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## Reflecting on a year of innovation and looking ahead: the exciting future of energy materials and green energy

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As we close the chapter on an extraordinary year at *Energy Advances*, we pause to reflect on our shared journey and the significant progress we have achieved in energy research. Our journal has consistently been a leader in sharing pioneering discoveries and nurturing a vibrant community of researchers committed to tackling the vital challenge of sustainable energy. A highlight of this journey has been the inclusion of *Energy Advances* in the Web of Science (WoS) Emerging Sources Citation Index (ESCI), marking a significant milestone in our growth. Additionally, we take pride in being fully indexed in Scopus, ensuring our contributions remain accessible and impactful within the global scientific community.

### Publication highlights

*Energy Advances* has been a beacon for innovative research and insightful science this past year. We have seen a plethora of impactful papers that have expanded our understanding and paved the way for practical applications in the energy field. Let me highlight five selected works in particular based on the number of citations and access.

- In the realm of photoelectrochemical cells, two-dimensional (2D) materials

have proven revolutionary, offering unique electronic and mechanical properties distinct from their bulk counterparts. The review “Two-dimensional materials for photoelectrochemical water splitting” by Jun *et al.* explores 2D materials to enhance unassisted solar water splitting by integrating their unique characteristics into semiconducting photoabsorbers. It highlights the intrinsic advantages of 2D materials, such as transition metal dichalcogenides, graphene, graphdiyne, black phosphorus, layered double hydroxides, and MXenes, all of which are pivotal in improving the photoelectrochemical performance of photoelectrodes. The paper emphasizes the potential of carefully constructed heterostructures combining photoabsorbers with 2D materials for efficient light harvesting and hydrogen and oxygen evolution. It concludes with a discussion on the future outlook, focusing on developing synthetic technologies for mass production, enhancing stability, and building tandem architectures for unbiased solar water splitting [<https://doi.org/10.1039/D2YA00231K>].

- The review article “Defect engineering in antimony selenide thin film solar cells” by Wijesinghe *et al.* focuses on antimony selenide (Sb<sub>2</sub>Se<sub>3</sub>), an emerging inorganic absorber in thin-film photovoltaics and water splitting devices, recognized for its excellent optoelectronic properties, low toxicity, and abundance. Despite achieving a record power conversion efficiency of

10.12%, further efficiency improvements in Sb<sub>2</sub>Se<sub>3</sub> solar cells are challenged by open circuit voltage deficits due to defects and interfacial recombination. These defects impact charge carrier generation, transportation, intrinsic electrical conductivity, and film crystallinity, thus affecting the efficiency and stability of the cells. The paper comprehensively reviews defect chemistry in Sb<sub>2</sub>Se<sub>3</sub> solar cells, focusing on surfaces, grain boundaries, interfaces, and community efforts in defect passivation. It concludes with potential challenges and strategies for developing highly efficient and stable Sb<sub>2</sub>Se<sub>3</sub> solar cells [<https://doi.org/10.1039/D2YA00232A>].

- The communication paper by Ugata *et al.* entitled “Improved reversibility of lithium deposition and stripping with high areal capacity under practical conditions through enhanced wettability of the polyolefin separator to highly concentrated electrolytes” focuses on the development of an enhanced separator for lithium metal batteries using highly concentrated electrolytes (HCEs), which are known for improving the reversibility and cycling performance of lithium metal negative electrodes. The research addresses the challenge of poor wettability in conventional polyolefin separators when used with HCEs. The team reports that using a meta-aramid-coated polyolefin separator significantly improves wettability due to its polar surface functional groups. This innovation enables stable

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and dendrite-free lithium deposition and stripping, achieving a high Coulombic efficiency of approximately 98% at a practical areal capacity of  $2 \text{ mA h cm}^{-2}$  over 100 cycles. This advancement, combining HCEs with functional separators, holds promise for developing practical lithium metal batteries [<https://doi.org/10.1039/D2YA00359G>].

