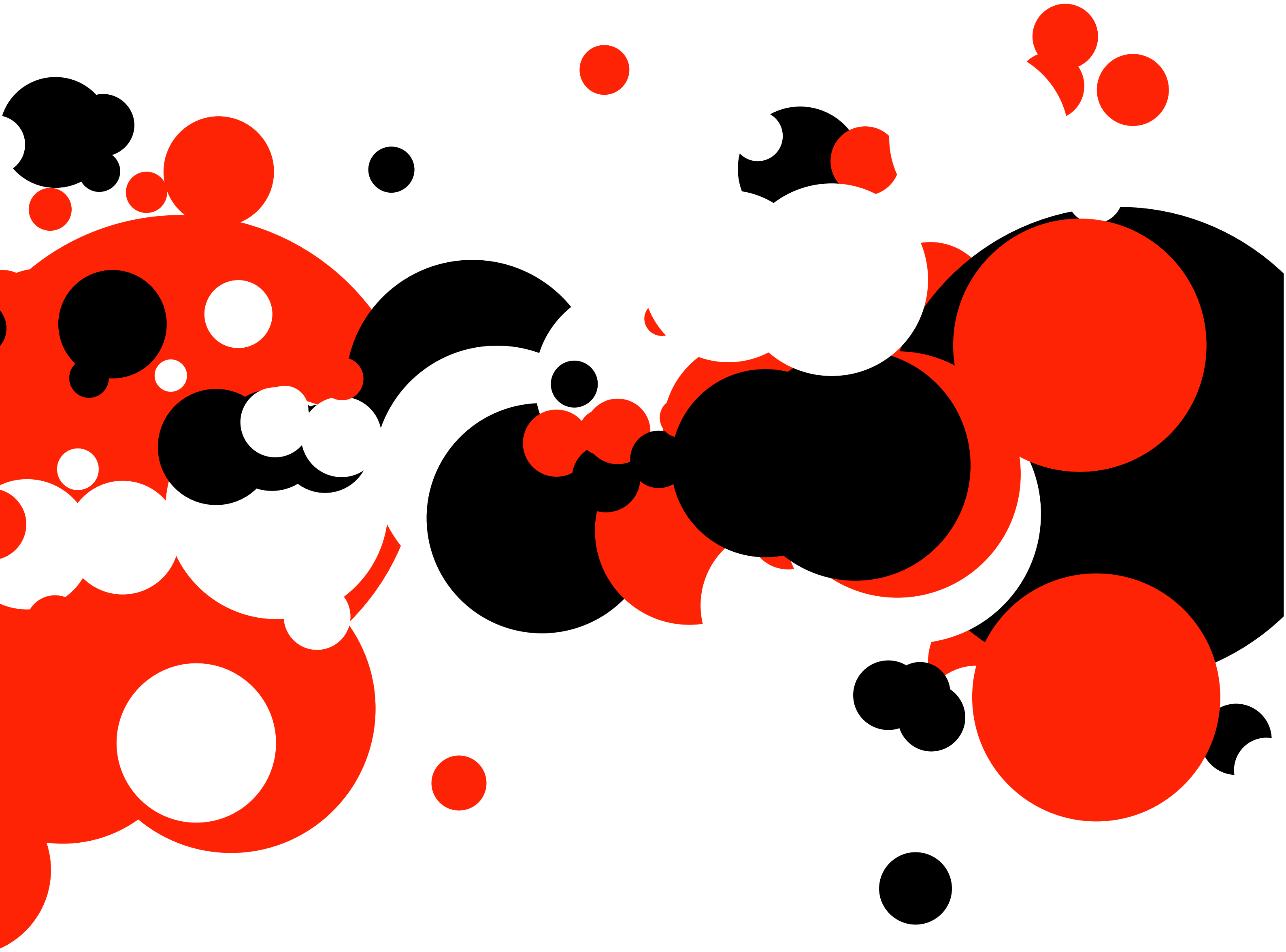
University of Technology Sydney

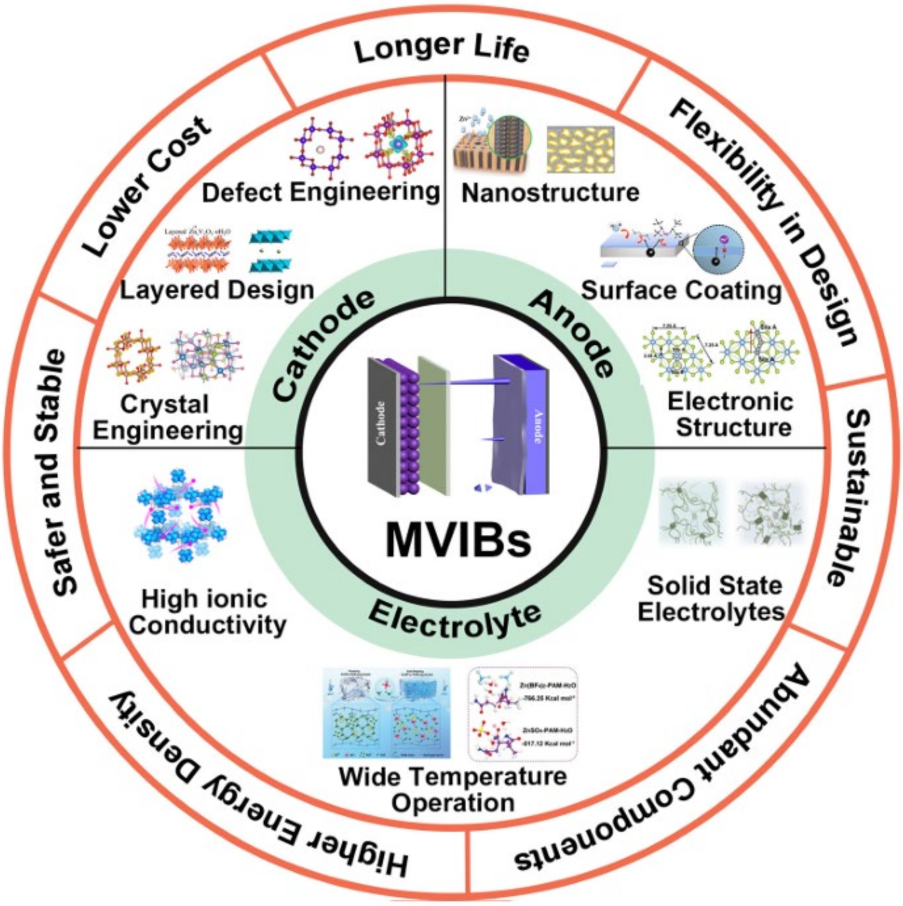
# Centre for Clean Energy Technology

## Research Highlights in 2025(Jan-Jun)



1. Asif Mahmood,†* Zhe Bai,† Tan Wang, Yaojie Lei, Shijian Wang, Bing Sun, Hajra Khan, Karim Khan, Kening Sun and **Guoxiu Wang***, "Enabling high-performance multivalent metal-ion batteries: current advances and future prospects", **Chemical Society Reviews**, 54, 2369-2435, 2025. IF = 40.4. DOI: 10.1039/D4CS00929K

**ABSTRACT:** The battery market is primarily dominated by lithium technology, which faces severe challenges because of the low abundance and high cost of lithium metal. In this regard, multivalent metal-ion batteries (MVIBs) enabled by multivalent metal ions (e.g. $Zn^{2+}$, $Mg^{2+}$, $Ca^{2+}$, $Al^{3+}$, etc.) have received great attention as an alternative to traditional lithium-ion batteries (Li-ion batteries) due to the high abundance and low cost of multivalent metals, high safety and higher volumetric capacities. However, the successful application of these battery chemistries requires careful control over electrode and electrolyte chemistries due to the higher charge density and slower kinetics of multivalent metal ions, structural instability of the electrode materials, and interfacial resistance, etc. This review comprehensively explores the recent advancements in electrode and electrolyte materials as well as separators for MVIBs, highlighting the potential of MVIBs to outperform Li-ion batteries regarding cost, energy density and safety.



