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Title : Optimizing Tropical Solar PV via CFD and IoT Tracking

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CONTENT

Grafted silica nanoparticles for water shut-off operations with enhanced structural properties.

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Abstract

Grafted silica nanoparticles for water shut-off operations with enhanced structural properties. Excessive water production in petroleum reservoirs remains a major constraint on hydrocarbon recovery, with polymeric gel systems frequently employed for conformance control. However, conventional organic and inorganic crosslinking approaches often suffer from poor thermal stability and nanoparticle aggregation under high-temperature, high-salinity conditions. In this study, polyethyleneimine-grafted nanosilica was synthesized via grafting of PEI chains to silica surfaces1 and evaluated as a multifunctional additive in sulfonated hydrolyzed polyacrylamide (SHPAM)/PEI gels. Structural analyses confirmed successful grafting, high amine functionality, and enhanced dispersion stability in saline media. Incorporation of SEP into SHPAM/PEI gels reduced gelation time, suppressed syneresis, and significantly improved gel strength.2 Long-term aging studies demonstrated thermal stability without structural collapse. Core flooding experiments in sandstone cores revealed permeability reduction exceeding 98%, confirming efficient in-situ plugging under simulated reservoir conditions. These results establish polymer grafted nanoparticles as a dual-purpose crosslinker and gel-strengthening nanofiller, enabling the design of thermally stable, salinity-tolerant polymer gels. This work provides a mechanistic basis for employing grafted nanohybrids in water shutoff operations and offers a scalable strategy for enhanced oil recovery in harsh reservoir environments.

Keywords: Enhanced Oil Recovery; Grafted nanoparticles; Gel Strength.

Optimizing Tropical Solar PV via CFD and IoT Tracking

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Abstract

Commercial office building operations in hot and humid tropical regions face significant energy efficiency barriers due to high cooling loads and thermal degradation of rooftop solar installations. Current research work proposes a multi-step approach to unlock the maximum energy potential of the office building, taking IEM Kolkata as a case study, thereby overcoming common thermal penalty in hot and humid climates. Our approach involves climate analysis using climate consultant software. Renewable energy generation by PV solar panels are calculated via PVsyst to quantify the baseline energy yield. To address the efficiency drops caused by elevated cell temperatures, 3-D Computational Fluid Dynamics

(CFD) simulation is executed using ANSYS software. This study investigates the aerodynamic and thermal distribution across the panel array, optimizing the mounting geometry to enhance convective heat dissipation. The final phase introduces an IoT-based dual-axis tracking system that dynamically orients the PV panels to maintain an optimal angle of incidence as well as considering airflow patterns. By synthesizing high-fidelity thermal simulations with active mechanical tracking, the proposed system ensures that panels are oriented for both peak solar gain and maximum passive cooling. This approach offers a technically robust blueprint for the deployment of high-performance renewable energy systems, demonstrating generating approx 20–40% more energy compared to conventional static installations in challenging urban climates.

Keywords: Solar Photovoltaics; Hot and Humid Climate; CFD Simulation; IoT Tracking; Office Buildings; Thermal Management

Green Synthesis of ZnO-NiO Nanocomposite via Neem Leaf Extract for Photocatalytic Applications

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Abstract
We report on the environmentally friendly synthesis of zinc-nickel oxide nanocomposite (ZnONiO NC) utilizing *Azadirachta indica* (neem) leaf extract. The average size of the crystallites for ZnO-NiO NC was 30nm. The obtained ZnO-NiO NC have been characterized by X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), TEM/ HRTEM (Transmission Electron Microscopy), Selected Area Electron Diffraction (SAED), and Energy Dispersive Spectroscopy (EDAX) techniques. PXRD analysis confirms the presence of two distinct phases in the ZnO-NiO NC, ZnO with a hexagonal wurtzite structure and NiO with a face-centered cubic (FCC) structure. UV-diffuse reflectance spectroscopy (UV-DRS) determined the bandgap energy of ZnO-NiO NC to be 3.32 eV. When exposed to UV radiation (from 0 to 120 min), the degradation tests were conducted for two dyes, Fast Orange (FO) and Congo Red (CR). The decolorization of FO & CR dye using ZnO-NiO NC was 68 & 79 % respectively. ZnO-NiO NC demonstrated the highest photocatalytic activity for Congo Red (CR).
Keywords: ZnO-NiO NC; Green synthesis; *Azadirachta indica* (Neem) leaf; Photocatalytic activity.

Experimental study of axle oil containing Hybrid nanoparticles for automotive applications

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Abstract
Automobile components and assemblies depend on advanced lubricants that offer superior heat transfer ability and minimized friction between the mating components even in demanding operating environments. In this article, the tribological performance of CuO (50%)/TiO_2 (50%) hybrid nanoparticles in axle oil was investigated to enhance its applicability. A two-step methodology was adopted to prepare the nanolubricant samples with hybrid nanoparticles at volume fractions of 0.03%, 0.06%, and 0.09% (v/v). The thermo-physical and tribological characteristics of these samples were experimentally evaluated according to ASTM standards. The lubricants' load bearing capability was also determined from a Four ball tester. The findings established that the nanolubricants enhanced thermal conductivity, with a maximum improvement of 1.85% compared to the base oil. Additionally, the coefficient of friction (COF) was reduced by 61.35%, indicating superior friction-reducing capabilities. Improvement in load metrics indicated that the hybrid nanoparticles provide synergistic effect to axle oil. Also, a maximum reduction of 35.42% in surface roughness value was recorded with 0.06% Nanolubricant over base oil. These results demonstrate the promise of CuO/TiO_2 hybrid nanolubricants in improving the performance of lubricants for axle drive systems, supporting their potential adoption in automotive and industrial applications.

Keywords: Hybrid nanoparticles; Coefficient of Friction; Load bearing

Production of Biodiesel using Aluminium Based Nanocatalyst: A Short Review

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Abstract
Biodiesel, derived from renewable sources such as vegetable oils and animal fats, has emerged as a promising alternative to conventional fossil fuels due to its environmental benefits and potential for sustainable energy production. However, the conventional transesterification process for biodiesel synthesis often faces challenges such as long reaction times, chances of saponification and the generation of significant amount of waste. To address these issues, heterogeneous nanocatalysts have gained increasing attention in recent years for their ability to improve reaction kinetics, increase conversion, and enhance selectivity in biodiesel

production process. This review explores the recent advancements in biodiesel production utilizing heterogeneous nanocatalysts. It provides an overview of various nanomaterials employed as catalysts, including metal oxides, supported metals, and metal nanoparticles, along with their synthesis methods and catalytic mechanisms. Especially Aluminium based metal oxide catalysts, their synthesis technique and properties are reviewed in this chapter. The key factors affecting the efficiency and stability of heterogeneous nanocatalysts in biodiesel synthesis, including catalyst loading, reaction conditions, and catalyst recycling strategies has been reviewed. The potential of heterogeneous nanocatalysts to revolutionize biodiesel production processes, offering a sustainable pathway towards greener energy solutions and reducing dependence on fossil fuels.

Keywords: Heterogeneous Nanocatalyst, Biodiesel, Transestarification, Conversion, Selectivity.

Structure-Activity Relationships in CO_2 Electroreduction over Size-Controlled Au-Ag Alloy Nanoparticles

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Abstract
Gold and silver-based nanoparticles are widely explored as electrocatalysts for the electrochemical carbon dioxide reduction reaction (CO_2RR) due to their high selectivity toward carbon monoxide (CO). In this study, we systematically investigated the size, composition, and structure-dependent CO_2RR performance of monometallic Au and Ag nanoparticles and bimetallic Au-Ag alloy nanoparticles with controlled particle sizes in the 15-50 nm range. Electrochemical CO_2RR measurements reveal a pronounced size dependence for both Au and Ag catalysts, with smaller nanoparticles exhibiting enhanced CO selectivity and higher CO partial current densities. Across all sizes, Au nanoparticles consistently outperform Ag, reflecting more favorable CO_2 activation and *CO binding energetics. Importantly, Au-Ag alloy nanoparticles demonstrated superior CO_2RR activity and selectivity compared to their monometallic counterparts, which is attributed to synergistic electronic and geometric effects that optimize reaction intermediate adsorption and suppress the competing hydrogen evolution reaction. Among the catalysts studied, nanoporous gold exhibits the highest CO formation rates and distinct catalytic behavior, arising from its large electrochemically active surface area, interconnected porous framework, and abundance of low-coordination active sites. These findings highlight the critical role of catalyst size, composition, and structural architecture in tuning CO_2RR efficiency and selectivity and provide design principles for advanced bimetallic and nanoporous CO_2 reduction electrocatalysts.

Keywords: CO_2 reduction reaction (CO_2RR); Gold nanoparticles; Silver nanoparticles; Au-Ag alloy nanoparticles

Novel Palladium Dithiocarbamates: Synthesis, Characterization, Microbial Activity, and Use as Single Source Precursors for Nanoscale Palladium Sulfide

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Abstract

Palladium dithiocarbamate (DTC) complexes and palladium disulfide have attracted significant research interest due to their versatile applications, including anticancer, antimicrobial, catalytic, dye-degradation, and sensor applications, as well as serving as nanomaterial precursors. Air stable and diamagnetic Palladium dithiocarbamate (DTC) complexes, $[Pd(S_2CNH^iBu)_2]$ (**1**), $[Pd(S_2CNEt_2)_2]$ (**2**), $[Pd(S_2CNMe_2)_2]$ (**3**), $[Pd(S_2CNPh_2)_2]$ (**4**), $[Pd\{S_2CN(p\text{-tolyl})_2\}_2]$ (**5**), and $[Pd(S_2CNHBz)_2]$ (**6**) and were synthesized from the reaction of ES_2CNR_2 (E = Na/Li) with Na_2PdCl_4, with moderate yields. Comprehensive characterization was carried out using spectroscopic methods and single-crystal X-ray diffraction analysis. The ^1H and ^{13}C NMR spectroscopy supported the ligand framework around the Pd(II) center. Single-crystal X-ray diffraction showed a triclinic crystal system. After complete molecular characterization, we investigate their reactivity and application in microbial activity and use as single-source precursors for PdS. The anti-microbial activity assays revealed moderate to significant inhibition against selected gram-positive and gram-negative bacterial strains, where complex **1** exhibited a very good activity against *T. harzianum*. Furthermore, we decomposed the Pd-DTCs single-source precursors to produce palladium sulfide (PdS) nanoparticles, which is the maiden example of controlled solvothermal decomposition of Pd DTCs into PdS nanoparticles. The nanoparticles exhibited a degradation efficiency of 100% against malachite green, emphasizing their promising potential as catalysts for organic dye removal.

Keywords: Palladium dithiocarbamate; Catalysis; Palladium sulfide.

Rhenium (IV) dithiocarbamate complex, $[Re_2(\mu\text{-}S)_2(S_2CNEt_2)_4]$ as a single-source precursor for 2D ReS_2 catalyst for malachite green dye degradation

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Abstract

The relentless rise in global population and industrial expansion has intensified water pollution, creating a pressing crisis that endangers water availability, degrades quality, and undermines the health of both humanity and ecosystems. This escalating crisis has driven the search for innovative solutions, with nanotechnology emerging as a promising approach to remediate contaminated water and break down hazardous pollutants. In this study, nanoscale rhenium disulfide (ReS_2) has been prepared using $[Re_2(\mu\text{-}S)_2(S_2CNEt_2)_4]$ as a single-source precursor via the solvothermal heat-up method at 200°C. The obtained black powder of ReS_2 was characterized by PXRD, FESEM, EDX mapping, and HRTEM. PXRD pattern indicates orientation bias toward (002), contrasting with other methods where (001) dominates, and HRTEM image reveals the layered 2D ReS_2 with a central crystalline domain, where lattice fringes confirm high crystallinity and an interlayer spacing of 0.535 nm corresponding to the (002) plane. Here, this nanoparticle was employed as a catalyst for the degradation of malachite green (MG) dye under dark irradiation in an aqueous medium. The study investigated the effects of various parameters, such as irradiation time, pH, recovered catalyst dosage, and dye concentration. The results showed that ReS_2 nanoparticles exhibited high catalytic activity, degrading 94% of the dye in 100 min. A longer irradiation time led to increased dye degradation. Increasing the pH of the medium also enhanced the dye degradation, with 99% degradation achieved at pH 11 in 60 min. However, the degradation rate decreased with increasing dye concentration. ReS_2 nanoparticles demonstrate excellent potential as a reliable catalyst for the efficient degradation of organic pollutants.

Keywords: Rhenium disulfide (ReS_2); Single source precursor; Dye degradation.

Design and development of amine-functionalized graphene oxide-supported ZnO-CeO_2 nanocomposites for enhanced photocatalytic degradation of organic pollutants

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Abstract

Semiconductor-based photocatalysis has emerged as a promising and sustainable approach for eliminating toxic organic pollutants from wastewater; however, achieving high photocatalytic efficiency under diverse irradiation conditions remains a major challenge. In this study, a novel amine-functionalized graphene oxide-based ternary nanocomposite, NH_2-GO/ZnO-CeO_2, was successfully synthesized via a facile and cost-effective solvothermal method for environmental remediation. Comprehensive characterization using X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM), Fourier transform infrared spectroscopy (FT-IR), and UV-visible spectroscopy confirmed successful amine functionalization and the formation of phase-pure heterostructures composed of hexagonal ZnO and cubic CeO_2. The ternary nanocomposite exhibited enhanced photocatalytic activity compared to binary ZnO-CeO_2 under UV, visible, and natural sunlight irradiation. Under UV

light, degradation efficiencies of 87.36%, 51.94%, and 82% were achieved for methylene blue, methyl orange, and ciprofloxacin, respectively, outperforming the binary counterpart. Notably, under sunlight irradiation, the photocatalyst achieved 98.26% degradation of ciprofloxacin, demonstrating excellent solar-driven activity. Kinetic analysis revealed higher reaction rate constants, attributed to improved light harvesting, efficient charge separation, suppressed electron–hole recombination, and increased active surface area induced by amine functionalization. Furthermore, the photocatalyst demonstrated stability over five consecutive cycles with minimal performance loss. These findings highlight NH_2-GO/ZnO-CeO_2 as an efficient, stable, and sustainable photocatalyst with strong potential for wastewater treatment and environmental purification applications.

Keywords: Amine-functionalized; nanocomposite; photocatalyst; reusability.

Zinc-based Mixed-Linker Zeolitic Imidazolate Framework for Efficient Formaldehyde Removal in Indoor Air Purification

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Abstract

Indoor air quality has received increasing attention due to prolonged human exposure to confined indoor environments and the continuous release of gaseous pollutants from building materials, furnishings, and human activities. Among these pollutants, formaldehyde is a hazardous volatile organic compound that causes adverse health effects even at low concentrations, thereby deteriorating indoor air quality and impairing cognitive performance. The development of efficient, stable, and selective adsorbents capable of removing volatile organic compounds (VOCs), such as formaldehyde, under ambient conditions remains a significant challenge. In this study, a zinc-based mixed-linker zeolitic imidazolate framework (ZIF) was synthesized and evaluated for effective formaldehyde removal in indoor air purification applications. A mixed-linker strategy was adopted to tailor pore chemistry and surface heterogeneity, thereby enhancing gas–solid interactions and adsorption selectivity. The synthesized material was characterized using X-ray diffraction to confirm crystallinity, nitrogen adsorption–desorption isotherms to determine specific surface area and pore structure, and particle size analysis to assess morphology. Batch adsorption experiments were performed to evaluate the adsorption capacity, kinetics, and reusability of the mixed-linker ZIF towards formaldehyde. The results demonstrate that the mixed-linker ZIF exhibits superior adsorption performance compared to conventional single-linker frameworks, owing to the presence of diverse functional sites and enhanced host–guest interactions. Rapid adsorption kinetics and stable performance over multiple adsorption–desorption cycles indicate excellent material robustness. Overall, this study highlights the potential of zinc-based mixed-linker ZIFs as efficient and sustainable adsorbents for formaldehyde removal, offering a promising pathway toward advanced indoor air purification systems.

Keywords: formaldehyde; zeolitic imidazolate frameworks; gas-phase adsorption; adsorption kinetics

Lead sulfide nano-catalysts from monoaryl/alkyl dithiocarbamates of lead single source precursor for degradation of crystal violet dye

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Abstract
Earth-abundant metal sulfides such as PbS are promising candidates for catalytic environmental remediation owing to their favorable electronic structure, narrow band gap and high carrier mobility. Herein, we report a fast, low-cost and reproducible solvothermal and hydrothermal route for synthesize of crystalline PbS nanomaterials using lead dithiocarbamate complexes as single source precursors. Two molecular precursors $[Pb(L^1)_2]$ & $[Pb(L^2)_2]$ (where, L^1= bis (4-methyl-N-phenyldithiocarbamate), L^2=bis N-methyldithiocarbamate) were synthesized and fully characterized and subsequently decomposed under mild conditions to yield phase pure galena PbS nanostructures. Powder X-ray diffraction, SEM, TEM and EDX confirmed high crystallinity and exhibits, cubic, rod-like and spherical morphology. The prepared nanomaterials exhibit excellent catalytic activity toward the degradation of crystal violet dye achieving up to 95% degradation under dark conditions and 76% under visible light irradiation within 180 min.

Keywords: Dithiocarbamate, nanomaterials, solvothermal decomposition, crystal violet, catalyst

Effect of variation of electric field frequency on Impedance and Capacitance of E7 Nematic Liquid Crystal Cell

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Abstract

A fundamental understanding of how the electrical properties of liquid crystals respond to external stimuli is essential for advancements in material science and engineering. This study investigates the relationship between the variation of applied electric field frequency and the resistivity and capacitance characteristics of E7 nematic liquid crystal cells, focusing on molecular orientation dynamics. The research addresses how molecular alignment in E7 liquid crystals influences resistivity and capacitance under increasing electric field frequency. E7, a commercial nematic mixture composed of rod-shaped molecules with biphenyl groups and a permanent dipole moment arising from cyano groups, serves as an effective model system for examining these mechanisms relevant to liquid crystal-based technologies. E7 liquid crystal cells were fabricated by sandwiching the material between indium tin oxide (ITO)-coated glass substrates. Series-equivalent impedance and static capacitance measurements were obtained using an LCR meter over a frequency range of 1 kHz to 5000 kHz. Experimental results reveal a consistent decrease in both impedance and capacitance with increasing frequency. The reduction in resistivity is attributed to steric hindrance and dipolar interactions that limit molecular reorientation under rapidly oscillating electric fields. Similarly, capacitance decreases as molecular polarization becomes insufficient to sustain effective charge storage at higher frequencies. These findings highlight the influence of molecular orientation, polarizability, and anisotropy on the electrical response of E7 nematic liquid crystal cells, contributing to the optimization of liquid crystal-based electronic devices.

Keywords: Nematic liquid crystals; E7 liquid crystal; Frequency variation; Electrical impedance; Static capacitance; Molecular orientation; Dielectric properties; Polarizability; Anisotropic materials; Material science and engineering; Liquid crystal devices; Electro-optic materials.

Plant-Mediated Synthesis of Iron Oxide Nanoparticles Using *Persicaria orientalis* Leaf Extract: Structural Insights and Antibacterial Potential

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Abstract
Persicaria orientalis-mediated iron oxide nanoparticles (PO-IONPs) were synthesized using *Persicaria orientalis (PO)* leaf extract as a natural reducing, capping and stabilizing agent. The formation of PO-IONPs was confirmed by a distinct UV–Vis absorption band around 331 nm and X-ray diffraction (XRD) peaks matching the cubic spinel magnetite structure. Scherrer analysis indicated an average crystallite size of approximately 10 nm. Fourier transform infrared (FT-IR) spectra revealed the functional groups from phytochemicals on the nanoparticle surface, alongside strong Fe–O bands (558 and 417 cm^{-1}) further confirming PO-IONPs formation. Electron microscopy (SEM, TEM) showed quasi-spherical

nanoparticles. Energy-dispersive X-ray spectroscopy (EDX) confirmed the elemental composition as primarily Fe and O, with minor C and S. PO-IONPs were also thermally stable up to 700 °C as observed by thermogravimetric analysis (TGA). In antibacterial tests against Gram-positive (*Staphylococcus aureus*, *Bacillus cereus*) and Gram-negative (*Escherichia coli*, *Salmonella typhi*) bacteria, the NPs showed dose-dependent growth inhibition. Gram-positive strains were more susceptible, showing maximum inhibition of 66.45% for *Staphylococcus aureus* and 58.24% for *Bacillus cereus* at 500 µg/mL, whereas Gram-negative bacteria showed lower sensitivity, with *Escherichia coli* and *Salmonella typhi* exhibiting 44.24% and 34.32% inhibition, respectively, at the same concentration. This study established an eco-friendly, quick and easy synthesis of PO-IONPs with moderate broad-spectrum antibacterial activity.
Keywords: Green synthesis, Iron oxide nanoparticles, *Persicaria orientalis, Antibacterial activity.*

Novel Nickel Dithiocarbamates as Single-Source Precursors for phase controlled Nickel Sulfide Electrocatalyst for the Oxygen Evolution Reaction

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Abstract
Nickel sulfides are an attractive energy materials for energy storage and conversion applications including cathode materials for lithium ion batteries, supercapacitors and water splitting. In this study, we present a fast and cost effective solvothermal and hydrothermal method to synthesize nickel sulfide nanomaterials. Nickel sulfide nanoparticles were prepared by the controlled thermal decomposition of nickel dithiocarbamate (DTC) complexes i.e, $Ni\{S_2CNH^iBu\}_2$ and $Ni\{S_2CNHBz\}_2$ as a single source precursor. The structure of the complexes was unravel through complementary spectroscopic and crystallographic techniques. Furthermore, controlled thermal decomposition $Ni(DTC)_2$ yielded $Ni_{4.5}S_4$ nanoparticles, as confirmed by PXRD, SEM, EDX and TEM analysis. In both cases hexagonal $Ni_{4.5}S_4$ were produced with average length 77 ± 14.6, 71 ± 14.3 nm respectively. Comparative water splitting efficiencies of the synthesized samples were evaluated through linear sweep voltammetry (LSV) and electrochemical impedance spectroscopy (EIS) by using nickel foam modified with $Ni_{4.5}S_4$ in 1M KOH solution. It is noteworthy that solvothermally produced nickel sulfide at 180°C demonstrated remarkable oxygen evoluation reaction (OER) performance, delivering a current density of 50 mA cm^{-2} at a low overpotential of 341 mV. Long-term stability was confirmed through chronoamperometry over 10 hours.

Keywords: Dithiocarbamate; nanomaterials; solvothermal & hydrothermal decomposition; Oxygen evoluation reaction (OER), electrocatalyst.

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Next Generation Thin Film Lead Free Perovskite Solar Cells: A Numerical Approach Towards Eco -Friendly Low Cost Optimization

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Abstract
This study explores the design and optimization of next generation thin film solar cells using lead free perovskite materials specially Tin based, Cu based ,platinum based ,silver-bismuth Double perovskites like MASnI3, Cs2CuBiBr6, Cs2PtI6 and Cs2AgBiBr6. These materials were selected for their promising optoelectronic properties and environmental compatibility. I simulated their photovoltaic performance to identify the optimal configuration that balances efficiency, stability and cost. My results shows the potential of eco-friendly non- toxic perovskites to replace lead based counterparts in future solar technologies. Specially I focussed on the parameter thickness tuning , Defect minimization , Interface Engineering to achieve the goal like Maximization of absorption ,reduction of recombination ,improvement of charge transport and long term performance .The efficiency of photovoltaic systems of perovskite materials based on organic–inorganic halide has increased and they are nearing commercialization. Leadfree perovskite materials have recently attracted the interest of researchers and the scientific community due to the toxicity issue and harmful lead-based perovskite materials. Tin, like lead (Pb) is a group 14 metals; hence, it is the most likely substitute. I use SCAPS-1D numerical simulation to optimize the device efficiency of a lead-free n-i-p based planar heterostructure perovskite solar cell composed of intrinsicCH3NH3SnI3 methyl ammonium tin iodide (MASnI3) as an i- and p-layer Spiro Ome-TAD with SnO2 for the n layer. Conclusions show that the absorber layer has a thickness of 600 nm, which is required for optimal cell performance and efficiency. The thickness and defect density of this absorber layer was taken into account absorption coefficient is inversely proportional to defect density. The performance of device worsens when the defect density of absorber layer increases .In recent years, vacancy-ordered halide double perovskites have emerged as promising non-toxic and stable alternatives for their lead-based counterparts in optoelectronic applications. In particular, vacancy ordered Cs_2PtI_6 has emerged as a star material because of its high absorption coefficient, band gap of 1.37 eV, and long minority carrier lifetime. Despite substantial experimental research on this new class of material, theoretical simulations of their device properties remain scarce. In this work, a novel n-i-p device architecture ($FTO/SnO_2/Cs_2PtI_6/MoO_3/C$) is theoretically investigated using a solar cell capacitance simulator (SCAPS-1D). Theoretical investigations are carried out in order to optimize the device performance structure by varying the perovskite and selective charge transport layer thickness, absorber and interface defect density, operating temperature, back contact, series and shunt resistance, respectively.

Keywords: Perovskite Solar Cells, Eco Friendly , Thin Film, Lead Free Active Layer,Optimum Efficiency, Low Cost

Hydrogen Production and Utilization for Sustainable Energy Development

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Abstract ID: OP-818

Abstract

The rising issue of climate change and the exhaustion of fossil fuels have led to the rise in interest in alternative energy carriers, with hydrogen being one of the promising alternatives. This paper seeks to discuss the process of hydrogen production and its use in the development of sustainable energy. The analysis examines the traditional and modern methods of hydrogen production, such as steam methane reforming, coal gasification, partial oxidation, and water electrolysis. According to the production pathways, hydrogen is classified into grey, blue, and green hydrogen based on the carbon emissions and the utilization of carbon capture or renewable energy sources.

