocompatible polymers may extend their use in **bioimaging, drug delivery, and sensor technologies**. Their distinct emission characteristics and magnetic properties also open pathways toward **spintronics, quantum computing, and energy storage** applications. Thus, this study lays a strong foundation for future interdisciplinary research combining **nanophotonics, catalysis, and electronic nanomaterials**, establishing Mn-doped ZnS QDs as a versatile, sustainable, and high-performance material for diverse nanotechnological innovations. The present study, as well as future work, aligns with various fields of nanotechnology and their applications. We propose to continue the research on pure and Mn-doped ZnS QDs for their potential use as "quantum materials" in "quantum sensing" applications.

Keywords: Zinc sulphide; Mn-doped ZnS; Quantum dots; Microwave-assisted synthesis; Photoluminescence; Bandgap engineering; Nanomaterials; Optoelectronic devices; Quantum confinement.

Abstract ID: 122

Improved Electrochemical Performance of Sodium-Ion Batteries with Fes_2/C Nanocomposite Anodes

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It is imperative to develop extremely efficient energy conversion and storage systems in order to meet the growing demand for energy and address the major environmental issues. Lithium-ion batteries (LIBs) have advanced significantly and achieved a high level of industrialization during the past few decades, as is well known. However, the growing demand for lithium and the limitations of the extraction process will undoubtedly result in a shortage of lithium resources and a price increase. For this reason, it is essential to design and develop rechargeable batteries that are inexpensive, highly effective, environmentally friendly, and abundant in lithium. Due to sodium's inexpensive price and availability, sodium ion batteries (SIBs) hold great promise as LIB substitutes. Furthermore, Na and Li are in the same main group and have the similar characteristics in physics and chemistry, so the mechanism of SIBs is also similar to that of LIBs. Until now, there are a large number of electrode materials have been studied and reported for SIBs, such as carbon materials, metal oxides, metal phosphates, metal sulfides and metal-carbon nanocomposites. Among these materials, metal sulfides, especially FeS_2, attract special attention. Not only does FeS_2 widely exist in nature, but also it is of low toxicity and low cost. It also has a high theoretical capacity of 894 mAh g^{-1} [1]. However, there are still some problems need to be solved. First of all, as the anode material for SIBs, FeS_2 has poor rate performance and bad cycling stability, which is mainly caused by two reasons. One is the large volume expansion of FeS_2 (nearly 280% [30]) during the conversion process from FeS_2 to Na_2S and Fe, which could result in the internal friction increase and capacity loss due to the pulverization and mechanical deformation of the electrode material during the cyclic process. The other one is that FeS_2 has poor electrical conductivity, leading to slow reaction kinetics and increasing polarization. To solve these problems, some scientific research teams have

reported various Na-FeS_2 batteries as energy storage equipment. For example, D. Stucky and his partners prepared a neural network nanostructure composite of FeS_2/ CNT, which shows excellent rate performance because it is able to shorten the diffusion path of Na ions and improve the electrical conductivity. Chen et al. demonstrated that adjusting the charging discharging voltage range from 0.8 to 3.0 V could make the FeS_2 microspheres have high-rate capacity and long cycle stability. Lou et al. synthesized FeS_2@C nano boxes with a structure of yolk-shell, which provided enough space to buffer volume expansion of FeS_2 during charge-discharge process and greatly improved the cycle stability. In a word, these problems of FeS_2 as anode material for SIBs could be solved through following paths: narrowing voltage range and enlarging the space to buffer the volume expansion of FeS_2 during the charging/discharging process, improving the electrical conductivity and reducing the size of FeS_2 [2]. Besides, carbon materials including graphene, hard carbon, carbon nanotube, nanowires, nanoflakes, and porous carbon can be used as a skeleton to load iron oxide or sulfides, wherein the abundant defects at the interface between carbon skeleton and metal oxide or sulfides are achieved, thus relieving the volume expansion. The carbon skeleton could provide a 3D conductive network between Fe-based particles to promote electron transfer. Furthermore, the carbon material can be taken as a supporter to construct unique structures, such as hollow spheres, porous structures, nanoparticles and so on, wherein the Na^+ diffusion kinetic is promoted. Moreover, the freestanding electrode with high specific capacity and energy density per unit area can be constructed by taking flexible membranes as supporter Currently, hard carbon (HC) materials are considered commercially viable anode materials for SIBs due to their advantages, including larger capacity, low cost, low operating voltage, and inimitable microstructure. Among these materials, renewable biomass-derived hard carbon anodes are commonly used in SIBs. However, the reports about biomass hard carbon from basic research to industrial applications are very rare. One capable candidate for commercializing SIBs is hard carbon (HC), otherwise called non-graphitizable carbon. Its structure is short, highly curved, and defective graphenic nanosheets are oriented randomly and loosely stacked with vast Van Der Waals distances [3]. Owing to the large interlayer distance, it can act as a host for Na-ions so that these ions undergo easy intercalation into their respective storage sites. The pyrolysis of biomass can easily attain HC because the O/C ratio in the carbon precursors is large, leading to the formation of a disordered and amorphous structure of HC. As a result of the pyrolysis of the materials, the breaking of hydrogen bonds occurs and leads to decomposition of the organic materials such as lignin, cellulose and hemicellulose. This may result in a more porous nature of the synthesized materials. These pores or voids can accommodate more Na-ions during the intercalation through pores. The defects and porosity were considered to be necessary to further improve the capacity and EC performance of HC. Several biomass precursors, such as lignocellulosic materials (rice husk, date pam seeds, coconut shell, wood, fruit bunch, bamboo, corncob residue, waste tea leaves, orange peel) have been conventionally employed so far to improve the porosity of carbon. There are a variety of fibrous materials available in developing countries. They are sisal, jute, coir, *Musa acuminata* (*Ma*), etc. In recent years, these materials have been utilized in a typical manner for the production of mats, yarn, hangings, handbags, and purses. Among them, *Ma* is extensively obtained and is appraised as one of the world's most beneficial plants. This plant belongs to the Musaceae family. In this work FeS_2 is incorporated with hard Carbon to overcome the issues [4]. The inner porous hard carbon

skeleton can support the outer FeS_2 to cast excellent flexibility and leading to the fast redox reaction kinetics. The porous structure at the boundary between the hard carbon supporter and FeS_2 heterojunction can offer free space to release volume expansion during the charging or discharging process, thus improving cycling stability. In addition, direct contact of the outer FeS_2 with the electrolyte can shorten Na^+ diffusion path, combining with fast electron diffusion to promote the rapid and reversible electrochemical reaction.

Abstract ID:123

Sustainable Green Synthesis of Bi_2O_3 Nanoparticles for Efficient Visible Light Driven Photocatalytic Activity

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In this study, Alpha-Bismuth Oxide (α-Bi_2O_3) nanoparticles (NPs) have been successfully synthesized using a cost-effective and environmentally friendly green synthesis method. Originally, the extract of green fresh leaves of the Calotropis Gigantea (CG) plant was used for the fabrication of NPs, which were further calcined at various times and temperatures to obtain the α-Bi_2O_3 NPs. Thermal properties of the synthesized NPs were investigated by TGA/ DTA. XRD and Raman confirmed the formation of α-Bi_2O_3. Under visible light irradiation, the photocatalytic performance of the prepared nanoparticles was tested for Indigo Carmine (IC) dye. The efficiency of IC dye degradation was found to be 88.58% in 210 min.
Keywords: Green synthesis; IC dye; nanoparticles; photocatalysis; bismuth oxide.

Abstract ID: 124

Green Synthesis of ZnO and NiO Nanoparticles for Photocatalytic and Photodetection Applications

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The ZnO and NiO nanoparticles were synthesised by the green synthesis method using the aqueous extract of *Clitoria ternatea*, as a natural reducing and stabilising agent with zinc nitrate hexahydrate and nickel sulphate hexahydrate as respective precursors. Structural characterisation performed using X-Ray Diffraction, confirmed the formation of wurtzite phase of ZnO and cubic phase of NiO with corresponding crystallite sizes of 17.39 nm. and 3.29 nm. The optical properties of ZnO and NiO investigated through UV-Visible Diffuse Reflectance spectra, revealed the optical band gaps of 3.21eV. for ZnO and 1.76eV. for NiO. The photocatalytic activity of both ZnO and NiO were assessed through the degradation of

Malachite Green in aqueous solution under visible light irradiation for 210 min. ZnO achieved a degradation efficiency of 77.88%, while NiO recorded a degradation efficiency of 84.21%. demonstrating the potential of these nanoparticles as photocatalyst, environmental remediation and water purification. The eco-friendly synthesis process, coupled with the excellent photocatalytic efficiencies under mild conditions, represents a sustainable and economical solution for water purification applications. Furthermore, n-ZnO/p-Si and NiO–based junction diodes were fabricated to explore photodetector applications. These devices exhibited high photosensitivity and responsivity, underscoring the versatility of ZnO and NiO nanoparticles for multifunctional applications.

Keywords: ZnO, NiO, Green synthesis, Photocatalysis, Photodetection, Clitoria ternatea.

Abstract ID: 125

Reassessing The Role of Ito Thickness to Optimise the Device Performance In Perovskite Solar Cells

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Perovskite solar cells (PvSCs) are promising next-generation photovoltaic devices due to their high efficiency and low fabrication cost. Indium tin oxide (ITO) used as a transparent electrode in solar cells significantly impacts device performance, however, its thickness is unaccounted for due to standardised commercial availability. In this work, using the Semiconductor Optoelectronics Device Simulation Tool (drift-diffusion model), simulations were performed for an n-i-p perovskite solar cell to investigate the influence of varying ITO thickness on device performance.

Keywords: Perovskite Solar Cells (PvSCs), ITO Thickness, Device Physics, Optoelectrical Simulations

Abstract ID:127

Surface Functionalization of Graphene Oxide with Vitamin K For Lipid Removal: A Molecular Dynamics Simulation Study

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Surface modification with Vitamin K, a hydrophobic chain-bearing fat-soluble substance, may be an efficient way to enhance lipid adsorption by improved surface compatibility. This work focuses on Molecular Dynamics (MD) simulations with LAMMPS to explore lipid adsorption tendencies on Vitamin K-functionalized GO. The entire computational workflow is carried out with Avogadro (for structure building), Moltemplate (for LAMMPS data and topology),

LAMMPS (for running simulations), and OVITO (for post-processing and visualization) (Figure 1). The aim is to provide a reproducible, simulation-based insight into the mechanisms of adsorption without any docking or quantum mechanical preprocessing.

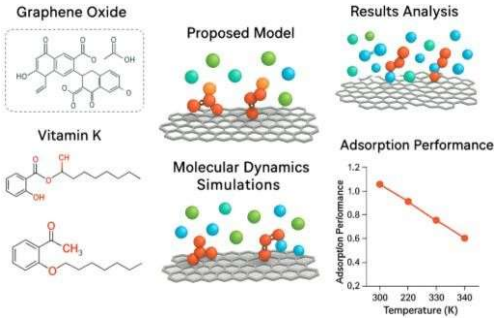

Figure 1. summary of the overall work

Keywords: vitamin K, LAMMPS, md simulation, GO, adsorption

Abstract ID: 129

Electrochemical Immuno-Biosensor for HE4 Biomarker Detection Using Titanium Carbide MXene/PANI Composite

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The asymptomatic nature of early-stage ovarian cancer, there is a critical demand for biosensing platforms that enable rapid, label-free, and highly sensitive detection of Human Epididymis Protein 4 (HE4). This study presents an electrochemical immuno-biosensor fabricated using a synergistic interaction of Titanium carbide (Ti_3C_2) MXene/polyaniline (PANI) composite to enhance conductivity, increase antibody binding affinity, improve surface activity and superior immobilization of anti-HE4 antibodies. Electrochemical response of the material was studied through CV and EIS. Fabricated electrochemical immunosensor response over the different antigen concentration were analyzed through DPV. The fabricated sensor demonstrated a LOD, wide linear range, and strong reproducibility, supporting its suitability for real-time clinical monitoring. These results indicate that the proposed biosensor is a promising alternative to conventional immunoassays for point-of-care screening.

Keywords: HE4, MXene, PANI, electrochemical biosensor, ovarian cancer

Abstract ID: 130

Transparent Biopolymer Hydrogel with Self-Healing and Conductive Properties for Wearable Devices

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Substantial developments in hydrogels' characteristics have enabled their implementation in various technological domains. With advancements in wearable and flexible sensors, hydrogels can be integrated as biomaterials for sensor design. The biocompatibility and biodegradability of gelatin, along with the hydrophilic nature of choline chloride, enhance the water retention capability and stability of the resulting material. A hydrogel system was designed using gelatin and choline chloride to exhibit shape memory and self-healing properties. Preliminary analyses were performed to evaluate mechanical and electrical characteristics using FTIR, XRD, and SEM. Additionally, electrochemical impedance spectroscopy (EIS) using an electrochemical workstation was conducted to assess the ionic conductivity and interfacial resistance of the hydrogel, confirming its stable charge transport behaviour. These attributes enable the gelatin–choline chloride hydrogel system to function as a potential E-skin material owing to its conductivity and transparency. This work provides insights into the physicochemical and electrochemical properties of the hydrogel and its versatile potential in biomedical and flexible electronic applications.
Keywords: Biomaterial, Gelatin Choline Chloride hydrogel, Self-healing, Shape memory, Eskin.

Abstract ID: 131

CW Electron paramagnetic resonance study of paramagnetic centers of Boron nitride quantum dots

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Paramagnetic spin defects of 2D materials have greater potential in quantum technology. Boron nitride quantum dots (BNQDs) are 2D material-based nanoparticles that have a wide band gap, chemical stability, low toxicity, and excellent optical properties. In this work, we have identified four different paramagnetic centers (with Spin S = 1/2) of BNQDs using the Continuous Wave Electron Paramagnetic Resonance (CWEPR). Future research on BNQDs for Optically detected magnetic resonance (ODMR), based on our will help to understand the defect properties and their application in quantum sensing and quantum memory.
Keywords: Paramagnetic centers, Boron nitride quantum dots, CW EPR, defects.

Abstract ID: 132

Understanding the Role of Temporal Surface Treatments in the Charge Transport Behaviour of $CsPbBr_3$ Nanoparticles

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Lead halide perovskite (LHP) nanoparticles (NPs) exhibit high photoluminescence efficiency, long carrier lifetimes, and strong light absorption, making them promising candidates for advanced optoelectronic applications. However, their charge transport is often limited by long-chain insulating ligands that encapsulate the nanoparticle surface and impede carrier conduction. In this work, we investigate the role of controlled temporal surface treatments in modulating the charge transport behavior of $CsPbBr_3$ nanoparticles. Systematic post-methyl acetate annealing enables progressive ligand removal, resulting in significantly enhanced electrical conductivity and improved environmental stability. Temperature-dependent transport measurements reveal a variable range hopping (VRH) conduction mechanism, where optimized treatment conditions result in an increased localization length, indicative of improved electronic coupling between nanoparticles. FTIR and KPFM analyses confirm effective surface modification, reduced trap density, and favorable Fermi level alignment. These findings elucidate the critical role of surface treatment time in governing charge transport pathways and provide a scalable route toward stable, high-performance perovskite nanoparticle-based optoelectronic systems.