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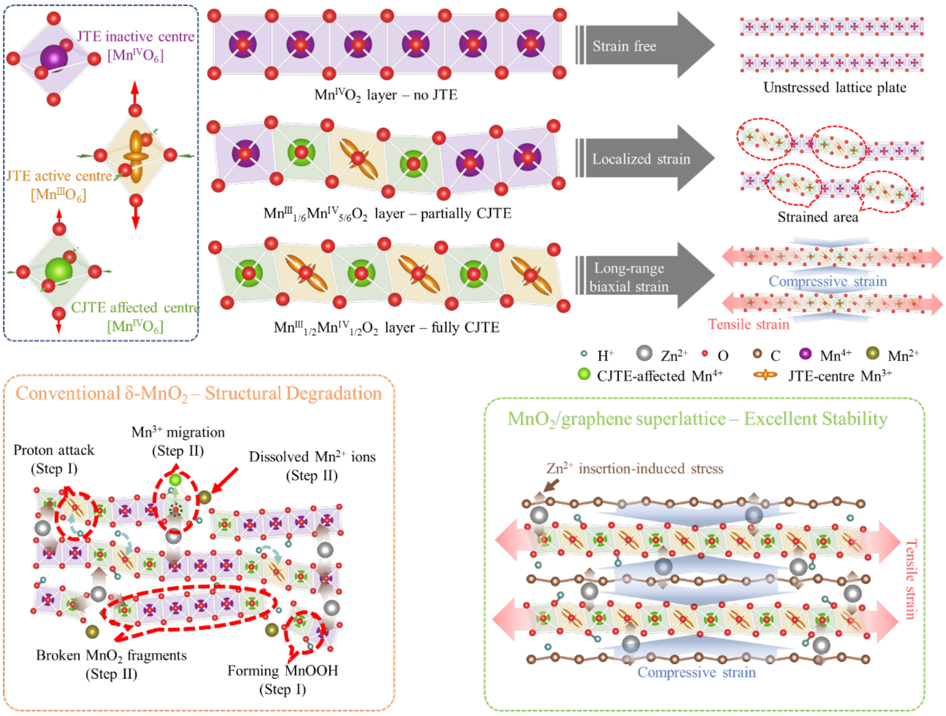
2. Shijian Wang[1], Xin Guo[1], Kun Huang[1], Amritroop Achari, Javad Safaei, Yaojie Lei, Dongfang Li, Qinfen Gu, Chenghua Sun, Lucy Gloag, Steven Langford, Andre Geim, Rahul Raveendran Nair*, and **Guoxiu Wang***, "Cooperative Jahn-Teller effect and engineered long-range strain in manganese oxide/graphene superlattice for aqueous zinc-ion batteries", **Nature Communications**, 16, 5191, 2025. IF = 16.6. DOI: 10.1038/s41467-025-60558-y.

   **ABSTRACT:** The Jahn-Teller and cooperative Jahn-Teller effects are phenomena that induce asymmetry in individual ions and solid-state lattices and are commonly observed in structures containing specific transition metals, such as copper and manganese. Although the Jahn-Teller effect causes lattice distortions that stress electrode materials in rechargeable batteries, strategically utilising the strain generated by cooperative Jahn-Teller distortions can enhance structural stability. Here we introduce the cooperative Jahn-Teller effect on $MnO_2$ by constructing a two-dimensional superlattice structure with graphene crated in the bulk $MnO_2$/graphene composite material. The strong interaction between $MnO_2$ and graphene increases the concentration of high-spin $Mn^{3+}$ ions, creating orderly long-range biaxial strains that are compressive in the out-of-plane direction and tensile in the in-plane direction. These strains mitigate $Zn^{2+}$ intercalation stress and proton corrosion, enabling over 5000 cycles with 165 mAh $g^{-1}$ capacity retention at 5 C (1 C = 308 mA $g^{-1}$) in aqueous zinc-ion batteries. Our approach offers an effective strategy to significantly enhance the lifetime of rechargeable batteries by introducing the cooperative Jahn-Teller effect that overcomes the stress of ion insertion in electrode materials.