The paper notes that hydrogen has a high energy content and zero carbon emission at the point of use; thus, it can be used in fuel cells, power generation, ammonia production, petroleum refining, and energy storage systems. Nevertheless, the mass use of hydrogen is hampered by such factors as the high cost of production, storage and transportation issues, and infrastructure limitations.

One can conclude that despite the great potential of hydrogen to contribute to global decarbonization, technology development and policy facilitation are needed to make it possible to implement it on a large scale and in a cost-effective manner.

Keywords: Hydrogen energy; Hydrogen production; Grey hydrogen

Nanocrystal-Based Oxygen-Generating 3D Bioprinted Immunoprotected Microdevice Containing Xenogeneic Islets for Long-Term Reversal of Type 1 Diabetes

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Abstract ID: PP-821

Abstract

Transplantation of encapsulated islet cells has the potential to restore physiological glycemic control in patients with Type 1 diabetes. However, clinical success remains hindered by robust immune responses, inadequate insulin secretion, and acute hypoxic stress. This research focuses on the development of an implantable, immunoprotective, pectin methacrylated (Z4A10-PECMA)- based, 3D bio-printable, retrievable microdevice with a patterned lumen loaded with oxygen-generating nanocrystals that provide controlled oxygen delivery to directly overcome post-implantation hypoxia. Magnesium peroxide (MgO_2) is employed as a sustained molecular oxygen source, while manganese dioxide (MnO_2) catalyses the decomposition of hydrogen peroxide intermediates, stabilising oxygen release and minimising

reactive oxygen species-mediated toxicity. The MgO_2+MnO_2 nanocrystal system enables regulated oxygen delivery within physiologically relevant ranges and addresses a key limitation of earlier oxygen-generating systems. Furthermore, the functionalized pectin polymer with Z4-A10 will prevent initial immune rejection and fibrosis. Lastly, the 3D-printed device will be loaded with isolated primary xenogeneic rat islets and oxygen-generating material, which will be administered subcutaneously for long-term reversal of diabetes in a STZ-induced type 1 diabetic C57BL/6 mouse model. This work aims to enable durable endogenous insulin secretion and establish a translationally relevant, device-based strategy for Type 1 diabetes.

Development of a NIR-activated Nano-coated Implantable Chip for Deep-tissue UTI Treatment

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Abstract ID: PP-822

Abstract

Urinary tract infections (UTIs), predominantly caused by uropathogenic *Escherichia coli* (UPEC), represent one of the most common bacterial infections worldwide, affecting more than 150 million individuals annually. Despite antibiotic therapy, relapse occurs in 30–50% of cases, and the growing resistance of UPEC to last-resort antibiotics, including carbapenems and colistin, poses a critical clinical challenge. Nanomaterial-based photothermal and photodynamic therapies have recently emerged as promising alternatives due to their ease of application, potent antibacterial activity, and reduced risk of resistance. Herein, an implantable and retrievable chip was fabricated for targeting deep-tissue bacteria using near-infrared (NIR) irradiation. The nano-coated thin film exhibited a broadened absorption spectrum spanning UV–Vis to NIR-I and NIR-II regions, with a plasmonic peak near 750 nm and strong absorption up to 1500 nm, enabling deep-tissue penetration. Thermal imaging confirmed rapid and reversible localized heating, generating transient hyperthermia, whereas nanoparticles achieved short-term free radical generation. This localized thermal effect, coupled with the intracellular production of ROS, resulted in effective bacterial suppression and significant disruption of mature biofilms. Biocompatibility was validated using the chorioallantoic membrane model, where the chip supported vascularization and angiogenesis. In vivo studies on wound healing and dermal infections demonstrated accelerated tissue repair and infection control within 11 days, as evidenced by histological restoration of the epithelial barrier and expression of key regenerative biomarkers. In a rat UTI model, the NIR-triggered nanoplatform inhibited the colonization of GFP- *E. coli* within 48 hours of implantation, as confirmed by IVIS imaging and colony culture of surrounding tissues and body fluids. Collectively, these findings highlight the photo-responsive chip as a promising alternative for targeted eradication of deep-seated bacterial infection and promotion of host tissue repair.

Additionally, efficacy on clinical isolates and long-term toxicity and biodistribution studies are currently underway to assess its therapeutic potential as a medical device.

Keywords: Antibacterial Photothermal therapy; Antibacterial Photodynamic therapy; Reactive oxygen species; Urinary tract infections; Infective wound healing; Antibacterial Photodynamic therapy

Role of positional isomerism in A-site organic cation: structural variation driven photophysical and ferroelectric responses in centrosymmetric layered perovskites

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Abstract

Low-dimensional layered perovskites (LDLPs) have emerged as promising candidates in photovoltaics owing to their enhanced environmental stability. However, their high exciton binding energy, relatively poor conductivity, and low charge-carrier concentration limits its application as photoactive materials in photovoltaic devices. One effective method to overcome this bottleneck is to introduce an inherent dipole moment by fluorinating the organic cation within the perovskite crystal structure. In this work, the structure-property correlation in LDLPs based on the position of the fluorine atom (*ortho*-, *meta*-, and *para*-) in monofluorinated N-methyl-1-phenylmethanaminium ($NMPM^+$) as an A-site cation was investigated. Positional isomerism at the A-site cation resulted in variation in crystal packing, including changes in the interlayer spacing and distortions of the inorganic layers. These structural changes lead to variation in photophysical properties, as supported by both experimental and theoretical calculations. Further, the positron annihilation spectroscopy study suggested variations in the concentration of intrinsic defects in the as- synthesized materials, leading to ferroelectric responses in an otherwise centrosymmetric crystal structure.

Keywords: halide perovskites; centrosymmetric; defects; photophysical; ferroelectric

Elucidating Interfacial Charge Transfer in an Organic Chromophore/ Inorganic Quantum Dot Hybrid Heterostructure

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Abstract ID: PP-839

Abstract

Small organic chromophores have garnered immense attraction as semiconductors owing to their flexibility, low cost, and solution processability, while inorganic perovskites are known for their excellent optoelectronic properties. However, the poor conductivity of the organic chromophores and the processing challenges of perovskites have limited their applicability. Herein, a hybrid heterostructure is developed by combining a small organic chromophore with an inorganic halide perovskite. Crystallographic analysis, including SC-XRD, PXRD, XPS, and HR-TEM, is employed to confirm the formation of the heterostructure. Furthermore, PL and TRPL studies reveal interfacial charge transfer from the inorganic perovskite to the organic chromophore. The energy levels of the frontier molecular orbitals, obtained from CV, were realigned upon heterostructure formation, resulting in a type-I heterojunction. Finally, chronoamperometry measurements were performed to assess the improvement in the photo-response of the hybrid heterostructure.

Keywords: organic chromophore**,** inorganic perovskite, type-I heterojunction

Magnetic Field-Driven Overpotential Reduction in Ni–Fe Alloy Electrodes for Hydrogen Evolution Reaction

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Abstract

The growing demand for sustainable energy has intensified research toward efficient, low-cost electrocatalysts for water electrolysis, a key route for green hydrogen production. Among various candidates, nickel–iron (Ni–Fe) alloys have gained significant attention due to their high activity, abundance, and stability in alkaline media. However, minimizing overpotential while maintaining high catalytic efficiency remains a major challenge. In this work, Ni–Fe alloy electrodes were synthesized via electrodeposition with controlled potentials to tailor morphology and catalytic properties. Where face-centered cubic (FCC) Ni–Fe deposition at higher potential (−1.45 V) produced well-defined nanoflakes, while lower potential (−1.00 V) resulted in aggregated structures. The optimized nanoflake-based electrodes exhibited low overpotential of 168 mV for HER at 10 mA cm^{-2}, attributed to enhanced surface area and composition. To further improve performance, a Ni–Fe (1:1) alloy system was investigated under externally applied magnetic fields during electrolysis. The magnetic field reduced overpotential by improving mass transport, bubble detachment, and charge transfer kinetics at the electrode–electrolyte interface. This study demonstrates a combined strategy of controlled electrodeposition and magnetic fild assisted electrolysis to overcome kinetic limitations in water splitting. The findings provide a promising pathway for efficient hydrogen production.

Keywords: Hydrogen Evolution reaction; Ni-Fe alloy; Magnetic field; Electrodeposition; Electrocatalysis.

Development of nanocrystalline hexagonal $LuFeO_3$ with significant magnetoelectric properties

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Abstract ID:OP-865

Abstract

Metastable hexagonal $LuFeO_3$ with $P6_3cm$ space group has been successfully synthesized in nano regime by sol-gel method. X-ray diffractogram (*Fig. 1(a)*) and Selected Area Electron Diffraction (SAED) pattern confirm the desired crystallographic phase formation with no impurity. Field emission scanning electron microscopy (FESEM) (*Fig. 1(b)*) analysis exhibits that average particle size is ~30 nm. Frequency-dependent dielectric properties with temperature variation are studied and the relevant quantities are also determined. Polarization vs. electric field (PE) measurements confirmed the presence of ferroelectric ordering of the sample at room temperature (*Fig.1(c)*) and antiferromagnetic ordering (*Fig. 1(d)*) with a high value of Néel temperature was also established in magnetic measurements. Magnetocapacitance measurement (*Fig. 1(e)*) confirms that LuFeO3 is multiferroic good coupling (~ 1.09 %) between two ordering. This new multiferroic would be quite interesting in magnetoelectric device applications.

$[SiCl_3(PR_3)]$: A New Class of Inorganic Superalkalis

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Abstract ID:OP-866

Abstract

Superalkali is a class of superatom and is eminent for its excellent reducing properties. It is a cluster of molecules that is stable as a cation. Conventionally, when the number of ligands exceeds the valency of the central metal and shows superalkali behaviour. A recent experiment shows that phosphine and chloride ligand-substituted penta-coordinate Si species are stable as a cation i.e., $[SiCl_3(PMe_3)_2]^+$. This study reveals that the calculated ionization energy of this system is lower than 5 eV. Further proper ligand manipulation of pentacoordinate Si systems gives us even lower ionization energy than 4 eV.

Frontier molecular orbitals (*FMOs)* analysis gives an idea about the variation of the ionization energy of the systems. Significant hyperpolarizability of these systems is responsible for high non-linear optical (NLO) properties. Several bonding analyses, such as Bond critical point (BCP), and AdNDP, give a clear idea about the bonding nature of these systems.

Sustainable Waste Management (SWM)

The Study on Energy Recovery Opportunities from the Wastes generated in the Rural Hospital and the Scope of Its Management

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Abstract ID: OP-26

Abstract
India generates approximately 743 tons of biomedical waste per day, as reported by the CPCB in 2023. The improper management of biomedical waste poses serious environmental and public health risks, contributing to over 5.2 million global deaths annually. This study addresses the urgent need for sustainable biomedical waste management by proposing an integrated model that focuses on energy recovery along with environmental sustainability. A year-long observational study was conducted in three rural hospitals, which revealed an average biomedical waste generation of 0.73 kg/bed/day, which was further validated by a KAP survey involving 60 staff members from each hospital, revealing high awareness among clinical staff, but sanitation workers lacked critical knowledge. Advanced statistical methods like ANOVA, chi-square tests, etc., were employed to maximize data analysis, and their detailed comparative analysis revealed the key factors influencing the disparity and discrepancies. Different approaches in treating biomedical waste, such as incineration, autoclaving, etc., were assessed, bolstered by an industrial visit. The opportunity for energy recovery and the amount of carbon emission were calculated separately for each hospital using the quantified waste volume and standard calorific values. The findings indicate that efficient hospital waste management can significantly support the daily energy requirement of a rural hospital, establishing the foundation for self-sustaining, energy-positive healthcare systems that convert hospital waste into energy, enhancing efficiency & ecological resilience.

Keywords: Biomedical waste; Energy recovery; Carbon emission; KAP Survey; Incineration

Wastewater Treatment Methods for Sustainable Agriculture

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Abstract ID: OP-49

Abstract
Due to continuous increases of water pollution sources such as industrial waste, household, agriculture waste, it is creating imbalance between freshwater availability and consumption. Therefore, the treatment of wastewater remains a critical need before discharge it into natural

water source. In this article, the main motive is how to treat the domestic wastewater which includes kitchens, bathroom, laundry and toilets wastewater that safely reuse in agriculture, contributing to sustainable water management. This study is focused on environment friendly, energy efficient, cost-effective treatment methods. Usually, the treatment process has three stages: primary, secondary and tertiary. Primary treatment focuses only on physical removal of large particles through screening and sedimentation. Secondary treatment is a biological processes like activated sludge systems or biofilm reactors, to reduce biochemical oxygen demand and other harmful chemical contaminants. The final stage, tertiary treatment, involves advanced processes such as filtration, disinfection to remove biological impurities like coliform. In this article, we also discuss about modern wastewater treatment such as membrane bio-reactor, constructed wetlands etc. to improve treatment efficiency with using minimum energy. That not only removes harmful contaminants but also provides essential nutrients like nitrogen, phosphorus and potassium needed for crop growth. Additionally, treated domestic wastewater serves as alternative irrigation source. In conclusion, this approach not only enhances agricultural productivity but also helps to protect ecosystems, public health caused by direct discharge of untreated sewage into waterbodies. With growing urban population and increasing freshwater demand, the importance of domestic wastewater management continues to rise. Therefore appropriately treated domestic wastewater reuse can significantly contribute to sustainable farming, long term water resource management and improving food security in rural areas.

Keywords: Constructed wetlands, Membrane bio-reactor, Wastewater, Sustainable agriculture.

Synthesis and Adsorption Studies on Bio-Degradable Adsorbent for Reduction of Indoor Pollution (Air)

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Abstract

While the world focuses on sustainable fuels and the use of renewable energy, the transition is still incomplete. New technological advancements are yet to be optimized for use on a larger and more economical scale. Until this change happens, we still rely on non-renewable sources of energy such as petrol and coal, which produce various pollutants like NOx and SOx, reducing air quality. Indoor air pollution (IAP) poses a significant threat to human health, linked to respiratory issues and adverse effects on infants due to harmful pollutants. Bio-adsorbents have been thoroughly researched and developed to treat effluent water and sludges in process industries. However, research on the development of bio-adsorbents to reduce air pollution caused by pollutants generated from non-renewable energy sources is limited. The main objective of this experimental and quantitative study was to produce a biodegradable, bio-adsorbent from wastepaper to help reduce indoor pollution caused by these sources. The methodology involved chemical and physical activation in a series of steps to produce bio-adsorbents with a high surface area containing porous activated carbons. Wastepaper is shredded, chemically activated using potassium hydroxide (KOH), thermally

treated at 750 °C, and physically activated via steam distillation, highlighting the potential of waste-to-resource strategies in addressing indoor air pollution sustainably. Characterization revealed that bio-adsorbents produced from waste paper are effective, sustainable, and have potential for upscaling to combat air pollution.

Keywords: Renewable Energy; IAP; Bio-adsorbent; Bio-degradable; KOH; steam distillation

Recovery of Critical Metals from Spent Li-Ion Batteries and Valorization of Waste-Derived Carbon for Water Desalination through Capacitive Deionization

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Abstract ID: OP-66

Abstract
This study presents a sustainable approach to resource recovery and water purification by synthesizing value-added materials from waste. The initial step was to selectively recover metals from spent lithium-ion batteries through a leaching and precipitation process using a mild leaching agent, oxalic acid in our case. One of the recovered metal oxides (Manganese oxide) was used as a functional additive with activated carbon (AC), which was produced in-house from waste coconut shells and activated using KOH. The composite material was used as an electrode in capacitive deionization (CDI) for desalination applications, achieving a maximum salt removal capacity of 13.217 mg NaCl/g of active material. Moreover, the composite electrode demonstrated high electrochemical stability across multiple cycles of cyclic voltammetry.

Keywords: activated carbon; lithium-ion batteries; CDI

Zinc Based Metallic Soap from Fatty Acid Oil By Fusion Process

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Abstract
This study investigates the production and characterization of zinc-based metallic soaps using the fusion process. The primary objective is to utilize waste and by-products to create value-added metallic soaps. Historical context traces the origins and development of soap-like substances, highlighting the significance of affordable soda in the early 19th century, which revolutionized soap production. The fusion process, a key method in this study, involves reacting fatty acids with zinc oxide at temperatures above their melting points. Detailed experimental procedures outline the synthesis of zinc oleate metallic soap using both pure and recycled zinc oxide. The physicochemical properties of the resulting metallic soaps are characterized through various analytical techniques, including acid value determination, saponification value assessment, solubility tests, pH measurement, moisture content analysis, and advanced spectroscopic methods such as X-ray Diffraction (XRD) and Fourier Transform Infrared (FTIR) spectroscopy. Results indicate successful formation of zinc-based metallic soaps with significant implications for their application in lubricants, textiles, paints, and other industries. This research underscores the potential for sustainable practices in soap production, leveraging industrial by-products to achieve high-purity metallic soaps.

Keywords: Metallic soap , zinc oxide ,fusion process , fatty acid oil.

Preparation of High Capacity Adsorbent Using Waste Rubber Tyres for the Removal of Methylene Blue from Water

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Abstract
There has been growing interest in making adsorbents more cost-effective and feasible in low resource areas by using material that is cheap or would usually be considered waste. In the present study, a high-capacity regenerable adsorbent is synthesized by the treatment of waste tire rubber (WTR) with concentrated sulfuric acid. We have done pyrolysis of waste rubber tyre under 300°C for 1 hour.The sulfuric acid reflux carbonized as well as functionalized the WTR with the sulfonic acid group. The as-prepared sulfonated carbonaceous WTR was used for the removal of organic dyes and antibiotic viz. methylene blue (MB), methyl orange (MO) and Tetracycline (TC) from water. The maximum adsorption capacity was found to be about 833, 588, and 303 mg/g towards MB, MO, and TC, respectively. The adsorption of MB, MO, and TC from the tap water matrix was also performed and shown to maintain similar adsorption capacities as the deionized water. In addition, a packed glass column was prepared to demonstrate the continuous adsorption of MB and TC from the tap water matrix. The regeneration of the column was achieved by using mixture of aqueous and organic solvents with dissolved NaOH and it was demonstrated that the adsorbent not only recovered but also increased its adsorption capacity after every time it was regenerated.

Keywords: Adsorption; Pyrolysis; methylene blue; Waste rubber tire.

Zero Waste Beyond: Sustainable Waste Management Solutions

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Abstract ID: OP-96

Abstract
This study explores the concept of zero waste, emphasizing the need to minimize waste generation and maximize resource recovery through sustainable waste management solutions. It identifies and evaluates innovative strategies that contribute to zero waste goals, including circular economy principles, waste-to-energy technologies, decentralized composting, and advanced recycling systems. The research methodology involves an extensive review of global case studies, an analysis of resource recovery models and the incorporation of stakeholder perspectives on policy and community engagement. The results reveal that integrated approaches—combining advanced technologies, supportive policy frameworks, and community participation—enhance waste management efficiency and long-term sustainability. Case studies highlight the success of waste-to-energy conversion, block chain-based waste tracking, and artificial intelligence-driven material sorting, demonstrating the potential for traceability and operational efficiency. However, challenges remain, including infrastructural limitations, inconsistent policy enforcement, and barriers to public participation. Addressing these issues requires a holistic approach that merges technological innovation, regulatory support, and behavioral change. The applications of these strategies span urban and rural contexts, offering scalable solutions for municipal, industrial, and residential waste management. The novelty of this study lies in the integration of digital technologies and community-driven models to improve sustainable and resilient waste management systems. By extending beyond conventional recycling and disposal methods, this paper provides a roadmap for transitioning toward a zero waste future.

Keywords: Zero waste: Sustainable waste management; Circular economy; Resource recovery; Waste-to-energy; Block chain and AI.

Toxic Arsenic Contaminated Sludge: Immobilized in Glass Waste Turns into Insulating Foam for Practical Utility

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Abstract

Arsenic-contaminated sludge (AsCS) from arsenic removal units poses significant environmental concerns due to its toxicity and potential for recontamination. To address this issue, researchers have explored immobilizing the sludge in non-toxic soda-lime silicate (SLS) glass waste through a melt-quenching method. The elemental analysis of the dried sludge was performed using FESEM-EDX, and the potential for arsenic leaching was examined through AsCS water extract tests. The results showed that arsenic leached out into the aqueous medium, highlighting the need for immobilization. The SLS glass was substituted with AsCS in varying proportions (3-10 wt%) to prepare sludge-immobilized glass samples. The thermal behavior of these samples remained unchanged, making them suitable for glass foam fabrication. Therefore, the glass prepared with 10% of As-contaminated sludge is used for fabrication of glass foam. The sintering behavior was evaluated using hot stage microscopy (HSM), and the samples were sintered at 735 °C.

The resulting glass foam samples had bulk densities ranging from 0.492-0.603 g/cm³ and porosities between 80-76%. The mechanical properties, characterized by modulus of elasticity (MOE) and cold crush strength (CCS), varied within the ranges of 3.9-5.54 GPa and 73-190 Kg/cm², respectively. Additionally, the physical and mechanical properties of the glass foam can be further tailored by adjusting process parameters. This study demonstrates a promising approach to converting hazardous waste into a valuable material, contributing to environmental sustainability. By immobilizing toxic sludge in glass, this method offers a potential solution for mitigating arsenic contamination and promoting sustainable waste management.

Keywords: Arsenic contaminated sludge, Waste glass, Glass foam, As-sludge utilization in glass

Design and Development of Remote-Controlled Aquatic Trash Collecting Machine

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Abstract ID: OP-111

Abstract

Aquatic trash is a serious menace which requires to be addressed on top priority to save our water bodies and aquatic life. There is a need for the development of sustainable solution for the floating waste from the aquatic bodies. This paper discusses in detail about the design and development of remote-controlled Aquatic Trash Collecting Machine. This indigenously developed low cost machine is capable of collecting the floating debris present in the water bodies and is operated using a radio frequency transmitter and receiver based remote control with a range of 150 m from the land. This machine is powered by solar panel (20W,12V) and rechargeable battery (12V, 65AH) capable of four hours of continuous operation in single charging. Three permanent magnet direct current motors (12 V, 9 A) are used as the prime mover for the water wheel and the conveyor in this machine. A customized conveyor with chain drive is designed for lifting the floating trash from the water surface and to deposit the

same in the removable trash collecting bin attached in the machine. The developed machine has been tested in the water bodies and it is capability is assessed.

Keywords: Floating debris; Trash collector; Sustainable engineering; Waste management

The Chemistry of Biochar: A Sustainable Approach for Wastewater Remediation and Contaminant Adsorption

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Abstract ID: OP-118

Abstract
Biochar based wastewater treatment has become one of the most environmentally friendly and economically attractive technologies in recent years. Synthesized from abundant biomass from agricultural and organic wastes (cotton stalk), biochar effectively absorbs heavy metals, organic pollutants, and wastewater nutrients due to its porous structure, high specific surface area, and diverse functional groups. The XRD, FTIR and SEM properties in various biochar models have confirmed this strength. Biochar is graded by metal oxides and chemical handling for high purification effectiveness. These have led to their versatile use in wastewater treatment by enhancing their absorption and catalytic properties. Biochar is emerging as a great alternative to traditional technologies due to its low heat requirement, reusability and low production cost. Low resource use in rural areas is likely to contribute to water security. But future research should focus on standardization of production methods, the achievement of recycling and widespread industrialization.

Keywords: Biochar-based wastewater treatment; Heavy metal adsorption; Surface functionalization of biochar; Sustainable water purification; Low-cost adsorbent technology

Rice Straw Valorization via Pyrolysis: Kinetic Modeling, Process Optimization and Product Distribution

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Abstract
Rice straw, a widely available agricultural byproduct, has been processed via pyrolysis to investigate its suitability for biofuel generation. The thermal degradation behavior was analyzed using thermogravimetric analysis (TGA) under Ar atmosphere at varying low heating rates in between 3 – 15 °C/min. Iso-conversional model-free kinetic methods were employed to determine the activation energies across different level of conversion and the study revealed a multi-step decomposition mechanism with lesse activation energy requirement.

Complementary to the kinetic evaluation, pyrolysis experiments with rice straw were conducted within the temperature range of 400–700 °C & the condensable and non-condensable products were characterized. The bio-oil fraction was analyzed for its physicochemical properties. Detailed analysis of the condensable liquid fraction showed moderate acidity, favorable energy content, and a complex composition dominated by phenolic, ethers, ketonic compounds etc. as revealed by GC–MS and FTIR. The solid biochar characterization included proximate analysis, ultimate analysis, High heating value, BET surface area (indicating high porosity), surface morphology (SEM), elemental mapping (EDX), and crystallinity (XRD). Non-condensable gaseous products were quantified via gas chromatography, highlighting the presence of energy-rich components. The study provides insights into the thermal degradation and product potential of rice straw, emphasizing its viability for biofuel and value-added applications. This integrated study combining kinetic modeling and detailed product characteristics offers a complete understanding of rice straw pyrolysis and underscores its potential in sustainable energy conversion and resource recovery.