• Cai and Koenig have presented in their work “Enhancing low electronic conductivity materials in all active material electrodes through multicomponent architecture” a novel approach in lithium-ion battery technology exploring the use of “all active material” (AAM) electrodes, which are composed solely of electroactive materials that have been mechanically compressed and mildly thermally treated to create a porous electrode pellet. The focus is on integrating a material with high gravimetric capacity but low electronic conductivity, specifically  $\text{LiNi}_{0.5}\text{Mn}_{0.5}\text{O}_2$  (LNMO), into an AAM cathode. The study addresses the issue of high polarization in LNMO due to its low electronic conductivity by blending it with  $\text{LiCoO}_2$  (LCO), a material with higher electronic conductivity but lower gravimetric capacity. This combination forms a multicomponent AAM cathode, where the LCO/LNMO blend shows improved electrochemical properties. The enhancement is attributed to LCO forming a percolated network for electron transport while maintaining segregation between LCO and LNMO particles in the electrode structure. The paper presents a new concept in incorporating materials with relatively low electronic conductivity into AAM electrodes, utilizing a multicomponent architectural approach, with outcomes analyzed through pseudo-two-dimensional simulations of cell cycling [<https://doi.org/10.1039/D2YA00269H>].

• The paper of Srivastava *et al.* “Effect of  $\text{Ti}_{1-x}\text{Fe}_x\text{O}_2$  photoanodes on the performance of dye-sensitized solar cells utilizing natural betalain pigments extracted from *Beta vulgaris* (BV)” explores the enhancement of dye-sensitized solar cells (DSSCs) using naturally occurring dyes, specifically focusing on the performance and stability of these cells with engineered photoanodes. Fe-doped  $\text{TiO}_2$  nanorods (NRs) were synthesized on fluorine-doped tin oxide (FTO) electrodes using a hydrothermal method. The research

examined the effects of varying concentrations of Fe in  $\text{Ti}_{1-x}\text{Fe}_x\text{O}_2$  photoanodes on their physicochemical and electrical characteristics. Utilizing a natural dye extracted from *Beta vulgaris* (BV), the study demonstrated a significant improvement in the photovoltaic performance of DSSCs. Including 5 at% Fe in  $\text{TiO}_2$  NRs increasing photocurrent density from 80 to  $129.758 \mu\text{A cm}^{-2}$  and doubling the power conversion efficiency (PCE) from 0.26% to 0.52%. This improvement is attributed to enhanced charge injection and separation by the  $\text{Ti}_{1-x}\text{Fe}_x\text{O}_2$  interlayer. The results suggest that such photoanodes, with their improved responsiveness, could surpass pure  $\text{TiO}_2$  nanostructures in photovoltaic applications and also show promise for use in photocatalysis and photo sensors [<https://doi.org/10.1039/D2YA00197G>].

My personal 2023 highlight, among many excellent works, was the perspective written by Knehr *et al.* “From material properties to device metrics: a data-driven guide to battery design” [<https://doi.org/10.1039/D3YA00137G>]. This paper offers a data-driven analysis of the key factors influencing battery performance, including material parameters, cell design choices, and manufacturing costs, and how they impact crucial battery metrics like energy, power, cost, lifetime, and safety. Utilizing Monte Carlo simulations of lithium-ion batteries through the Battery Performance and Cost (BatPaC) model from Argonne National Laboratory, the study identifies the most critical parameters for optimizing each metric. It also explores the potential trade-offs required to achieve multiple objectives, such as high energy density and extended battery life, providing valuable insights for designing and developing more efficient and sustainable battery technologies.

## Open access and community

At the core of our journal's ethos is the mission to unite individuals from the scientific community, creating a dynamic platform where research is not only published but also made widely accessible. Embracing Open Access is fundamental to our pursuit of Open Science. The Royal Society of Chemistry ardently supports the

shift towards complete open access. This commitment extends beyond merely facilitating access to knowledge; it also aims to amplify our authors' reach, enhancing the dissemination and citation of their work. Our dedication to cultivating an engaging scientific community is further reflected in our active involvement in international conferences. These gatherings are not just events, but catalysts for progress, offering researchers from around the globe opportunities to connect, collaborate, and exchange ideas, thereby propelling advancements in their respective fields.