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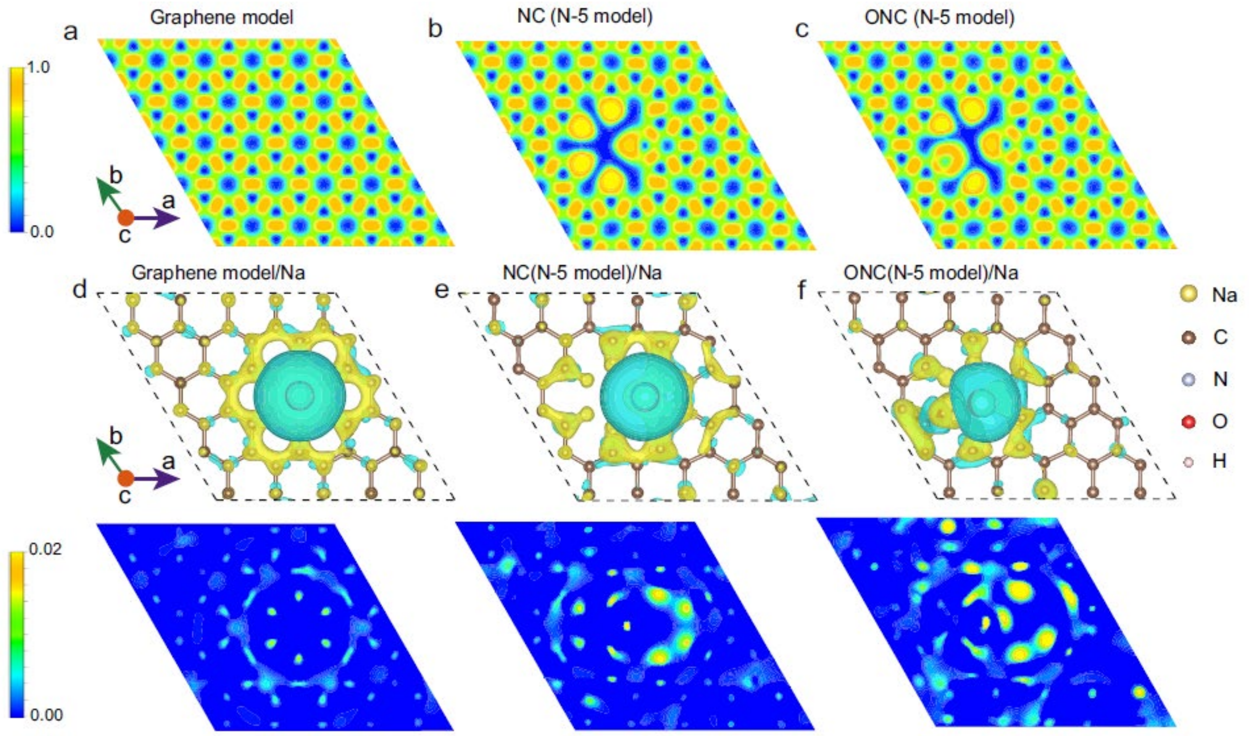
3. Jiabao Li, Ruoxing Wang, Lanlan Han, Tianyi Wang, Yusuke Asakura, Chengyin Wang, **Guoxiu Wang**, Xingtao Xu, Yusuke Yamauchi, “Unveiling the neglected role of oxygen dopin gin nitrogen-doped carbon for enhanced capacitive deionization performance”, **Nature Communications**, 16, 1996, 2025. IF= 16.6. DOI: 10.1038/s41467-025-56694-0.

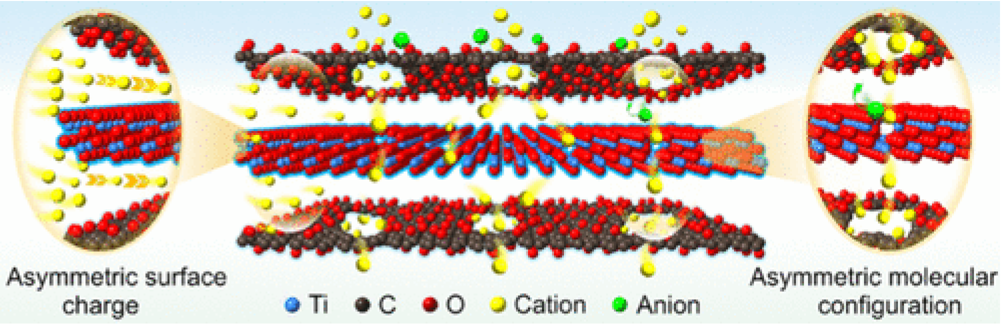
**ABSTRACT:** Nitrogen-doped carbons (NCs) have demonstrated notable advantages for application in capacitive deionization (CDI). However, the potential roles of different nitrogen configurations in the CDI process, especially how the neglected oxygen doping synergistically works, remain unclear. In this work, we systematically addressed these critical issues and revealed the significant role of trace oxygen doping in enhancing the desalination performance of NC electrodes. By introducing oxygen into nitrogen-doped carbon nanosheets (ONC-S), using guanine as the precursor, we obtained abundant pyridinic and pyrrolic nitrogen configurations. This design aims to synergistically enhance the charge distribution, wettability, and ion diffusion of the target electrodes. Compared with commercial activated carbon and other state-of-the-art materials, our ONC-S electrode demonstrates superior specific capacitance, excellent cycling stability, and enhanced desalination efficiency. These findings highlight the synergistic effects of trace oxygen doping and the nitrogen configuration, offering valuable insights into the mechanisms driving the improved CDI performance.