Keywords: Rice straw, Pyrolysis, Kinetics, Bio-oil, GC–MS, Biochar

Development of Chemically Activated Paper Waste Adsorbents for Dye Removal from Wastewater

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Abstract ID: OP-125

Abstract
The escalating crisis of water pollution, especially due to industrial dyes, necessitates sustainable and costeffective treatment technologies. This study explores the transformation of paper waste a major urban solid waste component into a functional bio-adsorbent for wastewater treatment. Paper waste, rich in cellulose, was subjected to physical and chemical preprocessing followed by activation using hydrochloric acid (HCl) and sodium hydroxide (NaOH) at varying ratios (1:10, 1:15, and 1:20). The activated bio-adsorbents were then evaluated for their efficiency in removing methylene blue (MB), a model cationic dye, under controlled laboratory conditions. Characterization techniques including FTIR, SEM, EDX, pH, conductivity, solubility, turbidity, and ash content analysis confirmed significant structural and surface functional modifications postactivation. Spectrophotometric calibration and dye removal tests revealed that HCl-activated adsorbents at a 1:15 ratio exhibited the highest dye removal efficiency (~51.41%), while NaOH-activated samples followed closely (~55.32%). pH measurements showed acidic and basic surface behaviors, aligning with the activation agents used. Solubility and turbidity results further indicated enhanced stability and clarity of treated water using the synthesized adsorbents. FTIR spectra identified hydroxyl, carbonyl, and carboxyl groups responsible for dye binding, while SEM analysis highlighted the increase in surface roughness and porosity after chemical activation and adsorption. Electrical conductivity readings correlated well with the reduction in ionic strength post-treatment, supporting effective pollutant removal. This work presents a novel approach to upcycle low-value paper waste into high-performance bio-adsorbents, offering a dual benefit of waste valorization and environmental remediation.

Keywords: Paper waste; bio-adsorbent; wastewater treatment; methylene blue; adsorption; FTIR; SEM; Sustainability

Computational Modelling on Electrochemical Performance of Jute Waste Derived Activated Carbon as Supercapacitor

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Abstract
For sustainable development valorization of lignocellulosic industrial waste into activated carbon emerges as a promising approach. In the present research, jute industrial waste is utilized for activated carbon preparation which shows potential for supercapacitor application in terms of amorphous nature of carbon having a specific surface area (SSA) of 1100 m^2/g as confirmed by BET isotherm and RAMAN spectral analysis reflected characteristics D and G peaks at 1300 cm^{-1} and 1500 cm^{-1} respectively indicating graphitic nature of the prepared carbon. Electrochemical performance was evaluated in a symmetrical 2032 supercapacitor full cell which delivered specific capacitance up to 70 F/g at a constant current of 1mA at 0.5mA/cm^2. Computational modelling methods including Density functional theory (DFT) and Molecular dynamics (MD) are significant for the exploration of charge storage mechanism. The present study is designed to use DFT for monitoring the functionalization of biochar to understand the synergistic effect of oxygen-containing functional groups incorporation in enhancement of the capacitance and energy density of supercapacitor. The overall study emphasizes a detailed understanding on utilization of lignocellulose rich jute waste as a potential substrate for development of active carbon in line with the waste to energy perspectives.

Keywords: Activated carbon, specific capacitance, supercapacitor, DFT

Extraction of Furfural from Sugarcane Bagasse

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Abstract
The purpose of this proposal is to offer a practical way to dispose of sugarcane bagasse so as to contribute to the Sustainable Waste Management by using it for the production of Furfural which possesses many useful industrial applications. Furfural finds its main applications in

Chemical Industry, Petroleum & Lubricant Industry, Agriculture and Agrochemical Industry, Pharmaceutical Industries and many more.

Approximately 90% of Gujarat's total sugarcane cultivation is concentrated in the southern region, which serves as the primary foundation for the state's sugar industry. According to CEIC Data, as of the 2023–24 agricultural year, Gujarat produced approximately 13.46 million tons of sugarcane which results into around 3.63 to 4.04 million tons of bagasse generation as per the Standard Industrial Ratio which is currently used as the fuel for cogeneration in the Sugar Industries itself wasting the valuable components simply by burning them into ashes.

Sugarcane bagasse primarily consists of cellulose, hemi-cellulose (rich in pentosans), and lignin—key constituents that serve as potential feed stocks for furfural production. Production of furfural from bagasse is an acid hydrolysis process of the hemicelluloses present in the lignocellulosic biomass to obtain xylose, which then undergoes through a dehydration reaction to produce furfural. Furfural is an organic compound with the formula $C_5H_4O_2$. It is colorless to yellow-brown liquid having boiling point of 161.7 ^{0}C and molar mass 96.08 g/mol.

Keywords: Furfural; Sugarcane Bagasse; Solid waste Management; Lignocelluloses; Pentosans.

Biodegradable Packaging Films – A Sustainable Approach for Green Environment

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Abstract ID: OP-150

Abstract

This review paper examines biodegradable packaging films derived from natural sources as an eco-friendly alternative to conventional plastic. It analyzes various materials including starch-based, polylactic acid, polyhydroxyalkanoates, chitosan, cellulose, and protein-based films, evaluating their properties and applications in sectors like food packaging, pharmaceuticals, and agriculture. The paper highlights advantages of biodegradable films, such as addressing plastic waste issues and reduced carbon footprint, while acknowledging challenges like cost-effectiveness and quality concerns. It focuses on practical implementation aspects, including market considerations, regulatory frameworks, new material development, and resource recovery systems.

The review synthesizes current knowledge, offering a critical assessment of biodegradable packaging films' potential to revolutionize the industry. It examines material properties, performance in various applications, and environmental impact, including biodegradation processes and potential to reduce plastic pollution. The study investigates the market landscape, analyzing consumer preferences, industry trends, and regulatory environments. It discusses government policies promoting biodegradable materials and potential economic implications of

transitioning to these alternatives. Recent technological advancements in production, including innovations in material science and manufacturing processes, are highlighted. The paper also explores integration of biodegradable packaging into existing waste management systems and the potential for closed-loop systems incorporating resource recovery. In conclusion, this comprehensive review provides a balanced assessment of biodegradable packaging films' current state and future prospects, offering valuable insights for researchers, industry professionals, and policymakers working towards sustainable packaging solutions.

Keywords: Biodegradable Packaging; Eco-friendly Alternatives; Natural Sources; Sustainable Packaging; Plastic Waste Management; Environmental Impact; Resource Recovery

Ecofriendly Sorption of Oil from Water Using Natural Hair Resources

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Abstract

This paper explores the innovative use of human hair as an eco-friendly and cost-effective adsorbent for oil removal from contaminated water. The study addresses a critical environmental challenge faced by various industries, including oil and gas, petrochemicals, and food processing. While conventional oil-water separation techniques such as gravity separation, flotation, and membrane filtration have been widely used, they often face limitations in terms of efficiency, cost, and environmental impact.

The research focuses on adsorption using human hair as a sustainable alternative, leveraging its hydrophobic nature and high surface area to achieve considerable oil adsorption capacity with potential for reuse. The experimental findings of this study demonstrate promising oil removal efficiencies, indicating that human hair can effectively adsorb oil with minimal energy input and waste generation. This approach not only offers a sustainable solution to oil contamination but also presents an opportunity to repurpose a readily available waste material.

The paper delves into the advantages and challenges associated with using human hair as an adsorbent, highlighting its potential for modification and scalability in broader applications such as wastewater treatment and environmental remediation. By examining the future scope of this technology, the research contributes to the development of innovative, environmentally friendly solutions for addressing water pollution and resource recovery in industrial settings.

Keywords: Adsorption; Hair; Oil-Water separation; Ecofriendly adsorbent; Wastewater treatment

Microplastic Removal From The Environment: A Sustainable Approach For Wastewater Treatment And Pollution Control

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Abstract
Microplastic pollution poses a growing threat to aquatic ecosystems and human health due to the persistence and bioaccumulation of plastic particles smaller than 5 mm. These pollutants, originating from both consumer and industrial sources, often bypass conventional wastewater treatment plants (WWTPs), which are not specifically designed to capture them. This project reviews current physical, chemical, and biological microplastic removal methods and identifies membrane-based technologies as the most promising.
To address the limitations of existing approaches, we propose a novel Integrated Membrane Design using a dual-innovation, triple-layer system. The base layer consists of electrospun biodegradable nanofibers made from Polylactic Acid (PLA) or Polycaprolactone (PCL), offering high porosity and mechanical strength. The middle layer features Graphene Oxide (GO) nanosheets embedded with TiO_2 or ZnO nanoparticles to ensure high microplastic retention, antimicrobial activity, and photocatalytic self-cleaning. The surface layer includes a bioinspired antifouling coating such as zwitterionic polymers (polySBMA) or PEG-like brushes, reducing membrane fouling via a hydration barrier.
This integrated design achieves high microplastic removal efficiency (up to 99%) while offering environmental sustainability, low maintenance, and scalability. The proposed solution supports the development of next-generation wastewater treatment technologies, aligning with global goals for environmental protection and sustainability.

Keywords: Microplastic removal, wastewater treatment, membrane technology, biodegradable nanofibers, graphene oxide, photocatalysis, antifouling coating, zwitterionic polymers, environmental sustainability, advanced filtration systems.

Biomass-Sustainable Approach for Separation of Pollutant from Wastewater: A Brief Review

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Abstract

This study explores the economic and environmental viability of utilizing biomass as a sustainable solution for pollutant removal and wastewater treatment. Given the escalating concerns surrounding industrial, agricultural, and domestic water pollution, conventional separation methods prove to be costly and environmentally detrimental. In contrast, biomass offers a natural and renewable alternative, prompting increased interest in its applications.

The report investigates a range of biomass materials, such as agricultural residues, wood waste, algae, and plant fibers focusing on their roles in adsorption and membrane separation processes for the effective removal of contaminants like heavy metals, dyes, and oils. Through an analysis of various biomass-based adsorbents, including biochar and activated carbon, as well as membrane technologies employing cellulose, chitosan, and lignin, this research presents real-world efficiency data that underscores the effectiveness of these materials. Additionally, the economic benefits of employing low-cost biomass and its minimal environmental impact are thoroughly examined. However, the study also addresses significant challenges, including biomass variability, the complexity of regeneration processes, and limitations in scaling up applications. Future trends in the field are projected to emphasize the development of hybrid materials, advancements in nanotechnology, and process optimization to further enhance the efficiency of biomass utilization. Ultimately, this research highlights the potential of agricultural and fruit waste as sustainable biosorbents, contributing effectively to wastewater remediation efforts and addressing critical issues related to water pollution in an environmentally responsible manner.

Keywords: Biomass - Biodegradable Materials; Adsorption; Membrane Filtration; Heavy metals Separation; Wastewater treatment; Sustainable- Ecofriendly approach

Thermal Conversion Of Petroleum Waste Into Value Added Materials

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Abstract

Lube oil or lubricating oil, is crucial for smooth and efficient operation of machinery by reducing friction, preventing wear, and protecting equipment from damage. Waste lube oil poses significant environmental hazards, including water and soil contamination, air pollution and threats to wild life. Improper disposal can lead to the leaching of heavy metals and other contaminants into the soil reducing fertility and harm plant life.

The demand for the lube oil ids expected to continue growing globally, with India and other developing nations showing significant potential for growth due to their robust automotive and industrial sectors.

Waste lube oil can pollute the environment through soil and water contamination, harming plant and animal life. Improper disposal such as dumping or leaking can contaminate soil and

water sources reducing soil fertility and affecting plant growth. Waste lube oil poses significant environmental threats due to its persistent toxicity, and potential to contaminate soil and water. Experimental remediation methods aim to mitigate the detrimental effects by recovering valuable components, detoxifying contaminates and reducing overall waste. Rerefining technologies, bio remediation, integrated and hybrid approaches nanotechnologies (focusing on pyrolysis.)

To effectively examine the composition of waste oil after pyrolysis, a combination of analytical techniques is employed to characterize the various fractions (liquid-oil, and gas and solid char).GC-MS, FTIR , Elemental analysis, Physical and fuel properties testing (ASTM),Gas –GC analysis., Char soiled residue-TGA: SEM, XRD.

The findings from the examination of the waste lube oil after pyrolysis make significant contribution to the across several domains, primarily in environmental sustainability resource recovery, and development of alternate energy sources. After the pyrolysis of waste lube oil (WLO) three main resources are recovered Liquid pyrolysis oil (Pyro oil), Pyrolysis gas, and solid char. each of these has a distinct application contributing towards more sustainable and circular economy by diverting hazardous waste from landfills and transforming it into a range of valuable products, including alternative fuels, chemical feed stocks and functional carbon materials, thereby promoting circular economy.

Keywords: lube oil, hydrocarbons, pyrolysis.

Waste to Wealth: Cigarette Stub as a Sustainable Membrane Filler

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Abstract

India has been cultivating tobacco since 17th century and currently produces approximately 800 thousand tonnes of tobacco products annually. This results in the generation of nearly 1315.16 tonnes of cigarette stubs, a major environmental pollutant. These cigarette stubs are primarily composed of cellulose acetate (CA) fibres containing nicotine (or variants) which is extremely toxic. The usual lifespan of these stubs in the environment varies from 2 years to 10 years, depending on the environment. In this study, a facile and sustainable method was developed to extract nicotine from these waste cigarette stubs, thereby enabling their potential reuse in the synthesis of CA-based membranes for various commercial applications. Nicotine extraction was optimized with the help of Response Surface Methodology (RSM) using a "Box-Behnken Design" model. The influence of critical operational parameters such as washing duration, stirring speed (during wash), and the water-to-ethanol ratio in the washing solution was evaluated to maximize the extraction. Optimal conditions for maximum nicotine extraction were identified and applied to produce cleaner CA material. The optimum conditions as identified from the RSM design was Water to Ethanol in the ratio of 1:2, washing speed as 391 rpm and washing time as 7 minutes. This purified CA stock offers a

promising route toward the development of value-added, refurbished membranes, supporting the broader goal of waste-to-resource sustainability.

Keywords: Waste to Wealth; Refurbished Cigarette Stub; Design Optimization;

Rapid Solar Vapor Generation Using Photothermic Oxidized Graphene Coated Surface for Seawater Treatment

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Abstract
The growing demand for thermal energy in wastewater treatment, particularly seawater evaporation, calls for efficient and sustainable vapor generation methods. Conventional systems rely on fossil fuels, making them unsustainable. Solar thermal vapor generation offers a clean, renewable approach for harnessing solar energy to treat wastewater through evaporation. Recent developments in nanomaterials and findings suggest that photothermic materials turn light into thermal energy efficiently. So, the present study demonstrates the utility of photothermic oxidized graphene mixed in black paint coating to act as a photothermic surface. In open-air solar heating test, the oxidized graphene mixed black paint (OGBP) coated absorber surface was heated up to temperature 78.4°C, which was 13.8% higher than the black paint (BP) coated absorber surface of 68.9°C. Resulting photothermal conversion efficiency of 58.8% with BP and 76.7% with optimized OGBP coating was achieved. The OGBP-coated surface exhibited 27% enhancement in solar vapor generation rate, achieving 880 $g/m^2.h$ compared to 693 $g/m^2.h$ for the BP-coated surface during evaporation test. Correspondingly, thermal efficiency increased from 50% to 63.5%, and exergy efficiency improved from 3.6% to 5.5% with the OGBP coating. It shows OGBP-coated surface is more suitable for efficient solar vapor generation than BP-coated.

Keywords: Seawater treatment; Vapor generation; Solar Energy; Oxidized graphene paint.

Synthesis of Gamma Alumina (Γ-Al_2o_3) from Waste Aluminium Foil and Its Application in Adsorptive Removal of Malachite Green (MG) Dye From Wastewater

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Abstract
This study explores the sustainable synthesis of gamma alumina from waste aluminium foil and its efficacy in removing Malachite Green (MG) dye from synthetic wastewater. The synthesis process involves the transformation of waste aluminium foil into gamma alumina through a controlled procedure using hydrochloric acid and Sulfuric Acid. The structural and morphological properties of the prepared γ-Al_2O_3 are characterized using BET, FTIR, FESEM, and XRD. The γ-Al_2O_3 is then employed as an adsorbent to remove MG dye from aqueous solutions by varying temperature, agitation speed, pH, and initial dye concentration. The results reveal that the optimal conditions for maximum MG dye removal are achieved at pH 8, with a removal efficiency of approximately 90% after 3 hours, using a 30 ppm dye solution, 130rpm agitation speed, and a 1.5g/L adsorbent dose. Kinetic studies are conducted to understand the adsorption behavior over time, providing insights into the mechanism and rate of the removal process. The adsorbent is successfully regenerated 6 times. The findings contribute to the development of eco-friendly and cost-effective solutions for wastewater treatment, utilizing recycled materials for environmental remediation.

Keywords: gamma alumina; recycled materials; adsorption

Comparative Experimental study of Alkali and Acid Pre-treatments for Enhanced Xylose Recovery from Various Waste Biomass Feedstocks

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Abstract
This study presents a comparative experimental analysis of alkali and acid pre-treatment methods for enhancing xylose recovery from various lignocellulosic waste biomass feedstocks, including rice husk, moringa leaf powder, water hyacinth, papaya peel powder, and wood waste. Pretreatment is a crucial step in disrupting the complex lignocellulosic matrix to release hemicellulosic sugars such as xylose, which are key intermediates in synthesis of biofuels. Biomass samples were subjected to acid pre-treatments using 2%-3% dilute sulfuric acid (H_2SO_4), hydrochloric acid (HCl), and alkali pre-treatments using sodium hydroxide (NaOH) and potassium hydroxide (KOH), under controlled temperature and concentration conditions. The pretreated hydrolysates were analyzed using spectrophotometric methods to determine xylose concentration. Structural and compositional changes in the

biomass samples were further characterized by X-Ray Diffraction (XRD), Fourier-Transform Infrared Spectroscopy (FTIR), and Thermogravimetric Analysis (TGA). XRD provided insights into crystallinity alterations, while chemical state changes in the biomass were analysed through FTIR. Results showed significant differences in xylose yield depending on both the pre-treatment method and the type of waste biomass. Acid pre-treatments generally resulted in higher xylose release, while alkali pre-treatments were more effective in delignification. The primary objective of this experimental study is to make a right combination of pre-treatment method and waste biomass feedstock for getting higher biofuel production.

Keywords: Waste Biomass; Pre-treatment; Xylose; Lignocellulose

Degradation of Crystal Violet Using Bi_2wo_6 Photocatalyst via Persulfate-Based Advanced Oxidation Process

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Abstract
Textile wastewater containing synthetic dyes like crystal violet (CV), a toxic cationic dye from the triphenylmethane group, poses a significant environmental challenge due to its high toxicity, chemical stability, and resistance to conventional treatment methods. In this study, n-type Bi_2WO_6 photocatalyst were synthesized via a hydrothermal approach by maintaining the reaction temperature between 160 and 200 °C overnight. The synthesized material was systematically characterized using X-ray diffraction (XRD), UV–Vis spectroscopy, photoluminescence (PL), field emission scanning electron microscopy (FESEM), energy-dispersive X-ray spectroscopy (EDS), Fourier-transform infrared spectroscopy (FTIR), Brunauer–Emmett–Teller (BET) analysis and zeta potential. The photocatalytic performance of Bi_2WO_6 was assessed under visible-light-driven persulfate-assisted advanced oxidation processes (PS-AOPs) for the degradation of CV dye. The results demonstrated almost complete degradation in around 45 minutes. Radical scavenging experiments confirmed that sulfate ($SO_4^{\bullet -}$) and hydroxyl (•OH) radicals were the dominant reactive species responsible for CV degradation. The superior photocatalytic activity is attributed to the efficient activation of persulfate by Bi_2WO_6, which enhances the generation of reactive oxygen species (ROS) under visible light. This study highlights the potential of Bi_2WO_6 as a promising photocatalyst for sustainable and effective treatment of dye-contaminated wastewater, offering an alternative for advanced wastewater remediation technologies.

Keywords: Textile wastewater; Photocatalytic degradation; Reactive oxygen species

Monitoring and Accumulation of Atmospheric Heavy Metals Using *Pterospermum Acerifolium* Plant Biomonitor and Its Phytoremediation Potential

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Abstract

The continuous influx of heavy metals (HMs) in the environment through anthropogenic activities has become an environmental problem due to their toxicity, persistence, and biomagnification characteristics. This study evaluates the biomonitoring and phytoremediation potential of *Pterospermum acerifolium* plant for atmospheric HMs mainly Pb, Cd, Hg, As and Cr based on accumulation and bioconcentration pattern. The study was conducted in the Maidan region of Kolkata, an urban area with heavy traffic load in West Bengal, India. The individual metal concentration was checked in leaves and root of the plant and surrounding soil by acid digestion followed by ICP-OES analysis. The leaves of *P. acerifolium* exhibited high level of accumulation of Pb (199 mg Kg^{-1}), Cr (7 mg Kg^{-1}), Hg (5.84 mg Kg^{-1}), Cd (5.7 mg Kg^{-1}) and As (3.4 mg Kg^{-1}) whereas the root shows different pattern of HM capturing; Pb> Hg>As>Cr>Cd. To understand the phytoremediation potential of the plant, HMs load of surrounding soil sample was investigated and resulted the presence of Pb (92 mg Kg^{-1}), Hg (6.08 mg Kg^{-1}), Cr (3.82 mg Kg^{-1}), As (2.93 mg Kg^{-1}) and Cd (1.8 mg Kg^{-1}). The HMs concentration level in soil suggests very high Contamination Factors along with high Geoaccumulation Index values for Hg and As, demonstrating serious pollution level. The high Metal Accumulation Index (MAI) value of plant leaves (76.76) indicates plant's biomonitoring potential for capturing HMs from air. For most of the HMs, the Bioconcentration Factor (BCF) values are greater than unity which demonstrates the plant's phytoremediation potential as well. Hence, findings reveal remarkable capacity of *P. acerifolium* in simultaneous accumulation of HMs in leaf and root from air and soil, respectively.

Keywords: Heavy Metals; Biomonitoring; *Pterospermum acerifolium*; Bioconcentration factors

Substrate-Free Synthesis of Ni- Cnf for Efficient Adsorptive Cr(Vi) Removal from Water and Cr (Vi)-Spiked River Water with Electrochemical Insight

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Abstract

This study investigates the efficiency of Ni-CNF for the removal of hexavalent chromium [Cr(VI)] from both wastewater and Cr(VI)-spiked river water. Cr(VI) adsorption behavior was studied under varying conditions, including contact time, solution pH, initial metal concentration, and adsorbent dosage. Optimal adsorption was observed at pH 2, a contact time of 180 minutes, a Cr(VI) concentration of 100 mg/L, and an adsorbent dosage of 0.25 g/L at 30 °C. The maximum adsorption capacity, modeled using the Liu isotherm, was found to be 98.18 ± 7.85 mg/g. Kinetic studies indicated that the adsorption process follows a pseudo-second-order kinetic model. The adsorption mechanism is primarily governed by electrostatic interactions (under pH ≤ PZC), the presence of surface functional groups, and pore-filling effects. Compared to previously reported materials, Ni-CNF showed a notably high Cr(VI) uptake capacity. Electrochemical studies were also conducted using cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) in a three-electrode setup. The CV results displayed clear cathodic and anodic peaks, attributed to reversible Ni^{2+}/Ni^{3+} redox transitions. Additionally, a linear relationship between peak current and the square root of scan rate confirmed diffusion-controlled, reversible electrochemical behavior, which is favorable for battery-type applications. Electrochemical impedance spectroscopy (EIS) analysis revealed a solution resistance (R_s) of 76 Ω, indicating good ionic conductivity of the electrolyte. The charge transfer resistance (R_{ct}) was measured at 126 Ω, suggesting efficient electron transfer kinetics at the electrode–electrolyte interface. The observed Warburg impedance (W) of 577 $mMho \cdot S^{1/2}$ at low frequencies is indicative of diffusion-controlled process. Additionally, a double-layer capacitance of 15.6 µF was associated with the electrochemical interface, as represented in the Randles equivalent circuit. Overall, the study demonstrates that Ni-CNF is not only an effective adsorbent but also shows electrochemical activity that can be useful for remediation applications in the future.

Keywords: Carbon nanofiber; Chromium; Adsorption; Wastewater remediation.

Residence Time Distribution Measurement in a Subsurface Vertical Flow Constructed Wetland Using Radiotracer

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Abstract

Engineered subsurface constructed wetlands (CWs) has been proven to be reliable, cost effective and long-term solution for wastewater treatment. The optimal design and efficient operation of the CWs depends its hydraulic efficacy. Residence time distribution (RTD) measurement is an experimental tool to measure the hydraulic efficacy of CWs in terms of wastewater hydrodynamic parameters. For the measurement of the RTD of wastewater impulse of radiotracer was injected at feeding line of CW and monitored at different location

of the CW using radiation detectors. From the measured experimental curves different parameters such as flow distribution, mean residence time, hydraulic efficiency index, effective volume fraction and short-circuiting index of the wastewater in CW were estimated. Moreover, a flow model was developed to identify flow pattern and degree of mixing in the CWs. The experimental data indicated non-uniform distribution of the wastewater in wetland and the dead volume present was ~ 40%. The model and hydrodynamic parameter were suggested that e overall flow behavior of wastewater inside the wetland was to the plug flow as desired.

Keywords: Wastewater, Hydraulic Efficacy, Radiotracer

Utilization of Luffa Cylindrica Seeds Waste To Making Value Added Novel Adsorbent

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Abstract ID: OP-212

Abstract

Water is an essential element for human survival. Ensuring safe water supply and waste management benefits communities, the environment, and companies. As the city's water demand rises, resilient and efficient water and wastewater systems become increasingly important for long-term growth, viability, and sustainability.