Keywords: perovskite nanoparticles, Ostwald ripening, charge transport, surface passivation.

Abstract ID: 133

A Defective Structure of Copper Incorporated Molybdenum Disulfides on Biopolymeric Carbons for Effective Removal of Diclofenac from Water

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This study focuses on developing defective MoS_2 by incorporating Cu^{2+} ions into a chitosan-derived carbon (ChiC) matrix at varying concentrations to achieve efficient removal of diclofenac (DCF) from water. The synthesized adsorbents were thoroughly characterized before and after DCF adsorption using FE-SEM, XPS, and powder XRD analyses. The maximum adsorption capacity, calculated from the Langmuir isotherm, was 1.530 mmol g^{-1} for $Cu_xMo_{1-x}S_2$@C100. The adsorption performance was independent of pH, demonstrating stability across a wide pH range (3–12), and exhibited high selectivity even in the presence of coexisting organic compounds.

Keywords: Diclofenac, Defective structure, Biopolymeric carbons, Maximum adsorption.

Abstract ID: 134

Optimization Of $CsPbBr_3$ Nanocrystals Featuring Enhanced Stability and Optical Efficiency

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Perovskite Nanocrystals (PNCs) have emerged as frontrunners in the paradigm shift involving a ground breaking move from traditional semiconductors, with Cesium Lead Halide Perovskites (LHPs) gaining significant traction due to their superior optoelectronic properties. Although conventional synthesis procedures yield highly efficient PNCs, they suffer from extremely poor stability in air, hindering their large-scale industrial use. Herein we perform an elaborate study involving variation of reaction time, temperature, passivation methods, and polarity of PNC environment. Substantial improvement in $CsPbBr_3$ stability is achieved by employing a mixture of Toluene and Ethyl Acetate in the synthesis route, while preserving most of their light-yield, further solidifying their position in this field.
Keywords: Colloidal nanocrystals, Perovskites, Stability, Optoelectronics

Abstract ID: 135

Effect of Addition of Lead Tungstate Nanoparticles on the B - Phase Modification and Structural, Optical, Thermal, Mechanical and Dielectric Properties of Poly Vinylidene Difluoride Nanocomposite Film

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This study investigates the synthesis and characterization of lead tungstate reinforced poly(vinylidene difluoride) (PVDF) nanocomposite films, aiming to enhance the optical, thermal and dielectric properties of the polymer matrix. FTIR and FT Raman studies confirmed the enhancement of electro active β phase in the film. Optical studies show an enhancement of emission intensity with the addition of $PbWO_4$ nanoparticles. The study shows significant improvement in dielectric constant, thermal stability and tensile strength.The study highlights the potential of PVDF/$PbWO_4$ nanocomposite films for applications in energy storing devices and sensors, paving the way for further research in polymer- based nanocomposites for advanced technological applications.

Abstract ID: 136

Synthesis And Characterization of Ytterbium Oxide (Yb_2O_3) Nano Particles for Dielectric and Ferroelectric Applications

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In this work, Ytterbium oxide (Yb_2O_3) nanoparticles were synthesized through a wet chemical route and annealed at three different temperatures. The so-obtained nanoparticles were pelletized in a hydraulic press for studying various physical properties. The formation of spherical Ytterbium oxide nanoparticles below 20nm size were confirmed using XRD, SEM and FTIR analysis. The bandgap of the prepared nanoproducts was evaluated using diffuse reflectance spectroscopy.

Abstract ID: 137

Transformation Of Carbon-Based Waste into Renewable Energy Through Triboelectric Nanogenerator

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Daily accumulation of waste continues to show a disastrous effect on the environment. Here we are exploring the innovative use of waste materials for sustainable electricity generation through Triboelectric Nanogenerator (TENG), addressing the growing need for renewable energy solutions. The work investigates a detailed study about the carbon-based wastes in the environment and its recycling process and chemical, mechanical properties. Also, their potential for energy conversion through triboelectric contact separation processes. These findings highlight the economic, ecological and sustainable benefits of using the waste carbon into the green energy harvesting, which in turn provides a pathway in reducing carbon emissions and minimizing landfill waste. This research gives some new insights into sustainable development goals (SDG) and renewable energy technologies which leads to a circular economy, focused on resource optimization and environmental sustainability.
Keywords: TENG, Waste Carbon based Material, SDG, Energy Harvesting

Abstract ID: 138

Purification And Characterization Of Acid Phosphatase from Vigna Radiata

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Acid Phosphatase (AP) represents phosphatases, active in acidic media that is crucial for phosphate metabolism and stress adaption in plants by scavenging inorganic phosphates (Pi) from phosphate monoesters via hydrolysis. The present study envisages the characterization of AP from germinating mung beans *(Vigna radiata)* by partial purification subjecting to ammonium sulphate precipitation (30-60%) followed by ion exchange chromatography using DEAE Sephadex A-50. The activity table shows the enhanced specific activity and significant peaks in the chromatogram of Ion exchange chromatography. The pooled peaks were analysed for the activity and evaluated for protein estimation. This may further progress with molecular and biophysical characterization to study stability effects.

Keywords: Acid Phosphatase, Phosphate metabolism, Pi scavenging, Ammonium sulphate precipitation, Ion exchange chromatography.

Abstract ID: 140

Development of Electrochemical Sensor for Neurotransmitter Epinephrine Detection using MXene/$NiCo_2O_4$ nanocomposite.

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A highly sensitive electrochemical biosensor was fabricated using a MXene/$NiCo_2O_4$ nanocomposite for the detection of epinephrine, a key neurotransmitter implicated in several neurological and cardiovascular disorders. The incorporation of two-dimensional titanium carbide (Ti_3C_2) MXene with binary metal oxide $NiCo_2O_4$ provided superior conductivity, electrocatalytic activity, and surface area for enhanced electrochemical interaction. Cyclic voltammetry, Electrochemical impedance spectroscopy and differential pulse voltammetry techniques were used to quantify epinephrine concentrations. The sensor exhibited high selectivity, fast response and demonstrated a linear detection range in micromolar concentrations with an ultralow detection limit, high selectivity, and excellent stability, signifying its potential for clinical monitoring of neurotransmitter-related diseases.

Keywords: Ti_3C_2 Mxene, $NiCo_2O_4$, Epinephrine, Electrochemical sensor, Neurotransmitter detection.

Abstract ID: 141

Rapid Nitrogen Doping of Graphene Directly from Graphite in Seconds

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There is an urgent need for a direct, scalable, and environmentally benign route to tailor graphene properties for advanced electrochemical energy applications. Existing nitrogen-doping techniques rely on multistep, solvent-based, or post-treatment processes that limit yield and uniformity. Here, a one-step plasma-spray technique is introduced that simultaneously exfoliates and nitrogen-dopes graphite within seconds, achieving a remarkable throughput of 45 $g \cdot h^{-1}$. The resulting nitrogen-doped graphene (4.56 at.% N) exhibits a high specific surface area (582 $m^2 \cdot g^{-1}$), electrical conductivity (8000 $S \cdot m^{-1}$), and superior electrocatalytic activity (≈320 $F \cdot g^{-1}$, 380 mV overpotential), establishing a universal and sustainable pathway for large-scale NDG production and deployment in energy storage and conversion systems.
***Keywords*:** Nitrogen-doped graphene, Graphite Exfoliation, Scalable synthesis, Plasma Spray, Electrochemical performance.

Abstract ID: 142

Green Synthesis of ZnO@Activated Carbon Nanocomposite for Efficient Photocatalytic Degradation of Ciprofloxacin Under Visible Light

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This study reports the green synthesis of zinc oxide-decorated activated carbon (ZnO@AC) nanoparticles using a sustainable plant extract as a reducing and stabilizing agent. The synthesized nanocomposite was characterized by XRD, FTIR, SEM, and UV–Vis analyses, confirming the successful integration of ZnO onto the carbon surface. The ZnO@AC exhibited enhanced photocatalytic performance in degrading the antibiotic ciprofloxacin under visible light irradiation. The synergistic interaction between ZnO and activated carbon facilitated efficient charge separation and pollutant adsorption. This eco-friendly approach provides a sustainable and cost-effective solution for water purification and the removal of pharmaceutical contaminants.
Keywords: Green synthesis, Photocatalysis, Pharmaceutical, Ciprofloxacin, Wastewater treatment

Abstract ID: 143

Turning Marine Waste into Power: Crab Shell–Pvdf Derived Electrospun Fibers Based Piezoelectric Nanogenerators for Wearable Devices

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This work reports the design and fabrication of piezoelectric nanogenerators (PENGs) derived from electrospun fibers of crab shell–poly(vinylidene fluoride) (PVDF) composites for high-performance wearable electronics. Crab shell-derived chitin nanoparticles act as natural fillers enhancing the β-phase crystallinity and mechanical strength of PVDF fibers. The developed composite nanogenerator efficiently converts low-frequency biomechanical motion into electrical energy, demonstrating a peak output voltage of 48 V under 10 N stimuli. This bio-derived, flexible, and lightweight PENG provides a sustainable strategy toward eco-friendly self-powered wearable devices.
***Keywords**:* Piezoelectric nanogenerator (PENG), PVDF, crab shell composite, electrospinning, wearable electronics.

Abstract ID: 145

Development Of Mn-Mil100 Mof-Derived Manganese Oxides Electrode for Asymmetric Supercapacitor

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We aimed to develop manganese-based oxides from the Mn-MIL 100 MOF by calcining it in air at various temperatures (400-1200 °C) to control its phase for supercapacitor applications. The optimal material, calcined at 800 °C (Mn-800), exhibited a high specific capacitance of 289.5 F g^{-1} at 1 A g^{-1} with 78 % retention after 2000 cycles. An asymmetric supercapacitor (ASC) using this material (Mn-800||SPC) demonstrated practical viability, delivering an energy density of 11.9 Wh kg^{-1} at a power density of 730 W kg^{-1}. This device also showed excellent stability, retaining 82 % of its capacitance after 3000 cycles.
Keywords: MOF derived Mn_2O_3, asymmetric supercapacitor, metal-organic framework

Abstract ID: 146

Ferroelectric - Photocatalytic Coupling in Bi/Fe-Modified BCZT With Morphotropic Phase Boundary

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Ferroelectric semiconductors have emerged as promising photocatalysts owing to their internal electric fields. In this work, we report the chemical modification of $Ba_{0.85}Ca_{0.15}Zr_{0.10}Ti_{0.90}$ (BCZT) with Bi^{3+} and $Fe^{2+/3+}$ to engineer defect states while stabilizing a morphotropic phase boundary (MPB) between tetragonal (P4mm) and orthorhombic (Amm2) phases. The incorporation of Bi^{3+} and $Fe^{3+/2+}$ enhances ferroelectric stability and electrical conductivity. Xray diffraction analysis and ferroelectric measurements reveal larger tetragonality (c/a) and remanent polarization (P_r =1.63 μC/cm^2) in S1 owing to the built-in electric field. As a result, the photocatalytic degradation efficiency and rate constant (k) of Methylene Blue (MB) improves from ~69% (5.89×10^{-3} min^{-1}) in pristine BCZT to ~79% (7.81×10^{-3} min^{-1}) in the optimally doped sample. This study highlights the role of built-in electric field in tailoring photocatalytic properties for environmental remediation and sustainability.

Keywords: $Ba_{0.85}Ca_{0.15}Zr_{0.10}Ti_{0.90}O_3$, Spontaneous polarization, Morphotropic phase boundary, Defect engineering, Photocatalysis

Abstract ID: 150

From Photons to Food: Quantum Dot Applications in Smart Agroecosystems

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QDs embody a highly dynamic class of nanoscale semiconductor materials with unique optical and electronic properties, extending their application beyond biomedical and electronic areas to agriculture. Because of their tuneable fluorescence, and surface functionalization capabilities, QDs emerged as efficient nanoprobes to monitor plant physiology and detect pathogens with the aim of enhancing crop productivity. This extended abstract summarizes the current status, mechanisms, and potential applications of quantum dots in precision agriculture. The integration of quantum dots within smart farming systems, biosensors, and nutrient delivery technologies was discussed giving emphasis to biosafety concerns and regulatory challenges linked to their deployment in agroecosystems (Figure 1).

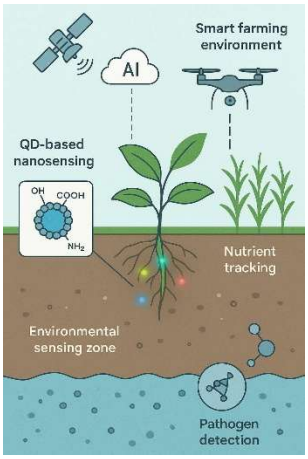

Figure 1 overall summary of the paper

Keywords: QDs, Agro, agronomy, sensing, tool

Abstract ID: 151

Scaling Up Simultaneous Exfoliation And 2h To 1t Phase Transformation of MoS_2

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Large-scale production of high-quality ultrathin layers (1-3 nm) of molybdenum disulfide (MoS_2) with absolute (~100%) 1T-phase remains challenging. Therefore, it is extremely crucial to have a technique for the synthesis of ultrathin 1T-MoS_2 layers. Here, we demonstrated a direct, single-step, and ultra-fast, solvent-free technique that produces high-quality ultrathin layers of 1T-MoS_2 with a production rate (~58 g h^{-1}). These exfoliated ultrathin 1T-MoS_2 layers exhibited ~100% 1T-phase with a large specific surface area (67 m^2 g^{-1}), and higher specific capacitance of 420 F g^{-1}; Our work sheds light on the simultaneous exfoliation and phase transformation of MoS_2.

Keywords: Molybdenum disulfide, Exfoliation, Ultrathin layers, Phase transformation, Plasma spray

Abstract ID: 153

Nickel-Iron Based Semimetallic Electrocatalyst for Efficient Alkaline Oxygen Evolution Reaction

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Oxygen evolution reaction (OER) is a vital electrochemical reaction in water-electrolysis and metal-air-batteries (rechargeable) to attain clean hydrogen energy generation and effective energy-storage. The electrochemically active semiconductors are promising candidates for OER, whereas their intrinsic electrocatalytic activity can be hampered by poor electronic conductivity. This study demonstrates the efficient semi-metallic material as OER electrocatalyst with improved intrinsic electrocatalytic activity along with enhanced electronic conductivity. The improved intrinsic-activity of semi-metallic catalyst for OER is attributed to the high electronic conductivity, which induced the generation and stabilization of metal sites with high-valency in oxyhydroxide-intermediates as inferred from the DFT and Raman studies.
Keywords: OER electrocatalyst, Hydrogen energy, semi-metallic material, intrinsic activity, Gas evolution.

