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ARISTON PUBLICATIONS
Energy & Environment Advances
ISSN: 3066-5728 https://aristonpubs.com/energy-environment-advances https://doi.org/10.69626/eea.2025.0120

EDITORIAL

A Special Issue on "Advanced Functional Nanomaterials for Sustainable Environmental and Energy Applications"

The defining challenge of our time is harmonizing societal advancement with ecological preservation. As industrial and population growth intensify, the intertwined crises of environmental pollution and escalating energy demands create urgent global imperatives. The search for sustainable solutions has therefore transitioned from theoretical pursuit to essential action. Central to this mission is materials science, with nanotechnology offering a revolutionary toolkit. By manipulating matter at the nanoscale, researchers unlock extraordinary properties, vast surface areas, quantum confinement, tailored porosity, and heightened reactivity, unavailable in bulk counterparts. This special issue of *Energy and Environment Advances* showcases this powerful convergence. The five collected studies are interconnected chapters in a broader narrative of innovation, each demonstrating how precisely engineered nanomaterials provide efficient, scalable solutions to specific environmental and diagnostic challenges.

A commitment to practical, green engineering unifies this collection. Each article emphasizes relatively simple, scalable syntheses operable under benign conditions, while applications focus on low-energy consumption, reusability, and direct environmental or health benefits. This marks a decisive shift from conventional, often wasteful and energy-intensive technologies toward smarter, sustainable alternatives.

The issue opens with the work of *Kamtekar et al.*, addressing a critical need in healthcare and environmental monitoring: volatile organic compound (VOC) detection. The authors present an elegant, energy-efficient alternative to high-temperature metal-oxide acetone sensors. Using the Successive Ionic Layer Adsorption and Reaction (SILAR) method, they fabricate polyaniline (PANI) thin films operable at room temperature. The resulting nanostructured, porous film exhibits an 85% response to acetone with excellent selectivity. This work embodies "energy efficiency by design," eliminating power-hungry heating elements to enable portable, wearable sensors for breath-based diabetes diagnostics and continuous air quality monitoring.

Next, *Mujawar et al.* tackle oil-water separation, a pervasive environmental problem. They ingeniously create a superhydrophobic sponge by dip-coating polyurethane with a composite of candle soot, silica nanoparticles, and polymers. This biomimetic material achieves a water contact angle of 165° and 99% oil separation efficiency. Its true innovation lies in remarkable mechanical durability and chemical stability, overcoming the fragility typical of superhydrophobic surfaces. This transforms the sponge from a lab prototype into a viable, reusable tool for industrial wastewater treatment and oil spill response, highlighting that sustainable solutions must be both effective and economically scalable.

Where physical removal is insufficient, destructive degradation becomes key. Barve and Lanjewar contribute to this domain with hydrothermally synthesized cadmium oxide (CdO) nanorods for photocatalytic dye degradation. The nanorods' quantum-confined bandgap (3.75 eV) enhances their activity under UV light, leveraging increased surface area and improved charge carrier dynamics to degrade methyl red dye efficiently. This study provides a blueprint for using nanostructure morphology and quantum effects to advance semiconductor photocatalysts, a crucial step toward solar-driven water purification systems.

Complementing destruction, adsorption remains a cornerstone of remediation. Thonge, Kulal, Gurame, and colleagues employ a sophisticated iron-based Metal-Organic Framework (Fe-TBA MOF) for dye adsorption. MOFs offer unparalleled porosity, and the authors demonstrate exceptional methylene blue adsorption capacity. Their rigorous mechanistic analysis confirms chemisorption via pseudo-second-order kinetics. Critically, the Fe-TBA MOF is regenerable for over seven cycles, underscoring the move toward circular, material-efficient processes and away from single-use adsorbents.

Concluding the issue, Pawar et al. bridge environmental and biomedical sensing with a zinc oxide nanostructure-modified nickel foam (ZnOx/NF) electrode for electrochemical potassium ion detection. The 3D porous

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architecture, combining conductive foam with catalytic ZnOx nanosheets, yields superior sensitivity (3.84 µM) and a low detection limit (5.81 µM). This platform exemplifies the trend toward miniaturized, sensitive devices enabled by nanoengineering, with potential for field-deployable environmental and health monitors.

Collectively, these articles affirm that strategic nanomaterial design provides a versatile pathway for addressing diverse challenges, from sensing and separation to degradation and detection. Unifying themes include ambient-condition operation, durability, reusability, exploitation of nanoscale phenomena, and green synthesis.

The path forward, however, requires overcoming translational challenges: ensuring long-term stability, conducting comprehensive lifecycle and toxicity assessments, and integrating materials into user-friendly systems. Future research must pursue even greater sustainability through bio-derived precursors, enhanced solar photocatalysis, and designs facilitating material recovery.

We are inspired by the quality and relevance of the work in this special issue. These contributions reflect a vibrant, global commitment to solving pressing planetary problems. We hope this collection serves as both a snapshot of current progress and a catalyst for continued interdisciplinary collaboration. By harnessing the unique capabilities of advanced functional nanomaterials, the scientific community can develop the sophisticated tools necessary to protect our environment and build a sustainable, healthier future.

I extend my heartfelt appreciation to all the authors, reviewers, and editorial board members who contributed their time and expertise to make this special issue possible. Their dedication and scholarly insight have ensured the high quality and relevance of the published work. Special thanks are also due to the publication team for their continuous support in curating and presenting this issue to the academic community.

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The research interests of Dr. Tehare include nanomaterials, TiO_2 nanostructures, dye-sensitized and perovskite solar cells, renewable energy systems, and advanced materials for energy applications. He has published a great number of research articles in reputed international journals, which have garnered a wide citation impact. He is also the author of multiple book chapters on solar cells and energy devices for various reputed publications. He actively serves the scientific community as a reviewer for leading journals.

Dr. Tehare is also a co-inventor of multiple published Indian patents related to advanced solar cell technologies and AI-assisted energy materials. He has participated in and organized numerous international and national conferences, workshops, and symposia. Through teaching, research, editorial service, and interdisciplinary collaboration, Dr. Tehare continues to contribute to the advancement of materials science, renewable energy research, and physics education. He currently serves as an Editorial Board Member of *Energy and Environmental Advances*.

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