Many countries and regions have strict environmental regulations and standards governing the discharge of wastewater. Industries are required to treat their wastewater to meet these standards before releasing it into water resources. Failure to comply with regulations can lead to legal consequences and penalties. In summary, tertiary treatment of industrial wastewater is essential to protect the environment, preserve water quality, ensure compliance with regulations, safeguard public health, and contribute to sustainable water management practices.This project explores the removal of heavy metal ions from industrial wastewater using Luffa cylindrica sponge as an adsorbent. Many researchers have tried various adsorbents prepared using agro-industrial waste. Most commonly used materials include coconut, walnut shell, corn cobs etc. Luffa cylindrica is also used as adsorbent by few researchers for removing heavy metals like Cr. However, most researchers have used either virgin or processed agricultural-waste and have used synthetic samples for experimentation. This work attempts to check separation efficiencies using virgin and processed material (luffa and seeds) as well as blends of virgin and treated materials. This will help in identifying the best material combinations for enhanced removal efficiency. Moreover, we will be also exploring the adsorption study for removal efficiency on an industrial wastewater.

Keywords: Luffa cylindrica, agricultural-waste, adsorption, heavy metals, industrial wastewater.

Performance Evaluation of Cement Mortars Incorporating Jarosite Waste Residues

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Abstract
This experimental investigation explores the utilization of 43-grade Ordinary Portland Cement (OPC-43 Grade) partially replaced by jarosite residue (JR). JR, after adsorption being a hazardous material due to adding one more pollutant in jarosite, was used in mortar instead of landfilling, therefore leading towards a sustainable use of materials, producing mortar. Cement mortar cubes were prepared with varying JR replacement levels-0% (control, 0% JR), and 3% to 15% JR in increments of 3% JR. The study aims to assess the influence of jarosite incorporation on compressive strength, initial setting time, and final setting time of the cement mortar. The inclusion of jarosite up to 15% notably increased these parameters compared to the control mix, with compressive strength, initial setting time and final setting time. These findings highlight jarosite's potential as a beneficial supplementary material for cement replacement. Among all mixes, the JR 9% formulation exhibited the highest compressive strength, 38.72 N/mm² at 7 days and 48.37 N/mm² at 28 days. While compressive strength showed a decreasing trend with higher JR content, indicating jarosite's viability as a partial cement substitute without compromising early-age strength. This study presents an innovative approach to sustainable processes, offering a potential solution to managing waste.

Keywords: Cement,Jarosite Residue, Sustainability, Mortar Cubes

Waste to Watts: Potassium Acetate-Activated Litchi Peel as a Green Electrode for Supercapacitors

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Abstract

The development of low-cost, high-performance, and eco-friendly electrode materials is crucial for advancing sustainable energy storage systems. In this study, litchi peel, an abundant agricultural waste, was employed as a carbon precursor and activated through a one-step chemical activation using potassium acetate (CH_3COOK). The resulting biochar demonstrated an exceptionally high specific capacitance of 428.23 F/g at 2 mV/s, outperforming those activated with acetic acid (CH_3COOH) and potassium hydroxide (KOH), which exhibited capacitances of 229.37 F/g and 38.4 F/g, respectively. The CH_3COOK-activated carbon also exhibited high Brunauer–Emmett–Teller (BET) surface area, indicative of a highly porous architecture conducive to enhanced ion transport. Electrochemical cycling revealed 75% capacitance retention after 4000 cycles, affirming the material's long-term stability. Unlike conventional activators such as KOH, potassium acetate is a milder, biodegradable agent, aligning with principles of green chemistry. This study highlights the potential of CH_3COOK as a sustainable and effective activating agent, paving the way for environmentally benign fabrication of high-performance carbon-based electrodes from biowaste. The approach offers a promising route for scalable and cost-effective supercapacitor production, while contributing to circular economy and waste valorization strategies.

Keywords: Biowaste valorization; Chemical activation; Activated carbon; Potassium acetate activation; Supercapacitor electrode

Pilot Scale Study on Textile Wastewater Treatment Using Coagulation-Flocculation

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Abstract
This study addresses the feasibility of coagulation-flocculation method as an effective treatment for textile industry wastewater, utilising a pilot-scale setup. Efficacy of the treatment was assessed based on the coagulant-flocculant dosages, and pH, resulting in effluent that satisfied standards of permissible limits. Here, aluminium sulphate is considered as coagulant and sodium aluminate as flocculant were effective in reducing colour, COD, turbidity and TDS levels from Real textile wastewater (RTWW). The ideal coagulant-flocculant dosage of 1000 mg/L was determined to achieve an exceptional colour removal effectiveness of 99.9%. This dosage resulted in significant reductions in COD (75%) and total elimination of turbidity (100%). Despite, achieving a TDS reduction of 19.56%, the final concentration of 3680 mg/L still over the CPCB (Central Pollution Control Board) allowed limit of 2100 mg/L. Similarly, conductivity decreased by 13.04%, yet remained above the acceptable threshold limit. Optimized coagulant -flocculant dosage achieved maximum colour removal efficiency with minimal sludge generation. This study highlights the sustainability and effectiveness of coagulation and flocculation techniques in the treatment of textile industry wastewater, offering a sustainable alternative for wastewater management. Further research is needed to optimise TDS and conductivity reduction for complete regulatory compliance, ensuring truly sustainable and ecological practices. Finally, This study highlights the potential of

coagulation-flocculation for large-scale textile wastewater treatment and provides valuable insights into optimizing treatment processes for maximum efficiency.

Keywords: COD; TDS; turbidity; conductivity; real textile wastewater; coagulant-flocculant dosage; sludge generation; colour removal.

Suitable Metal Recovery from E-waste : A Clean Technology Approach

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Abstract
The rapid growth in the use of lithium-ion batteries (LIBs) in electronic devices and electric vehicles has led to increasing concerns over environmental pollution due to the improper disposal of spent batteries. These batteries contain valuable and hazardous metals such as lithium, cobalt, nickel, and manganese, which, if not managed properly, can lead to significant environmental and health risks. This study presents a comprehensive review of various techniques for metal recovery from waste LIBs, with an emphasis on pyrometallurgical, hydrometallurgical, and emerging alternative methods. Each method is critically analyzed based on its recovery efficiency, economic feasibility, scalability, and environmental impact. The hydrometallurgical process is highlighted for its selectivity and lower operating temperatures, whereas the pyrometallurgical method is noted for its simplicity and high throughput. Novel approaches, including bioleaching and electrochemical methods, are also explored for their potential in sustainable battery recycling. The report also discusses the reintegration of recovered metals into the battery production cycle to promote circular economy principles and reduce dependency on virgin raw materials. Overall, this study aims to guide future developments in sustainable battery waste management and contribute to the advancement of green technologies and responsible resource utilization.

Keywords: Battery, Lithium, Hydrometallurgical, Metal, Economy

Conversion of Cigarette Butt Waste into Functional Composite Biochar: A Sustainable Approach to Waste Valorization and Adsorption Applications

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Abstract

Cigarette butts (CBs), one of the most commonly littered single-use wastes globally, pose a significant environmental hazard due to their non-biodegradable cellulose acetate (CA) filters and residual toxic chemicals. This research investigates the recovery and valorization of CA from discarded CBs for formation of biochar. CBs are systematically collected, segregated, and subjected to a rigorous pre-treatment process involving sequential aqueous and ethanol washes, followed by alkaline soaking to remove nicotine, tar, and other water-soluble and hydrophobic contaminants. The purified filters are then oven-dried, mechanically shredded, and dissolved in various organic solvent systems to obtain casting solutions of controlled viscosity and polymer concentration. The purified CBs are chemically activated using KOH and simultaneously doped with transition metal salts such as $FeCl_3$ and $Ni(NO_3)_2$, then pyrolyzed at controlled temperatures (500–700 °C) under a nitrogen atmosphere to yield porous, metal-doped biochar composites. The resulting materials are characterized using FTIR (functional groups), SEM/EDX (morphology and elemental distribution), TGA (thermal stability), and XRD (phase composition). Surface area and pore structure are evaluated via BET analysis. To evaluate environmental performance, the biochar is applied in adsorption studies involving methylene blue and Pb^{2+}/Cu^{2+} heavy metals, with adsorption capacity determined through UV-Vis spectroscopy. The study demonstrates a sustainable route to convert hazardous waste into a low-cost, high-performance material capable of addressing multiple global challenges. This work not only diverts CBs from landfills and water bodies but also provides a novel carbon-based platform with hybrid functionality for both environmental purification and clean energy technologies.

Keywords: Cigarette Butts; Composite Biochar; Chemical Activation; Adsorption; Waste Volarization; Sustainability

Design of a Smart Multi-Stage Filtration System for Rural and Industrial Water Purification

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Abstract

The Smart Multi-Stage Filtration System is an innovative solution designed to provide clean and safe water for both rural communities and industrial applications. It utilizes a combination of chemical and biological processes to remove a wide range of contaminants including microbes. The system combines physical, chemical, and biological filtration using locally available media—gravel, sand, activated carbon, and nanobiochar enhanced with iron oxide nanoparticles—to remove turbidity, heavy metals, and odors. Nanobiochar, prepared from agrowaste provides a promising alternative over conventional adsorbents due to its high specific surface area, cost effectiveness, environmental friendliness and has excellent capability of adsorbing pollutants and contaminants thus offering a potential waste management substitute. An antimicrobial layer using silver nanoparticles is incorporated to eliminate pathogens. The model is integrated with low-cost sensors (pH, TDS, turbidity, conductivity) connected to a microcontroller for real-time water quality monitoring. Data is displayed on an LCD or transmitted via an IoT platform for remote tracking, powered by solar

or USB battery. It is adaptable for both small-scale rural applications and large-scale industrial use. The flowdiagram of the process is presented.

Keywords: Smart filtration; agrowaste; nanobiochar; water quality monitoring

Sustainable Recovery of BHET from Polyester-Cotton Textile Waste via Hydrothermal Separation and Glycolysis

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Abstract
The persistent accumulation of polyethylene terephthalate (PET) waste from polyester textiles poses a significant environmental challenge due to its slow degradation in landfills. Chemical recycling through glycolysis offers a sustainable approach by converting PET into bis(2-hydroxyethyl) terephthalate (BHET), a key monomer for producing new PET and other materials. This study examines the glycolysis of waste polyester cloth using ethylene glycol and a catalyst, with an emphasis on optimizing reaction conditions to enhance efficiency and sustainability. The process employs a catalyst at concentrations of 0.1-1% (w/w), achieving high PET conversion and BHET yields at temperatures ranging from 150-200°C, with reaction times between 2 to 5 hours and stirring speeds of 400-600 rpm. The methodology includes preprocessing the textile waste through shredding and cleaning, followed by catalytic glycolysis and subsequent purification of BHET, effectively transforming waste into valuable chemical precursors. The catalyst is selected for its cost-effectiveness and environmental compatibility, making it suitable for industrial-scale applications. However, challenges such as high energy consumption and the handling of impure PET waste require further optimization. By facilitating the recycling of polyester textiles, this glycolysis method supports circular economy principles, reducing dependence on virgin petrochemicals and alleviating plastic pollution. The research highlights the potential of catalyzed glycolysis as a viable, scalable approach for textile waste management, encouraging its wider implementation in industrial recycling practices.

Keywords: Cotton waste, BHET, textile recycling, circular economy, PET production

Sustainable Waste Management and Circular Economy: Innovative Practices

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Abstract

Sustainable waste management (SWM) is vital for advancing circular economy (CE) transitions by improving resource efficiency, reducing environmental impacts, and enhancing climate resilience. However, despite progressive CE policies, translating them into effective industrial practices remains difficult due to regulatory gaps and enforcement limitations. This study integrates academic perspectives with operational insights to develop a scalable framework for circular waste governance. It assesses the alignment of industrial waste practices with CE principles, identifies key enablers of circular transitions, and explores how practical experience can inform cross-sector scalability. Technological innovations—such as AI-powered sorting (improving recyclability by 40%), digital traceability systems (enhancing compliance by 30%), and bio-waste valorization (reducing organic waste by 50%)—are supported by policy tools like Extended Producer Responsibility (EPR) and Environmental, Social, and Governance (ESG)linked financial incentives. Together, these mechanisms enhance accountability and attract investment in recovery infrastructure. By combining practitioner experience with academic models, the study proposes a practical, multi-level approach that connects industrial strategies to regulatory mandates. The findings offer actionable pathways to accelerate CE adoption, especially in emerging economies constrained by infrastructure and enforcement challenges. This research contributes to sustainable waste governance by delivering evidence-based recommendations with direct applicability to industry, policymakers, and development stakeholders.

Keywords: Sustainable Waste Management; Circular Economy; Digital Traceability; Bio-Waste Valorization; Extended Producer Responsibility (EPR); Environmental, Social, and Governance (ESG); Climate Resilience

Mechano-Chemical Assisted BRS Processing of Agricultural Waste to MCC to Highly Functionalized LGO: A Sustainable and Greener Solution

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Abstract

A paradigm shifts towards sustainability and reduction in carbon footprints evolved the concept of bio-refinery based on utilization of renewable biomass feedstock for production of high value chemicals, which has the potential for commercialization in near future. Among variety of biomasses, coconut leftover i.e., husk often improperly disposed of, poses environmental challenges. This study outlines a sustainable, green pathway to convert coconut husk into high-value products—microcrystalline cellulose (MCC), furfural, and levoglucosenone (LGO)—with applications in chemicals, food, pharma, cosmetics, and composites. The process integrates: (i) hydrodynamic cavitation pretreatment to extract cellulose, (ii) acid hydrolysis to produce α-MCC, (iii) NADES-assisted catalytic pyrolysis to obtain LGO and furfural, and (iv) downstream recovery of lignin and hemicellulose from pretreatment effluents. This approach ensures waste valorization and promotes circular bioeconomy principles. Rice husk is pretreated under optimized non-thermal conditions by varying alkali concentration (2–5%), rotational speed (1200–1800 rpm), and time (60–90 min) to maximize lignin removal with 75% cellulose recovery. The recovered cellulose undergoes

HCl acid hydrolysis to yield α-MCC with >75% crystallinity index and 95% purity. Subsequently, MCC is functionalized via catalytic pyrolysis using biodegradable, recyclable deep eutectic solvents (NADES: choline chloride with p-toluene sulphonic acid/zirconium sulphate). This process achieves high selectivity for LGO (9.59%) and furfural (56.8%). This investigated process supports the circular economy by converting coconut waste into valuable chemicals, which reduces chemical usage and energy demands and reliance on fossil fuels promoting environmental sustainability.

Keywords: Sustainability, NADES, Hydrodynamic cavitation, cellulose, Pyrolysis, LGO, MCC.

Development of a Cao/G-C_3N_4 2d Material For The Elimination Of Cr (Vi) from Wastewater: Characteristics, Optimization, Kinetic, Isotherm and Thermodynamic Studies

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Abstract

The release of untreated industrial effluents containing heavy metals poses severe threats to ecosystems and public health, with chromium (Cr), particularly in its hexavalent form, being among the most toxic contaminants. Conventional treatment methods often face limitations in cost, selectivity, and efficiency, necessitating the development of novel adsorbents. In this work, a CaO/g-C_3N_4 2D composite was synthesized and characterized by XRD, FT-IR, SEM-EDX and BET techniques. The adsorption trials were executed and found the optimized solution using response surface methodology (RSM). The experiments included parameters like pH 2, initial chromium concentration 10 mg/L, adsorbent loading 0.5 g, and contact time 60 min, respectively. Cr (VI) removal achieved high removal efficiency at the optimum combination of these process parameters. The synergistic coupling of green-synthesized CaO with sheet-like g-C_3N_4 enhanced surface area, porosity, and reactive sites, enabling improved adsorption. Kinetic modeling confirmed pseudo-second-order chemisorption, while isotherm analysis showed Langmuir monolayer adsorption. Also, the uptake process followed the thermodynamic study indicated that the uptake process is exothermic and spontaneous.

Keywords : Industrial effluents, CaO/g-C_3N_4 nanocomposite, green synthesis, Cr (VI), Adsorption, Wastewater treatment, kinetics, isotherm

Green Hydrogen Generation from Waste ZLD Salt Generated in the Tannery Industry from Waste Water Treatment

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Abstract
This paper proposes a novel method to produce green hydrogen from waste salt generated in Zero Liquid Discharge (ZLD) processes in the tannery industry. Saline effluents produced by tanneries often account for large volumes of saline effluent, and after treatment and crystallization of ZLD processes, these salt wastes pose a disposal challenge. This research study presents a sustainable option to utilize waste salts for energy. The study contains an in-depth characterization of the ZLD salt using XRD and SEM to analyze its crystal structure and composition, which is important for optimized electrolysis. The electrolysis is done appropriately with a solar-powered system that features a 1.5V photovoltaic cell, and the dissolved salt acts as an electrolyte. During electrolysis, the system utilizes a copper cathode and a nickel anode. During the electrolysis process, hydrogen gas is produced by electrolysis producing green hydrogen gas for the environment. The hydrogen gas was captured using a Pressure Swing Adsorption (PSA) system, which achieved a significant value of 75% hydrogen-collection efficiency. The evidence proved that even while simultaneously dealing with industrial waste, environmentally conscious methods could be operationalized for the clean energy transition. Having multiple systems in place achieves dual objectives of a remediation measure for pollutants and recovery of sustainable materials used for functionality.

Keywords: Zero Liquid Discharge (ZLD), Tannery Industry, Pressure Swing Adsorption.

Sustainable Utilization and Detoxification of ZLD Salt Waste Generated from Pharmaceutical Industries

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Abstract
The rapid expansion of pharmaceutical industries has resulted in significant environmental concerns, particularly due to the generation of Zero Liquid Discharge (ZLD) salt waste. Although ZLD systems minimize liquid effluent discharge, the accumulated salt waste poses serious challenges in terms of safe disposal, environmental toxicity, and resource recovery. This project focused on the sustainable utilization and detoxification of ZLD salt waste generated from pharmaceutical processes. The collected samples of ZLD salts were characterized for their physico-chemical properties and toxic metal content. A combination of

detoxification techniques including washing, chemical treatment, and bio-remediation approaches was successfully implemented to reduce the concentration of hazardous constituents such as heavy metals and residual organics. The treated salt was evaluated for possible value-added applications, such as its reuse in secondary industrial processes, preparation of construction materials (e.g. bricks), and recovery of useful inorganic compounds. Toxicity studies confirmed that the detoxified salt exhibited a significant reduction in environmental risk. The outcomes of this project demonstrate that through appropriate treatment, ZLD salt waste can be transformed from an environmental liability into a potential resource.

Keywords: ZLD, salt waste, pharmaceutical industry, detoxification, sustainable utilization, circular economy.

Harnessing Agricultural Waste for Sustainable Oil-Water Separation

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Abstract
Two major environmental problems have been identified i.e. the proper disposal of agriculture waste and the treatment of oil-polluted water. The present study addresses a path toward sustainable transformation of agricultural waste into separation material. The process began with making wood paper from post-harvest trash. Paper underwent chemical treatment after which a polystyrene coating was applied which produced hydrophobic-oleophilic characteristics necessary for selective filtering. The filter performance was measured through oil/water separation efficiency tests together with contact angle evaluations for surface wettability and durability tests across multiple use cycles. The modified agriculture waste filter showed performance by attaining separation efficiency higher than 85% for oil water mixtures. The modified surface showed a water contact angle of 98° while letting oil pass through freely. The filter retained its top performance for five back-to-back filtration operations. This research marks the initial proof of using agriculture as a raw material for developing durable oil/water separation filters that can be reused. Finally, this study presents a practical way of transforming agricultural waste to a value-added product. This method is a cost effective, eco-friendly option which at the same time solves issues regarding waste management & control of pollution and presents a sustainable option over traditional methods.

Keywords: Hydrophobic-oleophilic; Separation efficiency; Post harvest trash valorisation

Studies on Physicochemical Properties of Carbon Nanotubes Modified Bitumen

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Abstract
Bitumen, a viscous by-product of crude oil distillation, plays a vital role in global infrastructure as a key material in road construction. With increasing urbanization and a rising number of vehicles on the road, the demand for high-performance road pavements has grown significantly. Traditional bitumen, however, has limitations in withstanding heavy loads and prolonged traffic exposure, leading to issues such as rutting, cracking, and reduced service life of pavements. To address these challenges, enhancing agents are incorporated to improve the mechanical and rheological properties of bitumen. These agents include chemical additives, waste derived materials, polymers, and emerging nanomaterials. Nanotechnology has recently gained prominence in the field of pavement engineering due to the exceptional characteristics of nanomaterials, such as their high surface area-to-volume ratio, mechanical strength, and ability to interact at the molecular level with bitumen. Nanoclay, nanosilica, and carbon nanotubes are some examples that have shown promising results in enhancing bitumen's durability, stiffness, and resistance to environmental factors. Concurrently, the reuse of waste materials like plastic, rubber, fly ash, and construction debris has emerged as a sustainable solution to both improve bitumen performance and reduce the environmental burden caused by waste disposal. Numerous studies are reported in the recent literature on the application of both nanomaterials and waste-derived additives in modifying bitumen properties, resulting in improved pavement lifespan, reduced maintenance costs, and lower ecological footprints. This dual approach not only advances road engineering but also aligns with circular economy principles by converting waste into valuable resources.

Keywords: modified bitumen; nanomaterial; physicochemical

Advancing Net-Zero Goals in the Pulp Industry through Methanol Recovery from Black Liquor

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Abstract
The kraft pulping process generates significant amounts of black liquor, a complex and highly alkaline waste stream rich in organic compounds, particularly methanol. Traditionally, black liquor is incinerated to recover energy; however, this practice leads to emissions of volatile organic compounds (VOCs) and greenhouse gases, undermining sustainability goals in the pulp and paper industry. This study explores a more sustainable alternative by recovering methanol from black liquor using laboratory-scale batch distillation. The objective is to support the industry's transition toward net-zero carbon emissions.

Experiments were conducted under varying operating conditions to optimize methanol recovery and purity. The recovered methanol was characterized using FTIR, GC-MS, and UV-Vis spectroscopy to confirm its chemical integrity and potential for reuse. Under optimal conditions, methanol recovery reached 78.5% with a purity exceeding 94.5%, demonstrating the process's technical viability.

Integrating methanol recovery prior to black liquor combustion offers a promising strategy to reduce VOC emissions, lower the overall carbon footprint, and promote resource circularity. This research positions methanol recovery not just as a waste reduction technique, but as a proactive step toward more sustainable and environmentally responsible pulp production.

Keywords: Methanol recovery; Black liquor; Kraft pulping; Volatile organic compounds (VOCs); Batch distillation; Sustainable pulp and paper industry.

A Sustainable Chemocatalytic Route for Waste to Bioethanol Production: A Techno-Economic Perspective

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Abstract ID: OP-362

Abstract

The rise in population directly contributes to a heightened demand for food consumption, thereby resulting in its wastage. Managing this waste remains a significant challenge, as traditional methods such as landfilling and incineration harm the environment by polluting air, water, and soil. However, food waste, particularly non-edible cellulosic biomass such as vegetable peels, offers a sustainable and economical resource for biofuel production. Converting such waste into bioethanol not only addresses environmental concerns but also reduces dependency on limited petroleum reserves. Bioethanol and biodiesel are currently the most widely adopted biofuels due to their commercial viability. This study focuses on converting Potato Peel Waste (PPW) into ethanol using a bimetallic FeNi catalyst supported on multi-walled carbon nanotubes (MWCNTs). The catalyst's structural properties were thoroughly analyzed using various techniques, and its effectiveness in enhancing ethanol yield was successfully demonstrated. Our research emphasizes the valorisation of vegetable waste as a feedstock for bioethanol production, offering a sustainable alternative to conventional

disposal methods that contribute to greenhouse gas emissions. By replacing petrol in the transportation sector, bioethanol usage significantly curbs CO_2 emissions. Additionally, this approach reduces the need for virgin resource extraction, promoting annual environmental efficiency.

Keywords: Potato peel; Sustainable waste management; Biofuel; Circular economy; Technoeconomic analysis.

Sustainable Solid Waste Management a Potential Review

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Abstract
Rapid urbanization and population growth result in the production of large amounts of solid waste. Hence, proper handling of this huge amount of produced solid waste has become a global challenge. Although various conventional methods like landfilling, incineration, etc., are available for disposal of waste materials, most of these methods result in the generation of various greenhouse gases and land pollution, which creates serious environmental concern. Therefore, Integrated Solid Waste Management (ISWM) systems have become popular over traditional treatment techniques of solid wastes. This approach mainly emphasizes reducing, reusing, recycling, recovering, and disposing of generated solid wastes. These approaches serve as a better alternative to landfilling and incineration, as they reduce the environmental impact. It also encompasses the designing of effective Extended Producer Responsibility (EPR) schemes to minimize waste generation. In addition to this, material recovery and recycling is one of the crucial aspects. Besides, energy recovery through Waste-to-Energy (WtE) technologies also helps to improve the circular economy. The factors affecting the ISWM mainly include proper governance policy frameworks, engagement of the concerned community, and innovative financial mechanisms. Furthermore, the involvement of policymakers to develop regulatory environments and develop proper public awareness regarding waste segregation at the source also plays a pivotal role in effective waste management. Apart from this, integration of smart technologies like applications of IoT sensors for waste collection and systemic life-cycle assessments are essential parts of proper waste management technique.

Keywords: Integrated Solid Waste Management (ISWM); Recycle; Waste-to-Energy; Smart Technologies; Extended Producer Responsibility (EPR).