Abstract ID: 155

Optical Detection of Environmental Pollutants and Biomolecules by Localized Surface Plasmon Resonance

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Plasmonics is the science & engineering of confining electric field of free propagating electromagnetic radiation in low dimensional systems. Low dimensional systems are exciting and play a vital role in technical and biological applications. Environmental pollutants and biomolecules sensing is much required in the current days for environmental sustainability with

more ease. The plasmonic nanostructures of metal film over Nanospheres are fabricated by DC Magnetron sputtering process and are used for chemical and biomolecule sensing. Morphological and optical characterization were performed for all plasmonic nanostructures. This work helps in the cost-effective, and label-free detection of chemical and biomolecules.

Keywords: LSPR, optical sensor, biomolecule sensing, Environmental pollutants, optical sensing

Abstract ID: 156

Layered Double Hydroxide Catalysts Driven Hydrogen Production from Aluminium–Water Systems

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Hydrogen (H_2), a zero-emission fuel with high energy density (~120 MJ/kg), can be generated through the aluminium–water reaction. Aluminium (Al), an abundant and cost-effective material with high specific energy, reacts with water to produce H_2; however, the formation of a protective Al_2O_3 layer on its surface hinders the reaction. Conventional alkaline methods used to remove this layer are inefficient and environmentally harmful. Our research focuses on layered double hydroxide catalyst-assisted alumina disruption to minimize induction time and achieve an overall H_2 yield of ~1250–1340 mL under optimal reaction conditions.

Keywords: Carbon footprint, Hydrogen, Al-water reaction, Layered double hydroxide, clean energy sources.

Abstract ID: 1158

Performance and Mechanism of MoS_2 Nanoflowers for NO_2 Detection at Room Temperature

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Room-temperature nitrogen dioxide (NO_2) detection remains critical for environmental and health monitoring. Despite MoS_2's promise as a sensing material, the influence of synthesis parameters on its performance is inadequately understood. This paper systematically investigates the influence of hydrothermal temperature on MoS_2 morphology and NO_2 sensing properties. SEM, XRD, Raman spectroscopy and XPS confirmed nanoflower morphology with mixed 1T/2H phases, a key factor for enhancing conductivity. The optimized thin films achieved 0.4 ppm detection limit with rapid response/recovery (25s/50s) at room temperature.

These findings demonstrate that controlled hydrothermal synthesis enables superior MoS_2based sensors, advancing practical gas detection technologies.

Keywords: MoS_2 nanoflower, Room Temperature, NO_2 Sensing, Chemiresistive Sensors, Thin Films

Abstract ID: 1159

Green Synthesis Of Cuo Nanoparticles For Microplastic Degradation Into Biodegradable Nanoplastics And Assimilation By Bacillus Subtilis In Aquatic System.

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This study introduces an eco-friendly, energy-efficient water purification method using CuO nanoparticles synthesized from waste apple peel via microwave-assisted synthesis. The process minimizes energy consumption and hazardous waste compared to conventional methods. The CuO nanoparticles efficiently degrade microplastics, which are then assimilated by Bacillus subtilis, promoting sustainable remediation. Characterization through SEM, XRD, and EDAX confirmed the nanoparticles' morphology, structure, and composition, while FTIR verified microplastic degradation. Overall, this approach provides a cost-effective and sustainable solution for microplastic pollution control.

Keywords: water purification, CuO nanoparticles, Bacillus subtilis, microplastic pollution control

Abstract ID: 1160

Valorization Of Invasive Water Hyacinth Into Cellulose-Based Hydrogel Using Citric Acid as a Green Crosslinker

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Water hyacinth, a highly invasive aquatic weed, was successfully transformed into a functional cellulose-based hydrogel using citric acid from lemon juice as a green crosslinker. Cellulose extracted from dried biomass (17.5% yield) was crosslinked at 70-80°C under alkaline conditions. FTIR spectroscopy confirmed successful esterification through the appearance of carbonyl peak at 1780 cm^{-1}. The synthesized hydrogel demonstrated exceptional water absorption capacity with 370% swelling efficiency, making it promising for agricultural water retention and controlled-release applications. This eco-friendly approach aligns with green chemistry principles and waste-to-wealth paradigm.

Keywords: Water hyacinth, Cellulose hydrogel, Crosslinking, Green chemistry.

Abstract ID: 1161

Green-Synthesized Okra-Derived Cuo Nanostructured Electrode For Prospective Electrochemical Screening of Microplastics in Coastal Waters (Cuddalore, Bay Of Bengal)

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We report a green, okra-mediated synthesis of CuO nanostructures and their deposition as electroactive films for the prospective screening of microplastics in Cuddalore coastal waters. XRD confirms nanocrystalline CuO, SEM reveals porous aggregates and cyclic voltammetry shows stable Cu-redox features with adsorption coupled responses in the presence of model microplastic leachates. The platform is low cost, scalable and field amenable, supporting rapid triage before confirmatory spectroscopy.
Keywords:Okra-mediated synthesis, CuO nanoparticles, Electrochemical sensor, Microplastics, Coastal water.

Abstract ID: 1162

Synthesis and Application of Pani-Go-Cutio$_3$ Ternary Nanocomposites as an Electrode Material for Next-Generation Supercapacitor Energy Storage

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Polyaniline (PANI) has emerged as a promising material for energy storage applications due to its unique properties and versatile nature. Here, we describe the synthesis of pure PANI, PANI-GO (binary), and PANI-GO-$CuTiO_3$ (ternary) nanocomposites using a practical and eco-friendly chemical oxidation polymerisation technique. Employing characterisation methods such as Fourier transform infrared spectroscopy (FTIR), ultraviolet-visible spectroscopy (UV-Vis), x-ray diffraction (XRD), and scanning electron microscopy (SEM), the physicochemical properties of the synthesised materials were investigated. Electrochemical characterisations electrochemical impedance spectroscopy (EIS) and cyclic voltammetry (CV) were used to analyse the resulting electrodes' supercapacitor performance.
Keywords: Polyaniline (PANI) nanocomposite, Chemical oxidation polymerization, PANI-GO-$CuTiO_3$, Electrochemical Properties and supercapacitor.

Abstract ID: 1163

Synthesis of Novel Elctochemically Active and Asymetrically Distributed Bimetallic Copper-Iron Carbon Nanofibers/Activated Carbon Matrices For The Removal Of Potentially Toxic Chemicals from Water

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The present study demonstrates the synthesis of multi-scale web of bimetallic (Cu-Fe) nanoparticles-carbon nanofibers (CNFs)-activated carbon fibers (ACFs) matrix by a combination of calcination, H_2-reduction, and catalytic chemical vapour deposition (CCVD) steps. The calcination operation facilitated transformation of metal salts into its corresponding oxide phases and further H_2-reduction reduced the metal oxides into its metallic states. Finally, CCVD operation in the presence of acetylene (C_2H_2) as the hydrocarbon gas facilitated the growth of CNFs on the surface of ACFs. The synthesized material was further characterized using several characterization tools including SEM, TEM, BET, XPS, and many others. TEM data confirmed that Cu nanoparticles captured the tips of CNFs, thereby suggesting that the growth of CNFs followed tip-growth mechanism. The synthesized material was further applied for the removal of potentially toxic lead (Pb^{2+}) ions and methylene blue (MB) dye molecules from water under batch mode. The material was capable of removing 122.43 ± 2.82 mg/g of Pb^{2+} ions at pH 5.5 and 251.71±3.59 mg/g MB at pH 12. Regeneration and reusability studies confirmed the material was highly regenerable and the material was capable of retaining high adsorption capacity after several test runs.

Keywords: Catalytic Chemical Vapour Deposition, Carbon nanofibers, Surface characterization, Toxic pollutants, Regeneration

Abstract ID: 1164

Synthesis And Characterization Of Cas:Sb^{3+} Phosphor Based Pig For Led Applications

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In this study, $Ca_{1-x}S:_xSb^{3+}$(x=1,3,5,7,9 %) phosphor was synthesis by solid state. The prepared phosphor was characterized by various techniques. The optical absorption study of prepared phosphor samples was investigated using UV–Vis absorption spectra. The energy band gap values for direct and indirect transitions of Sb^{3+} , were calculated by using Tauc's plot. The optimized phosphor was used to prepare phosphor in glass (PIG). The Prepared PiG, exhibited excitation peak at 397nm and emission peak at 535nm thus the emission and excitation peak of PiG is same as that of Phosphor which can be used for W-LEDs.

***Keywords*:** Phosphor; PL; glass; PiG

Abstract ID: 1166

CCD technique- RSM approach, comparative analysis, multiparameter optimization, spacecraft radiator cooling, Hybrid nanofluid flow, different ethylene glycol/water mixtures ratios

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Efficient cooling is crucial to spacecraft radiators so that they can be comfortable to operate and prevent overheating that may cause equipment failures and decrease system reliability. To address this challenge, the current paper examines the properties of flow and heat transfer in an inclined thin needle geometry assembled in a heat pipe of a spacecraft radiator cooling system. The novelty of this research is that the three ratios of ethylene glycol:water base fluids (20:80, 40:60, and 50:50) are compared with the addition of Al_2O_3 and Fe_3O_4 nanoparticles and optimized using the Response Surface Methodology (RSM) with the Design Expert 13. Statistical methods, such as Analysis of Variance (ANOVA), Pareto charts, and desirability plots, are employed to achieve optimal performance and durability. A novel governing equation with all the necessary parameters was developed and solved numerically through the bvp4c solver of MATLAB. Velocity and temperature profiles, skin friction, and Nusselt number were analyzed in detail. The findings demonstrate that the hybrid nanofluid with 20: 80 (ethylene glycol:water) ratio has 13.6% and 21.6% higher average heat transfer than the 40: 60 and 50:50 ratios, respectively and with the lowest skin friction. Moreover, raising the thermal radiation parameter from 1.5 to 4.5 improves the Nusselt number by 145 % and decreases the skin friction by 9 %, indicating better heat transfer with minimal resistance. The optimization reveals that high radiation and needle size, moderate Darcy-Forchheimer number, and low heat generation and Eckert number are key factors in achieving good cooling and low flow resistance. The linear regression model substantiates the quality of accuracy with R^2 =0.9998 in the case of skin friction and R^2 = 0.999 in the case of Nusselt number. The results can provide crucial information on the development of spacecraft radiator thermal management systems, enhancing the efficiency and durability of these systems.

Keywords: Spacecraft radiator cooling; inclined thin needle; ethylene glycol:water; Response surface methodology; statistical optimization.

Abstract ID: 1169

Bright yellow fluorescent N-doped Ti_3C_2 MXene quantum dots as an "on/off/on" nanoprobe for selective As^{3+} ion detection

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Ti_3C_2 MXene quantum dots (MQDs) are considered to be an emerging nanomaterial in recent times, but the majority of MQDs exhibit limited emission properties in the blue-light region. Longer-wavelength emissive quantum dots are highly desirable in terms of various biological aspects including deep tissue penetration, superior signal-to-noise ratio, reduced radiation damage, etc. In this study, bright yellow fluorescent nitrogen-doped MQDs (N-MQDs) were successfully prepared using a one-pot hydrothermal method. The synthesized N-MQDs showed maximum emission at 570 nm upon excitation at a wavelength of 420 nm, with an optimum fluorescence quantum yield of 13.8%. Interestingly, the emission of the N-MQDs was significantly quenched upon the addition of As^{3+} ions. A mechanistic investigation revealed that static quenching was involved in the decrease in the fluorescence via the formation of a non-fluorescent complex due to the interaction of the functional groups of the N-MQDs and As^{3+}. The quenched fluorescence was surprisingly recovered upon treatment of the complex with 2-amino-6-methoxybenzothiazole (MBTZ). The strong interaction of MBTZ with As^{3+} led to the detachment of the quencher from the N-MQDs, resulting in fluorescence recovery. The reappearance of the functional groups of the N-MQDs after the addition of MBTZ was confirmed via spectroscopic study. Thus, the fluorescence "on/off/on" phenomenon of the N-MQDs nanoprobe was utilised for the instantaneous detection of As^{3+} and MBTZ. The limit of detection values were calculated to be 30 nM and 0.44 μM with a good linearity for As^{3+} and MBTZ, respectively. In addition, a solid sensor has been fabricated to recognize As^{3+} in wastewater, revealing its potential for on-site application in the near future.

Keywords: MXene quantum dots, yellow fluorescence, As^{3+} selective detection, solid sensor, static quenching.

Abstract ID: 1170

Eco-friendly Synthesis and Antioxidant Evaluation of novel Turmeric-Mediated Carbon Nitride Nanoparticles

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In the realm of biomedical applications, carbon-based nanomaterials are an emerging domain for their tunable structure, satisfactory stability, redox activity and low cytotoxicity. *Curcuma longa* rhizome peels were used to synthesize a novel carbon nitride nanoparticle (TCN), which showed excellent radical scavenging activity. TCN showed two types of morphology in nanoscale dimensions, mostly spherical but also rod like. The antioxidant potential of TCN was concentration dependent and was systematically evaluated using DPPH assay which gave an impressive IC_{50} value at 5.63ug/ml, which can be attributed to synergistic interaction between nitrogen rich carbon network as well as bioactive phytochemicals from Curcuma longa. These findings give a future scope to their potential applications in drug development in mitigating oxidative stress related pathologies including neuroprotective formulations.
Keywords: carbon nitride nanoparticles, antioxidant, DPPH

Abstract ID: 1172

Evaluation Of Nano Composites For Electrochemical Application

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In this present study, Multiwalled carbon nanotubes@Tungsten oxide nanocomposites ($MWCNT/WO_3$) loaded on a GCE are used as an electrochemical sensor for the sensitive detection of antihistamine drug (Promethazine hydrochloride: PMZ). $MWCNT/WO_3$ nanomaterial was synthesized using a simple hydrothermal method. The hydrothermal method allows controlled growth of WO_3 nanoparticles and uniform mixing with MWCNTs. Adding MWCNTs improves the composite's conductivity, surface area, and electron transfer. Electrochemical methods, such as cyclic voltammetry (CV) and differential pulse voltammetry (DPV) were used to investigate the electrocatalytic oxidation of PMZ at the surface of the modified electrode in Phosphate buffer solutions (pH = 7.0).

***Keywords*:** Hydrothermal synthesis, Promethazine hydrochloride, MWCNT/WO3 nanocomposites, Electrochemical performance.

Abstract ID: 1173

Eco-Friendly Nano Biofertilizer Composite for Yield Enhancement in Capsicum

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The growing demand for sustainable agriculture has encouraged the search for efficient and eco-friendly fertilizer systems. This study reports the formulation and evaluation of a

biopolymer-based nanocomposite fertilizer composed of chitosan, sodium alginate, humic acid, and hydroxyapatite nanoparticles for improving the growth of Capsicum annuum. The nanocomposite was synthesized using ionic gelation and characterized by FTIR, XRD, SEM, and DLS. Results confirmed nanoscale, stable, and porous particles capable of sustained nutrient release. Greenhouse trials showed significant improvement in plant growth, chlorophyll content, and yield, demonstrating the nanocomposite's potential as a sustainable bio-nanofertilizer.

