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EDITORIAL

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Energy Advances 2025 Outstanding Papers

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We are proud to announce the *Energy Advances* 2025 Outstanding Papers. This is an opportunity to recognise the excellent work published in the journal and celebrate the authors behind the work by selecting one Outstanding Article and one Outstanding Review each year.

These papers are chosen from a shortlist compiled by the Editorial Office using a range of metrics. The journal's Editorial and Advisory Boards review and vote on these papers based on the science presented and the potential impact. The Editor-in-Chief selects the final winning papers, taking the Board members' votes into account.

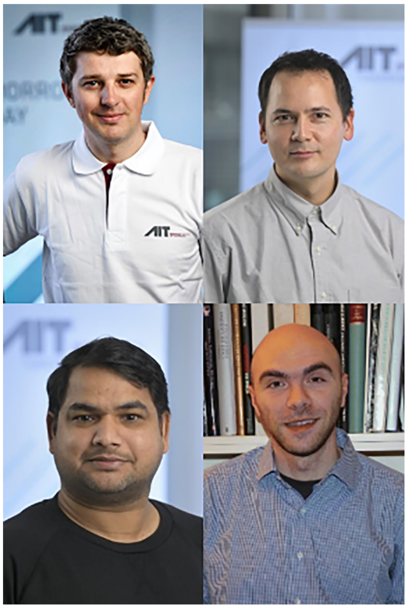
We are delighted to introduce the 2025 Outstanding Article and Outstanding Review. Please join us in congratulating the authors behind these excellent contributions.

Energy Advances 2025 Outstanding Article

Insights into the chemical and electrochemical behavior of halide and sulfide electrolytes in all-solid-state batteries

Artur Tron, Alexander Beutl, Irshad Mohammad and Andrea Paolella

''*All-solid-state batteries hinge on interfacial stability, and this work offers a very clear, experimentally grounded contribution to that challenge.*[1] *By comparing halide and sulfide electrolytes and demonstrating a composite electrolyte concept (halide plus argyrodite), the authors show a tangible pathway to suppress unfavorable reactions at the Li metal interface. The reported improvements in symmetric-cell stability and critical current density, alongside better performance in NCM half-cells, make this paper stand out as both rigorous and implementation-oriented.*'' – Volker Presser, Editor-in-Chief, *Energy Advances*



We spoke to the authors Artur Tron, Alexander Beutl, Irshad Mohammad and Andrea Paolella about their work.

Which part of this paper do you think will have the greatest impact?

In my opinion, the most impactful part of this work is the clear link we establish between electrolyte design, interfacial behaviour, and overall cell performance. The study provides practical guidelines that other researchers can directly apply when developing next-generation energy storage systems. I believe the community will benefit most from the methodology and the design principles, as they can be transferred to different chemistries and device concepts.

What was the most challenging part of completing this research?

The most challenging aspect was achieving reproducible results while dealing with highly sensitive interfacial processes. Small variations in materials or conditions can significantly influence the outcome, so we had to optimise and control every step carefully. Integrating different characterisation techniques and keeping a consistent mechanistic picture was demanding, but essential for drawing reliable conclusions.

What are the next steps for this research?

The next steps involve testing the developed concepts under more practical conditions and exploring their compatibility with new electrode materials. We also plan to use more advanced in situ and operando techniques to deepen the mechanistic understanding. Finally, the goal is to move *from laboratory-scale optimisation toward device-level implementation.*

Energy Advances 2025 Outstanding Review

Unlocking catalytic longevity: a critical review of catalyst deactivation pathways and regeneration technologies

Ifeanyi Michael Smarte Anekwe and Yusuf Makarfi Isa

"*Catalyst deactivation remains one of the key bottlenecks in industrial catalysis, and this review tackles it with impressive breadth and structure.*[2] *The authors critically map major deactivation pathways – from coking and poisoning to thermal and mechanical degradation – and discuss both established and emerging regeneration concepts. The balanced discussion of effectiveness, trade-offs, and environmental implications makes this a genuinely useful reference for researchers and practitioners aiming for catalytic longevity.*" – Volker Presser, Editor-in-Chief, *Energy Advances*

The authors Ifeanyi Michael Smarte Anekwe and Yusuf Makarfi Isa were invited to answer a few questions about their review.

What do you see as the most significant insights or conclusions from your review?

The central insight is that catalyst deactivation is not a single failure mode, but a dynamic, multi-mechanistic process driven by structural, chemical, and operational factors that interact over time. By systematically mapping these pathways – poisoning, fouling, sintering, phase transformation, and leaching – the review clarifies how each mechanism evolves and demonstrates that regeneration strategies must be tailored rather than generic. A second key conclusion is that regeneration is most effective when incorporated into the catalyst lifecycle, rather than treated as an after-the-fact repair step. Integrating operando diagnostics, predictive modelling, and materials engineering enables catalysts to maintain activity far longer than traditional approaches suggest. The complex processes leading to deactivation will inevitably alter catalyst properties, which may increase selectivity for by-products at the expense of the main product. While this is undesirable in many processes, it may be valuable in the production of other chemicals. From a design perspective, this raises an important question: as we continue to advance our synthesis techniques, will we reach a point where catalysts are designed from first principles around controlled deactivation – engineering their eventual, more selective state from the moment they are first synthesised?