Removal of Organic Pollutants from Food Industry Waste Water by Using Photocatalytic Method

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Abstract
Wastewater from the food industry is often rich in organic pollutants, including oils, lipids, proteins, carbohydrates, and synthetic pigments from processing and cleaning operations. If released untreated, these pollutants can cause serious environmental pollution and increase chemical and biochemical oxygen demands (BOD and COD). Conventional treatment methods such as coagulation, adsorption, or biological processes are often unable to fully breakdown these complex chemical compounds. In this study, the photocatalytic method is employed to break down organic pollutants in wastewater from the food sector using semiconductor catalysts (such TiO) and UV/visible light irradiation. During the process, highly reactive hydroxyl radicals are created, which oxidize organic contaminants to produce harmless byproducts like carbon dioxide and water. Degradation effectiveness, which ranges from 88 to 92% in terms of organic pollutant elimination, is highly dependent on important factors such catalyst dosage, irradiation duration, pH, and pollutant concentration. This method has the benefits of great efficacy, low energy use, and little sludge production when compared to conventional treatments. According to the findings, photocatalytic technology holds promise as a sustainable and ecologically friendly way to treat food sector effluent, protecting the environment and purifying water sources.

Keywords: Wastewater Treatment, Organic Pollutant Removal, UV Irradiation, Photocatalysis, TiO Nanoparticles, and Environmental Sustainability

Removal of Arsenic Using Solar Powered Electrocoagulation System

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Abstract ID: OP-396

Abstract
This work focuses on a sustainable and innovative method for removing arsenic from water using a solar-powered electrocoagulation system. Arsenic contamination is a major concern in many parts of the world, particularly in rural and underdeveloped areas where access to clean drinking water and advanced treatment systems is limited. The electrocoagulation technique used in this study employs aluminium electrodes, which dissolve under direct electrical current to generate coagulants that effectively bind and remove arsenic from the water. By using solar energy as the power source, the system becomes environmentally friendly and cost-effective, making it ideal for deployment in off-grid and resource-limited settings. Key process parameters such as initial arsenic concentration, reaction time, current density, and reaction volume are carefully optimized to enhance arsenic removal efficiency. The addition of a synthetic adsorbent further improves performance by increasing the system's ability to capture and remove even low concentrations of arsenic. This hybrid approach of

electrocoagulation combined with adsorption ensures high purification rates while maintaining simplicity and affordability. Overall, this method offers a reliable, eco-friendly, and scalable solution for providing access to safe drinking water in arsenic affected regions, aligning with sustainable development and public health goals.

Keywords: electrocoagulation; adsorbent; contaminant

Removal of Lead Ions from Wastewater by Ultrafiltration Using Membrane

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Abstract
The removal of hazardous lead ions from synthetic wastewater can be accomplished more successfully with ultrafiltration (UF). The method is based on a high-performance cross-flow ultrafiltration device that incorporates a sturdy polysulfone membrane. The project's goal is to evaluate how well the PSf UF membrane minimizes lead concentrations to meet environmental discharge requirements. UF produces less secondary chemical sludge and runs continuously, providing more sustainability than more traditional techniques like chemical precipitation. Monitoring the system under certain operating circumstances, such as fluctuating transmembrane pressures, feed flow rates, and solution pH levels, is one part of the procedure. Determining the separation efficiency and viability of this membrane-based method for actual heavy metal removal in industrial wastewater streams is the main objective of the research. The goal of the research is to offer trustworthy, data-driven insights into a highly effective, sustainable, and successful lead removal technique in order to establish UF as a leader in heavy metal wastewater treatment applications in the future.

Keywords: Lead removal, Ultrafiltration, Polysulfone membrane, Wastewater treatment, Heavy metal remediation

Foam Fractionation as an Emerging Technology for PFAS Removal from Wastewater

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Abstract
Treatment of large volumes of water polluted with per- and polyfluoroalkyl substances (PFAS) has been considered a major challenge due to their persistence, bioaccumulation, and toxicity. Five main PFAS types—Perfluoroalkyl Carboxylic Acids (PFCAs), Perfluoroalkane Sulfonic Acids (PFSAs), Perfluoroalkyl Sulfonamides and Sulfonamidoacetic Acids, Fluorotelomer Compounds, and Common PFAS—have been identified and studied, comprising 26 compounds. The PFCAs group has included PFBA to PFDoDA (C4–C12), and the PFSAs group has consisted of PFBS to PFDS (C4–C10). Sulfonamide derivatives have included FOSA, N-MeFOSA, N-EtFOSA, N-MeFOSAA, and N-EtFOSAA, while Fluorotelomer Compounds have comprised 4:2, 6:2, and 8:2 FTSAs. Common PFAS have included GenX and ADONA.The sources of PFAS have been associated with paper coatings, stain repellents, surfactants, cleaning products, food packaging, textile finishing, non-stick cookware, lubricants, firefighting foams, coatings, and by-products from fluoropolymer manufacture. Some have also originated as degradation intermediates or replacements for PFOS and PFOA in industrial and firefighting applications.PFAS removal has been investigated through foam fractionation (FF), which has utilized air–liquid interfacial adsorption to separate PFAS from aqueous matrices. Although municipal wastewater has contained lower PFAS levels, landfill leachates and industrial effluents have shown higher concentrations. Aeration in wastewater treatment plants (WWTPs) has promoted PFAS adsorption and foaming, and integrating foam collection into aeration systems has enhanced removal. However, high suspended solids have hindered FF performance. Other removal methods have included adsorption, reverse osmosis, advanced oxidation, membrane separation, and coagulation.

Keywords:polyfluoroalkyl substances, persistence, foam fractionation, air bubbles, adsorption.

Magnetic TiO_2-Fe_3O_4- Alginate Nanocomposite for Efficient Photocatalytic Degradation Of Industrial Dye Under Solar Irradiation

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Abstract
The discharge of untreated industrial effluent, particularly from chemical, pharmaceutical, textile, and dyeing industries, has a significant harmful environmental effect due to the presence of nonbiodegradable, toxic, and color-intensive organic compounds. These pollutants significantly imbalance the ecosystem and also pose human health risks like cancer, endocrine disruption, etc., through bioaccumulation in the food chain. Traditional wastewater treatment

methods are available to remove industrial pollutants, but they are often inefficient, ineffective, costly, poor in reusability, energy intensive, and productive of secondary pollutants. To resolve this issue, advanced photo oxidation processes, especially hybrid semiconductor nanocatalyst-based photodegradation, have high efficiency, reusability, sustainability, cost-effectiveness, and environmentally friendly approaches for industrial pollutant degradation.

In the present work, magnetic Fe_3O_4-TiO_2-alginate nanocomposite was prepared via the ionic gelation method under ultrasonication at room temperature for efficient photocatalytic degradation of industrial pollutants in wastewater under natural solar irradiation. This system was designed for the degradation of industrial pollutants from real wastewater; here methylene blue was used as a model pollutant to evaluate the photocatalytic performance and kinetics. The nanocomposite was characterized using FT-IR spectroscopy, which confirmed the metal-oxygen bond, the functional group of alginates, and the nanoparticle-matrix interaction. The UV-visible absorption spectrum of synthesized TiO_2 and Fe_3O_4 nanoparticles showed a distinct λ max around 312nm and 290nm, indicating successful formation of nanoparticles. Dynamic light scattering (DLS) analysis showed an average hydrodynamic particle size of Fe_3O_4 and TiO_2 Nps of 878 nm and 179.4 nm, while zeta potential measures of -31mV and -26.1 mV, respectively, indicate moderate colloidal stability. In photocatalytic experiments, 90% degradation efficiency of the nanocomposite was achieved within 5 h at an 0.002mg/L initial concentration of MB and an initial dose of 2.5g/L under sunlight at neutral pH. Photocatalytic degradation rate followed pseudo-first-order kinetics (k=0.0089). This result signifies that the nanocomposite will become a remarkable tool for decontaminating organic pollutants from wastewater in the near future.

Keywords: Nanocomposite; industrial dye; photocatalyst; wastewater treatment.

Hybrid Electro-Chemical Coagulation Process for Waste Water Treatment

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Abstract

The Hybrid Electro-Chemical Coagulation (HECC) process is an emerging and sustainable wastewater treatment technique that integrates chemical coagulation with electrocoagulation to enhance pollutant removal efficiency. In this study, highly polluted industrial wastewater was treated using coagulants such as DK-SET, poly-aluminum chloride, and sodium hexametaphosphate (SHMP), followed by electrocoagulation performed at 3 V and 5 V with currents of 15–25 A for 1–4 hours. The initial wastewater exhibited high contaminant loads, including COD (6000 mg/L), TSS (2537 mg/L), TDS (267 mg/L), and turbidity (25 NTU). Chemical coagulation achieved moderate reductions, such as COD removal of 58.33% and TSS reduction of 64.60%. Subsequent electrocoagulation significantly improved treatment performance, with COD decreasing to 250 mg/L after 4 hours (95.83% removal). TSS and turbidity removals reached 98.42% and 98.8%, respectively, while TDS removal increased to 66.3%. The pH stabilized near neutrality (7.1–7.5) throughout EC treatment, indicating

improved water quality. The results confirm that HECC provides superior pollutant removal compared to conventional chemical coagulation alone. Its high efficiency, reduced chemical consumption, and improved effluent quality highlight HECC as a promising, eco-friendly, and cost-effective option for treating industrial wastewater.

Keywords: HECC, Chemical Coagulation, Flocculation, Energy Efficiency, Wastewater Treatment Optimization.

Experimental investigation on Fluoride Removal through the Adsorption Process Using Al-Activated Groundnut Cake Biochar

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Abstract
Fluoride contamination in groundwater remains a major public health and environmental concern in many Indian states, including Gujarat, Rajasthan, Odisha, Andhra Pradesh, and Telangana, where naturally occurring fluoride levels frequently exceed the WHO safe limit of 1.5 mg/L. The groundnut cake, typically generated in large quantities after oil extraction, was pyrolysed in a muffle furnace at 450°C to prepare biochar. This biochar was then crushed into a fine powder and chemically activated using aluminum chloride ($AlCl_3$). To evaluate the adsorption performance, batch experiments were conducted by varying adsorbent dosage (1–3 g), contact time (60–180 minutes), and initial fluoride concentrations (10 ppm- 30 ppm). SEM images revealed notable changes in surface morphology, showing enhanced roughness and the formation of micro- and mesopores after activation, while FTIR confirmed the presence of Al–O and other oxygencontaining groups that directly contributed to improved fluoride interaction. The activated biochar exhibited a maximum adsorption capacity of 1.48 mg/g, demonstrating that even a simple material derived from waste can offer meaningful treatment performance.
Keywords: Fluoride removal, agricultural waste biosorbent, biochar, waste utilization

A Review on Nano Silica Based Filter Medium for River Water Purification

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Abstract

Today water pollution is a global threat to the entire world. Source of surface water and ground water is decreasing day by day and for this reason alternative sources are to be chosen such as river water. River is such a source of water on which the people of both rural and urban areas are dependent. Considering necessity of water purification, different purification techniques, especially filtration techniques were studied in detail. Types of different filter medium were explained along with examples. Among various filter medium special focus was given on silica as filter medium. It was found to be advantageous over many filter medium on the basis of source, synthesis process, characterization, and efficiency. Sources of silica are easily available and are mostly found in natural products such as rice husk, sugarcane bagasse, different types grasses, vegetable wastes. Methods of silica synthesis from different sources were studied and acid-alkali-extraction processes were found to be easy and cheap. Size dependent properties of silica were identified and were found to be attractive for applications in filter medium. Size of silica was found to be a major parameter in application as filter medium because of activated surface area. Nano silica based gravity filter was found to be an efficient technique for river water purification. Water quality testing was done in terms of various parameter studies of water such as hardness, heavy metal content, TSS, TDS, BOD, COD, electrical conductivity (EC), pH, etc.

Keywords: River Water; Nano Silica; Gravity Filter; Water Purification; Extraction.

Extracting Cellulose Nanocrystals (CNCs) from Waste Paper

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Abstract ID: OP-463

Abstract

The conversion of waste paper into high-value nanomaterials offers a sustainable solution to deforestation, pollution, and landfill accumulation. In this study, waste paper was used as a renewable feedstock for extracting cellulose nanocrystals (CNCs), nanoscale biomaterials known for their high strength, crystallinity, and biodegradability. The extraction procedure involved deinking, alkali pretreatment, bleaching, and controlled sulfuric acid hydrolysis. Acetone deinking removed inks and dyes, while sodium hydroxide pretreatment eliminated hemicellulose and lignin, producing purified cellulose fibers. Acid hydrolysis selectively removed amorphous regions, yielding rod-shaped CNCs with improved crystallinity. FTIR analysis confirmed characteristic O–H and C–H stretching vibrations and β-1,4-glycosidic linkages, while SEM images showed the transformation of coarse fibers into smooth, needle-like CNCs. Further, CNCs were doped with TiO_2 nanoparticles using ultrasonication and heat treatment to enhance photocatalytic, mechanical, and antimicrobial performance. The findings highlight waste paper as a low-cost, renewable source for CNC production, promoting advancements in green nanotechnology.

Keywords: Cellulose nanocrystals, Waste Paper Recycling, deinking, alkali pretreatment, sulfuric acid hydrolysis, FTIR, SEM, TiO_2 doping.

Plastic Waste Conversion to Valuable Product

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Abstract ID: OP-465

Abstract
Waste caused by plastic is a major environmental problem because it is non-biodegradable. Through the use of chemical recycling, pyrolysis, or catalytic conversion, it can be converted to plastic trash into bio-based products or reusable monomers. In addition to addressing waste management issues, this strategy promotes a circular economy by turning garbage into environmentally beneficial substitutes. A major environmental problem that is affecting ecosystems and adding to global pollution is the build up of plastic garbage. Sustainable and creative waste management strategies are needed to meet this challenge. Using sophisticated chemical recycling methods including pyrolysis, depolymerization, and catalytic conversion. Plastic polymers can be broken down using these techniques into their basic monomers or biobased precursors, which can subsequently be converted into valuable commodities. Developing an eco-friendly and effective method to turn plastic waste into a depolymerised monomeric solution. The proposed methodology gives the glance of the conversion of polyethylene plastic into a monomeric solution which is depolymerised by the process of solvolysis of the plastic waste. It is a low temperature process comparative to pyrolysis which makes it more suitable for recycling of plastic waste.

Keywords: Depolymerisation, pyrolysis, catalytic conversion, monomeric solution, solvolysis.

Removal of Silica from Agro Biowaste

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Abstract

This project investigates a sustainable method for extracting high-purity silica from agro-biotech waste, specifically Rice Husk Ash (RHA), with the aim of reducing environmental impact and lowering production costs associated with conventional silica manufacturing. Rice husks, an abundant by-product of the rice milling industry, were subjected to controlled combustion at different temperatures—500°C, 600°C, and 700°C—to

obtain ash with improved reactivity and composition. The resulting ash was processed through acid and alkali treatment methods to remove impurities and isolate silica in both crystalline and amorphous forms. The purification significantly increased the silica content, which rose from approximately 9.24% in untreated ash to more than 90% after chemical treatment, demonstrating the effectiveness of the extraction process. This approach converts low-value agricultural waste into a high-value product, offering a promising alternative to traditional mining-based silica production and contributing to resource conservation. The project highlights the environmental benefits of reducing land waste and pollution while also presenting economic opportunities by utilizing a readily available and low-cost raw material. The high-purity silica obtained has the potential for wide application in industries such as ceramics, catalysts, composites, and advanced material development. Overall, the study supports the integration of waste management with sustainable material production, aligning with circular economy principles and promoting greener technological practices.

Keywords: Silica extraction, Rice husk ash, Agro-waste, Acid treatment, Alkali treatment.

Electrocatalytic Conversion of Nitrate-Contaminated Real Wastewater into Ammonia Integrated with Zn-Nitrate Batteries

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Abstract

Nitrate pollution in water has become a major environmental concern, largely driven by excessive fertilizer use and untreated industrial discharges. At the same time, ammonia is indispensable for food and chemical industries, though its traditional synthesis consumes substantial energy and contributes about 1.5% of global CO_2 emissions.[1] In contrast, electrocatalytic nitrate reduction reaction (NO_3RR) emerges as a promising route for achieving both efficient nitrate removal and sustainable NH_3 production from wastewater. However, attaining high NH_3 yield and Faradaic efficiency (FE) from wastewater remains a significant challenge.[2] In this work, we developed noble metal-free electrocatalysts synthesized via one-step, binder-free electrodeposition method. The optimized catalyst achieves an outstanding NH_3 yield of ~7600 $\mu g.h^{-1}.mg_{cat}^{-1}$ and an FE of ~90% at –0.9 V (vs. RHE) from wastewater. Furthermore, a Zn-NO_3^- battery assembled using best performed catalyst as the cathode exhibits a high peak power density of ~8 mW cm^{-2}, excellent stability, and FE of ~85%. This work demonstrates "a triple-win approach" for simultaneous nitrate removal, ammonia synthesis and powered zinc-nitrate battery, highlighting a novel "waste to-resource" strategy that aligns with the principles of a circular economy.

Keywords: Electrochemical Ammonia Synthesis; Zinc-Nitrate Battery; Electrodeposition; Nitrate Removal

Biodegradable Cellulose-Ionic Liquid Adsorbent for Heavy Metal capture from Model Refinery Effluent

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Abstract ID: OP-478

Abstract
Fresh water is one of the most important commodities for the sustenance of life. Therefore, water needs to be used responsibly and care should be taken not to pollute existing sources of fresh water. One of the major industrial consumer of fresh water are the petroleum refineries. However, after the water is used, it becomes laden with various pollutants viz. hydrocarbons, particulate impurities and salts of heavy metals. Thus, this waster cannot be discharged into water bodies without prior treatment. Conventionally, this polluted refinery discharge is treated in an effluent treatment plant (ETP) to meet the environmental regulatory parameters before being discharged. In ETP, the heavy metal contents are mainly removed by adsorption, chemical co-precipitation or via membrane separation. However, these methods are not environmentally friendly, since the release of the waste sludge generated in the process creates further pollution. Therefore, a novel sustainable alternative such as green adsorbent might be used for the treatment of refinery waste water. In this investigation, a cellulose based adsorbent loaded with an acetate based ionic liquid was synthesized and characterized by FTIR, SEM and BET. The synthesized adsorbent was further utilized for the removal of heavy metal components from model refinery waste water. The highest removal efficiencies of 98.4%, 93.5% and 96.5% were achieved for Cr^{3+}, Ni^{2+} and Pb^{2+} respectively after a treatment time of 3hrs maintaining an adsorbent:feed ratio of 0.003:1 (w/v) under ambient conditions of temperature and pressure.

Keywords: Ionic liquid, Cellulose, Adsorbent, Heavy metal, Refinery waste water.

Comparative Analysis of Adsorptive Desulfurization Process Using Modified Deep Eutectic Solvent Based Adsorbents Towards Model Jet Fuel Treatment

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Abstract

Fuels derived from petroleum crude contains high amount of sulphur and jet fuel is no exception. Combustion of fuels with high amount of sulphur compounds releases sulphur dioxide into the atmosphere which is not only a pollutant but also a green-house gas. In order to mitigate these environmental problems, desulphurization of fuels is done conventionally by the hydrodesulfurization (HDS) process. HDS however, has some drawbacks viz. extreme operating conditions (high temperature and pressure) along with the need for expensive catalysts. This process is also inefficient in the removal of heterocyclic sulphur compounds. These facts necessitate the development of alternative desulphurization approaches that will have lower operating cost and be capable of removing heterocyclic sulfur compounds efficiently. One such alternative is adsorptive desulfurization using a green adsorbent viz. Deep Eutectic Solvents (DESs) immobilizer on suitable support. In this research work, choline chloride and glycerol based DES modified with cupric chloride have been synthesized. This DES has been further immobilized in gelatin matrix varying the loading ratio (gelatin:DES) from 0.5:1 to 1.25:1 (by mass). These adsorbents have been characterized by Fourier Transform Infrared spectroscopy (FTIR) and ^{H}NMR. The highest desulfurization efficiency of about 92% has been achieved for model jet fuel employing the adsorbent containing 1:1 gelatin:DES when used in the ratio of 1:5 (adsorbent:feed), a treatment time of 180 minutes under ambient conditions of temperature and pressure.

Keywords: Desulfurization, model jet fuel, deep eutectic solvent, choline chloride/glycerol, adsorption.

Facile Solvo Thermal One Pot Synthesis of MIL-53(Fe) For Effective Adsorption Of MO And Rb – Insight into Performance, Mechanism and Economic Analysis

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Abstract ID: OP-481

Abstract

Dyes pose a significant threat to aquatic ecosystems due to their persistence and toxicity. Adsorption using Metal-Organic Frameworks (MOFs) offers a favorable approach for dye confiscation from wastewater. The present study investigates the potential of MIL-53(Fe), an iron-based MOF, for the exclusion of dyes Methyl Orange (MO) and Rhodamine B (Rb). MIL-53(Fe) is synthesized through Solvo thermal, followed by its thorough characterization using techniques such as X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Fourier Transform Infrared Spectroscopy (FTIR) and Brunauer–Emmett–Teller (BET). These characterizations confirmed the successful synthesis and provide insights into the structure and morphology of the synthesized MIL-53(Fe). Subsequently, the surface assimilation capacity and efficiency of MIL-53(Fe) for both dyes are evaluated through batch adsorption experiments. Factors such as initial dye concentration, interaction time, sorbent dosage, and

solution pH on the adsorption process followed by the isotherm and kinetic studies of both dyes are investigated. Further, thermodynamic studies, regeneration process followed by economic analysis are carried out. The research aims to establish MIL-53(Fe) by way of a viable and resourceful material for dye removal from wastewater, contributing to a more sustainable approach to wastewater treatment.

Keywords: MOF, MIL53(Fe), Methyl Orange, Rhodamine-B, Adsorption

Degradation of Pharmaceutical Contaminants and Inactivation of Pathogens in Simulated Hospital Wastewater by an Ozonation Process

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Abstract ID: PP-494

Abstract
Wastewater from the food and medical industries is one of the major causes of contamination of water bodies. The food industry accounts for 50-60% of industrial wastewater while the medical industry has a small yet significant amount due to the large concentration of contaminants such as antibiotics and bacteria. In India, easy access to antibiotics has resulted in the overuse of antibiotics in agriculture, livestock farming, and medical treatments, contributing to the development of resistant bacteria.
Ciprofloxacin (CIP) is an important antibiotic that kills bacterial cells by inhibiting the catalytic activity of DNA gyrase and topoisomerase IV enzymes during replication and transcription. CIP can also interact with human DNA topoisomerase II and has the potential to kill various human cells. Thus, CIP, along with other antibiotics like Enrofloxacin (EFX), pollution has become a serious threat to the environment and public health.
The scope of this study is to determine the reactive oxygen species formed and the effectiveness of using ozonation (an AOP) for decontaminating S. aureus, as well as degrading antibiotics CIP and EFX present in wastewater. We observed a 2-log reduction every 10 minutes before the colony count falls below detection limits. We also observed the formation of ROS even after scaling our setup to 15L indicating a drastic increase in ozonation efficiency.

Keywords:Reactive Oxygen Species (ROS); Advanced Oxidation Process (AOP); Ozonation

Linear and Nonlinear Modeling of Ciprofloxacin Uptake by Paper Cup/Natural Soil Fabricated Nanocomposite

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Abstract ID: OP-497

Abstract

This study explored the valorization of waste materials, specifically used paper cups and natural soil, by transforming them into efficacious bio-adsorbents, PC/NZnO and PC/NZnO/AAC@Fe_3O_4 through torrefaction followed by chemical modification for the eradication of the pharmaceutical micropollutant ciprofloxacin (CIP). The physicochemical characteristics of these adsorbents were evaluated using spectral analyses such as, SEM, TEM, FT-IR, XRD, VSM, XPS and EDX. The CIP adsorption capacity was examined under the parametric conditions, including pH (2-12), initial CIP level (5–80 mg/L), dose (0.01-1 g), sorption temperature (20-45°C), adsorption period (0.5-6 h), and rotation speed (90-140 rpm). The maximum CIP removal under ideal conditions was 87.31% for PC/NZnO and 98.62% for PC/NZnO/AAC@Fe_3O_4. Among the eight isotherm models tested, the Freundlich model demonstrated the best fit to the isotherm data while the adsorption kinetics followed the pseudo-second-order model among the five kinetic models. Thermodynamic investigations revealed that the process was spontaneous and endothermic in nature. Both PC/NZnO and PC/NZnO/AAC@Fe_3O_4 could be reused for up to six desorption-adsorption cycles. Notably, after six consecutives cycles of adsorption and desorption, the PC/NZnO/AAC@Fe_3O_4 sorbent maintained a removal efficiency of 75.86%. It also exhibited outstanding efficacy in eliminating CIP from real-life wastewater. This study suggests that PC/NZnO/AAC@Fe_3O_4 holds great promise as an effective and viable adsorbent for treating CIP-contaminated water towards potential real-world applications.