Keywords: chitosan, alginate, humic acid, hydroxyapatite, nanofertilizer

Abstract ID: 1175

Enhancement Of Nir Reflectance Behaviour Of $Ba_{1-x}y_xwo_4$ Phase Materials for The Application Of Solar Reflective Pigments

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The main aim of this study is to investigate the change in optical features of the $BaWO_4$ materials by doping with Y ($Ba_{1-x}Y_xWO_4$). For the synthesis of $Ba_{1-x}Y_xWO_4$ (x = 0, 0.02, 0.04, 0.06, 0.08, 0.1) series materials, the ball-milling method was employed. Regardless of doping concentration "x", all the as-milled powder exhibited tetragonal symmetry with no impurity phase. The gradual increase in NIR reflectance is noted from 22.7% to 68.4 % by increasing "x" in $Ba_{1-x}Y_xWO_4$ series especially in the solar reflectance region (750 to 1350 nm) which warranty the application of solar reflecting pigments.
Keywords: $Ba_{1-x}Y_xWO_4$ phase; Ball-milling; Thermal analysis; Micro-structure; Optical properties

Abstract ID: 1176

Anticancer, Antioxidant, Antidiabetic and Antibacterial Activity of Biopolymer Chitosan Nanocomposite

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The present study aims to the synthesis of Chitosan –ZnO nanocomposite and it is characterized by different characterization techniques namely XRD, FTIR, UV-Vis, SEM, TEM analysis. The synthesized nanocomposite has good cytotoxicity against human breast cancer cells (MCF-7) and minimum toxicity against normal L929 cell lines. It has good antioxidant, antidiabetic and antibacterial activity.
Keywords: Nanocomposite, cytotoxicity, MCF-7, L929

Abstract ID: 1177

Layered Double Hydroxide-Based Delivery of Effector DSRNA Confers Prolonged Resistance Against Pea Powdery Mildew

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Layered double hydroxides (LDHs) are promising nanocarriers for RNAi-based crop protection, yet their use against obligate biotrophs remains unexplored. Here, we evaluate Magnesium–Iron LDH (MgFe-LDH) as a carrier for fungal effector dsRNA (Ef-dsRNA) to control *Erysiphe pisi* causing powdery mildew (PM) diseases in pea. LDH shows leaf adherence, high dsRNA loading, and protects dsRNA from RNase degradation while enabling sustained release. Foliar application of Ef-dsRNA–LDH enhances effector gene silencing and provides prolonged local and systemic powdery mildew resistance compared to dsRNA alone. The nanocarrier is internalized into plant cells and fungal hyphae via haustoria, enabling effective RNAi-based disease suppression.

Keywords: *Erysiphe pisi*, nanocarrier, obligate biotroph, RNA interference, foliar spray.

Abstract ID: 1179

Interfacial Studies of Metallenes with Mxene Nanosheets for High Performance Supercapacitor

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Frontier two-dimensional materials have attracted significant attention as a design philosophy for enhancing energy storage performance. Two-dimensional systems exhibit excellent physicochemical properties, surpassing those of surface chemistry and quantum chemistry, and also enhance electrochemical performance in supercapacitors. Metallenes are the new family of 2D materials, which contains a single atomic layer composed of metal atoms. In this work, MoBiene is introduced as a functional active material for the fabrication of hybrid electrodes with high mechanical compliance. MoBiene was synthesized by the standard liquid phase exfoliation technique. Incorporation of MXene enhances the environmental stability as electrode materials and delivers excellent performance in supercapacitor applications.

Keywords: Mxene, bimetallenes, Graphite sheet, Asymmetric capacitor.

Abstract ID: 1180

Micro-structural and Sprayability Assessment of Nano YSZ Powders for High-Temperature Coatings

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Nano-sized (20–90nm) yttria-stabilized zirconia (YSZ) powders were transformed into micrometers (30–60µm) plasma-sprayable powders via polymer-based agglomeration using manual processing and spray drying. The resulting plasma-flowable powders were deposited onto Al–Si substrates using atmospheric plasma spray (APS) equipment. The characterizations involved flow test meter, scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS). This paper presents the processing methodologies and study outcomes related to powder characteristics including yield, powder flow, morphology, elemental composition, grain size and microstructure. Additionally, it evaluates the suitability of these powders for use in plasma spray coating, specifically for thermal barrier coating applications. The importance of powder characteristics to develop coatings with nano microstructures is highlighted.

Keywords: Nanometres, High Temperature Coatings, Spray Drying, Plasma spraying

Abstract ID: 1181

Electrochemically Active Catalytic Chemical Vapour Deposition Grown Carbon Nanofibers for the Effiecient Removal of Lead Ions from Water

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Carbon nanofiber (CNF) was synthesized using Cu-tartrate as a precursor salt via combination of H_2-reduction and catalytic chemical vapour deposition (CCVD) routes. H_2-reduction performed at 300 ^oC resulted in the formation of Cu NPs and further CCVD at 350 ^oC facilitated the growth of CNFs (Cu-CNFs). The selection of reduction temperature was based on temperature-programmed reduction (TPR) analysis. Next, the synthesized material (Cu-CNF) was further functionalized with tetraethylenepentamine (TEPA) at varying loadings (10–40%) to incorporate nitrogen functionalities in the nanofibrous matrix. The TEPA functionalized materials are denoted as x-TEPA-Cu-CNF (x= loading of TEPA). Characterization data (SEM/TEM) confirmed tubular morphology of CNFs and the average size of Cu NPs located at the tips of CNFs was determined to be 24 nm, by XRD analysis. The materials were further tested for the removal of Pb^{2+} removal from aqueous solutions. The removal mechanism involved electrostatic attraction, surface complexation between oxygen containing surface functional groups (–OH, -COOH) and Pb^{2+} ions, pore filling, and NH_2–Pb^{2+} complexation.

Keywords: Catalytic chemical vapour deposition, Carbon nanofibers, Electron microscopy, Toxic, Wastewater

Abstract ID: 1182

Synthesis, Characterization, and Application of Fe- Modified MSN for Visual Detection of Waterborne Bacteria

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Contaminated water can spread harmful bacteria, making rapid and reliable detection essential for public health. This study reports the synthesis of iron-modified mesoporous silica nanoparticles (Fe-MSN-NH_2) and their use as a simple color-based test for identifying bacterial presence in water. The process and particle structure were confirmed using advanced methods, and the colorimetric system easily distinguished clean water (blue color) from contaminated samples (no color). These findings show the promise of Fe-MSN-NH_2 particles for affordable, user-friendly water quality screening, with future improvements possible by tailoring their surfaces for higher sensitivity using antibodies**.**
Keywords: Nanoparticle, Detection, Bacteria

Abstract ID: 1186

Optimization of Laser Additive Manufacturing Parameters for Fe-Based Nanocrystalline Magnetic Materials Using Ant Colony Algorithm

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Industry 5.0 offer new opportunities for magnetic sensors, magnetostrictive transducers and magnetic actuators due to their high saturation magnetostriction compared with that of traditional materials. Further, the properties of Fe-based nano-crystalline magnetic materials (Fe–Si–B–Nb–Cu- FINEMET) like soft magnetism, Saturation Magnetization, Coercivity, Magnetostriction, etc making them superlative utilization for high-frequency transformer and motor applications. So this research focused on the Fe-based nano-crystalline magnetic materials. However, the major challenge faced by the researchers are in protecting the nanostructure during Laser Additive Manufacturing (LAM). To overcome this contest, in this research, Ant Colony Optimization Algorithm (ACO) have been implemented to identify the best optimal LAM process parameters for accomplishing the desired magnetic properties. The parameters - scan speed (v), hatch spacing (h), laser power (P) and layer thickness (t).

as the outcome, It has been observed that bulk density directly proportional to P and t and inversely proportional to v and h. As well, the sizes of the nanocrystallites Fe2B and Fe3Si

govern the magnetic properties and consecutively the saturation magnetisation and enhanced Coercivity. These desirable sizes can be obtained by setting the machine parameter provided by the ACO.

Keywords: Nanocrystalline Materials, Laser Additive Manufacturing, Ant Colony Algorithm, Soft-Magnetic Properties, Parameter Optimization.

Abstract ID: 1188

Growth and Characterization of 1D CuO-ZnO Mixed Oxide Thin Films

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Mixed CuO–ZnO (CZO) nanostructures combine the complementary p–n characteristics of CuO and ZnO are successfully grown using a simple thermal oxidation process. CZO 1D nanostructures were synthesized by controlled thermal oxidation of co-deposited Cu and ZnO thin films prepared via dual DC–RF sputtering. Structural, morphological, and surface chemical analyses confirmed the formation of mixed oxide nanowires with tuneable wettability and semiconducting behaviour. The results demonstrate the potential of CZO 1D nanostructures for gas sensing and self-cleaning surface applications.

Keywords: Mixed metal oxide, 1D nanostructure, Heterojunction, Gas sensing.

Abstract ID: 1190

$Cs_2Nafecl_6$ Double Perovskite Thin Films: A Potential Material for Reversible Thermochromic Applications

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Iron-based halide double perovskites (IHDP) are an emerging class of sustainable semiconductors with numerous potential applications in the field of energy generation and conversion. In this study, we synthesized $Cs_2NaFeCl_6$ single crystal (SC), a nascent class of IHDP, using the hydrothermal method. We processed the as-grown crystals in the solution phase to prepare their thin films. We further demonstrate that $Cs_2NaFeCl_6$ thin films exhibit reversible thermochromism, which is stable across a wide temperature range. This work promises potential applications of this material in thin-film-based smart windows and temperature-sensing devices.

Keywords: Lead-free double perovskite, Thermochromism, Optoelectronic applications.

Abstract ID: 1192

A Novel 0d/1d Plasmonic Heterostructure with Ohmic Contact and Hot Electron Dynamics to Enhance the Visible Light Driven H_2O_2 Generation

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A plasmonic Cu-decorated $BiPO_4$ (Cu/BPO) heterostructure was developed as an efficient, low-cost, and eco-friendly visible-light photocatalyst for H_2O_2 production. The decoration of Cu nanoparticles enhanced light absorption and charge transfer, leading to a 1.4 times higher H_2O_2 yield (774 $\mu M\ h^{-1}\ g^{-1}$) compared to pure $BiPO_4$ (BPO). The structural properties identified using XRD, FESEM, XPS, and HRTEM, UV-DRS. We have confirmed the effective Cu–BPO interface and favourable band alignment evaluated using Mott-Schottky and VB-XPS further demonstrating the potential of metal–semiconductor heterostructures for high-yield photocatalytic H_2O_2 generation.
Keywords: H_2O_2 production, heterojunction, LSPR, Ohmic contact, Cu-BiPO4

Abstract ID: 1193

Trivium-Based NLFSR Stream Cipher for Area-Efficient and Secure SSN Testing

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As integrated circuits become more sophisticated, securing test data is crucial to prevent intellectual property theft and reverse-engineering during scan-based testing. Although the Streaming Scan Network (SSN) efficiently manages test data, it lacks inherent security measures to protect sensitive information. To overcome this limitation, this work introduces a lightweight and optimized stream cipher integrated into the SSN framework, ensuring secure test compression and pattern transmission. The proposed design features a dynamic Trivium-based key generator with partitioned NLFSRs, enhancing randomness, diffusion, and attack resistance while maintaining low hardware overhead. Synthesis results show reduced area, unpredictable keys, and accurate data recove ry, confirming the design's strength and practicality for secure SSN-based testing.
Keywords: Streaming Scan Network, Lightweight Stream Cipher, NLFSR, Trivium, Hardware Security, Less Area.

Abstract ID: 1194

Automated sub grain boundary detec on in experimental and synthe c crystal orienta on maps of deformed polycrystals

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Understanding sub-grain forma on and their evolu on under different deforma on modes is essen al for linking crystallographic orienta on changes to mechanical behaviour. Conven onal EBSD-based grain segmenta on, such as standard TSL-OIM rou nes, o en fails to capture fine la ce curvatures and leaves par ally open sub grain boundaries, resul ng in incomplete microstructural interpreta on. In this work, we develop a fully automated and deforma on aware sub grain boundary detec on framework for experimental and synthe c EBSD orienta on maps of deformed polycrystals. The methodology integrates an AlGrID inspired graphical deforma on gradient network with a Dijkstrabased fron er-closing algorithm to reconstruct con nuous sub grain boundary networks with significantly improved fidelity. KAM based filtering and unsupervised clustering refinement are further applied to isolate deforma on topology, remove noise, and reveal physically meaningful crystallographic neighbourhoods.

To validate the robustness of the segmenta on, we combine high quality EBSD datasets with full field crystal-plas city simula ons generated in DAMASK. Copper polycrystals were deformed under tension, compression, and shear to the same von Mises strain using a phenomenological cons tu ve model, enabling a controlled comparison between experimental and simulated orienta on fields. The results demonstrate a strong correla on between local misorienta on pa erns, ac ve slip-system constraints, and the density and morphology of sub-grain boundaries. The proposed workflow consistently outperforms conven onal EBSD segmenta on in boundary con nuity, angular sensi vity, and the ability to detect subtle intragranular deforma on structures.

The integrated EBSD DAMASK framework presented here provides a reliable pathway for automated sub-grain quan fica on and offers new insight into the mechanics-driven evolu on of deforma on microstructures.

Keywords: Subgrain Boundaries (SGBs), ALGrID, DAMASK, GND, Low Angle Grain Boundaries(LAGBs), EBSD, Crystal Plas city.

Abstract ID: 1195

Nested Anti-Resonant Hollow-Core Fiber for Mid-Ir Applications

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In this paper we proposed a hollow core anti-resonant fiber (HC-ARF). The optimized fiber having a three-layered nested ring in both x, y direction. The intermediate tubes provide crucial mechanical support and enhance anti-resonance reflection which increase the light confinement. By proper arrangement of these rings to the outer tube is essential for maintaining mechanical stability and optical loss. Proposed design results a very low-confinement loss of 1.07×10^{-13}dB/m at 2 □m wavelength for As_2Se_3.