https://www.nature.com/articles/s41467-025-56694-0

4. Chao Liu, Caichao Ye, Jiali Wang, Ting Yang, Anqi Ni, Tianning Zhang, Kunpeng Mao, Long Chen, Shijian Wang, Jingwen Sun, Wenqing Zhang, Xin Wang, Jianfei Che, Pan Xiong*, **Guoxiu Wang***, Junwu Zhu*, "Molecular-Scale Asymmetry Nanochannels for High-Efficiency Osmotic Energy Generation", **Journal of the American Chemical Society**, 2025. IF=15.6. DOI: 10.1021/jacs.5c08016

**ABSTRACT**: Osmotic power, as an example of iontronics, can convert an ion gradient to electrical energy by the membrane-based reverse electrodialysis technique. However, its efficiency in harvesting osmotic energy is mostly dependent on ion permeability and selectivity during transmembrane diffusion. The two-dimensional (2D) heterogeneous interface establishes molecular-scale asymmetric structure and charge that is expected to exert a crucial effect on the ion permeability and selectivity but remains unexplored. Here, we designed a 2D nanofluidic membrane with molecular-level asymmetric channels that can achieve high cation selectivity while maintaining outstanding ion conductivity. When applied to osmotic energy generators, this membrane can exhibit a high cation selectivity coefficient of 0.985 and a superior energy conversion efficiency of up to 47.1%, coupled with an excellent output power density of over 20 W $m^{-2}$ in mixing the artificial seawater and river water. The $Na^+$ ions transport through a 2D heterostructured membrane via an interface-induced contiguous ion adsorption-diffusion mechanism is uncovered. The asymmetric pore structure and negative charge distribution enable highly selective adsorption of $Na^+$ ions and subsequently fast transport in the molecular-scale asymmetric nanochannels. This work provides an in-depth understanding of ion transport in asymmetric nanochannels and further inspires their applications in other advanced energy-harvesting devices.



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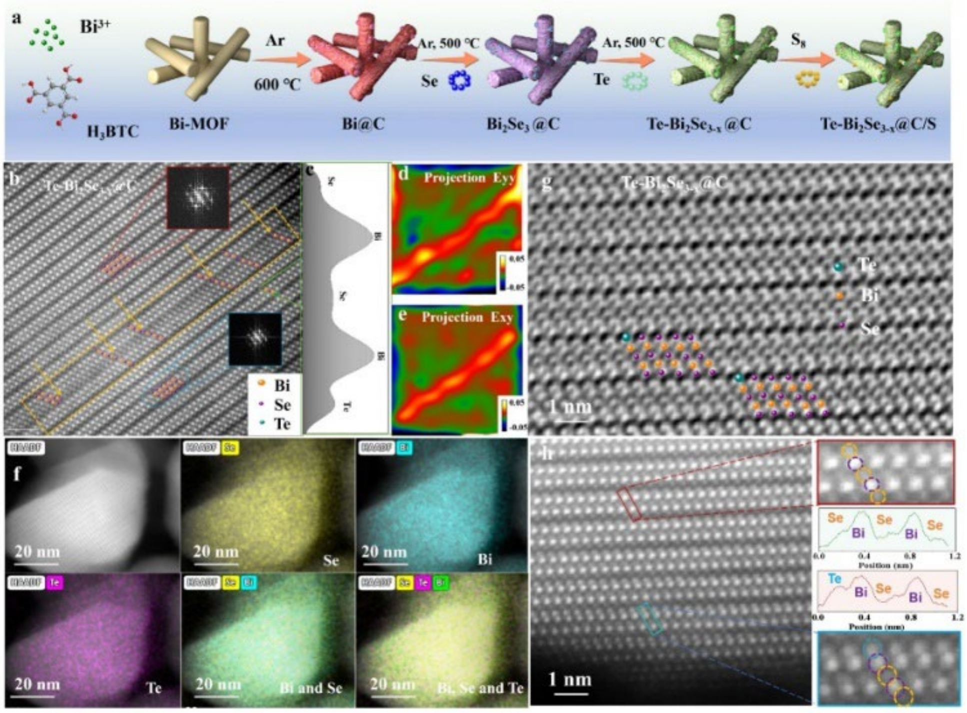
5. Chen Huang, Jing Yu, Chao Yue Zhang, Zhibiao Cui, Ren He, Linlin Yang, Bingfei Nan, Canhuang Li, Xuede Qi, Xueqiang Qi, Junshan Li, Jin Yuan Zhou, Oleg Usoltsev, Laura Simonelli, Jordi Arbiol, Yao-Jie Lei*, Qing Sun*, **Guoxiu Wang*** and Andreu Cabot*, "Anionic Doping in Layered Transition Metal Chalcogenides forRobust Lithium-Sulfur Batteries", **Angewandte Chemie International Edition**, 64, e202420488, 2025, IF=16.6. DOI: 10.1002/anie.202420488