Keywords: Ciprofloxacin; Waste paper cup; Magnetic; Mathematical modelling; Reusability

Optimized Biofilm-Based Sulfate Removal from Industrial Wastewater Using a Tailor-Made Sulfate-Reducing Bacterial Consortium

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Abstract ID:OP-502

Abstract

Sulfate-reducing bacteria (SRB) are highly effective in remediating sulfate-rich industrial wastewater by reducing sulfate (SO_4^{2-}) to less toxic products such as hydrogen sulfide or elemental sulfur. This study employs a tailor-made SRB consortium previously validated in a patented two-chamber sulfate removal process (U.S. Patent 8,398,856 B2, Indian Patent 341914). The consortium also demonstrated high performance in a biofilm-based bioreactor, reducing sulfate from 1600 mg/L to discharge levels within 3.5 hours under ambient conditions, with a treatment capacity of 1.51 m^3/day using a 220-L reactor. Among tested configurations, a single-unit bioreactor was most suitable for continuous operation. Response Surface Methodology (RSM) optimization identified optimal conditions at an initial sulfate concentration of 1250 mg/L and a flow rate of 1.8 L/h. However, use of modified DSMZ 641

medium increased COD, limiting large-scale applicability. Medium optimization using a one-variable-at-a-time approach achieved sulfate removal efficiencies of 70% in suspended cultures and 78% in immobilized biofilms at 2000–3000 mg/L sulfate. Scale-up to a 9-L batch biofilm reactor achieved 76% sulfate reduction with optimized medium and 74% with DSMZ 641 within 4 hours. RSM identified optimal nutrients: 6 mL/L lactic acid, 500 mg/L yeast extract and ammonium chloride, and 750 mg/L potassium phosphate. Lower COD:SO_4^{2-} ratios enhanced reduction kinetics. Elevated COD was mitigated using an activated charcoal adsorption column incorporated in the existing treatment process.

Keywords: Sulfate-reducing bacteria, Sulfate bioremediation, Biofilm-based bioreactor, Response Surface Methodology, Activated charcoal adsorption

Sustainable Enhancement of Lemongrass Production Using Biofertilizer: Essential Oil Yield, GC-MS Profiling, and Post Extraction Waste Utilization for Mushroom Cultivation

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Abstract
Lemongrass (*Cymbopogon citratus*) is an aromatic crop valued for its citral rich essential oil, widely used in pharmaceuticals, nutraceuticals, and fragrances. This study presents a sustainable and circular approach to enhance lemongrass (var. Krishna) production upto 2 folds (compared to chemical fertilizer) through the application of liquid biofertilizer (Indian patent application 201731003023**),** and bacterial biofertilizer (Indian patent 347939). Essential oils were extracted using both hydrodistillation using conventional and indigenous steam distillation (ISD) techniques. GC–MS analysis revealed around 43 compounds. Neral (38.47%) was dominant in the liquid biofertilizer, while geranyl acetate (17.75%) dominant in the bacterial biofertilizer. Molecular docking revealed strong anti-angiogenic activity, and antimicrobial, antifungal potential components like by succinic acid di(geranyl) ester, germacrene B and α-sterol demethylase. Furthermore, oil extracted lemongrass biomass showed 69.49% biological efficiency for nutritionally rich, protein (11.11%), carbohydrates (66.9%), crude fiber (8.14%), fat (1.13%), and energy (322.21 cal g^{-1}) containing pharmaceutically important *Pleurotus ostreatus* production, demonstrating a circular, sustainable approach that enhances lemongrass productivity while reducing chemical fertilizer inputs. This is being implemented at field level among the marginalized women farmers of West Tripura.

Keywords: Lemongrass, liquid biofertilizer, bacterial biofertilizer, GC-MS, *Pleurotus ostreatus*

Optimization of Integrated Coagulation–Electrocoagulation and Gravity Filtration for Sustainable Pre-Treatment of Coalbed Methane Produced Water

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Abstract
The water generated because of coalbed methane (CBM) is associated with high oil and grease content, suspended solids, colloids and fine particulates, and poses a significant challenge to traditional treatment systems and expedites fouling of subsequent membrane processes. To deal with these problems, it is necessary to have strong and streamlined primary pretreatment techniques. This paper has developed and optimized an integrated coagulation-electrocoagulation (C-EC) process and succeeded by gravity filtration as a systematic way of effectively pretreating CBM generated water, which is consistent with a sustainable and advanced form of chemical engineering. Electrocoagulation with adjustable, surface-modified electrodes was combined with iron- and aluminum-based chemical coagulation to enhance in situ coagulant generation and pollutant destabilization. The design of experiments (DOE) was implemented to maximize the most important operational variables, which comprised coagulant dosage (20-200 mg/L), solution pH (4-12), mixing intensity (50-200 rpm) and contact time (0.5-6 h). The integrated C-EC process under optimized conditions removed 90-96% of oil and grease, total suspended solids, turbidity, and colloidal matter with the creation of a dense, settleable sludge, with desirable settling properties. Afterward, the importance of gravity filtration was tested as a grade sand (0.40 mm 0.8 mm), gravel (25 mm 5 mm), and agro-based filter media (14 mm 4 mm) polishing mediumMedia selection and grain-size optimization were based on breakthrough performance, headloss development, and operational stability. The integrated pretreatment system enhanced effluent quality, reduced fouling, and ensured reliable forward osmosis and membrane distillation performance, offering a sustainable solution for CBM produced water management.

Keywords: Coagulation-Electrocoagulation; Pretreatment Optimization; fouling mitigation

Integrated Forward Osmosis–Membrane Distillation System for Desalination of Coal Bed Methane Produced Water: Solar-Thermal Driven MD Performance

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Abstract
The water generated by the coalbed methane (CBM) is high in salinity and inorganic substances, which makes it difficult to utilize directly and presents serious challenges to the conventional desalination methods. This study aimed to eliminate these shortcomings by exploring a hybrid forward osmosis-membrane distillation (FO-MD) system that could allow sustainable desalination and useful usage of CBM-generated water, especially through membrane distillation (MD) on the driving conditions of solar-thermal. Forward osmosis was used as a pre-treatment measure to decrease salinity and foulant loading before MD and enhance system stability and increase membrane lifespan. Experiments of direct contact membrane distillation (DCMD) were performed using CBM produced water as well as FO permeate as feed stream in order to determine flux behavior, temperature dependency, salt rejection, fouling and scaling propensity, and quality of permeate. DCMD demonstrated stable performance and great salt rejection throughout a broad temperature range. It is important to note that the rate of fouling and scaling was significantly low when FO permeate was used as the feed of MD and this shows that FO is indeed an effective pretreatment strategy. The MD process was also tested in simulated solar-thermal conditions (50-90°C) to determine its suitability with renewable energy sources. Findings revealed a positive relationship between thermal driving force and permeate flux, which was strong. A detailed energy model of the integrated FO-MD system with the operation of solar-assisted MD was also created. Energy analysis showed the combined FO and solar-thermal MD system can attain high energy savings with high water recovery and permeate quality that can be reused in agriculture after post-treatment, which is specific to the site. Altogether, the results indicate that solar-thermal-powered FO-MD systems are technically feasible and sustainable as an innovative membrane-based system for CBM-produced water desalination and resource recovery.

Keywords: Forward osmosis-membrane distillation (FO-MD); Coalbed methane produced water; Solar-thermal desalination

Optimization of Hexavalent Chromium Removal from Tannery Wastewater by Electrocoagulation: A Comparative Electrode Study Using RSM

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Abstract
Industrial wastewater contaminated with hexavalent chromium poses significant environmental and public health hazards due to its persistent nature and toxicity demand reliable and cost-effective treatment technologies. This study investigates the potential of electrocoagulation as a pre-treatment method for chromium removal using aluminum and

copper electrodes, examined independently. The objective is to optimize the process parameters and perform a comparative evaluation to identify the most suitable electrode material for efficient and sustainable chromium remediation.

A Central Composite Design (CCD) was used to conduct the process optimization within the context of Response Surface Methodology (RSM) to determine how four operating parameters which seem to be critical (current density (4-8 mA/cm^2), initial pH (4-8), initial chromium concentration (100-160 mg/L) and electrolysis time (45-105 mins) affect chromium removal efficiency. A set of thirty experimental runs was conducted, and statistical analysis showed a good correlation of values between experimental and predicted ones with high coefficient of determination (R2 = 0.90) indicating sufficiency and validity of the developed quadratic model.

The optimal working conditions of the two electrode systems were identified as current density of 6 mA/cm^2, initial pH at 4, and 60 mins of electrolysis. Although both aluminum and copper electrodes exhibited promising removal efficiencies, clear distinctions were observed in terms of energy consumption, sludge characteristics, and post-treatment water quality. Such comparative insights are valuable for informed decision-making in real-world scenarios, particularly for industries seeking to adopt eco- friendly and cost-effective wastewater treatment strategies. In general, the combination of electrocoagulation and modern statistical optimization emphasizes the potential of the solution to be an inexpensive, non-toxic, and scalable method of heavy metal removal in industrial wastewater treatment.

Keywords: Electrocoagulation; Hexavalent chromium; Tannery wastewater; Response Surface Methodology; Sustainable treatment.

Selective Determination of Cr(Vi) in ACR Process Effluent Using UV-Visible Spectrophotometric Method

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Abstract

Activated Copper Chromite (ACR) is a burn rate modifier in solid propellant formulations for rocket engine. The effluent generated during the production of ACR contains toxic hexavalent chromium (Cr(VI)) metal ions, which is potentially hazardous for the environment. As per CPCB, general standards for discharge of environmental pollutants, Cr(VI) concentration, should be less <0.1 ppm for safe disposal. In this study, a UV-Visible spectrophotometric method was developed and standardized for the determination of Cr(VI) in the ACR effluent using 1,5diphenylcarbazide as the chromogenic reagent. The parameters such as, concentration of chromogenic reagent and reaction time were optimized for the estimation of Cr(VI). This analysis exhibits a level of precision and accuracy, evident from the RSD values below 1 % and the recovery values falling within the range of 90-110 %. As the ACR process effluent contains, several other cations such as Cu(II), Ba(II) and Cr(III), the interference of these ions on determination was evaluated by spiking with the known standards.

Sustainable Nanocomposite SPEEK Membrane for Heavy Metal Reduction in Microbial Fuel Cells

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Abstract
Hexavalent chromium (Cr(VI)) is a major source of environmental pollutants from tannery effluents. Reduction of hexavalent chromium was performed in a 500 mL working volume dual chamber microbial fuel cell (MFC). Synthetic wastewater containing Cr(VI) was used as anolyte and substrate for mixed microbial consortia to release electrons. The ions produced were transferred to cathodic chamber via a Proton Exchange Membrane (PEM). In this study, sulphonated polyether ether ketone (SPEEK) – Nanocomposite was used as PEM and compared with the earlier study where only SPEEK was used as PEM. The microbial consortia that aided the treatment were used as biocatalysts. The Cr(VI) reduction observed were ±50% in both cases for a hydraulic retention time of ± 20 days. However, COD and BOD were reduced below the detection level. Nanocomposite membranes offer a powerful, adaptable, and economical solution for improving MFC efficiency and longevity. They significantly enhance proton conductivity, mechanical strength, anti-fouling resistance, and cost-efficiency, making MFCs more practical for large-scale and long-term use. Further optimization and scale up studies are to be conducted in 10 L reactor. Thus, MFC with nanocomposite membrane proves to be a promising technology in wastewater treatment complying with the Sustainable Development Goals (SDG) 6 and 7.

Keywords: hexavalent chromium removal; microbial fuel cell; SPEEK - nanocomposite

Biopiles Treatment of Petroleum Contaminated Soils at Petrol Stations

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Abstract
Petrol stations are vulnerable to soil contamination due to accidental spillages and leakages of petroleum products such as gasoline, diesel, and lubricating oils. These contaminants pose significant environmental risks, particularly to soil quality and ground water resources. Biopiles represent an effective ex-situ bioremediation process for the treatment of hydrocarbon-contaminated soils generated from such sites. In this process, contaminated soil is excavated and placed into engineered piles constructed on impermeable liners to prevent secondary contamination and to enable controlled leachate collection. The biopile system is designed to enhance aerobic microbial activity through proper aeration, moisture control, nutrient supplementation (biostimulation) and also using bioaugmentation process, indigenous

or selected microbial cultures for further accelerates hydrocarbon degradation. The primary remediation mechanism involves microbial respiration, wherein petroleum hydrocarbons are utilized as a carbon and energy source, resulting in their breakdown into environmentally benign end products. Biopiles are particularly suitable for petrol station remediation due to their comparatively lower land requirement than conventional land farming, costeffectiveness relative to thermal desorption or incineration, and adaptability to sitespecific constraints. Upon meeting regulatory standards, the treated soil can be safely reused as backfill material, contributing to sustainable waste management practices. This study also highlights the operational parameters, design considerations, and practical applicability of biopiles for managing hydrocarbons contamination at petrol stations, demonstrating their potential as an environmentally sustainable and economically viable remediation solution.

Keywords: Soil Contamination, Hydrocarbons, Biopiles

Valorization of Agro and Textile Waste: Starch Films from Artocarpus Heterophyllus Seeds Reinforced With Microcrystalline Cellulose From Waste Cotton Fabrics

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Abstract

The global consumption of nearly 350 million tons of petroleum-based plastics annually has resulted in severe environmental pollution due to their non-biodegradable nature and reliance on finite fossil resources. This study explores a sustainable alternative through the development of biodegradable bioplastics derived from renewable biomass. Jackfruit (*Artocarpus heterophyllus*) seeds, an underutilized agricultural by-product, were utilized as a starch source for bioplastic formulation. Starch, composed of amylose and amylopectin, undergoes gelatinization upon heating, enabling film formation through hydrogen bonding with water. To enhance mechanical strength and flexibility, cellulose fibers were incorporated as a reinforcing agent, while glycerol was employed as a plasticizer to improve flexibility by reducing intermolecular forces between polymer chains. The jackfruit seed–derived bioplastic exhibited rapid biodegradability, achieving a 67% weight reduction within five weeks. Among the plasticizers studied, glycerol-based bioplastics showed superior plasticity, minimal colour deviation, and faster biodegradation compared to sorbitol-based films, establishing glycerol as a more effective and eco-friendlier plasticizer for sustainable bioplastic production. This work contributes to the advancement of green technology and highlights the feasibility of converting agricultural waste into environmentally sustainable materials.

Keywords: *Artocarpus heterophyllus seeds; Waste cotton fabrics; Starch films; Cellulose; Bioplastics*

Safe Handling SWM Tools for Used Blood Transfusion Bags

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Abstract

Used Blood transfusion bags constitute a critical category of infectious biomedical waste due to the potential presence of blood-borne pathogens such as HIV and Hepatitis (B&C). Improper handling and disposal of these materials pose serious risks to healthcare workers, public health, and the environment. This paper discusses solid waste management (SWM) tools and safe handling practices adopted for the effective management of used Blood transfusion bags in healthcare facilities.

This paper also aims to provide practical insights for healthcare institutions and waste management professionals to strengthen biomedical waste governance systems.

Key elements of SWM include segregation at the source, utilization of color-coded and leak-proof non-chlorinated plastic bags, and deployment of puncture-resistant containers for associated sharps. On-site pre-treatment through autoclaving is highlighted as a reliable disinfection method, ensuring pathogen inactivation prior to further processing. Post-treatment, waste is transferred to authorized Common Biomedical Waste Treatment Facilities (CBWTFs) for final disposal through environmentally compliant incineration or secured landfilling.

The study also emphasizes the importance of safe handling protocols such as mandatory use of personal protective equipment (PPE), proper needle management practices, and elimination of manual recapping or bending of sharps. Integration of digital tools, including barcode-based tracking systems, enhances traceability, regulatory compliance, and accountability across the waste lifecycle.

Keywords: Safe handling , SWM tools & Blood Transfusion bags

Sustainable Energy Recovery from Municipal Solid Waste: A Waste-to-Energy Approach for Urban Environments

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Abstract

Rapid urbanization, economic advancement and evolving lifestyles have resulted in an exponential rise in municipal solid waste (MSW) generation across the globe leading to new and increasing environmental and waste management issues in our towns and cities. The increase in the number of MSWs is being attributed to the increase of waste generated through conventional disposal techniques, including open dumping and unregulated land filling, which

result in large-scale methane emissions, foul odours, the leaching of contaminants into the environment, and create additional public health risks, while the potential energy contained in the organic waste is still not being maximized. In this project we are assessing the feasibility of utilizing waste-to-energy (WtE) systems to sustainably manage MSW through methane recovery from landfills and other avenues of anaerobic conversion. Detailed study is made on variation of material composition of different areas' MSW, organic fraction of waste products, the anticipated quantity of methane produced from that organic fraction, and the potential for recovering energy from it. Further, analyze the roles of landfill gas capture, anaerobic digestion, and controlled biological treatment as potential sources of renewable energy in reducing greenhouse gas emissions and decreasing dependency on fossil fuels. Implementing WtE not only cuts down on waste but also produces valuable energy, marking a bold stride toward sustainability. By generating renewable power and lowering carbon emissions, it paves the way for further progress in combating climate change.

Keywords: Waste to Energy (WtE), Municipal solid waste (MSW), Renewable energy.

Development of an Effective Microbial System for Aquaculture Industry

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Abstract
Ammonia (NH3) and nitrite (NO2-) are major pollutants in aquaculture wastewater, posing severe threats to aquatic health through neurotoxicity and inhibited oxygen transport. These contaminants are traditionally removed using physicochemical and biological methods. However, conventional physicochemical approaches are limited by high operational costs and secondary pollution concerns. In contrast, the biological treatment offers an environmentally sustainable alternative characterized by with energy demands and high sludge generation. Therefore, developing an efficient microbial formulation is essential for achieving effective bioremediation and promoting ecological sustainability in intensive aquaculture. In this study, 61 bacterial isolates were screened, with 23 exhibiting measurable ammonia reduction potential. Among the tested combinations, the consortia SRCOD5 (Pseudomonas sp.):SRCOD6 (Bacillus sp.) and SRCOD3(Kytococcus sp.):SRCOD6 achieved >99% ammonia removal with 75% and 71% COD reduction, respectively, under suspended conditions within 36 hours. SRCOD5:SRCOD6 further showed 99.57% ammonia and 80% COD removal within 10 hours (initial NH3 :132 mg/L) upon immobilization. The Microbial Technology Group at Tripura University has already developed a patented (424161 granted Indian patent on 6th March 2023) immobilize microbial formulation for ammonia removal in a single-unit operation with a minimum retention time of 14 hours. The current consortium involves a retention time of 10 hours, hence faster than the earlier report. For nitrite remediation, nine of the 13 screened isolates achieved ≥ 99% nitrite removal within 6 hours from an initial load of 60 mg/L under suspended conditions. Detailed characterization of the isolates and development of optimize formulation could achieve efficient nitrite removal, can leading to providing microbial solution for both the aquaculture pollutant. Notably, this study reports, for the first time, the role of

Kytococcus sp. in ammonia removal and proposes a biofilm based microbial formulation as an effective and sustainable approach for nitrogen rich wastewater treatment.

Keywords: Ammonia; Nitrite; Chemical Oxygen Demand

Fe-Doped Orange Peel Biochar with MnO_2 Nanoparticles for High-Performance Microbial Fuel Cell Electrodes

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Abstract
Microbial Fuel Cells (MFCs) present a sustainable pathway for wastewater treatment and renewable energy generation. Their wider application, however, is constrained by the limitations of conventional electrodes and reliance on costly noble-metal catalysts. In this work, orange peel waste is converted into biochar through controlled pyrolysis and engineered into an efficient electrode material. The anode is developed by doping Fe into orange peel biochar, enhancing conductivity and microbial adhesion. For the cathode, Fe-doped orange peel biochar is further combined with MnO_2 nanoparticles to boost catalytic activity toward the oxygen reduction reaction (ORR). This dual modification utilizes the redox properties of Fe and the catalytic role of MnO_2, thereby overcoming electron transfer resistance at the anode and sluggish ORR kinetics at the cathode. COD & BOD tests along with Electrochemical analyses, including cyclic voltammetry (CV) and power density measurements indicate improved electron transfer, reduced internal resistance, and enhanced stability compared with unmodified biochar electrodes. The range of voltage being produced is 0.7 V to 0.85 V. The approach not only improves MFC performance but also demonstrates a circular economy model by valorizing agricultural waste into functional bio-electrodes. The findings highlight a cost-effective, eco-friendly, and scalable electrode design, contributing to the advancement of sustainable bioenergy technologies.

Keywords: Microbial Fuel Cell; Orange Peel Biochar; Waste-to-Energy; Sustainable Electrodes; Cost effective

Sustainable Nickel Recovery via Electrochemical Precipitation: Mechanistic Insights and Industrial Implications

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Abstract

Nickel is a critical industrial metal widely used in stainless steel, batteries and renewable energy systems, driving the need for sustainable recovery technologies. Conventional extraction methods, such as pyrometallurgical smelting and hydrometallurgical leaching, are energy-intensive and environmentally burdensome. This study investigates electrochemical precipitation from aqueous nickel nitrate solutions as a cleaner alternative. Systematic trials were conducted at varying voltages (5.1–12 V) and durations to evaluate deposition behavior, mass distribution, and process efficiency. Results indicate that intermediate voltages (5–10 V) achieve optimal balance between deposition rate, adhesion, and uniformity, while higher voltages accelerate growth but introduce porosity and gas evolution. Material and energy balance assessments confirm superior energy efficiency compared to traditional routes, particularly when powered by renewable electricity. Purity analysis reveals significant improvement in nickel fraction post-treatment, though co-deposition of other metals from mixed feeds remains a challenge. These findings validate electrochemical precipitation as a viable green technology for nickel recovery, supporting circular economy principles and resource conservation. Future research should focus on advanced electrode designs, real-time process control, and integration with renewable energy systems to enable large-scale, automated, and multi-metal recovery operations.

Keywords: Nickel recovery, Electrochemical precipitation, Energy-efficiency.

Recycling of Non-Lithium Battery Systems: Technologies, Challenges, and Future Perspectives

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Abstract ID: OP-593

Abstract

The trend towards the use of portable electronics has resulted in a great increase in the quantities of used batteries being disposed of. Lithium, cobalt, nickel, cadmium, manganese, and zinc are some of the toxic metals that are found in these batteries and are a significant environmental risk. Even though they still have significant industrial applicability and high, non-lithium content of metals, recycling of non-lithium batteries is relatively underdeveloped. Conventional approaches, such as pyrometallurgical and hydrometallurgical processes, are expensive and they do not extract all metals of interest effectively. Although these methods may be useful in recovery of metals, they are often characterized by energy wastage, as well as, they produce other waste. Bioleaching and electrochemical extraction are emerging methods that can provide green alternatives; unfortunately, due to their scalability and kinetic constraints, their use remains challenging. These processes help recycle precious metals, especially nickel, zinc, cobalt, manganese and rare earth elements which will be vital to future battery technologies and clean energy use. Despite being a highly efficient and environment-friendly technology, with minimal gas emissions and low energy requirements, battery bioleaching has slow kinetics and low pulp densities as the key limiting factors that

negatively affect the process of conversion to the pilot stage. This review is a critical assessment of the current technology of recycling of spent batteries other than lithium-ion batteries with respect to the potential in recoveries, limitations in technology and future studies related to recycled usage of batteries in a sustainable manner.

Keywords: hydrometallurgy; pyrometallurgy; bioleaching; electrochemical extraction; metal recovery

Valorisation of Mixed Food Wastes Using a Green Deep Eutectic Solvent System to Recover Lignin as a Value-Added Product and its Utilization in the Fabrication of Nanofibrous Mats

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Abstract ID:OP-607

Abstract
Valorising food waste using an eco-friendly solvent is proven to be an efficient strategy for the recovery of lignin as a value-added product together with alleviating adverse impact of this waste on the environment. The present study reports the recovery of lignin from mixed pomegranate and banana peels using a green deep eutectic solvent (DES) system composed of choline chloride and oxalic acid and its subsequent use in the fabrication of nanofibrous mats via electrospinning technique. The recovered lignin was comprehensively characterized **by various analytical techniques** to confirm its structural and morphological properties. A blend of lignin and polyvinyl alcohol was successfully electrospun into nanofibrous mats at an applied voltage of 14 kV and a flow rate of 0.3 ml/hr. The fabricated mats were characterized to assess their structure, morphology, and chemical content. Fourier Transform Infrared Spectroscopy revealed the presence of key lignin functional groups including syringyl, hydroxyl, and aromatic groups, in the mats, whereas X-Ray Diffraction verified their amorphous nature. Field Emission Scanning Electron Microscopy images clearly demonstrated the formation of uniform nanofibrous mats having interconnected pores. The elemental composition of the fabricated mats was confirmed from Energy Dispersive X-ray spectroscopy. In conclusion, lignin was successfully recovered from mixed food wastes using DES, and lignin based polymeric nanofibrous mats were fabricated by electrospinning, which can be further tested as membrane adsorbents for pollutant remediation.

Keywords: Food waste; lignin; DES; electrospinning; nanofibrous mats

Design and Optimization of a Hybrid Renewable Energy System Using Wind, Solar and Battery Storage

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Abstract ID: OP-608

Abstract

The increasing demand for sustainable, reliable, and decentralized energy solutions in India, particularly in rural and remote regions, necessitates the integration of renewable energy with advanced digital technologies. This research presents the design and development of a Hybrid Smart Energy Generation System that synergistically combines solar photovoltaic (PV) panels and a Vertical Axis Wind Turbine (VAWT) for optimized power generation. The system incorporates an IoT-enabled real-time monitoring framework, utilizing sensors and microcontrollers to track key environmental and operational parameters such as solar irradiance, wind speed, temperature, and battery state of charge. Additionally, AI-driven load forecasting models (including LSTM and XGBoost) are implemented to predict energy demand and generation, enabling intelligent energy dispatch and storage management. The prototype employs MPPT-based hybrid charge controllers and $LiFePO_4$ batteries for efficient energy conversion and storage. Field testing and simulations demonstrate the system's potential for scalability, costeffectiveness, and adaptability to varying climatic conditions. The proposed solution addresses critical challenges in rural electrification, disaster relief, and smart farming applications, while contributing to India's clean energy transition and smart infrastructure mission.