Keywords: Anti-resonant hollow core fiber (AR-HCF), Confinement loss, Optimization, Chalcogenide material, Sellmeier's Equation

Abstract ID: 1200

Graphene Nanoflakes-Reinforced PTFE Composite Packaging for Enhanced Temperature-Vibration Stability of SMS Fiber Ring Laser Sensors in Heavy Metal Detection

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This study presents a novel approach to address temperature-vibration cross-sensitivity in Single-Mode–Multimode–Single-Mode (SMS) fiber-optic sensors within fiber ring laser (FRL) cavities for heavy metal ion detection. The use of graphene nanoflakes (GNFs)-reinforced polytetrafluoroethylene (PTFE) composite packaging results in significant improvements. Temperature sensitivity is reduced from +0.08964 nm/°C to −0.04363 nm/°C, and vibration-induced spectral shifts are reduced from +0.03635 nm/Hz to −0.03136 nm/Hz. These enhancements stem from better heat dissipation, increased mechanical rigidity, and thermal expansion matching. The stabilized sensor achieves sub-nanometer wavelength resolution, enabling reliable detection in harsh environments.
Keywords: SMS fiber sensor, cross-sensitivity mitigation, graphene-PTFE composite, thermal stability, vibration resistance, heavy metal detection

Abstract ID: 1202

A Zig-Zag Triboelectric -Electromagnetic Hybrid Generator for Vaibration Energy Harvesting

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Herein a zig-zag triboelectric-electromagnetic hybrid generator (ZZ-HG) was fabricated consisting of zig-zag triboelectric nanogenerator (ZZ-TENG) and electromagnetic generator (EMG) for scavenging vibration energy. The ZZ-TENG device has two TENG components in its structure which operates with the movement of magnet that eventually actuates the ZZ-TENG. The ZZ TENG and EMG components generates a maximum voltage/current output of 40 V/5 μA (two TENGs in ZZ-TENG connected in parallel) and 3 mV/18 mA respectively. The ZZ-HG device has been tested for its real time application in powering up low power electronic devices such as LED and capacitors. The electrical response and the ability of the device to be used for powering low power application proves that ZZ-HG device has high potential to be used as self-powered sensors.
Keywords:Triboelectric nanogenerator, Electromagnetic generator, Hybrid generator, Vibration energy harvesting.

Abstract ID: 1203

Strontium-Modified $BaTiO_3$ Composite Nanogenerators for Flexible and Self-Powered Human-Machine Interaction

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Sr-doped $BaTiO_3$ piezoelectric nanogenerators were developed for wearable gesture-recognition applications. Sr incorporation (1-10 mol%) was achieved through a solid-state reaction using $BaCO_3$, TiO_2 and $SrCO_3$ to enhance ferroelectric activity. Composite films were prepared by dispersing the optimized powders into PDMS at 5-25 wt% and integrating them into flexible device structures. The nanogenerator delivered a peak-to-peak voltage of approximately 60 V under mechanical excitation. The output was coupled to an Arduino Nano interface to enable real-time gesture recognition. These findings highlight the potential of Sr-doped BTO composites as efficient, lead-free materials for self-powered wearable electronics.

Keywords: Piezoelectric, $BaTiO_3$, Strontium doping, Nanogenerator, Wearable.

Abstract ID: 1204

Enhanced physio-mechanical properties in ZnO/HA ceramic nanocomposites for 3D printed bioactive bone scaffolds

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3D printed bioactive ceramic bone scaffolds need to mimic the mechanical behaviour of bone to stimulate cell adhesion and promote osteogenesis. Herein, we prepared various compositions of zinc oxide and hydroxyapatite (0-10 % ZnO/HA). Extrusion-based 3D printing was used to fabricate the bone scaffold with an intended pore architecture, followed by sintering at 1150°C for 4 hours to obtain densification. X-ray diffraction showed a hexagonal wurtzite structure ZnO and HA. Adding ZnO into HA matrix improved the compressive strength by 64.1% for 10% ZnO. Thus, addition of ZnO into HA significantly enhanced the mechanical properties of 3D printed HA-based bone scaffold.
***Keywords*:** Hydroxyapatite, 3D printing, Bioactive scaffolds, Zinc Oxide

Abstract ID: 1205

Numerical Modelling of Excitonic Absorption Spectra from 2d-$CsPbcl_3$ Colloidal Quantum Well

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Two-dimensional (2D) lead halide perovskite (LHP) colloidal quantum wells (CQWL) are attractive materials in the field of solution processible thin-film optoelectronics, due to unique excitonic properties. In this study, we numerically modelled the experimentally determined optical absorption spectra of $CsPbCl_3$ colloidal quantum well, considering Sommerfeld enhancement factor at the optical band edge. The model enables us to separate out exciton absorption from band-to-band transition and allow us to extract the exciton binding energies, excitonic linewidths, and optical band gaps as a function of quantum well thickness.

Keywords: Colloidal Quantum well, Excitonic absorption, Elliot model

Abstract ID: 1206

Development of $MgCr_2O_4$ Materials and Analysing its Structural, Thermal, and Optical Features

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Mechanothermal method was employed for the preparation of $MgCr_2O_4$ materials using MgO and Cr_2O_3. Nearly single phase of cubic spinel of $MgCr_2O_4$ materials was formed after

annealing the as-milled powder at 650°C/ 3-9h and 1000°C for 3h. Highly aggregated particles of $MgCr_2O_4$ materials were observed from SEM micro images. The NIR reflectance of 37% is noted for the cubic $MgCr_2O_4$ phase materials which is rather lower than other oxides especially scheelite phase materials. In order to enhance the NIR efficiency of $MgCr_2O_4$ phase materials in the NIR region between 750 and 2500 nm, further work is important to better understand the NIR spectral features of the spinel $MgCr_2O_4$ phase.
Keywords: $MgCr_2O_4$ phase; Ball-milling; Thermal analysis; Micro-structure; Optical properties

Abstract ID: 1207

Multi-Site Engineered BZT Perovskites with Ca/Sr Doping for High-Performance Flexible PENG Devices

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Multi-site-engineered $Ba(Zr,Ti)O_3$ BZT perovskites were synthesized for flexible piezoelectric nanogenerator (PENG) applications. BZT served as the parent structure, while Ca and Sr were incorporated at the B site through a solid-state reaction to enhance lattice distortion, ferroelectric polarization and dipole alignment. The doped powders were uniformly dispersed into a PDMS matrix to fabricate flexible PENG devices. Under mechanical excitation, the optimized composition produced enhanced voltage output and stable electromechanical response, confirming the effectiveness of multi-site doping. These results demonstrate the potential of Ca/Sr-modified BZT systems for developing efficient, lead-free energy harvesting and wearable sensing technologies.
Keywords: BZT, Multi-site doping, Ca/Sr doping, PENG, Wearable.

Abstract ID: 1208

Bio-Inspired Green Synthesis of Bifunctional Mn-N-C Electrocatalysts for Efficient ORR/OER In Pem Fuel Cells and Electrolyzers

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A bio-inspired, green synthesis approach is used to fabricate Mn-N-C electrocatalysts with dopamine as the precursor. The optimized material achieves superior activity as well as stability for oxygen reduction and evolution reactions, featuring an ORR onset of 0.965 V and OER performance at 1.76 V (10 mA cm^{-2}). Synergistic MnO-N active sites, confirmed by spectroscopic analysis, drive the bifunctional performance, making this catalyst a promising, low-cost alternative for advanced energy conversion devices.
Keywords: Electrocatalysts, Manganese Oxide, Green Synthesis, ORR, OER

Abstract ID: 1209

Utilizing multiferroic rare-earth orthoferrite-doped BTO composite films for magneto-mechano-electric energy harvesting systems to power steady-state, low-power, sustainable systems.

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Ferroelectric responsive hybrid piezoelectric–triboelectric system has been developed to convert stray magnetic fields into electrical energy using multiferroic rare-earth erbium orthoferrite ($ErFeO_3$ - $RFeO_3$) doped barium titanate ($BaTiO_3$) nanoparticles. These nanoparticles were synthesized using the mixed oxide route at an elevated temperature of 1200°C for 6 hours. Using PDMS to blend with the $RFeO_3$ - $BaTiO_3$ nanoparticles to archive the composite film. A 4×4 cm composite film with attached aluminum electrodes was analyzed for its piezoelectric response, where the 10 wt% composite device exhibited the highest peak-to-peak output voltage of 95 V and current of 2.7 μA. This 10 wt% device was further modified into a triboelectric system and tested using a stable Helmholtz magnetic coil to generate a stray magnetic field, forming a magneto-mechano-troboelectric (MMTEG) generator for powering low-power electronics.
Keywords: Rare earth orthoferrite, Piezoelectric nanogenerator, Triboelectric nanogenerator, Magneto-Mechano-Technology.

Abstract ID: 1211

Unravelling the Influence of Structural Variability on Magnetic Properties in Ba_2feteo_6 Double Perovskites

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Double perovskites material, Ba_2FeTeO_6, was synthesized by solid-state reaction technique. Rietveld refinement was carried out for the powder diffraction pattern which confirmed the hexagonal structure of the prepared compound with P63/mmc (194) space group. The unit cell parameters were found to be a = 5.76924(27) Å, and c = 14.1929(4) Å. The lattice parameters and B'-O and B"-O bonds exhibit the expected trends based on the B size. The distances of B'-O and B"-O bonds were calculated from the Rietveld-refine structures. Aggregated spherical microspheres are having a hexagonal crystal structure with an average particle size of ~1 μm. XPS confirms the oxidation states of the compounds. ZFC and FC curves exhibit a phase transition from ferromagnetic (FM) to paramagnetic (PM) at the Curie temperature Tc which was observed at 165K for Ba_2FeTeO_6. Room temperature and low temperature field dependent magnetic properties were measured through the magnetic measurements.

Keywords: Powder X-ray diffraction; Rietveld refinement; Double Perovskite; Curie temperature

Abstract ID: 1213

Synthesis and Characterization of Ti_2C MXene for Interfacial Engineering in Next-Generation DSSCs:

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This study presents the controlled synthesis of two-dimensional Ti_2C MXene produced from the Ti_2AlC MAX phase through selective chemical etching followed by delamination to obtain few-layer nanosheets. Removal of Al layers yielded Ti_2C sheets with a distinct lamellar morphology. Structural evolution, bonding states and surface terminations were verified using XRD, FTIR, XPS, FESEM and HRTEM, confirming successful formation of high-quality MXene. The resulting Ti_2C is incorporated as an interfacial layer between FTO and anatase TiO_2 in dye-sensitized solar cells. Its high electrical conductivity, metallic layered structure and favorable energy-level alignment promote efficient electron extraction, reduced recombination and lower interfacial resistance. The ultrathin, uniform MXene coating also strengthens interfacial stability, thereby improving output. This enhancement underscores the material's capacity to facilitate more robust charge transport and efficient device performance.

Abstract ID: 1214

Pt-Nanoparticles Integrated Conducting Polymer Nanostructures on RGO-Coated Screen-Printed Electrodes for Sensitive Detection of Neurotransmitter Associated to Parkinson's Disease

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Dopamine, a crucial neurotransmitter plays an important role in neurological well-being and also an important biomarker in Parkinson's disease. In this work we have developed the sensor for the quantification of Dopamine using reduced graphene oxide (RGO) as the main carbon-based conducting material on which thiadiazole based monomer, 5- amino 1, 3, 4 thiadiazole-2-thiol (ATDT) is electropolymerized and finely decorated with platinum nanoparticles to increase the sensitivity of the sensors. This synergistic combination has provided a good linear range of detection from 0.2μM to 14 μM and detection limit 0.081μM for dopamine. The developed sensor can be suitable for the quantification of DA from biological fluids.

***KeyWords*:** Dopamine (DA), RGO, 5- amino 1, 3, 4 thiadiazole-2-thiol (ATDT), PtNPs, Disposable electrochemical sensor.

Abstract ID: 1215

Synthesis Of Ta_2C Mxene and its Application in TiO_2-Based Composite Photoanodes for Dye-Sensitized Solar Cells

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This study reports the successful synthesis of Ta_2C MXene derived from the Ta_2AlC MAX phase via selective chemical etching using hydrofluoric acid (HF). By optimizing the HF etching process, the Al layers in Ta_2AlC were efficiently removed, enabling the transformation of the parent MAX phase into a layered Ta_2C MXene structure with well-defined two-dimensional (2D) morphology. The etching process involved the strong interaction of HF with Al atomic layers, selectively etching them and leaving behind the metal carbide in 2D structure. This resulted in exfoliation and the formation of an accordion-like MXene morphology, characteristic of selectively etched MAX-derived structures. Further delamination using mild sonication yielded few-layer nanosheets, increasing their dispersibility and suitability for integration into photoanode composite films.

Comprehensive characterization techniques were employed to confirm the phase transformation and elucidate the structural, chemical, and morphological evolution associated with MXene formation. X-ray diffraction (XRD) patterns showed the expected downshift of the (002) peak, confirming the removal of Al and interlayer expansion. Fourier-transform infrared spectroscopy (FTIR) detected surface terminations, including –OH, –O, and –F, originating from the HF etching environment. These functional groups enhance hydrophilicity and influence energy-level alignment when interfaced with semiconducting oxides. X-ray photoelectron spectroscopy (XPS) provided further evidence for the chemical conversion to Ta_2C MXene, displaying characteristic Ta–C bonding and a significant reduction in Al content.

In this work, the synthesized Ta_2C MXene is employed not just as an additive but as a functional composite material integrated with TiO_2 (anatase) to develop an efficient photoanode for dye-sensitized solar cells (DSSCs). The Ta_2C-TiO_2 composite is designed to address the intrinsic limitations of pristine TiO_2, such as low electrical conductivity, moderate electron mobility, and charge recombination at the semiconductor–electrolyte interface. Thanks to its metallic conductivity, layered structure, and tunable surface terminations, Ta_2C MXene acts as a conductive highway within the TiO_2 matrix, facilitating rapid electron extraction from dye molecules and promoting efficient transport across the photoanode to the FTO substrate. Surface terminations of MXene also foster stronger interfacial bonding between MXene flakes and TiO_2 nanoparticles, reducing electron scattering and enhancing the structural compactness of the film.

Energy band alignment analysis suggests that Ta_2C MXene has favorable electronic positioning relative to the conduction band of TiO_2, creating an energetically smooth pathway for electron transfer while inhibiting back electron transport towards the electrolyte. This dual function enhanced electron mobility and recombination suppression is critical for improving charge-collection efficiency in DSSCs. Furthermore, the high specific surface area of the few-layer MXene sheets increases dye adsorption within the composite, thus enhancing light-harvesting efficiency and photocurrent generation.

DSSC devices fabricated with the Ta_2C-TiO_2 composite photoanode exhibited superior photovoltaic performance compared to those using pure TiO_2. Key parameters such as short-circuit current density (J_{sc}), open-circuit voltage (V_{oc}), and overall power conversion efficiency (PCE) were all improved. A significant reduction in charge-transfer resistance and a longer electron lifetime for the composite photoanode has been revealed. These improvements confirm the beneficial role of Ta_2C MXene in facilitating interfacial charge transfer and transport dynamics. The thin, conformal Ta_2C-TiO_2 layer between the FTO substrate and the dye-sensitized TiO_2 network creates a more efficient photoanode architecture, supporting improved electrical conductivity and long-term interfacial stability.

Overall, this work highlights the promise of HF-etched Ta_2C MXene as an effective component for advanced DSSC photoanodes. The study demonstrates that MXene-semiconductor hybrids can be rationally designed to overcome the limitations of conventional oxide photoanodes. The insights gained from the synthesis, characterization, and device performance evaluation of Ta_2C-TiO_2 composites can guide future development of MXene-based interfacial layers, composites, and hybrid nanostructures for next-generation photovoltaic and optoelectronic technologies.

Keywords: Ta_2C MXene, HF Etching, exfoliation, Ta_2C-TiO_2 Photoanode, Interfacial engineering, DSSC.