**ABSTRACT**: Lithium-sulfur batteries (LSBs) are among the most promising next-generation energy storage technologies. However, a slow Li-S reaction kinetics at the LSB cathode limit their energy and power densities. To address these challenges, this study introduces an anionic-doped transition metal chalcogenide as an effective catalyst to accelerate the Li−S reaction. Specifically, a tellurium-doped, carbon-supported bismuth selenide with Se vacancies ($Te-Bi_2Se_{3-x}@C$) is prepared and tested as a sulfur host in LSB cathodes. X-ray absorption and in situ X-ray diffraction analyses reveal that Te doping induces lattice distortions and modulates the local coordination environment and electronic structure of Bi atoms to promote the catalytic activity toward the conversion of polysulfides. Additionally, the generated Se vacancies alter the electronic structure around atomic defect sites, increase the carrier concentration, and activate unpaired cations to effectively trap polysulfides. As a result, LSBs based on $Te-Bi_2Se_{3-x}@C/S$ cathodes demonstrate outstanding specific capacities of 1508 $mAh \cdot g^{-1}$ at 0.1 C, excellent rate performance with 655 $mAh \cdot g^{-1}$ at 5 C, and near-integral cycle stability over 1000 cycles. Furthermore, under high sulfur loading of 6.4 $mg \cdot cm^{-2}$, a cathode capacity exceeding 8 $mAh \cdot cm^{-2}$ is sustained at 0.1 C current rate, with 6.4 $mAh \cdot cm^{-2}$ retained after 300 cycles under lean electrolyte conditions (6.8 $\mu L \cdot mg^{-1}$).



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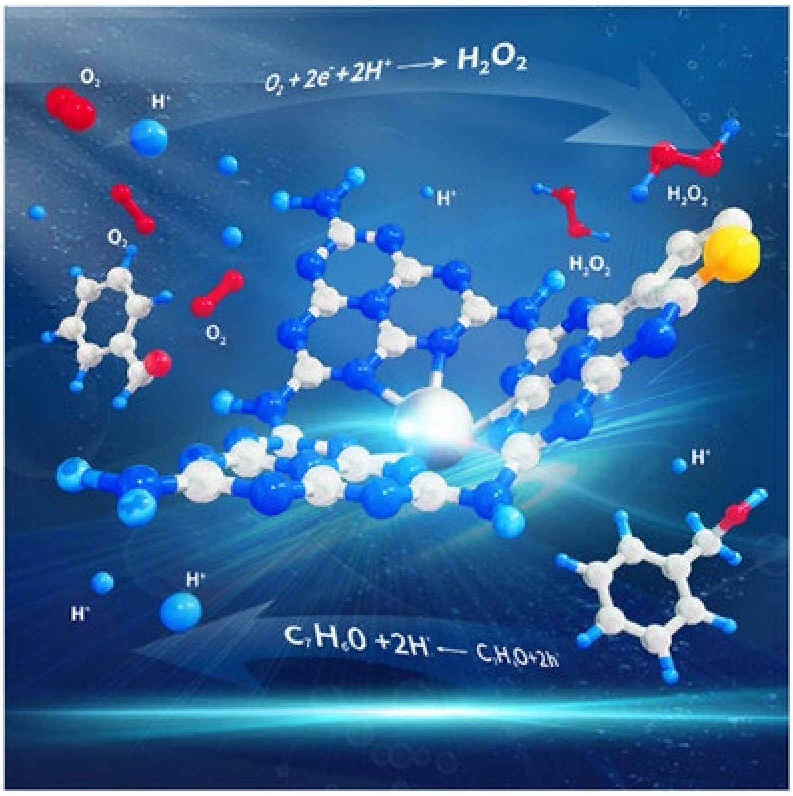
6. Xiaoyu Zhou, Kuanhong Cao, Shouqiang Huang, Haonan Wu, Zhen Cao, Hang Liu, Peng Chen, Dawei Su, **Guoxiu Wang**, Tianyi Wang, Chengyin Wang, Huan Pang, "Synergistic Conversion of Hydrogen Peroxide and Benzaldehyde in Air by Silver Single-Atom Modified Thiophene-Functionalized g-$C_3N_4$", **Angewandte Chemie International Edition**, 64, e202505532, 2025, IF=16.6. DOI: 10.1002/anie.202505532