Keywords: Hybrid Energy System, Renewable Energy, Solar Power, Wind Energy, Energy Optimization

Sustainable Materials for Water and Wastewater Treatment

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Abstract

The deterioration of water quality from industrial and urban activities has heightened the demand for sustainable water and wastewater treatment. Conventional treatment materials are often non-biodegradable and environmentally persistent, highlighting the need for eco-friendly alternatives. This review summarizes recent developments in sustainable materials for water and wastewater remediation, focusing on chitosan, fly ash, natural clays, bio-based activated carbon, cyclodextrin-based porous polymers, and natural zeolites. These materials exhibit

favorable physicochemical properties that enhance pollutant removal, primarily through adsorption mechanisms. Chitosan provides biodegradability and high adsorption capacity due to its functional amino groups. Fly ash and natural clays are abundant, low-cost, and possess suitable surface area and ion-exchange capabilities. Bio-based activated carbon offers high porosity, facilitating efficient removal of organic pollutants. Cyclodextrin-based porous polymers enable selective adsorption through their cavity structures, while natural zeolites contribute structural stability along with ion-exchange potential. Collectively, these materials combine sustainability, cost-effectiveness, and reusability, making them promising alternatives to conventional treatment agents. Future research should focus on scaling up, regeneration strategies, and long-term performance to support practical environmental applications.

Keywords: Sustainable materials; Water and wastewater treatment; Biodegradable materials; Adsorption; Physicochemical properties

Experimental Recovery of Lithium Carbonate from Discarded Mobile Phone Lithium-Ion Batteries by Acid Leaching

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Abstract

The purpose of this study is to recover the base metals from spent lithium-ion batteries (LIB) by using hydrometallurgical processes. The decomposition of nine different types of spent LIBs by NH_4OH followed by leaching the resulting alkali paste by 2.0 M H_2SO_4 and 4.0% H_2O_2. The effects of reaction time, acid concentration, liquid/solid mass ratio, and reaction temperature on the leaching rate are investigated. The results obtained are validated by testing to fit a kinetic model and characterize the process. Lithium and cobalt are the main species needed to be separated and recycled using proper methods. The process selected has been found out to be more economical and efficient in production of lithium carbonate according to the literature survey and the experimental analysis done.

Keywords: LIB (Lithium ion batteries), leaching, Lithium carbonate

AI based AQI Classification and TiO_2 Photocatalytic Mitigation of Air Pollution

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Abstract ID: OP-630

Abstract
Air pollution arising from vehicular emissions has become a serious environmental and public health concern in urban regions, where particulate matter $PM_{2.5}$ and PM_{10} significantly contribute to declining Air Quality Index (AQI) levels. This paper proposes an integrated framework combining real-time air quality sensing, artificial intelligence–based AQI classification, and nanomaterial-driven chemical mitigation for effective traffic-related pollution control. A hardware-based monitoring system is developed to continuously measure ambient $PM_{2.5}$ and PM_{10} concentrations, from which AQI values are computed according to standard environmental guidelines. Artificial intelligence and machine learning techniques are employed to classify air quality into distinct AQI categories, enabling accurate assessment of pollution severity, temporal variation, and identification of high-risk traffic conditions. The classified AQI outputs further serve as intelligent triggers for initiating appropriate pollution mitigation actions. For chemical mitigation, titanium dioxide (TiO_2) nanomaterials are utilized due to their excellent photocatalytic activity, chemical stability, non-toxicity, and environmental compatibility. Under solar irradiation, TiO_2 nanoparticles promote oxidation–reduction reactions that degrade vehicular pollutants such as nitrogen oxides and organic residues into less harmful compounds. This passive photocatalytic process enables energy-efficient pollution reduction without secondary contamination. The proposed framework demonstrates a scalable and sustainable approach for urban air pollution monitoring and TiO_2-based traffic pollution mitigation, suitable for smart city and green chemical engineering applications.

Keywords: Air Quality Index (AQI), $PM_{2.5}$ and PM_{10}, TiO_2 Nanoparticles, Photocatalytic Degradation, Traffic Pollution Control.

Ethanol and Benzene Separation by Extractive Distillation Using p-Xylene

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Abstract

In the present work, the separation of an ethanol–benzene mixture was studied using the extractive distillation process. Ethanol and benzene form a minimum boiling azeotrope, due to which their separation by simple distillation becomes difficult. Because of this limitation, extractive distillation was selected as an alternative method to achieve better separation. This technique is widely used in the chemical and biofuel industries for the separation of azeotropic mixtures. In the current research work, a physical model of extractive distillation was developed to explain the working of the process. The distillation column was charged with a mixture of ethanol and benzene, and p-xylene was used as the extractive solvent. The solvent was added to the upper part of the distillation column. Because of the higher boiling point of p-xylene compared to ethanol and benzene, the solvent changes the volatility of the mixture, thus improving the separation of the mixture.

In the experiment, the heating was provided using a heating mantle. As the temperature increased, the ethanol-rich vapor rose to the top of the distillation column and was condensed to form the distillate, while benzene together with the extractive solvent settled at the bottom of the column. Temperature readings were taken at different points of the distillation column to determine the separation properties of the mixture.

Keywords: Extractive Distillation, Ethanol, Benzene, p-Xylene, DWSIM

Production of Biodiesel From Waste Cooking Oil

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Abstract

This research aims to meet the growing need for renewable fuels and the need for efficient waste management by studying the production of biodiesel from waste cooking oil (WCO). The paper describes a simulation of the biodiesel production process from WCO using the open-source process simulator DWSIM. To model a one-step base-catalyzed transesterification reaction and evaluate material and energy balances for biodiesel production: pretreat waste cooking oil, transesterify triglycerides with methanol using KOH as a catalyst, separate biodiesel and glycerol by gravity separation, recover methanol, and finally purify biodiesel. The most important components in the model are triglycerides (waste oil), methanol, fatty acid methyl esters (FAME, biodiesel), glycerol, recovered methanol, and trace water. Suitable models were used to describe the non-ideal behavior of the polar and non-polar components.

Parametric simulation analysis using DWSIM was carried out to investigate the effects of the methanol-to-oil ratio, catalyst concentration, and reactor residence time on product separation. Under optimized simulation conditions, the simulation model predicted a biodiesel separation of about 95-97% (mass basis), along with high triglyceride conversion to fatty acid methyl

esters. The simulation results provide information on process operation, energy demand, and separation efficiency.
This study clearly shows that DWSIM is a valid tool for simulating biodiesel production from waste cooking oil and can be used effectively for process optimization, scale-up simulation, and initial techno-economic analysis of small-scale and decentralized biodiesel production plants.

Keywords: Waste Cooking Oil, Free Fatty Acid, Potassium Hydroxide, DWSIM

Advances in Mixed Dye-laden Wastewater: Strategies, Performance Evaluation and Scale-up Prospective

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Abstract ID: OP-646

Abstract
Industrial effluents cause pollution, which is a significant environmental challenge and dye-laden wastewater is one of the major contributors of water pollution. Mixed dyes are stable and have a complex interaction with water. Dye-laden wastewater does not just affect the quality of water, but also affects aquatic life, contributes to air and soil pollution and affects the whole ecosystem. This review outlines the recent developments on the removal of mixed dyes through various methods like adsorption, photocatalysis, membrane filtration and advanced oxidation processes (AOPs). All the methods have their own merits and demerits. Adsorption is easy and efficient but restricted by regeneration, photocatalysis is capable of complete degradation but has scale-up problems, membranes guarantee high-quality separation but fouling issues are there and AOPs are capable of rapid oxidation but demand high levels of reagents. Challenges for treating mixed dye-bearing water, need of removal, measurements are also elaborated in detail. Dye-laden wastewater is generated in huge quantities and removal also needs to be done on larger scale and for that scale-up related studies, their results and challenges are also incorporated in this paper. In general, the combination of several methods with emphasis on cost, efficiency and sustainability is a necessary element of feasible mixed dye remediation.

Keywords: Wastewater; Mixed dye; Adsorption; Photocatalysis; Scaleup

Utilization of Fruit Waste and Vegetable Waste as Biogas Plant Feed and a Simulation in DWSIM

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Abstract ID: OP-648

Abstract

The ever-increasing amount of fruit and vegetable waste in households, markets, and processing plants makes it imperative to have proper waste management and sustainable energy technology. Dumping organic waste in landfills contributes to environmental degradation and inefficient use of organic resources. The purpose of this research is to evaluate the viability of using fruit and vegetable waste as a substrate for biogas production through anaerobic digestion, facilitated by process simulation using the DWSIM software. Fruit and vegetable waste have high organic matter, high moisture content, and high biodegradability rates, making them ideal for microbial fermentation and subsequent biogas production.

The aims are to assess the feasibility of biogas production, methane content, and overall process effectiveness while simultaneously considering waste reduction. Apart from the production of biogas, the anaerobic digestion process also produces a stabilized digestate that can be used as an organic soil conditioner, thus promoting sustainable agriculture. A steadystate simulation model of the anaerobic digestion process was developed in DWSIM to simulate material and energy balances in the biogas plant. The simulation model allows the assessment of gas composition, rate of conversion, and process performance for different feedstock, providing critical information for performance evaluation and optimization.

The coupling of simulation modeling with waste-to-energy analysis improves process understanding within the boundaries of experimental investigation. Organic waste can be harnessed for the production of renewable energy with a reduced environmental impact. Conclusion: The treatment of organic waste and simulation modeling is a viable, efficient, and environmentally sound method for biogas production.

Keywords: Fruit and vegetable waste; Biogas production; Anaerobic digestion; DWSIM simulation; Waste-to-energy;

Generative AI for Environmental Equity: Synthesizing Urban to Rural Pollution Gradients via Multi Modal GANs

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Abstract ID: OP-653

Abstract

Infrastructure gaps in air quality monitoring systems result in critical data deserts in rural areas, making it difficult to implement public health policies on an equal footing. The present work proposes a software intensive approach to synthesize high resolution maps of ground level air pollution in areas lacking physical sensors. The researchers employs a Multi Modal Generative Adversarial Network (GAN), more specifically a Pix2Pix model, to accomplish

spatial super resolution. The proposed approach utilizes the Google Earth Engine (GEE) platform to combine multi spectral satellite data from Sentinel-5P (CO, SO_2, NO_2) with high resolution meteorological data from the ERA-5 dataset (wind vectors and temperature). By training the GAN on urban areas such as Kolkata, the GAN learns complex non-linear relationships between atmospheric column density and ground-level concentrations. The main result of this work is a synthesized high resolution continuous pollution map for rural areas lacking air quality monitoring systems. Experimental results show that the GAN successfully reconstructs localized pollution patterns with a Structural Similarity Index (SSIM > 0.82), clearly outperforming traditional interpolation and regression approaches. By simulating virtual sensors in data scarce areas, this work contributes to the development of a scalable software intensive solution for environmental monitoring, promoting data equity and informing targeted policy interventions in areas where physical infrastructure is economically unfeasible.

Keywords: GANs, GEE, Sentinel-5P, ERA-5, Data Deserts, Environmental Equity

Preparation and Evaluation of Peanut Shell-Derived Activated Carbon Pellets and Membranes for Pollutant Removal

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Abstract ID:PP-674

Abstract

This research investigates the efficiency of peanut shell (PS) derived activated carbon in two forms—pellets and membranes—for removing industrial pollutants. Peanut shells were converted to activated carbon via chemical activation and fabricated into pellets and, consecutively, incorporated into filtration membranes. The adsorbents were characterized using SEM and BET methods, demonstrating a high surface area suitable for adsorption of heavy metals (e.g., Pb, Cr, Cd) and industrial dyes. Batch adsorption studies indicated that the activated carbon followed pseudo-second-order kinetic models and Langmuir isotherm, indicating monolayer adsorption on a homogeneous surface. The membrane, made from activated carbon and a polymer binder, was tested for the filtration of wastewater, exhibiting excellent removal rates for both, particulate and dissolved toxic pollutants, due to enhanced pore structure and surface functional groups. This approach offers a sustainable, cost-effective alternative to commercial activated carbon for wastewater remediation.

Keywords: At least three key words separated by; Peanut shells (agricultural waste); Drying; Pyrolysis; pellets and membranes; Removal of contaminants; sustainability (circular economy)

Sustainable Waste Valorization of Fish Scales into Activated Carbon for Efficient Removal of Acidic (Congo Red) and Basic (Methylene Blue) Dyes from Aqueous Solutions

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Abstract ID: OP-676

Abstract

Acidic dye Congo red and basic dye methylene blue are synthetic dyes extensively used in textile and printing industries. However, owing to their rich aromatic structures, these dyes exhibit strong resistance to biological degradation. Their high solubility in aqueous media enables prolonged persistence in aquatic environments, posing significant risks to aquatic life, as their degradation by-products are often carcinogenic in nature. In this study, a high surface area activated carbon was synthesized from waste fish scales via KOH activation and investigated for the efficient adsorptive removal of congo red and methylene blue from aqueous solutions. BET analysis showed that the prepared adsorbent has a high specific surface area of 913.81 m^2/g, while FTIR analysis confirmed that its surface is rich in oxygen-containing functional groups. The adsorption process was systematically studied and optimized with respect to key operational parameters, including solution pH, adsorbent dosage, adsorption isotherms, and thermodynamic behaviour. The prepared active carbon shows the optimum performance for both the dye is at pH 7.0 and 1 g/L of adsorbent. The prepared fish scale derived activated carbon demonstrated excellent adsorption performance toward both acidic and basic dyes, achieving removal efficiencies of approximately 99% at an initial dye concentration of 100 ppm. The results indicate favourable adsorption characteristics and strong affinity of the adsorbent toward both dye types.

Overall, this work highlights the potential of waste fish scale derived activated carbon as a low-cost, sustainable, and highly effective adsorbent for the treatment of dye-contaminated effluents from textile and related industries.

Keywords: Activated carbon; Adsorption; Solid waste management; Wastewater treatment,

Structure–Performance Relationship of Graphene-Reinforced Ceramic Membranes for Wastewater Treatment Applications

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Abstract ID: PP-701

Abstract

Graphene-reinforced ceramic membranes represent a promising class of advanced filtration materials capable of overcoming the limitations of traditional ceramic and polymeric membranes in wastewater treatment. This work presents a comprehensive understanding of the structure–performance relationship that governs the behavior of these hybrid membranes,

highlighting the role of graphene in tailoring membrane morphology and transport properties. The integration of graphene-based materials into ceramic matrices leads to the formation of hierarchical pore structures with a regulated pore size distribution, enhanced surface hydrophilicity, and well-defined nanochannel networks. These structural modifications collectively govern water permeability, solute selectivity, and fouling resistance by facilitating preferential water transport while restricting contaminant passage. Key structural factors, including graphene loading, dispersion homogeneity, interfacial bonding, pore connectivity, and nanochannel continuity, are identified as decisive parameters affecting membrane performance. In addition to improving mass transport, graphene imparts antimicrobial activity and enhanced chemical stability, enabling membranes to withstand harsh wastewater environments and repetitive chemical or physical cleaning cycles. The relationship between membrane microstructure and functional performance is critically evaluated across various wastewater treatment applications, such as dye removal, heavy-metal separation, oil–water separation, and biofouling control. By systematically linking pore architecture and nanochannel characteristics with separation outcomes, this work emphasizes the importance of rational material engineering in developing high-performance graphene-reinforced ceramic membranes. The insights provided offer guidance for future research and highlight challenges related to scalability and long-term operation, paving the way for practical implementation in advanced wastewater treatment systems.

Keywords: Graphene-based ceramic membranes; Hybrid membrane materials; Wastewater treatment; Fouling-resistant membranes

Selective Bromine Removal from Non-Metallic Fraction of Crushed Printed Circuit Boards Using Aqueous Sodium Carbonate

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Abstract ID: OP-719

Abstract
Printed circuit board waste contains brominated flame retardants that make recycling and reuse highly unsafe. In this work, crushed PCB was first segregated into metallic and non-metallic fractions using a gas–solid fluidized bed followed by magnetic separation. The non-metallic fraction was treated with low-concentration aqueous sodium carbonate to selectively leach bromine. The effects of alkali concentration, liquid-to-solid ratio, sonication time, particle size, and segregation condition were systematically studied. Bromine removal was quantified and the stability of metallic elements was also verified. The optimized sodium carbonate system achieved high bromine leaching efficiency without dissolving valuable metals. This study demonstrates a safe and low-cost route for detoxifying PCB non-metallic fractions prior to reuse or further processing

Keywords: E-waste; printed circuit boards; brominated flame retardants; sodium carbonate leaching; non-metallic fraction; detoxification

Waste-to-energy technologies: A sustainable Pathway for Resource Recovery and Materials Management

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Abstract
The rapid increase in municipal solid waste generation and escalating energy demand have intensified environmental and resource challenges worldwide. Advanced Waste-to-Energy(WtE) technologies provide a promising pathway for sustainable energy recovery and circular economy integration. There are various techniques that are helpful in dealing with problems of municipal solid waste generation and those are Advanced thermal technologies like Gasification for converting carbonaceous materials like municipal waste into combustible, clean burning gas , pyrolysis to convert organic materials into valuable products, Advanced biochemical technologies like Anaerobic Digestion for converting waste into methane rich gas, Landfilling & landfilling gas recovery etc., Advanced chemical technologies like transesterification, Hydrothermal carbonization. Criteria for evaluating the efficiency of Advanced Waste-to-Energy Technologies includes Energy efficiency, waste reduction, etc. This paper also reviews challenges and future perspectives to put systems in place for implementations of Waste-to-Energy Technologies. Waste-to-Energy Technologies convert waste to energy, supporting a circular economy.

Keywords: circular economy; thermal technologies ; sustainable energy; municipal solid waste;Waste-to-Energy Technologies

Organic source of biomass for synthesizing magnetic nano catalyst for biofuel production from industrial waste: characterization & Optimization, Kinetic studies.

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Abstract
Currently, around the globe energy utilization is depends on petroleum derivatives, which declines due to the continuous exploitation of fossil fuels. Thus, globally improvement in the future energy source relies on alternative fuel, which should be ecofriendly & provides a

sustainable environment with zero emission of pollutants. Thus, many research is focused on looking forward for producing biodiesel, which is the best alternative source of energy. The biomass was produced from peel of jackfruit which is synthesized through co-precipitation for deriving the nano magnetic catalyst. The synthesized catalyst was characterized through different analytical instruments for the identifying the morphological behavior as well as the physical and chemical properties. The activity of the catalyst was investigated through transesterification techniques. The optimization studies were carried out by analyzing the various process parameters such as methanol to oil ratio, catalyst concentration, reaction temperature and reaction time. The obtained yield of biodiesel was 97.8 wt%, which was examined by optimizing the process parameters. The kinetic study reveals that transesterification reaction follows pseudo first order with providing maximum activation energy. Thus, the reusability of nanocatalyst shows stable activity for seven cycles providing excellent yield upto 95% by using different solvents for better recovery of nanocatalyst. The produced biodiesel was characterized and various properties were analyzed and compared with that of ASTM D6751 standard.

Keywords: Biodiesel, Transesterification, Jackfruit, co-precipitation.

Microalgae Cultivation in Domestic Wastewater as a Sustainable Strategy for Biodiesel Production and Nutrient Remediation

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Abstract

Growing demand for sustainable energy has intensified interest in microalgae as a promising feedstock for biodiesel production. Compared to conventional oilseed crops, microalgae exhibit rapid growth rates, high lipid accumulation, and the ability to thrive on non-arable land using non-potable water. Cultivating microalgae in wastewater further enhances sustainability by supplying essential nutrients such as nitrogen and phosphorus, thereby reducing reliance on synthetic fertilizers while simultaneously lowering production costs and enabling wastewater remediation. Wastewater-tolerant microalgal strains cultivated under optimized conditions can achieve enhanced biomass productivity and lipid yields. The utilization of nutrient-rich municipal and industrial effluents allows simultaneous biofuel generation and pollutant removal, addressing both energy and environmental challenges. This study evaluates the influence of wastewater composition on microalgal growth, lipid accumulation, and biochemical characteristics, along with optimization of key culture parameters including light intensity, pH, and hydraulic retention time to maximize lipid productivity within shorter cultivation periods. In addition, biodiesel production is supported by the use of a reusable heterogeneous catalyst derived from waste shells, offering an environmentally benign and

cost-effective alternative to conventional homogeneous catalysts during the transesterification process. The application of shell-based catalysts enhances catalyst recovery, reusability, and overall process economics. The findings indicate that wastewater-grown microalgae, coupled with sustainable heterogeneous catalysis, provide a viable and economically attractive route for biodiesel production while promoting resource recovery and circular bioeconomy principles.

Keywords: Microalgae; Biodiesel; Wastewater treatment; Transesterification; Lipid production; Biofuels

Next-Generation Biodegradable Ternary BiOI/TiO_2/PPy Heterojunction Hydrogel for Efficient Photocatalytic Tetracycline Degradation

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Abstract ID: OP-755

Abstract

This study investigates the photocatalytic degradation of tetracycline (TC) using BiOI/TiO_2/PPy (BTPY) hydrogels, highlighting their efficiency and applicability for wastewater treatment. BTPY was synthesized via hydrothermal method followed by polymeric interaction with carboxymethyl cellulose and crosslinked with $FeCl_3$ to enhance stability and reusability. The photocatalytic performance was evaluated under visible light, achieving up to 91% degradation efficiency under optimized conditions. The process involved the activation of peroxymonosulfate (PMS), which facilitated the generation of reactive oxygen species (ROS) such as sulfate (SO_4•$^-$) and hydroxyl (•OH) radicals, identified as key contributors to TC degradation. Experimental parameters, including BTPY dosage, PMS concentration, pH, and water matrix composition, were systematically analyzed to optimize degradation efficiency. Scavenger studies confirmed the predominance of sulfate and hydroxyl radicals in the degradation pathway, with sulfate radicals having the most significant impact. While BTPY showed high efficiency in distilled and drinking water, its performance was reduced in complex matrices like lake water due to natural organic matter interference. These findings underscore the potential of BTPY hydrogels as cost-effective photocatalysts for environmental remediation. Future work should explore scalability, application in diverse water matrices, and integration into solar-assisted systems to advance sustainable water purification technologies.

Keywords - Bismuth Oxyiodide; Tetracycline; Photocatalysis; Heterojunction; Wastewater Treatment.

Process Simulation and Sustainability Assessment of Pine-Cone-Derived Biochar for Multicomponent Azo Dye Removal from Textile Wastewater

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Abstract

Textile effluents containing azo dyes, when discarded into waterways, pose a significant environmental challenge due to their high colour intensity, consequential toxicity, and resistance to biodegradation. Conventional biological treatment processes typically achieve less than 30– 40% colour removal, making advanced physicochemical treatment necessary. Although adsorption using commercial activated carbon is effective, its high production energy requirement (6–10 kWh kg^{-1}) and cost limit application in developing regions. In this study, a process design and simulation framework was developed to evaluate pine-cone-derived biochar, an abundant forest litter biomass, as a low-cost adsorbent for the removal of multicomponent azo dyes from wastewater.

The Indian subcontinent has an abundance of pine, which has led to accumulation and significant forest fire events in the past few years. To combat this, the Uttarakhand government has launched the 'Pirul Lao-Paise Pao' campaign to contain the raging forest fires in the state.

Pine cones composed of lignocellulosic biomass were considered for slow pyrolysis at 400–500 °C to produce porous biochar containing oxygenated functional groups (–OH, –COOH). Reported adsorption capacities for lignocellulosic biochars (80–180 mg g^{-1} for common azo dyes such as Congo Red and Reactive Black) were used as input parameters for modelling. A fixed-bed adsorption column was simulated for continuous treatment conditions. Equilibrium behaviour was described using the Langmuir isotherm. Bed-Depth Service-Time (BDST) modelling indicated that a bed height of 0.6–1.0 m at a flow rate of 5–10 L min^{-1} could achieve 80–90% colour removal for an inlet dye concentration of 50–100 mg L^{-1}, corresponding to regulatory discharge compliance.

A comparative cradle-to-gate Life Cycle Assessment was conducted using a functional unit of 1 m^3 of treated textile wastewater. Using the Indian grid emission factor (0.82 kg CO_2 kWh^{-1}), pinecone biochar production was estimated to reduce carbon emissions by approximately 55–70% compared to coal-based activated carbon, due to its lower activation temperature and the avoidance of raw material extraction. The results demonstrate that pine-cone-derived biochar can provide an environmentally sustainable and economically viable adsorption system suitable for decentralised textile wastewater treatment. The study highlights a circular approach linking wastewater remediation with forest biomass management and resource recovery.

Keywords: Pine cone biochar, multicomponent adsorption, fixed-bed adsorption column, azo dye removal, Life Cycle Assessment (LCA)

Waste-Derived Catalyst for Sustainable Biodiesel Production

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Abstract
This research advances the circular economy by integrating two distinct waste streams—nonedible seed oils and agricultural residues—into a streamlined, eco-friendly biodiesel production process. By employing a non-edible feedstock, the study bypasses the "food versus fuel" debate, instead focusing on the chemical conversion of underexploited biomass using a customengineered, waste-derived heterogeneous catalyst. This solid catalyst, synthesized through controlled thermal activation and characterized by its high basicity and crystalline stability, offers a sustainable alternative to traditional liquid catalysts due to its easy recovery and multi-cycle reusability. Under optimized transesterification conditions involving precise methanol ratios and temperature controls, the process achieved high-purity fatty acid methyl esters (FAME) that meet international fuel specifications for energy content and viscosity. Ultimately, this integrated approach minimizes industrial wastewater, reduces refining costs, and provides a scalable model for converting agricultural by-products into high-value renewable energy.