Abstract ID: 1216

Cr_2C Mxene as a Cost-Effective Counter Electrode for Dye-Sensitized Solar Cells

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Cr_2C MXene was successfully synthesised from the Cr_2AlC MAX phase through the selective removal of aluminium layers, a process that effectively transforms the parent MAX structure into a two-dimensional material with a characteristic accordion-like morphology. This conversion is achieved by chemically etching the Al layers, which weakens the interlayer bonding and releases the Cr_2C MXene sheets. The resulting material exhibits a distinctive layered arrangement with expanded interlayer spacing, clearly observable in both microscopic and diffraction-based characterization techniques. Such structural evolution is typical for MXenes and confirms the successful preparation of the Cr_2C phase.

A comprehensive set of characterization techniques, including X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), field-emission scanning electron microscopy (FESEM), and high-resolution transmission electron microscopy (HRTEM), was employed to validate the structural and surface features of the synthesized Cr_2C MXene. XRD provided evidence of the shift and broadening of peaks associated with the removal of Al and the creation of a more open layered structure. FTIR analysis confirmed the presence of functional groups associated with MXene surface terminations, which typically include –O, –OH, and –F functionalities introduced during etching. XPS further verified the elemental composition and surface chemistry by identifying the chemical states of Cr, C, and the terminating groups. FESEM images clearly revealed the 2D accordion-like sheets, while HRTEM offered a high-resolution view of the layered nanosheets. Together, these characterization methods confirmed the successful synthesis and morphological integrity of Cr_2C MXene.

Following its successful preparation, the Cr_2C MXene was explored as a potential alternative counter electrode (CE) material in dye-sensitized solar cells (DSSCs). In a typical DSSC configuration, the counter electrode plays a crucial role in catalyzing the reduction of the triiodide (I_3^-) species to iodide (I^-), thereby enabling the regeneration of the redox couple essential for the device operation. Platinum is conventionally used as the CE material due to its excellent catalytic activity and high conductivity; however, it suffers from several limitations, including high cost, limited abundance, and long-term degradation issues when exposed to the iodide/triiodide electrolyte. These drawbacks motivate the search for cheaper, stable, and efficient alternatives.

MXenes, particularly Cr_2C, possess several characteristics that make them promising candidates for CE applications. Their inherently high electrical conductivity aids charge transfer processes at the electrode–electrolyte interface. Their layered structure provides a large number of active sites and promotes rapid ion diffusion, both of which are advantageous for catalysis. Furthermore, the surface functionalities introduced during synthesis enhance the interaction between the electrode and electrolyte, improving the catalytic response toward the I_3^-/I^- redox couple.

In the present study, Cr_2C MXene demonstrated catalytic activity comparable to that of platinum when evaluated in DSSC devices. Its layered nature facilitated efficient electron transport, reducing charge-transfer resistance and enhancing catalytic kinetics. Additionally, the MXene's favourable surface terminations assisted in promoting redox reactions, allowing for effective regeneration of the electrolyte. These results collectively highlight the capability of Cr_2C MXene to function as an effective CE without requiring expensive noble metals.

The use of Cr_2C MXene as a counter electrode also aligns with the broader objective of reducing the overall cost of DSSC fabrication while maintaining performance reliability. Since MXenes can be synthesized from relatively inexpensive MAX-phase precursors and processed using scalable methods, their adoption in DSSC technology could significantly enhance the commercial feasibility of the devices. The successful demonstration of Cr_2C MXene in this work provides a pathway for exploring other MXene compositions and optimizing their electrochemical performance further.

Beyond the immediate DSSC application, the successful preparation and validation of Cr_2C MXene open opportunities for its integration into various electrochemical and energy-conversion technologies. Its conductivity, structural features, and chemical tunability make it suitable for applications such as supercapacitors, batteries, electrocatalysis, and sensors. Understanding its behaviour in DSSCs provides a foundation for exploring its broader electrochemical potential.

In summary, this work presents the synthesis of Cr_2C MXene through the selective etching of Cr_2AlC MAX phase, validated using extensive structural and surface characterization techniques. The resulting MXene exhibits the expected 2D layered structure with accordion-like morphology and suitable surface chemistry. Its application as a DSSC counter electrode demonstrates catalytic performance comparable to platinum, highlighting its promise as a cost-effective and efficient alternative. The findings contribute to the growing research interest in MXenes as versatile materials for high-performance electrochemical devices and encourage further studies to optimize their processing, integration, and long-term stability.

Keywords: Cr_2C MXene, Cr_2AlC, Counter Electrode, DSSC, Redox Catalysis

Abstract ID: 1217

Ensemble Machine Learning–Driven Detection of Damaged Cells Using Nanoparticle-Based Sensors

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The Nanotechnology and Artificial Intelligence play a vital role in modern healthcare system to predict the disease The biomolecules could be exposed by the components like nano-biosensors, nanoparticle probes and quantum-dot fluorescence[]. Using these components the diseases could be detected at the early-stage by amplifying the molecular signals which is difficult in conventional methods. The cancer tissues can be identified at the early stage using Nano-diagnostics, Gold nano-particles and quantum dots are used to detect tumor biomarkers with accurate clarity. Early detection of cancer is possible if ND-AI technique is applied than CT and MRI. The hybrid ensemble model combinations of Random forest tree and eXtreme Gradient Boosting methods are used to decreases the variance where as the XGBoost decreases the bias which helps to enhance the accuracy and stable prediction in detection of infected cells.
***Keywords*:** cancer detection, detect tumor biomarkers, RF-XGboost, accurate detection

Abstract ID: 1219

Structurally Engineered Activated Biocarbon from Red Cowpea Pods for Ultra-High Specific Capacitance Supercapacitors

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Driven by sustainability concerns in energy storage, biocarbon has emerged as a promising alternative to fossil-fuel, derived materials for supercapacitors. This study reports the preparation and characterization of biocarbon derived from red cowpea pods through NaOH activation and carbonization at 500°C, 700°C, and 900°C. Physicochemical analysis showed that the 500°C sample (P-500) offered the best properties, including abundant active sites, high surface functionality, efficient ion transport, and superior surface area. Electrochemical tests

confirmed P-500's highest performance, delivering 336.72 F/g capacitance, 37.88 Wh/kg energy density, and low charge-transfer resistance, demonstrating its potential as a sustainable high-performance electrode material.

Abstract ID: 1220

$Zn_xCo_{1-x}Fe_2O_4$ for Enhanced Broadband and Tunable EMI Shielding in the X-Band Frequency

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This work investigates the influence of Co–Zn stoichiometry in the spinel ferrite system $Zn_xCo_{1-x}Fe_2O_4$ (x = 0.00, 0.25, 0.50, 0.75, 1.00) for electromagnetic interference shielding. Ferrites were synthesized via the sol–gel auto-combustion method. Composite films with 10 wt% ferrite loading were cast using polyvinyl alcohol. X-Ray Diffraction (XRD) confirmed cubic spinel phase formation. Vector network analysis indicated that increasing Zn content shifts peak shielding to higher frequencies from 11.90 GHz ($CoFe_2O_4$) to 12.57 GHz ($ZnFe_2O_4$), with $CoFe_2O_4$ exhibiting the highest shielding effectiveness of -76.22 dB. Additionally, physically mixing stoichiometric ratios showed broadband shielding.

Keywords: Electro-magnetic interference (EMI), Vector Network Analyzer (VNA), X-Band, Polyvinyl Alcohol (PVA), Shielding effectiveness (SE)

Abstract ID: 1223

Metal-Organic Frameworks Functionalized with Earth Abundant Metals as Sensors and Catalysts for 4-Aminophenol and Ciprofloxacin

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We report a versatile, sustainable material synthesized by modifying Fe-MIL-101-NH_2 with an o-vanillin Schiff base and coordinating it with nickel metal. This Metal-Organic Framework (MOF) performs a dual function: i) Electrochemical Sensing: It acts as a highly sensitive sensor for 4-aminophenol (4-AP), achieving a low detection limit of 0.12μM with excellent selectivity and stability. ii) Pollutant Degradation: It effectively catalyzes the photocatalytic/Fenton-like degradation of ciprofloxacin under visible light. The material's superior, synergistic performance in both sensing and remediation demonstrates a promising strategy for developing earth-abundant, multi-tasking MOF platforms to address diverse environmental challenges.
Keywords:Sustainability, Metal-organic frameworks, Electrochemical Sensing, Environmental pollution remediation, Catalysis

Abstract ID: 1225

Synthesis and Performance Evaluation of Ni^{2+}-Doped $CuFe_2O_4$ Nanomaterials for Oil Spill Cleanup and Multifunctional Capabilites

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A $CuFe_2O_4$ nanomaterial containing Ni^{2+} was prepared using a traditional solid-state reaction process, and its structural, morphological, and adsorption characteristics were studied in a systematic manner. In the X-ray diffraction (XRD) analysis, the introduction of Ni^{2+} ion into the $CuFe_2O_4$ spinel lattice was confirmed by the minor changes in the lattice parameters and the size of the crystallites was estimated to be at the nano-meter scale. Spinel structure was also confirmed by the presence of typical metal oxygen vibrational modes which were identified by Fourier- transform infrared (FTIR) spectra. Scanning electron microscopy (SEM) of the surface morphology showed agglomerated clusters of nanoparticles, and the elemental composition and the successful substitution of Ni^{2+} were verified using the energy-dispersive X-ray spectroscopy (EDX). Adsorption experiments showed that this material has great affinity to oil contaminants and so, there is great capability of using this material in oil spill cleanup by the process of surface adsorption. These results indicate that Ni^{2+} -doped $CuFe_2O_4$ nanoparticles are high-potential multifunctional nanoparticles that can be used by the environmental sector, especially in oil spills and the subsequent treatment of the resultant waste.

Keywords: Powder X-ray diffraction, FT-IR, SEM, EDAX, XPS.

Abstract ID: 1226

Explainable Morphology Classification of Nanoparticles Using Generative AI

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Morphology analysis is vital in materials science, nanotechnology, and biomedical imaging, but traditional classification models remain black boxes with limited interpretability. This work introduces an explainable morphology classification framework powered by Generative AI to improve accuracy, transparency, and scientific understanding. The approach uses generative models to learn high-level morphological patterns, synthesize representative structures, and generate counterfactual examples that clarify prediction reasoning. By integrating feature attribution maps, latent-space analysis, and generative reconstruction with supervised classifiers, the system offers robust morphology categorization and intuitive visual explanations. Experiments on nano-gold morphology datasets show enhanced performance, reduced uncertainty, and improved interpretability for domain experts supporting trustworthy AI adoption in morphology analysis.

Keywords*:* Generative AI, Morphology classification, Materials science, Nanomaterials.

Abstract ID: 1228

Nano-Diagnostics and AI-Based Decision Tree Modeling for Early Detection of Neurodegenerative Diseases

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Neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's remain major global health challenges due to their complex pathology, late diagnosis, and lack of curative treatments. Integrating nanotechnology with artificial intelligence (AI) offers a powerful approach for improving early detection, monitoring, and therapeutic intervention. Nanotechnology enables ultra-sensitive detection of neurological biomarkers using nanosensors, nanoparticles, and nano-imaging agents capable of crossing the blood–brain barrier and identifying molecular changes at the earliest stages. AI techniques—including machine learning and deep learning—analyze nanosensor outputs, neuroimaging data, and biochemical patterns to classify disease states, predict progression, and support personalized treatment strategies. Together, nano-enabled diagnostics and AI-driven analytics create a next-generation framework for precise, timely, and patient-specific management of neurodegenerative diseases, holding significant potential to improve clinical outcomes and advance precision neuromedicine.
Keywords: Nanotechnology, Nano-diagnostics, Neurodegenerative Diseases, Biomarker Detection Artificial Intelligence, Decision Tree Algorithm

Abstract ID: 1229

Flexible Triboelectric Nanogenerator for Self-Powered Dopamine Sensing

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A flexible triboelectric nanogenerator (FTENG) was developed using thermoplastic polyurethane (TPU) and electrospun polyvinylidene fluoride (PVDF) nanofibers to achieve high mechanical compliance and stable electrical output. The triboelectric pair, designed in a contact-separation mode, enables efficient charge generation while maintaining excellent durability under repeated deformation. The device exhibits an output of 35 V (peak-to-peak) and 1 μA, and the PVDF nanofiber mat simultaneously serves as an active sensing layer. By integrating the FTENG with the nanofiber-based electrochemical sensor, self-powered

dopamine detection is successfully demonstrated, eliminating the requirement for external power sources.

Keywords: Triboelectric nanogenerator, PVDF nanofibers, TPU film, self-powered sensing, dopamine detection

Abstract ID: 1230

Biomechanical energy harvesting from human foot movement by using piezoelectric nanogenerator

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Lead-free piezoelectric nanomaterials-based devices are suitable for human wearable because of non-toxicity and good performance. This work presents the development of a flexible piezoelectric nanogenerator (PENG) designed for biomechanical energy harvesting from human foot movement. A potassium sodium niobate (KNN)-polydimethylsiloxane (PDMS) composite film was fabricated through a simple casting method and integrated into a multilayered sensor platform. The device converts mechanical pressure generated during gait into electrical output, demonstrating stable performance and applicability in foot-pressure sensing and low-power wearable systems.

***Keywords*:**Piezoelectric nanogenerator, biomechanical energy harvesting, flexible sensor, KNN-PDMS composite, foot-pressure sensing.

Abstract ID: 1231

Toxicity Prediction of Nanomaterials using Ensemble Learning

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Predicting the toxicity of nanomaterials is essential for ensuring their safe application in biomedical, environmental, and industrial domains. This work presents an ensemble learning framework that integrates multiple machine learning models to improve the reliability and accuracy of nano-toxicity prediction. Physicochemical features such as size, shape, composition, surface charge, coating, and exposure parameters are used to capture complex nano–bio interactions. By combining model outputs through stacking and boosting strategies, the framework reduces prediction variance and enhances robustness. Experimental evaluation on benchmark toxicity datasets demonstrates improved classification performance, offering a dependable, data-driven approach for assessing nanomaterial safety.

Keywords: Nanomaterials, Toxicity Prediction, Ensemble Learning, Boosting Algorithms, Computational Toxicology

Abstract ID: 1232

Text Summarization in Nanomaterial Science Using Generative AI

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Nanomaterial science generates vast and complex literature, making it difficult for researchers to quickly extract essential insights. This work presents a Generative Al-based framework for automated text summarization tailored to nanomaterial research. By leveraging transformer-based large language models, the system identifies key concepts, synthesis conditions, characterization details, and structural property relationships from scientific texts. The approach supports both extractive and abstractive summarization, providing concise, accurate, and domain-aware summaries. Experimental evaluation on nanomaterial datasets shows significant improvements in clarity, information retention, and relevance compared to traditional NLP methods. This framework enables faster knowledge discovery and enhances decision-making in nanomaterial research.