   **ABSTRACT**: This study reports the synthesis of silver single-atom-loaded thiophene-conjugated carbon nitride (Ag@T-C3N4), a material with high carrier concentration and efficient carrier separation. Under visible light, Ag@T-$C_3N_4$ catalyzes hydrogen peroxide ($H_2O_2$) production and benzyl alcohol oxidation to benzaldehyde, achieving production rates of 4729.82 $\mu mol \cdot g^{-1} \cdot h^{-1}$ for $H_2O_2$ and 19.71 $mmol \cdot g^{-1} \cdot h^{-1}$ for benzaldehyde. The synergy between thiophene conjugation and silver atoms extends visible light absorption and accelerates the 2-electron oxygen reduction reaction (ORR), enhancing $H_2O_2$ yield. Photogenerated holes oxidize benzyl alcohol to benzaldehyde, while the biphasic benzaldehyde-water system enables spontaneous product separation. In situ Raman spectroscopy, rotating disk electrode testing, EPR, GC-MS, and DFT calculations highlight the critical role of thiophene-silver synergy in optimizing reaction pathways, enhancing catalyst-intermediate interactions, and reducing Gibbs free energy, improving $H_2O_2$ and benzaldehyde synthesis. This study provides new insights for designing carbon nitride-based photocatalysts and offers a strategy for co-producing value-added chemicals.



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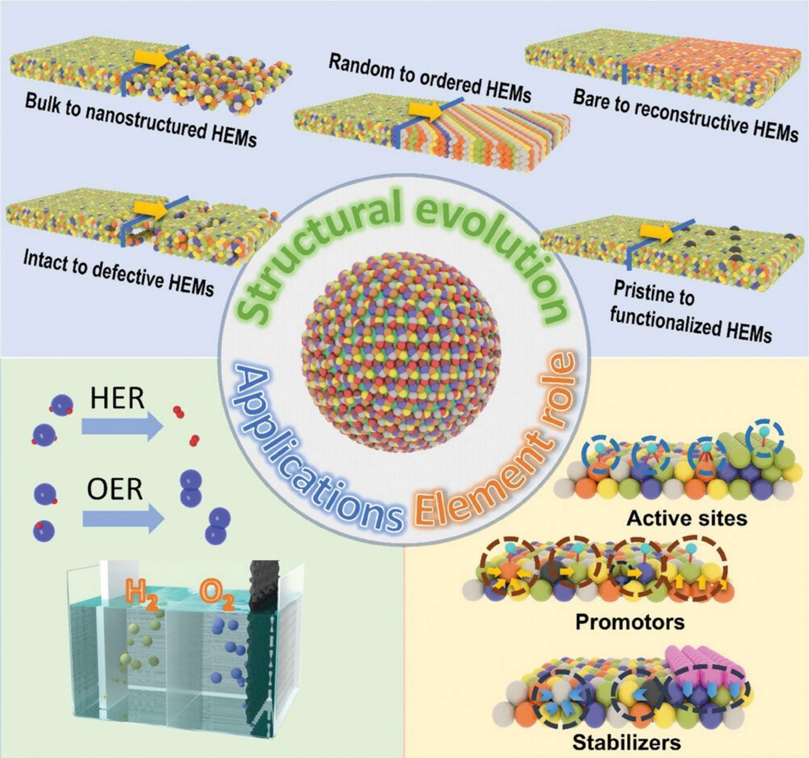
7. Yufei Zhao, Jinhu Wu, Xianjun Cao, Dongfang Li, Peng Huang*, Hong Gao, Qinfen Gu, Jinqiang Zhang*, **Guoxiu Wang**, Hao Liu*, "High-Entropy Materials for Water Splitting: An Atomic Nanoengineering Approach to Sustainable Hydrogen Production", **Advanced Materials**, 2025, 2506117. IF=27.4. DOI: 10.1002/adma.202506117.

   **ABSTRACT**: Green hydrogen production via water electrolysis is pivotal for achieving energy sustainability. However, the inherently sluggish kinetics of the hydrogen evolution reaction and oxygen evolution reaction impede the progress of water-splitting technology. Recently, high-entropy materials (HEMs) composed of at least five elements have garnered significant attention as promising electrocatalysts for water splitting, owing to their compositional versatility, structural robustness, and synergistic interactions among elements. This review comprehensively explores the development of HEMs, tracing their emergence and structural evolution via atomic nanoengineering strategies (i.e., from bulk to nanostructuring, from random distributions to relatively ordered architectures, from bare HEMs to reconstructed HEMs, from intact HEMs to defective structures, from pristine HEMs to functionalized variants) and revealing how these evolutionary steps contribute to the properties and enhance catalytic performance in water splitting. The fundamental roles of individual elements (e.g., active sites, promoters, stabilizers) in shaping the structure, stability, and catalytic activity of HEMs are examined, laying a foundation for the rational design of efficient HEM-based electrocatalysts. The review also highlights recent advances in HEM-based catalysts for water splitting, emphasizing desirable properties and elemental contributions. Finally, the remaining challenges and perspectives on the future directions of HEM-based materials in energy conversion technologies are discussed.