What are the biggest challenges currently facing researchers in this area?

The main challenge is the gap between laboratory-scale understanding of deactivation and the complexity of industrial operating environments. Real systems involve fluctuating feed compositions, thermal gradients, contaminants, and mechanical stresses that accelerate degradation in ways that are difficult to replicate experimentally. Another challenge is the limited availability of real-time characterisation tools capable of capturing deactivation as it occurs. Without operando insight, regeneration strategies remain reactive rather than predictive. The field still lacks unified frameworks connecting catalyst structure, reaction environment, and long-term stability, making it difficult to design catalysts with inherent resilience. A further challenge in catalysis is the continued reliance on empirical screening rather than rational design. Too often, catalysts are identified through iterative trial-and-error approaches instead of being deliberately engineered for a predefined target transformation.

What do you hope readers take away from your review?

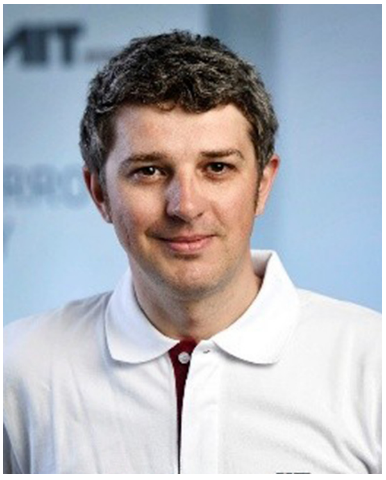
Readers should gain a clear, mechanistic understanding of why catalysts fail and how targeted regeneration can extend their useful life. This review provides both a conceptual roadmap and a practical guide, highlighting which deactivation pathways dominate under specific conditions and which regeneration techniques are most effective for each. Ultimately, the aim is to encourage researchers and industrial stakeholders to consider catalyst longevity as a design parameter from the outset, rather than as a downstream challenge. We often treat catalyst sensitivity as a flaw, but what if we harnessed it? Unlike a perpetual motion machine, which thermodynamics tells us is impossible, a catalyst with a purposefully shifting function is not. Instead of pursuing absolute stability, we could design for guided change: not catalysts that simply deactivate, but catalysts that transform.

We extend our sincerest congratulations to the authors of our 2025 Outstanding Papers, whose work will continue to advance and shape energy science. We look forward to celebrating more excellent work in the years to come.

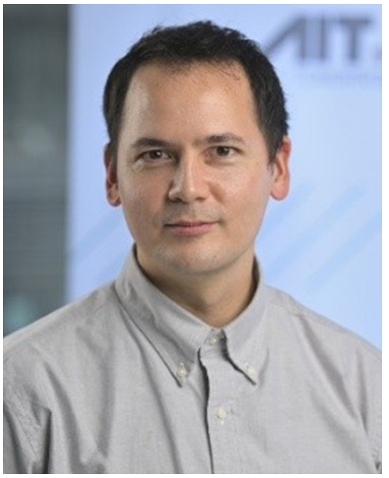
Author biographies

***Energy Advances* Outstanding Article 2025:**

Insights into the chemical and electrochemical behavior of halide and sulfide electrolytes in all-solid-state batteries



Artur Tron is a research scientist with over 15 years of international experience in lithium-ion and solid-state battery technologies. His expertise spans surface modification, coating processes, and the development of high-energy electrode materials for advanced battery systems, including lithium ion (LIBs), solid-state (SSBs) and aqueous rechargeable lithium batteries (ARLBs). He earned his PhD in Electrochemistry from the Ukrainian State University of Chemical Technology (Ukraine), conducting research at the Research Laboratory of Chemical Power Sources in collaboration with Enerize Co. Ltd (USA). His career includes R&D roles at Samsung SDI (South Korea), Incheon National University (South Korea), and SINTEF Industry (Norway), where he contributed to cathode development, aqueous systems, and solid-state battery innovation. Currently, Dr Artur Tron is a Scientist at the AIT Austrian Institute of Technology in Vienna (Austria), where he leads research on high-energy anode and cathode materials, solid electrolytes, and interfacial engineering for next-generation battery systems. He also serves as an Associate Editor for *Frontiers in Batteries and Electrochemistry*. He is the author of over 45+ peer-reviewed publications and holds six patents in the field.