Keywords: Biodiesel; Non-edible feedstock; Catalyst; Fatty acid methyl esters (FAME

Dual Z-Scheme $Cu_2(OH)PO_4$/g-C_3N_4/r-GO Ternary Heterostructure for Efficient Cr(VI) Reduction and Methylene Blue Degradation under Visible Light

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Abstract

This study presents the design and fabrication of copper hydroxy phosphate- and reduced graphene oxide-embedded graphitic carbon nitride ($Cu_2(OH)PO_4$/r-GO/gC_3N_4) nanocomposites through a one-step hydrothermal method for visible-light-induced photocatalytic dye degradation and toxic metal reduction applications. The synthesized nanocomposites, containing varying weight percentages of $Cu_2(OH)PO_4$, were systematically characterized for their structural, optical, morphological, and electrochemical properties using XRD, FTIR, Raman, XPS, UV-vis DRS, FE-SEM, TEM, and EIS techniques to understand the relationship between structure and performance. EIS spectra of the nanocomposite indicated effective separation and transfer of photo-induced charge carriers. The optimized nanocomposite CCG 361 shows the excellent photocatalytic activity, 99.98% reduction efficiency for Cr (VI) and 99.93% degradation efficiency for methylene blue (MB), more than binary composites (CHP/CN, CN/r-GO) and bare g-C_3N_4. The effect of several parameters such as pH, catalyst dose and initial pollutant concentration has also been recorded to find the optimum conditions. Scavenger tests revealed that $Cu_2(OH)PO_4$/r- GO/gC_3N_4 nanocomposites effectively produce superoxide anions and hydroxyl radicals for dye degradation and heavy-metal reduction. The material maintained ~100% efficiency over five cycles, showed strong pH-dependent photoreduction and stable dye degradation, making it promising for treating multi-pollutant wastewater.

Keywords: Graphene Oxide; Graphitic carbon nitride; Copper Hydroxy Phosphate, Hexavalent Chromium (Cr (VI)) photoreduction; Photocatalytic dye degradation; Methylene Blue.

Domestic Solid Waste in a Rural Area and the Challenges Aheadin Waste Management

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Abstract

Earlier years, rural waste was mostly biodegradable and could be composted or naturally decomposed. With increased access to manufactured goods, plastics, electronics, and chemical products, the nature of household waste in rural areas has shifted toward materials that are more toxic and difficult to manage safely. The load of plastic &hazardous waste in rural areas has shifted from small quantity in earlier years to ample quantity in recent years because of technological development. As the wastes are scattered in households, the collection and treatment are more complex and expensive. The traditional rural waste practices are to feed

leftover organic matters to livestock as there is absence of non-biodegradable materials. But due to the fast growth of packaged& synthetic products, and hazardous wastes the natural waste management systems become disrupted, leading most of the communities to rely on open dumping, backyard burning, or burial. Such methods release toxic gases causing air pollution, contaminate soil, and pollute groundwater, directly affecting productivity of agricultural land and the quality of drinking water. Rural communities often struggle to address these impacts due to limited technical expertise and financial resources. Although many countries now introduced strict Rules &Regulations for waste management, the rural panchayat in India are still facing challenges because of inadequate monitoring and infrastructure. In spite of adoption of recent technology like improved biological, chemical, thermal treatment, and decentralized waste-processing models which are accessible and efficient, the rural waste management systems are at stake due to lack of awareness, policy support, and community-based management. In this paper, the challenges being faced by a rural panchayat having waste management systems has been discussed.

Keywords: Rural domestic waste; Environmental pollution; Waste Management; Alternative Technologies; Challenges

Vertical Flow Constructed Wetlands for Efficient Nitrogen and Organic Matter Removal from Institutional Wastewater

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Abstract

Institutional wastewater often exhibits variable nitrogen and organic loadings, posing challenges for decentralized treatment systems. Conventional wastewater treatment plants (WWTPs) and natural treatment systems such as constructed wetlands (CWs) are widely utilized to treat municipal and institutional wastewater with diverse contaminant loads. Among these, CWs have emerged as an eco-sustainable, low-cost, and easy-to-operate technology, making them particularly suitable for decentralized wastewater management. In this study, the performance of vertical flow constructed wetlands (VF-CWs) operated at the National Institute of Technology Delhi was evaluated for the removal of nitrogen and organic matter from institutional wastewater. Six subsurface flow (vertical flow) wetland units with varying bed configurations—comprising sand, gravel, and sand–gravel mixed combinations—were investigated under controlled hydraulic conditions. The systems were planted with Canna indica and Typha species, while sand and stone chips served as the primary substrate media to support filtration and microbial activity. The experimental results demonstrated substantial pollutant removal efficiencies: BOD_5 (70–90%), COD (60–85%),

phosphate (20–60%), nitrate (50–80%), and total nitrogen (30–70%). The enhanced nitrogen removal observed in the final stages of the coupled wetland system was attributed to the release of organic carbon from decomposing macrophytes, which stimulated denitrification processes and improved nutrient uptake through plant roots. Additionally, the alternating aerobic–anaerobic zones within the vertical flow beds facilitated simultaneous nitrification–denitrification mechanisms. Overall, the study highlights the potential of VF-CWs as a sustainable, low-cost, and efficient treatment option for institutional wastewater management, contributing to nutrient pollution control and the broader goals of environmental sustainability.

Keywords: Vertical flow constructed wetlands; Wastewater treatment and reuse; Nutrient and organic pollutant removal;

Anaerobic Baffled Reactors as Sustainable Alternatives to Conventional Treatment Systems: A Critical Review

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Abstract
Sustainable remediation on global issue of wastewater is significantly hot and focused. In this concern the intensification of wastewater treatment with the Anerobic baffled reaction (ABR) utilization plays a crucial role. One of the most important strengths of ABR is its ability to naturally separate the different biological phases developed during. the anaerobic digestion along with the length of reactor. The combination of hydrolysis and acidogenesis is dominant in front section of reactor whereas, acetogenesis and methanogenic conversion was observed in the tail section of reactor. The spatial phases separation enhances process stability and protects sensitive methanogenic bacteria from sudden organic or toxic shocks. This leads performance enhancement of ABR towards the fluctuation in hydraulic retention time (HRT), initial organic loading rate (OLR) and complex nature of industrial effluent. These quality of ABR makes it a robust, low cost and energy efficient technology for sustainable wastewater treatment. The present review article provides the deep learning of the ABS working principles, demonstrated effective treatment performance analysis across diverse wastewater streams. The applications to the streams such as domestic sewage, distillery effluent, agro-industry and textile dye effluent.

Keywords: Sustainable approach; Wastewater treatment; Anaerobic baffled reactor; hydraulic retention time (HRT); organic loading rate (OLR).

Environmental Impact Assessment of Hydrothermal Carbonisation of Mixed Sewage Sludge for Energy Recovery

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Abstract
Sewage sludge management is a major environmental concern due to increasing wastewater treatment and the high moisture and organic content of sludge. This study performs a comparative cradle-to-grave life cycle assessment (LCA) of hydrothermal carbonisation (HTC) of mixed sewage sludge using SimaPro software and the ReCiPe 2018 midpoint impact assessment method. The functional unit was defined as the treatment of 1 tonne of wet, mixed (primary and secondary) sewage sludge. Two treatment pathways were assessed: conventional anaerobic digestion (AD) and an integrated HTC+AD system. The system boundary includes sludge treatment, biogas production, gas cleaning, combustion for energy recovery, and hydrochar utilisation. The results indicate a total climate change impact of 93.3 kg CO_2-equivalent per tonne of sludge treated in the HTC+AD system. Terrestrial acidification was 0.0685 kg SO_2-eq, while freshwater eutrophication reached 0.0677 kg P-eq, reflecting nutrient transfer to the aqueous phase. Energy recovery resulted in avoided fossil resource use of −40.2 kg oil-eq and a net water balance of −0.487 m^3. The findings show that HTC redistributes environmental burdens across impact categories while enabling resource recovery from sewage sludge. In future work, we will emphasise End Point analysis, grouping environmental impacts into human health, ecosystem, and resource damage categories.

***Keywords*:** Hydrothermal carbonisation; Sewage sludge; Life cycle assessment, Anaerobic digestion

Assessment and Mitigation of Indoor Air Pollution with Prototype Development

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Abstract
The rapid deterioration of ambient air quality in Indian cities has intensified concerns regarding occupational and public exposure in semi-enclosed micro-environments such as petrol filling stations. These locations experience continuous emissions from fuel evaporation, vehicular exhaust, and resuspension of settled particulates, yet remain inadequately characterized in conventional air quality monitoring frameworks. In the present study, a systematic assessment of indoor and near-field air pollution was carried out at four petrol pumps-two located in urban settings (Pump A and Pump B) and two in rural settings (Pump C and Pump D)-to quantify spatial and operational variability in pollutant concentrations.
Key pollutants, namely formaldehyde (HCHO), total volatile organic compounds (TVOC), and particulate matter fractions ($PM_{1.0}$, $PM_{2.5}$, and PM_{10}), were monitored using calibrated

portable sensors alongside meteorological parameters such as temperature and relative humidity. Observations indicate that urban petrol pumps experience substantially elevated pollutant levels during peak operational hours, with TVOC concentrations reaching **2.5-3.8 mg·m^{-3},** $PM_{2.5}$ levels in the range of **85-140 µg·m^{-3},** and PM_{10} exceeding **200 µg·m^{-3}**, particularly under high crowd density conditions. In contrast, rural petrol pumps exhibited comparatively lower baseline concentrations; however, episodic peaks were observed during refuelling rush hours, highlighting the role of activity intensity and limited dispersion even in low-traffic regions.

The study further demonstrates that crowd density, fuel handling frequency, and local ventilation conditions exert a stronger influence on pollutant accumulation than geographic location alone. **The novelty of this work lies in its integrated comparison of urban and rural petrol pump micro-environments combined with the development of a low-cost prototype-based mitigation framework**, offering a scalable approach for real-time monitoring and exposure reduction in occupational settings. The findings provide actionable insights for environmental management, policy formulation, and the design of targeted mitigation strategies to safeguard workers and commuters alike.

Keywords: Indoor air pollution; Petrol pump emissions; VOCs; Formaldehyde; Particulate matter; Urban-rural comparison; Air quality monitoring; Environmental mitigation.

Pharmaceutical Wastewater Treatment by ZLD an Advanced Wastewater Treatment: A Review

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Abstract

For eliminating liquid effluent discharge from industrial premises Zero Liquid Discharge is an advanced wastewater treatment approach. Indian, where high-strength wastewater and strict environmental regulations prevail, ZLD systems have become increasingly relevant for pharmaceutical industry waste water treatment. Zero Liquid Discharge treatment system utilizes advanced technological water treatment processes are environmentally friendly and highly reliable. For situations where scarcity of water demands water recovery (recycle/reuse) ZLD technologies help you achieve environmental compliance, reduce your carbon which eliminates liquid waste by converting it into disposable dry solids and recover around 95% of your liquid waste for reuse. Zero Liquid Discharge treatment process can adopted as advanced waste water treatment constituents to by-products that are more readily biodegradable and reducing overall toxicity, pH, COD, TDS, SS, BOD parameters. Zero Liquid Discharge system producing a clean stream suitable for use elsewhere in the plant processes and minimize the volume of liquid waste that requires treatment Zero Liquid Discharge capable to reduce the all types of waste water and make it reusable and recyclable further for different applications.

Keywords: Zero Liquid Discharge; Pharmaceutical Wastewater; Evaporation, RO; WWT.

Other Areas in Science, Engineering and Technology (OSET)

Oxygen Rich Technology In Secondary Steel Making Process

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Abstract ID:OP-147

Abstract

In the secondary steel project the witnessed a slow change of fuel type .Coal was transformations from the pre independence to the present abundantly used in the British era till in secondary steel making process .At that time most of furnaces were semi continuous , the fuel slowly was changed to liquid like furnace oil /low sulphur heavy stock etc ---- steady price rise of fuel oil made them to rethink about fuel change over .Natural gas resource was opened ,pipeline was laid from source to use points like HBJ pipeline , along with producer gas . But producer gas has tar related problem .Now a days gas fired furnaces are in operation . In a bid to go for more productive . Here next productive solution is to use 0xygen rich gas ,in place of air as secondary air .,objective was to eliminate “nitrogen” . The technology Dilute oxygen combustion technology helps to provide rolling mill process with higher productivity without high capital and operating cost .This process lower specific energy to heat steel and promote uniform temperature and heat transfer with lower specific energy to heat steel ,waste gas also contains lower heat content . Dilute oxygen combustion technology uses separate high velocity fuel and oxygen jets to generate strong in furnace gas recirculation ,these low NO x ,oxy fuel burners have been developed and commercially demonstrated in steel reheating furnace .The design of burner meets industry needs for increased productivity and reduced operating cost . .the sketch of oxy fuel burner in a reahting furnace is presented in figure In addition to typical oxy gen/fuel advantage ,fuel and oxtgen are injected through separate ports rather than a single burner .the reactants mix up with hot furnace gases before reacting with each other .This dilation effect prevents the high peak temperature .

Biomass-Derived Granular Activated Carbon (GAC), Analysis and its Applications in Wastewater Treatment: A Study of Removal of Emerging Pollutants

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Abstract

The presence of emerging pollutants (EPs) such as pharmaceuticals, personal care products, endocrine-disrupting compounds, and industrial chemicals in wastewater poses significant environmental and public health concerns due to their persistence and bioaccumulation potential. Conventional wastewater treatment processes often fail to effectively remove these contaminants. Biomass-derived granular activated carbon (GAC) has gained attention as a

sustainable and efficient adsorbent for EP removal, offering a low-cost and environmentally friendly alternative to commercial activated carbon. This review provides a comprehensive study of different biomass precursors, GAC synthesis methods, physicochemical characterization, and adsorption mechanisms of GAC synthesized from various biomass sources including agricultural residues, forestry by-products, and industrial wastes. Key parameters influencing GAC performance, such as surface area, pore size distribution, surface chemistry, and activation methods (physical and chemical), and operational conditions are critically analyzed. Furthermore, the review highlights recent advances in the application of biomass-derived GAC for the adsorption of specific classes of EPs, techno-economic feasibility of GAC in real-world wastewater treatment and addresses regeneration strategies, challenges, and future research directions. The findings emphasize the potential of biomass-based GAC as a viable material for advanced wastewater treatment technologies targeting emerging contaminants.

Keywords: Biomass; Precursors; Granular Activated Carbon; Emerging pollutants; Wastewater; Adsorption.

A Life Cycle Assessment of the Production of Important Polymers

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Abstract
Worldwide, the production of some of the widely used polymers has grown by more than double in the past couple of decades. About 18% of the annual global CO_2 emissions result from the chemical industrial sector, a majority of which is owing to production of major chemicals like ethylene, propylene, ammonia, methanol, benzene, toluene and xylenes. Most of these are important feedstocks of the polymer industry. Analysing the emissions is important to identify measures for reduction of emissions for a more sustainable polymer industry compliant with stricter emission standards and helping in our progress towards achieving net-zero emissions. Except for a small amount of polymers (less than 10%) produced by recycling, the entire industry is reliant on oil and natural gas as the feedstock for production of polymers. This work uses a combination of process simulation and statistical analysis to analyse the variation in greenhouse gas emissions resulting from various factors in the processes like oil and gas extraction, cracking of hydrocarbons to produce some of the

monomers required to produce several important polymers. It has been found that these processes have significant stakes in the total emissions of greenhouse gases in the life cycle of the polymers. Additionally, one type of polymer may be produced by multiple routes, resulting in widely different emissions for each route depending on variables e.g. process operating conditions, diverse sources of oil and gas, transportation, refinery configurations, etc. This again results in a large range of emissions associated with the production of any polymer.

Keywords: Life cycle assessment; polymers; emissions; analysis

Development of Centralized Control Strategies for Laboratory Scale OC-OTEC Plant

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Abstract
Open-Cycle Ocean Thermal Energy Conversion (OC-OTEC) is a dual sustainable energy technology capable of simultaneously producing power and freshwater from seawater based on temperature gradient for meeting the growing demands of remote island communities. One of the major challenges in operating an open-loop OC-OTEC system is the fluctuation in sea surface temperature, which adversely affects overall plant performance and reliability. Furthermore, the OC-OTEC system is highly interacting and highly sensitive to temperature variations. Hence, identifying a suitable control strategy is essential for automating the OC-OTEC process. In this paper, various centralized Proportional Integral (PI)-based control strategies were developed, and their performances and stability were compared to determine the most suitable approach for realtime application. Experimental data was collected from the laboratory-scale OC-OTEC plant, and a data-driven model was developed using system identification techniques. PI-based control strategies using the Davison Method, Decoupler Design Method, and Internal Model Control (IMC)-based Tuning Method were implemented, and their performances were evaluated under both servo and regulatory operations. The results demonstrate that the closed-loop response of the centralized IMC-PI controller outperforms the other techniques, providing improved tracking, superior disturbance rejection, and enhanced stability. Hence, the IMC-based controller can be recommended for automating the real-time OC-OTEC plant.

Keywords: OC-OTEC; Temperature gradient; Centralized controller; IMC-PI; Stability.

Radio-Tolerant Novel Bacterial Consortium for the Biodegradation of Hexamine

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Abstract ID: OP-595

Abstract
A rapidly growing nation faces increasing demand for water, resulting in generation of a matching volume of wastewater, demanding efficient and rapid wastewater management technologies. Such technologies impact global challenges like water scarcity, pollution abatement, and the Sustainable Development Goals (SDGs). Biofilm-based bioremediation of emerging organic pollutants on a large industrial scale is an economically viable and sustainable technology for prolonged use for wastewater treatment. It starts with development of microbial formulation at laboratory scale, its performance optimization, validation at pilot scale before moving to industrial operation. The problem becomes compounded under radioactive environment as seen in the sewage treatment plants of nuclear medicine centre. Tailor-made, strong biofilm-forming bacterial consortium was developed using six well-characterized bacterial isolates from the hexamine and formaldehyde-containing industrial effluent with ability of hexamine, formaldehyde and COD removal upon low doses of ^{60}Co g irradiation in a biofilm setup, revealing the consortium to be radio-tolerant recovering their efficiency within 96 hours post irradiation. The immobilized system, showed 94.6%, 86% and 52.5% reduction in hexamine, formaldehyde and COD after 3.75Gy of ^{60}Co g irradiation and 92.2%, 84.2% and 52.57% reduction in hexamine, formaldehyde and COD after 5.25 Gy of ^{60}Co g irradiation, when starting with an initial 51.6 mg/L hexamine, 39.1 mg/L formaldehyde and COD 13359 mg/L. In this study we report the hexamine removing ability of *Brucella pseudintermedia* and *Ochrobactrum sp.* A rapid and sensitive paper sensor was developed for the detection of formaldehyde in aqueous solution. The sensor could detect 1 mg/L, 5 mg/L, 10 mg/L 100 mg/L formaldehyde at ambient room temperature.

Keywords: Hexamine, Bioremediation, Paper sensor

Energy Harvesting from Waste Heat and Vibrations: Turning Lost Energy into Useful Power

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Abstract
A large amount of energy produced in industries, vehicles, and machines is wasted in the form of heat and mechanical vibrations. Energy harvesting is an effective method to capture this unused energy and convert it into useful electrical power. This poster focuses on energy harvesting from waste heat and vibrations, explaining its basic principles, methods, and applications.

Waste heat energy harvesting mainly uses thermoelectric generators based on the Seebeck effect, where a temperature difference between two surfaces produces electricity. These systems can be used in industrial furnaces, power plants, and automobile exhaust systems. Vibration energy harvesting converts mechanical vibrations into electrical energy using piezoelectric and electromagnetic materials. Such systems are suitable for low-power applications like wireless sensors and Internet of Things (IoT) devices.
Energy harvesting helps in reducing energy loss, improving energy efficiency, and supporting sustainable development. It also allows the operation of self-powered devices with low maintenance requirements. However, challenges such as low efficiency, limited power output, and high material costs still exist. Ongoing research in advanced materials and hybrid energy harvesting systems aims to overcome these limitations. Overall, energy harvesting from waste heat and vibrations is a promising technology for future renewable energy and smart engineering applications.

Keywords: Energy harvesting; Waste heat recovery; Thermoelectric generator; Piezoelectric materials; Vibration energy

Towards On-Site Detection: Advancing Wastewater Management with Optical Sensors for Toxic Pollutants

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Abstract ID:OP-680

Abstract

The increasing discharge of industrial, agricultural, and domestic effluents has led to severe contamination of water resources, necessitating the development of efficient and real-time wastewater monitoring systems. This work focuses on the development of a sensitive and reliable sensor for the detection of pollutants in wastewater. The proposed sensor is designed to monitor key contaminants such as heavy metals, organic pollutants, and toxic ions that pose significant risks to environmental and human health. By integrating advanced sensing materials with optimized transduction mechanisms, the sensor demonstrates high sensitivity, selectivity, and rapid response under complex wastewater conditions. The probe enables continuous, on-site monitoring, reducing reliance on labor-intensive laboratory-based analyses. Emphasis is placed on improving detection limits, operational stability, and cost-effectiveness to facilitate large-scale deployment in wastewater treatment facilities and environmental monitoring stations. Experimental validation shows that the sensor provides accurate and reproducible measurements over a wide range of pollutant concentrations, even in the presence of interfering species. The developed sensor holds strong potential for early detection of pollution events, regulatory compliance, and sustainable water resource management. Overall, this study

contributes toward the advancement of smart sensing technologies for real-time wastewater quality assessment and environmental protection.

Keywords: Environmental sensor; Smart sensing technology; Pollution detection; Wastewater monitoring; Water quality assessment.

Generative AI in Chemical Engineering Education: Case study of using Gen AI in Heat Transfer Course

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Abstract ID: OP-712

Abstract
Analytical reasoning is often underemphasized in foundational chemical engineering problem-solving, particularly in Heat Transfer, where conventional digital tools frequently prioritize direct solution delivery over conceptual understanding. This work presents a structured, AI-assisted framework designed to support stepwise reasoning and improve conceptual clarity in Heat Transfer. The approach adopts a prompt-based methodology inspired by Socratic enquiry, in which guided questioning leads users through governing equations, assumptions, and physical interpretations rather than revealing immediate numerical answers. The system is enhanced by a Reverse Tutoring mode where users must identify and correct conceptual fallacies presented by the AI to reinforce mastery. The framework utilizes adaptive scaffolding to dynamically adjust inquiry depth based on real-time user proficiency. Operating within a single interface, it offers adjustable interaction levels to accommodate various expertise degrees. Artificial intelligence serves as a reasoning support mechanism rather than a solution-generation tool. By prioritizing analytical progression over rote formula recall, the framework enhances independent problem-solving and deepens mastery of fundamental Heat Transfer principles. The proposed approach demonstrates how AI-assisted reasoning tools can be integrated into Chemical Engineering subjects while maintaining fundamental engineering rigor and highlights the potential role of structured AI support in chemical engineering training and technical skill development within advanced Chemical Engineering applications.

Keywords: Heat Transfer; GenAI; Chemical Engineering Education

Microbial Bioreactors for Emerging Contaminants: Mechanisms, Limitations, and Research Priorities

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Abstract

Microbial bioreactors are the backbone of biological wastewater treatment across municipal and industrial sectors, increasingly tasked with removing nutrients, refractory organics, and emerging contaminants while enabling safe water reuse. This review critically evaluates the performance of conventional activated sludge, biofilm systems (MBBR/IFAS), anaerobic bioreactors, and hybrid membrane bioreactors (MBRs), integrating pollutant complexity, microbial ecology, fouling mechanistic, and energy–quality trade-offs. Removal pathways for key contaminant classes are systematically examined, highlighting persistent uncertainties associated with transformation products, particularly for pharmaceuticals and endocrine-disrupting compounds. Major operational and knowledge gaps are identified, including EPS and SMP-induced fouling in MBRs, process resilience under salinity, temperature, and toxic shock conditions, stability of mainstream shortcut nitrogen removal pathways, and treatment limitations for high-salinity industrial wastewaters. In addition, the lack of standardized fouling characterization methods and lifecycle economic assessments linked to reuse objectives is discussed. The review concludes by proposing a structured decision framework and research priorities to guide reactor selection, process control, and system intensification, supporting the development of resilient, energy-efficient, and risk-aware biological wastewater treatment technologies.

Keywords: Microbial bioreactors; emerging contaminants; wastewater treatment; membrane bioreactors; biofilm processes; water reuse

Advances in Oxovanadium Complexes as Biofunctional Materials: From Molecular Design to Biomedical Applications

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Abstract

Oxovanadium complexes have gained significant attention as biofunctional materials due to their versatile redox behavior, structural tunability, and notable biological activities. Advances in ligand design have enabled precise control over their stability and reactivity, enhancing their ability to mimic enzyme functions such as haloperoxidase activity and insulin-like behavior. These properties make them promising candidates for applications in diabetes management, antimicrobial therapy, and anticancer strategies. Mechanistically, their biological effects are largely attributed to redox modulation, generation of reactive oxygen species, and interactions with biomolecular targets including DNA and proteins. Despite encouraging progress,

challenges related to toxicity, bioavailability, and long-term stability must be addressed for clinical translation. This review highlights recent developments in molecular design, mechanistic understanding, and biomedical applications of oxovanadium complexes, emphasizing their future potential as multifunctional therapeutic agents.