Abstract ID: 1233

Nano-Enhanced EEG and Hybrid CNN–LSTM Modeling for Accurate Epileptic Seizure Detection

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Epileptic seizure detection requires accurate interpretation of complex EEG patterns that traditional analytical methods often fail to capture. This study presents a hybrid deep-learning approach that integrates nano-enhanced EEG sensing with a combined Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) architecture. Nano-engineered electrodes incorporating graphene and gold nanoparticles improve signal quality and reduce noise, enabling clearer detection of subtle pre-ictal features. The CNN component extracts spatial and spectral characteristics from EEG segments, while the LSTM layers model temporal dependencies associated with seizure progression. Experimental evaluation demonstrates improved sensitivity, specificity, and early-warning capability compared to conventional models. The results show that the CNN–LSTM framework, supported by nanotechnology, provides a reliable solution for real-time seizure prediction and clinical decision support.

Abstract ID: 1234

Effect of Binder Fibrillation and Mass Loading on Dry-Processed Supercapacitor Electrodes

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The growing demand for clean and efficient energy storage systems has accelerated the development of environmentally friendly and cost-effective electrochemical devices. Among various technologies such as batteries and fuel cells, supercapacitors stand out due to their highpower density and rapid charge–discharge capability. To overcome the energy, cost, and time limitations associated with conventional wet-slurry processing, dry electrode fabrication has emerged as a transformative approach for producing high-performance electrodes. Dry manufacturing eliminates the use of volatile organic solvents, thereby reducing energy consumption, environmental impact, and processing complexity. In this method, active materials, conductive agents, and PTFE binders are dry-mixed, fibrillated, and compacted through pressing or roll-to-roll lamination. These fibrillation-based processes enable quantitative evaluation of electrode thickness, adhesion, and electrochemical cycling behaviour. The influence of binder content will be systematically studied to determine its role in providing mechanical stiffness, yield strength, and calendering response. Electrode films with controlled thicknesses ranging from 40 to 150 μm will be fabricated to assess areal mass loading and ion transport characteristics. The ability to create thick, high-loading electrodes with uniform microstructure, strong mechanical integrity, and enhanced electrochemical performance represents a key advantage of dry processing. Characterisation techniques will include SEM imaging of binder fibril networks, cross-sectional thickness analysis, and adhesion testing to quantify bonding strength. Electrochemical evaluations—such as cycling stability, rate capability, and impedance measurements—will provide insights into performance improvements enabled by solvent-free fabrication. Compared to conventional wet-processed electrodes, dry-processed electrodes demonstrate comparable or superior energy density, structural robustness, and long cycle life. Although challenges remain, including achieving uniform binder distribution, ensuring strong current-collector adhesion, and maintaining high mass loading, this work highlights the promise of dry-processing as a sustainable, scalable route for next-generation energy storage devices.

***Keywords*:** Dry Electrode Fabrication, Binder Fibrillation, High Mass Loading, Adhesion Strength, Energy Density, Supercapacitors.

Abstract ID: 1235

Boosting Photocurrent of Hematite Photoanodes Through Facile Zinc-Titanium Co-Doping for Solar Hydrogen Production

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We present a simple method for creating Zn-Ti codoped hematite photoanodes for efficient PEC water splitting. Incorporating Ti^{4+} enhances electron conductivity, while Zn^{2+} doping may passivate surface states and alter the electronic band structure. This synergy increases charge separation and collection efficiency, significantly improving the photocurrent density to 2.5 mA/cm2 and shifting the onset potential to a more negative value compared to undoped hematite. This study presents an in-depth theoretical analysis using DFT methods to understand the mechanisms underlying photocurrent enhancement for efficient solar hydrogen production.
Keywords: Photoelectrochemical water splitting, Hematite, Solar hydrogen, Doped semiconductor, Density functional theory

Abstract ID: 1236

Synthesis Of Novel Pyrazolo[3,4-*B*]Quinoline Analogues For Cytotoxicity And In-Silico Analysis

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A straightforward one-pot synthetic route has been developed for a new series of pyrazolo [3,4-*b*] quinoline derivatives. HCl was found to be an efficient catalyst, yielding higher yields. The structure of the products was confirmed by several spectroscopic techniques. Furthermore, products were evaluated for cytotoxicity using the MCF-7 (breast) cancer cell line. The compounds exhibited potent anticancer activity compared with the standard, doxorubicin. Finally, In silico analysis was performed using the Gaussian 09 software package at the B3LYP level. This investigation clearly shows that the compounds have higher binding scores than doxorubicin and the EGFR residue.
Keywords: pyrazolo [3,4-*b*]quinoline, Bronsted acid catalysts, Cytotoxicity, In silico analysis.

Abstract ID: 1237

Implementation Of Machine Learning Algorithms For DFT Applications

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Design-for-Test (DFT) methodologies are essential for ensuring fault coverage and yield in complex SoCs, but they significantly increase testing cost and time due to large test data volumes and prolonged Automatic Test Equipment (ATE) usage. This work proposes a machine learningbased adaptive framework for test cost minimization using algorithms such as Random Forest (RF), Gradient Boosted Decision Trees (GBDT), and K-Nearest Neighbors (KNN). The framework predicts an optimal 8-bit test threshold based on ATPG-generated report features and employs a hardware-software co-design loop to iteratively minimize test cost while maintaining coverage. Results show reduced test time, lower ATE energy, and stable fault coverage across ISCAS85 benchmarks.
Keywords: Design-for-Test, Machine Learning, Test Cost Optimization, Random Forest, Stop on First Fail

Abstract ID: 1238

Multifaceted Properties and Enhancement in B-Phase of PVDF/$PbWO_4$ Nanocomposite Films

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Poly(vinylidene difluoride) (PVDF) is widely used in applications that require pyroelectricity, piezoelectricity, chemical resistance, and excellent mechanical properties. This study investigates the synthesis and characterization of lead tungstate ($PbWO_4$) reinforced poly(vinylidene difluoride) (PVDF) nanocomposite films, aiming to enhance the optical, thermal, mechanical and dielectric properties of PVDF polymer. The prepared nanocomposite films were characterized using X- Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Fourier Transform Infrared (FTIR) spectroscopy and Raman spectroscopy for analyzing structure, morphology and functional groups. SEM analysis confirmed the uniform distribution of $PbWO_4$ nanoparticles within the PVDF matrix. FTIR and Raman studies revealed a significant enhancement of the electroactive β-phase in PVDF upon the addition of $PbWO_4$. Optical studies via photoluminescence and UV- Visible spectroscopy show an enhancement of emission intensity with the addition of lead tungstate nanoparticles. Furthermore, the nanocomposite films exhibited improved thermal stability, mechanical strength, and a higher dielectric constant compared to pristine PVDF. These findings demonstrate the significant potential of PVDF/$PbWO_4$ nanocomposite films for developing high performance, flexible sensor devices and advanced electronic applications.

Abstract ID: 1239

Temperature-Dependent Structural, Dielectric, and Ferroelectric Properties of Yb_2O_3 Nanoparticles

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In this work, Ytterbium oxide (Yb_2O_3) nanoparticles were synthesized through a wet chemical route and annealed at three different temperatures. The so-obtained nanoparticles were pelletized in a hydraulic press for studying various physical properties. The morphological and structural properties were analysed with XRD, SEM and FTIR characterization methods. The formation of spherical Ytterbium oxide nanoparticles of average crystallite size of 9.57nm and 18.6nm was confirmed. The bandgap of the prepared nanoparticles, which are sintered at different temperatures, was evaluated using diffuse reflectance spectroscopy and is found to vary from 3.876 eV to 3.830 eV. The dielectric properties of the nanoparticles with frequency were studied. Ferroelectric responses were also investigated.
Keywords: Ytterbium oxide (Yb_2O_3), XRD, SEM, FTIR

Abstract ID: 1241

Mxene -Reinforced Conductive Nanofibers Based Electrode For Energy Storage Applications

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The growing demand for efficient and flexible energy storage devices has driven extensive research into supercapacitors, focusing on two-dimensional (2D) materials such as MXenes due to their high conductivity, layered structure, and surface functionality. The electrochemical performance of the prepared nanofibers was evaluated, yielding specific capacitances (Csp) of 184.8 F/g at 1 A/g for Ti3C2Tx-CNF which exhibited enhanced capacitance value when compared to bare CNF. The comparative analysis depicted a significant enhancement observed in the Ti3C2Tx blended nanofibers than the Ti3C2Tx coated nanofibers is attributed to improved interfacial contact resistance, higher charge mobility, and synergistic effects between MXene sheets and the conductive polymer matrix. The results indicates that the Ti3C2Tx incorporated polymer CNF is suitable for electrode in energy storage application.

Abstract ID: 1243

Fabrication and Testing of Mxene/LDH Composite for Supercapacitor Application

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The surging demand for clean energies and rapid growth of modern electronic technologies and renewable systems has steered the researchers on novel energy storage technologies, notably for supercapacitors. Nickel-Cobalt layered double hydroxides (NiCo-LDHs) present high theoretical capacitance but suffer from poor conductivity and structural instability. To strike these limitations, a Nb2C/NiCo LDH composite was developed using a novel approach of reflux synthesis, combining the rich redox activity of LDH with the excellent conductivity and mechanical strength of MXene. The hybrid electrode exhibits enhanced electron transport, and superior electrochemical performance compared to pristine NiCo-LDH, as confirmed through three-electrode evaluations.

Abstract ID: 1245

Colorimetric Technique for Iron Detection in Water using Fabric-Based Analytical Device

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Present study explores the use of colorimetric technique for detection of iron content in drinking water using a wax-printed microfluidic wells over fabric. Iron concentration was varied from 50 to 1000 ppm by mixing ferric ammonium sulphate in DI water. Its reaction with ammonium thiocyanate, a chromogenic agent, resulted in a visible color change due to the formation of a red complex showing increasing color intensity with increasing iron concentration. Present sensor also demonstrated a low limit of detection of ~5ppm demonstrating a portable and eco-friendly colorimetric sensor for iron detection in water for low-cost, electronics-free on-site water quality analysis.
Keywords: colorimetric sensor, iron detection, beeswax, fabric based analytical device.

Abstract ID: 1246

Exploring the Pulsed Laser Deposition of $BiVO_4$ for Solar Water Splitting and the Impact of Protective Layer in Photoelectrochemical Oxidation

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To fulfil the global energy need on a terawatt scale, direct conversion of solar energy into chemical fuels represents one of the most promising methods. A photoelectrochemical cell (PEC) is employed to generate green hydrogen through the utilization of solar energy for water splitting without carbon footprints. Bismuth vanadate ($BiVO_4$) is regarded as an emerging material for the photoanode due to its narrow bandgap and moderate stability in neutral electrolytes. Pulsed laser deposition (PLD) was utilized for the deposition of $BiVO_4$, which offers advantages such as high uniformity and reproducibility. A protective layer was employed to mitigate corrosion and degradation, thereby enhancing the stability of the material. Titanium dioxide (TiO_2) has been deposited as a protective layer to attain a uniform and pinhole-free layer, with variations in thickness and temperature. This research aims to study the implementation of a protective layer and its influence on the PEC properties.
Keywords: Photoelectrocatalyst, Solar water splitting, Photoanode, Pulsed Laser deposition, Bismuth Vanadate

Abstract ID: 1247

Examine The Exchange Coupling Interaction Of Hard/Soft Ferrite Nanocomposites For Microwave Absorption Applications.

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The development of technology has increased electromagnetic interference, disturbed the function of electronic and communication devices and led to signal distortion. Ferrite-based nanocomposites effectively reduce EMI because of their magnetic and dielectric properties. This work focuses on the fabrication of hard/soft ferrite nanocomposites through the one-pot sol-gel auto-combustion method to enhance the absorption properties of the nanocomposites. The X-ray diffraction confirmed the structural formation, which exists in both the hard phase (SGFO) and soft phase (CFO) in the nanocomposites. The Vibrating Sample Magnetometry verified the magnetic properties, and the Vector Network Analyzer was used to determine the

absorption properties in the X-band frequency region. This work demonstrates the use of rare-earth-doped ferrite nanocomposites as a lightweight, efficient, and versatile microwave absorber.

***Keywords*:** hard/soft ferrite nanocomposites, Microwave absorption, Minimum reflection Loss, sol-gel auto combustion.

Abstract ID: 1248

Structural and Effect of Substitution on Linear and Non-Linear Optical Properties in Bis-Ferrocenyl Appended Y-Shaped Heteroaromatic Chromophores

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A series of Y-shaped ferrocene (Fc) conjugated "push-pull" chromophores (**1**-**6**) were synthesized and comprehensively characterized. The Y-shaped structure was confirmed through the single crystal X-ray diffraction, and the chromophores **5** and **6** revealed a triclinic system with a P-1 space group. Cyclic voltammetry showed a reversible Fe^{2+}/Fe^{3+} redox process, with stronger electron-withdrawing substituents lowering the HOMO–LUMO energy gap. Nonlinear optical measurements using the Kurtz-Perry powder method indicated that chromophore **6** exhibited superior SHG efficiency compared to KDP, arising from its enhanced donor-acceptor interaction. DFT (B3LYP/6-31+G**) calculations of electronic absorption and frontier orbital distributions validated the experimental results.

Keywords: Bis-ferrocene, Steric effect, SHG and DFT/TD-DFT.

Abstract ID: 1249

Carbon Ink-Based Strain Sensors for Wearable Applications

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The study explores the design, fabrication and evaluation of carbon ink-based flexible strain sensors for wearable applications. Sensors were made by deposition of commercially available carbon ink over PET sheets and nitrile glove as substrates, using cost-effective methods such as manual brushing and stencil printing. Single-layer sensors showed the highest sensitivity, but multilayer devices demonstrated reduced resistance over single coatings due to enhanced conductive networks and provided better durability and long-term reliability. Pre-stretched nitrile gloves yielded stable resistive changes without any spikes as compared to regular gloves due to the formation of buckles accounting for better flexibility for wearable applications.

Keywords: Carbon ink, Polyethylene Terephthalate (PET), Nitrile Gloves, Flexible strain sensors, Wearable sensors

Abstract ID: 1250

A Runtime-Swappable S-Box Architecture for AES-128 on FPGA: Design, Integration, and Comparative Evaluation

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This work discusses the implementation of an S-Box in such a way that it can be interchanged at runtime. This allows one to directly compare how memory-based (ROM) and logic-based (combinational) substitution modules perform (in terms of speed, power consumption, etc.) within a single SoC framework, and provides for the ability to have the flexibility in controlling the AES core (subsystem) from the host platform (Intel Nios II processor). In addition, this paper includes a description of how to create both a standard ROM-based S-Box implementation and a fully combinational case-based logic implementation for the purpose of evaluating the available architectural trade-offs in terms of size, frequency, and power requirements for both implementations. To show an example of the differences in performance and resource utilization between these two designs, they were synthesized and implemented on an Intel Cyclone IV EP4CE115F29C7 FPGA device using Intel's Quartus Prime Lite 20.1.1 Software and Vectorless Power Analyzer was used to estimate the power consumption of the two designs. The results demonstrate a significant difference in resource utilization and performance scaling of lightweight cryptographic hardware.
Keywords: S-box, Lightweight, Vectorless

Abstract ID: 1251

Unravelling the Energy Storage Properties of Multiferroic $BiFeO_3$-$BaTiO_3$ Solid Solutions

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The Dielectric capacitors have garnered significant attention in various applications due to their high-power density and stability. However, their reported energy storage density is relatively low, which poses challenges for miniaturization and integration. In the present work, Nd-modified solid solutions of $BiFeO_3$-$BaTiO_3$ have been synthesized using a solid-state reaction route. All ceramics sintered at 1000 °C for 2 h possess a pure perovskite structure.RD patterns show that the coexistence of rhombohedral and tetragonal phases. The average grain size decreases with x concentration. The dielectric constant is calculated for the frequency range of 1Hz-1MHz.Further the well-defined PE hysteresis loop of the samples suggests that Nd substitution at the Bi site of the solid solution strongly affects remanent and saturated polarization of the materials. Vibrating Sample Magnetometry confirms weak ferromagnetic behaviour at room temperature, confirming the material's multiferroic property.