Alexander Beutl graduated in the field of chemistry at the University of Vienna in 2018. He then joined the Battery Technologies group at the Austrian Institute of Technology where he continued his studies on materials relevant for next generation energy storage technologies. After being employed for one year as a post-doc, he joined AIT as a full-time employee as a junior scientist focusing on the development of solid-state lithium ion batteries. He currently holds the position of Scientist and has further broadened his expertise to include structural batteries. He has led and supported several projects including national funded ones, projects funded by the European Commission and privately funded projects (*e.g.* ESA). He authored 20+ publications and received the Editor's Choice Award for his work on sulfide-based composite cathodes from the *Nanomaterials* journal.

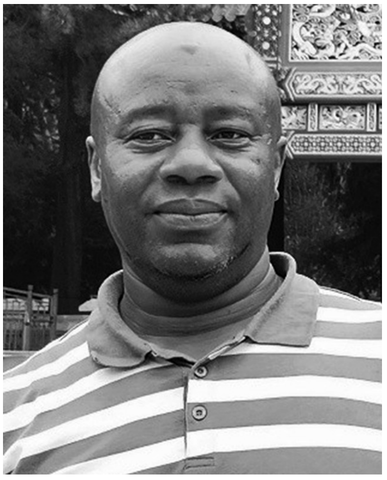
Irshad Mohammad is a materials scientist with extensive research experience in advanced energy storage materials. Currently, he works as a Scientist in the Battery Technologies competence unit at the Austrian Institute of Technology (AIT). He earned his PhD in chemistry from Tallinn University of Technology, Estonia, in 2019. Following his doctorate, he completed postdoctoral research at the University of Surrey in the UK and CEA Saclay in France. His research primarily focuses on developing and characterising next-generation batteries, including magnesium, lithium–sulfur, sodium-ion, and solid-state batteries. His skills include the design and synthesis of electrode and electrolyte materials, and advanced materials characterisation techniques such as solid-state NMR, XRD, XRF, and XPS. Dr Irshad has numerous publications in leading peer-reviewed journals on battery technology. His work aims to deepen the understanding of electrochemical energy storage and support the development of reliable, sustainable batteries.

Andrea Paolella obtained his PhD from the Italian Institute of Technology and the University of Genoa in 2013. Following a postdoctoral fellowship at McGill University in Montreal, Canada, he joined the Battery Unit at Hydro-Québec, where he served as a researcher and later as a team leader from 2016 to 2022. Since October 2022, he has been a Senior Scientist in Solid-State Battery Technology at the Austrian Institute of Technology in Vienna. In September 2023, he was appointed Associate Professor of Inorganic Chemistry at the University of Modena and Reggio Emilia. His current research focuses on novel anode-free configurations, innovative synthesis methods for solid electrolytes, and new architectures for solid-state batteries.

Energy Advances **Outstanding Review 2025:**

Unlocking catalytic longevity: a critical review of catalyst deactivation pathways and regeneration technologies

Ifeanyi Smarte Anekwe is a researcher in catalysis, with a strong focus on heterogeneous systems that drive innovation in renewable energy and sustainability. He earned his PhD from the University of the Witwatersrand, where he specialised in the design and application of heterogeneous catalysts for biofuel production. Dr Anekwe is part of the Advanced Fuels and Chemicals Synthesis Research Unit at Wits University, where he conducts his research. He also serves as a visiting researcher at the Leibniz-Institut für Katalyse (LIKAT) in Germany, collaborating on advanced catalytic materials and reaction engineering. He has presented his work at international conferences and published in reputable scientific journals. In recognition of his impactful scholarship, he received the prestigious Overall WITS Early Career Researcher Award and Researcher Author Award from Elsevier in 2025, underscoring his growing influence in the field.



Yusuf Makarfi Isa obtained his first degree in Chemical Engineering and Biotechnology. He further specialised in synthetic fuels and carbon materials. In addition to his training in fossil fuels, his doctoral study at the AV Topchiev Institute of Petrochemical Synthesis, Moscow, focused on catalyst synthesis and application in the transformation of fermentation broth to fuels and petrochemicals. His research interests lie in sustainable energy from carbon materials. He has practical experience in petroleum refining and the conversion of olefins to distillate. He has taught Chemical and Petroleum Engineering courses at the undergraduate and postgraduate levels. He has presented his works at many international conferences and reputable journals. He is a Professor at the School of Chemical and Metallurgical Engineering, and he leads the Advanced Fuels and Chemicals Synthesis research unit. He has synthesised and worked with various catalysts in the conversion of hydrocarbon-based materials.

References

1 A. Tron, A. Beutl, I. Mohammad and A. Paolella, Insights into the chemical and electrochemical behavior of halide and sulfide electrolytes in all-solid-state batteries, *Energy Adv.*, 2025, **4**, 518–529.

2 I. M. S. Anekwe and Y. M. Isa, Unlocking catalytic longevity: a critical review of catalyst deactivation pathways and regeneration technologies, *Energy Adv.*, 2025, **4**, 1075–1113.