## Themed collections

2023 has also seen the launch of several themed collections to address emerging and impactful research topics along the energy research landscape:

- Blue and green hydrogen production & storage
- Flowable energy storage
- High entropy energy materials
- AI & ML in energy storage and conversion

The Emerging Investigator Series is particularly dear to us, where we showcase the exciting research our fantastic early-career community conducts. So far, the research topics in this series include amorphous MOFs for next-generation supercapacitors and batteries [<https://doi.org/10.1039/D3YA00306J>], 2D–2D heterostructure hybrids for efficient electrocatalysis [<https://doi.org/10.1039/D2YA00318J>], computational approaches for rapid metal site discovery in carbon-based materials for electrocatalysis [<https://doi.org/10.1039/D3YA00321C>], photothermal catalytic Cl conversion on supported catalysts [<https://doi.org/10.1039/D3YA00315A>], anodic dissolution of aluminum in non-aqueous electrolyte solutions for sodium-ion batteries [<https://doi.org/10.1039/D3YA00233K>], and the reversible alkaline hydrogen evolution and oxidation reactions using Ni–Mo catalysts supported on carbon [<https://doi.org/10.1039/D3YA00140G>].

## A tribute to our team

The adage “it takes a village” aptly captures the essence of teamwork in



accomplishing multifaceted tasks, a principle that resonates deeply within our journal. At the RSC, we are extraordinarily fortunate to have a stellar team steering *Energy Advances*. Our team's dedication and expertise are embodied by Emma Eley, our Executive Editor; Jon Ferrer, our Deputy Editor; and Alex Holiday, our Editorial Assistant. We extend our appreciation to Sarah Whitbread, our Editorial Production Manager, and our diligent Assistant Editors, Jamie Purcell, Alexander John, Emily Ellison, Jack Pitchers, and Clare Fitzgerald. Special thanks to Lee Colwill, our Publishing Assistant, and Neil Hammond, our esteemed Publisher. Our Editorial Board Members – Guang Feng, You Han, B. Layla Mehdi, Michael Naguib, Matthew Suss, and Wai-Yeung (Raymond) Wong – deserve immense gratitude for their insightful feedback and meticulous work in reviewing submissions, selecting peer reviewers, overseeing the decision-making process, and engaging with our authors. Their roles are pivotal, ensuring that *Energy Advances* consistently aligns with the forefront of research and resonates with our contributing scientists' evolving needs and aspirations. We are also grateful to the wisdom and support provided to us by our 28 Advisory Board members from various research areas and across the world: from A, as in Nirmala Grace Andrews, to Z, as in Hongcai Zhou. Thank you in particular for helping with adjudicative reviews and advising us in many ways.

## A tribute to our reviewers

In our quest for scientific excellence, the integral role played by our reviewers is immeasurable. We extend our heartfelt thanks to these devoted individuals who consistently dedicate their time, expertise, and intelligent insights. Their service forms the bedrock of scientific integrity, a standard our reviewers uphold with their unwavering commitment to impartial, thorough, and constructive criticism. Far from being just evaluators, our reviewers are instrumental in sculpting scientific research and innovation trajectories. We sincerely appreciate each reviewer – your dedication, insight, and judicious discernment are fundamental to advancing science and enriching the global scientific community. We also thank our authors for their patience and willingness to engage constructively with our reviewers. Our commitment at *Energy Advances* is to provide prompt, unbiased, and equitable feedback, always prioritizing the quality and depth of the reviews we solicit. This collaborative process ensures the publication of research that is rigorous and innovative and contributes significantly to the ongoing dialogue in the scientific world.

## Outlook

The path forward is a tapestry woven with both challenges and opportunities. As we delve deeper into new materials and technologies, our commitment to pushing the

boundaries of knowledge and fostering a sustainable energy future remains unshakeable. One area that stands out in its potential is the development of advanced battery electrode materials. The quest for more efficient, sustainable, and cost-effective energy storage solutions is more pertinent than ever. Innovative electrode materials, including nanostructured compounds, novel battery chemistry beyond lithium, and hybrid materials, are at the heart of this quest. They promise to enhance the performance, longevity, and environmental footprint of batteries, which are crucial for various applications, from electric vehicles to grid storage. Also, augmented by artificial intelligence, the burgeoning field of predictive materials science is set to revolutionize research in unprecedented ways. AI, transcending its role as merely a tool, demands expertise, prudence, and thoughtful application. It's important to recognize that not every material predicted, chemical synthesis proposed, or electrochemical property anticipated will redefine the landscape. Indeed, some predictions might not be feasible or practical for implementation. Yet, AI facilitates the remarkable acceleration in material discovery and application, and stands as a formidable ally in humanity's endeavor towards a sustainable, eco-conscious, and peaceful tomorrow.

Let's continue to advance energy in 2024 and beyond!

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