Keywords: $BiFeO_3$-$BaTiO_3$ ferroelectric ceramics, Energy storage Efficiency, Dielectrics, Multiferroics, Electrostatic Capacitors

Abstract ID: 1252

Fabrication and Electrochemical Performance of W-Doped SnO_2/G-C_3N_4 Composites as Supercapacitor Electrodes

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The W-doped SnO_2@g-C_3N_4 composite was synthesized via a two-step hydrothermal method followed by calcination at 400°C. Structural and morphological analyses (XRD, FESEM, EDS, HRTEM, XPS, Raman) confirmed successful formation of the composite. When used as a supercapacitor electrode, it achieved a 85.29% retention after 10,000 cycles. W-SnO_2@g-C_3N_4 demonstrated excellent electrochemical performance for advanced energy storage applications.
Keywords: tungsten doping, SnO2, g-C3N4, supercapacitor, energy storage.

Abstract ID: 1255

Treatment-Induced Fermi Level Realignment at MoO_x/N-Si Interfaces and its Impact on Silicon Solar Cell Performance

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MoO_3 is a wide band gap transition metal oxide with a high work function that establishes pronounced band bending at MoO_x on n type silicon interfaces and thereby enables inversion-driven hole selective carrier transport. Such transition metal oxide based contacts provide a viable basis for junctionless silicon solar cell architectures by avoiding dopant introduction through toxic gas precursors and by remaining compatible with low thermal budget fabrication. In this study, MoO_x on n-type silicon is subjected to post deposition treatments at 100 °C in distinct gas environments and UV exposure to tune the O/Mo ratio and consequently tune the Fermi level alignment at the interface. XPS and UPS measurements determine variations in the O/Mo ratio, chemical states, valence band position and Fermi level location, while UV-Visible spectra quantify changes in optical band gap. Solar cells are fabricated using these treated layers on n type silicon. Dark J-V measurements and illuminated J-V measurements under controlled illumination from 0.1 to 1 sun, together with EQE analyses, establish how treatment driven modifications in interfacial energetics dictate the resulting photovoltaic response.
Keywords: MoO_x/n-Si interfaces, Fermi level alignment, Oxygen stoichiometry, Surface photoemission spectroscopy, Carrier selective silicon solar cells

Abstract ID: 1256

Calcium Modified Biochar as a High-Performance Adsorbent for Removal of Waterborne Pollutants

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Emerging contaminants (ECs) in water have intensified environmental challenges globally, driven by industrial expansion. This study presents a calcium-enhanced biochar made from spent coffee grounds and calcium sourced from blast furnace slag (BFS) for the treatment of water-borne Amoxicillin. The composite adsorbent was characterised using multiple morphological techniques. Optimisation studies, including anthracene removal efficiency, adsorbent dosage, and initial pH, demonstrated strong adsorption performance. The kinetics and isotherms of adsorption are analysed to understand the adsorption mechanism. The approach provides a circular economy-based solution for treating EC-contaminated wastewater.

Keywords: Modified biochar, Sustainability, Industrial waste, Domestic waste, Pharmaceutical pollution

Abstract ID: 1257

Laser Induced defect generation and propagation in n-type c-Si: A fluence dependent study

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Laser processing is widely used in advanced silicon photovoltaics, yet the resulting defect formation and its effect on minority carrier recombination remain insufficiently quantified. This study examines how laser induced defects evolve in n type c-Si as laser fluence varied. Raman spectroscopy was used to track stress, disorder and amorphous formation, while injection dependent lifetime measurements probed the associated electronic degradation. The results show a clear fluence dependent transition from reversible stress effects to the generation of point defects, extended defects and amorphous regions that severely reduce carrier lifetime. By linking Raman signatures with recombination activity, the work establishes practical fluence limits and clarifies defect propagation mechanisms relevant to laser assisted silicon processing.

Keywords: laser processing, silicon micromachining, laser-induced defects, n-type c-Si, laser fluence

Abstract ID: 1258

Nanotechnology in agriculture: Enhanced growth of Fabaceae crops using Strontium Hexaferrite nanoparticles ($SrFe_{12}O_{19}$)

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The Strontium Hexaferrite nanoparticle, recognized for enduring magnetic properties were produced via sol-gel auto combustion method. The resultant material was characterised to evaluate their structural and magnetic property. Additionally, *in vitro* antibacterial assay was performed at different concentrations revealing non antibacterial property. Cytotoxicity assessment on normal cell line confirms the material is biocompatible and indicating the potential application in Nano fertiliser. Seed priming with this nanoparticle at different concentration (10mg, 30mg, 50mg) enhanced the growth of fabaceae crop.
Keywords: The Strontium Hexaferrite nanoparticle, *in vitro* antibacterial assay, Cytotoxicity.

Abstract ID: 1260

Enhancement of Mechanical Properties of Laser Direct Energy Deposited Inconel 718 by a Modified Heat Treatment

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This study examines the effect of post-heat treatments on the microstructure, precipitation, and hardness of laser direct energy deposited (L-DED) Inconel 718 laboratory specimens used for turbine blades in aircraft.
It has been observed that modifying the solution treatment temperature from 950 °C to 1150 °C, which exceeds the solvus temperature, drastically dissolves the precipitates and detrimental secondary phases, such as the Laves phase. After direct aging and water quenching, the results reveal a uniform distribution of strengthening phases (γ', γ'') and a reduction in the Laves phase, leading to a fine microstructure and an increase in hardness from 290 HV to 410 HV.
Keywords: Direct Energy Deposition, Inconel 718, Heat Treatment, Microstructure, Hardness

Abstract ID: 1261

ZnO Quantum dots as Fluorescent sensors: From Synthesis to Sensing Applications

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Quantum dots (QDs) have emerged as promising candidates for a wide range of sensing applications. Various types of QDs, including semiconductor, perovskite, and chalcogenide systems, exhibit excellent optoelectronic and magnetic properties; however, their inherent toxicity remains a major concern. To address this issue, metal oxide quantum dots have gained significant attention as eco-friendly alternatives for developing sensors capable of detecting contaminants of emerging concern. Among them, ZnO quantum dots stand out due to their simple synthesis, high fluorescence efficiency, selectivity, and sensitivity. This review focuses on the recent advances in the synthesis, surface modification, and sensing applications of ZnO quantum dots. Sol–gel synthesis has emerged as a widely used route to achieve size-tunable QDs, where parameters such as reaction time, temperature, and pH strongly influence the final nanostructure. Additionally, surface modification using ligands or heteroatoms has proven effective in enhancing the stability and selectivity of ZnO QDs. We critically analyze reported studies demonstrating ZnO QD-based detection of various CECs, including heavy metal ions and pharmaceuticals, highlighting their sensitivity, detection limits, and response mechanisms. In addition, the fluorescence sensing pathways, including FRET, static and dynamic quenching, and surface defect modulation, are discussed to provide deeper insight into quencher QD interactions. The review addresses current limitations and future research directions necessary for developing robust, longterm, stable, and practical ZnO QD-based fluorescence sensors for real-time environmental monitoring.

Abstract ID: 1262

Stability, Leaching, and Biofunctionalisation of Nanoparticle-Coated Smart Textiles: Towards Safer and Sustainable Nano-Fabric Applications

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Nanoparticle-coated smart textiles offer antimicrobial and self-cleaning functions but suffer from coating instability and nanoparticle leaching during washing, leading to environmental and health concerns. This study systematically analyses fabric surface chemistry, coating techniques, and biofunctionalisation strategies to improve durability and safety. A meta-dataset and Python-based analysis reveal a strong inverse correlation between wash durability and leaching. Biofunctionalised coatings using chitosan and tannic acid reduce leaching and markedly lower zebrafish embryo toxicity. The findings highlight biofunctionalisation as a sustainable route for designing safe-by-design nanoparticle-textile systems.

Keywords: Nanoparticle-coated textiles; Leaching; Biofunctionalisation; Toxicity assessment; Sustainable nanomaterials.

Abstract ID: 1265

Towards Reliable High-Frequency FinFETs: Design, Threshold, And Thermal Challenges

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FinFETs are the most promising transistors in modern CMOS technologies because of their excellent electrostatic control, high scalability, and strong potential for high-performance analog and RF applications. Recent research has focused on improving FinFET performance using fin geometry optimization, metal gate work-function tuning, spacer engineering, and high-threshold-voltage (HVT) techniques. This review covers bulk-Si, SOI, and junction less FinFET structures and examines key analog/RF parameters such as transconductance, cut-off frequency, maximum oscillation frequency, linearity, and noise figure. The study shows that transconductance and cut-off frequency are widely reported whereas early voltage, output resistance, thermal effects, and large-signal linearity are often neglected. Reliability and selfheating under HVT operation remain major research gaps that require further investigation for future RF FinFET design optimization.
Keywords: FinFET, analog/RF metrics, thermal effects and HVT

Abstract ID: 1268

Rational Design of Tellurium-Free Compounds via Phonon-Dynamics Modulation for Thermoelectric Applications

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Higher Manganese Silicide (HMS), a p-type 14th electron semiconductor with high carrier mobility from partially filled d-orbitals, has its thermoelectric performance limited by high lattice thermal conductivity. Here, we focus on reducing KL in HMS via interfaces and multiple phonon-scattering mechanisms, enabling Te-free layered thermoelectric modules for efficient energy conversion. The comprehensive study of HMS with CNF composite exhibits enhanced transport properties, with a low κr of 1.95 W/mK, due to strong mass/strain field fluctuation. In addition, the dislocation networks and grain boundary effects minimized the KL to 1.14 W/mK at 703 K in the Mn0.92 Cro.08 Si1.739Sn0.001 sample.
Keywords: Te-free compounds, interface engineering, dislocation scattering, point defect scattering

Abstract ID: 1270

MXene-derived TiB2 formation in B4C at high temperatures

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Two-dimensional (2D) MXenes are nanometer-thick sheets of transition metal carbides, nitrides, or carbonitrides with high-temperature capabilities. MXenes can be used as nanofillers and functional additives in ceramic hybrids, enhancing sintering and mechanical and electrical properties. In this study, we systematically investigate the incorporation of titanium carbide (Ti3C2TX) MXene into boron carbide (B4C) using a one-step electrostatic self-assembly method. We tuned the zeta potential of B4C and Ti3C2Tx MXene solutions, gradually added B4C into the MXene solution, and prepared green bodies with 1 to 10 vol.% Ti3C2TX. MXene acts as a sintering additive, and the relative density was increased by increasing the MXene content, achieving 99% with 10 vol.% MXene. The measured hardness values were 20 ± 1.6 GPa and 41 ±0.8 GPa for B4C and B4C with 10 vol.% MXene Ti3C2 samples, respectively.

Abstract ID: 1271

Synergistic Role of Precursor Concentration and Redox-Active Electrolyte on the Electrochemical Behavior of ZnO Nanorods

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Using a facile wet chemical method, zinc oxide (ZnO) nanorods have been successfully synthesised, and their morphology variations with respect to variations in the concentration of the precursors have been studied. Their electrochemical properties have been studied for supercapacitor applications. Well-defined nano-rods with distinct flower-like morphologies were observed from the FESEM micrographs. A synergic strategy of morphology and electrolyte engineering using a redox additive has been implemented for enhancing the electrochemical performance of the ZnO nanorods. An outstanding specific capacitance of 771 F/g in the presence of redox electrolyte is observed due to fast redox reactions and improved ion diffusion. Keywords: Zinc oxide (ZnO), nanorods, redox electrolyte, supercapacitor.

. **Abstract ID: 1272**

Development of Nitrogen Rich Carbon on Mn Based Metal Oxide Clusters for Symmetric Supercapacitors

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The covalently functionalized 2-aminobenzothiazole (2-ABT) on GO (FGO) with at Mn-MIL100 to develop N-rich carbons on Mn based MOF by calcinating at 400° C in the N2 atmosphere. The optimum material developed was employed as the positive electrode for supercapacitors delivered a well pronounced conductivity, a high specific capacitance of 584

F/g at 1 A/g with a retention of 82% capacitance after 5000 cycles. A symmetric device fabricated using the same material has delivering an energy density of 6.1 Wh kg1 at a power density of 2050 W kg retained 85% capacitance even after 5000 cycles.
Keywords: Mn based MOF, conductivity, symmetric supercapacitor, functionalized GO

Abstract ID: 1273

A Review of Machine Learning Applications in Soil Analysis: Enhancing Agricultural Productivity and Environmental Conservation

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To guarantee sustainable agricultural productivity, environmental conservation, and global food security, the analysis of soils plays a crucial role. The time-consuming, labor-intensive and cost- heavy nature of traditional soil assessment methods poses many challenges for scaling the monitoring solutions and precision agriculture. All these limitations can be very well tackled by applying machine learning (ML) as it offers advanced potential to model complex, nonlinear relationships among soil properties, environmental variables, and crop performance indicators. A comprehensive synthesis of recent advancements in the application of machine learning for soil analysis will be the outcome of this review. The study comprehensively classifies machine learning applications across important metrics, such as nutrient estimation, moisture content estimation, texture, fertility, and organic carbon. From the most conventional ML models like Random Forest (RF) and Support Vector Machines (SVM) to complex deep learning architectures such as Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks, a wide range of algorithms are studied based on their predictive accuracy, scalability, and practical applicability. The evolving nature of innovation in integrating machine learning with Geographic Information Systems (GIS), remote sensing, and spectral data has empowered the creation of high-resolution, spatially explicit soil maps. Less availability of data, heterogeneous sampling protocols, interpretability of models, and lack of standardised evaluation benchmarks are some persistent challenges that still exist. Identifying these gaps and offering insights into emerging trends which hold scope to advance the field further. This review paper aims to serve as a foundational reference for all the researchers who are working to harness machine learning (ML) for sustainable soil management and precision agriculture; this will be achieved by studying current knowledge and outlining future research directions.
Keywords: LSTM, CNN, Random Forest, GIS, sustainable agriculture.