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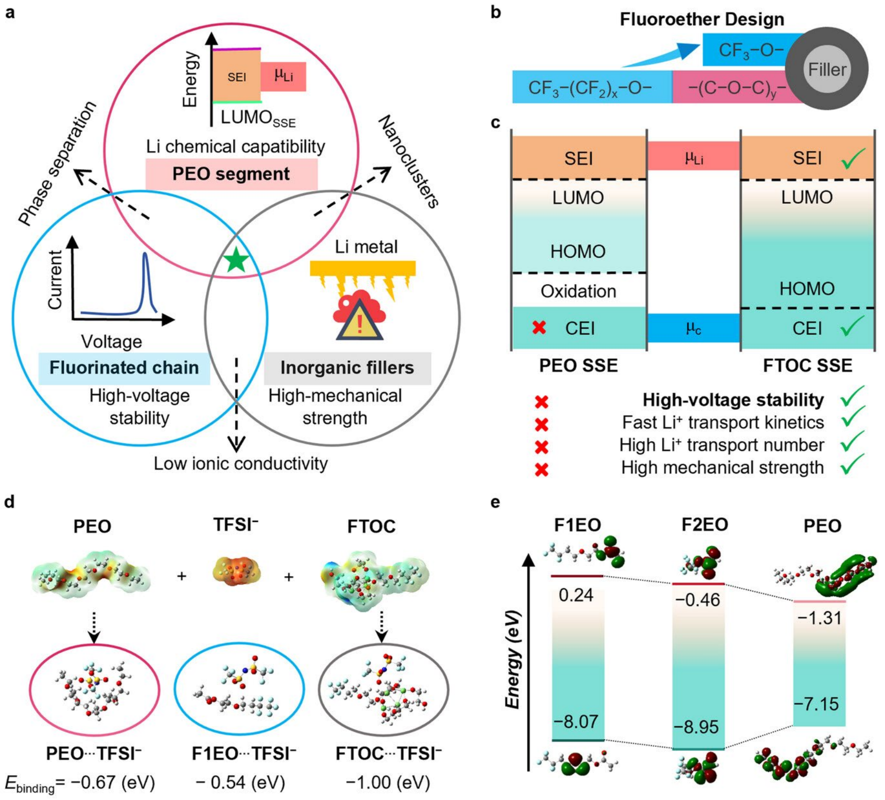
8. Yong Chen, Xu Yang, Tianyi Wang, Xiao Tang, Dongfang Li, Shijian Wang, Yaojie Lei, Yu Han, Shimou Chen, Michel Armand, Doron Aurbach, **Guoxiu Wang***, “Fluoroether Design Enables High-Voltage All-Solid-State Lithium Metal Batteries”, **Advanced Materials**, 2025, 2506020. IF=27.4. DOI: 10.1002/adma.202506020.

**ABSTRACT:** Developing high-voltage all-solid-state lithium metal batteries (ASSLMBs) holds transformative potential for next-generation energy storage technologies but remains a formidable challenge. Herein, a new prototype design is presented that integrates fluorinated ether segments into the traditional oxide nanocomposite phase, enabling poly(ethylene oxide)-based composite electrolytes with exceptional anti-oxidation durability and enhance overall electrochemical performance. Through a combination of experimental and computational analyses, it is demonstrated that the superior performance is attributed to the formation of reconstructed $Li^+$ solvation with weakly coordinating environments. The proposed formulation exhibits excellent Li-metal compatibility, enabling stable cycling in symmetric Li||Li cells for over 9500 h. The solid-state electrolyte also exhibits outstanding high-voltage stability with $LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$ cathodes, extending the operational voltage from 4.0 to 4.5 V. Moreover, the $LiMn_{1-x}Fe_xPO_4$||Li cells have delivered remarkable cycling performance, achieving over 1200 cycles with 99% capacity retention after 500 cycles. This work establishes an innovative platform for designing electrolytes with superior antioxidation properties and enhance structural durability, paving the way for the advancement of high-voltage all-solid-state lithium metal batteries.



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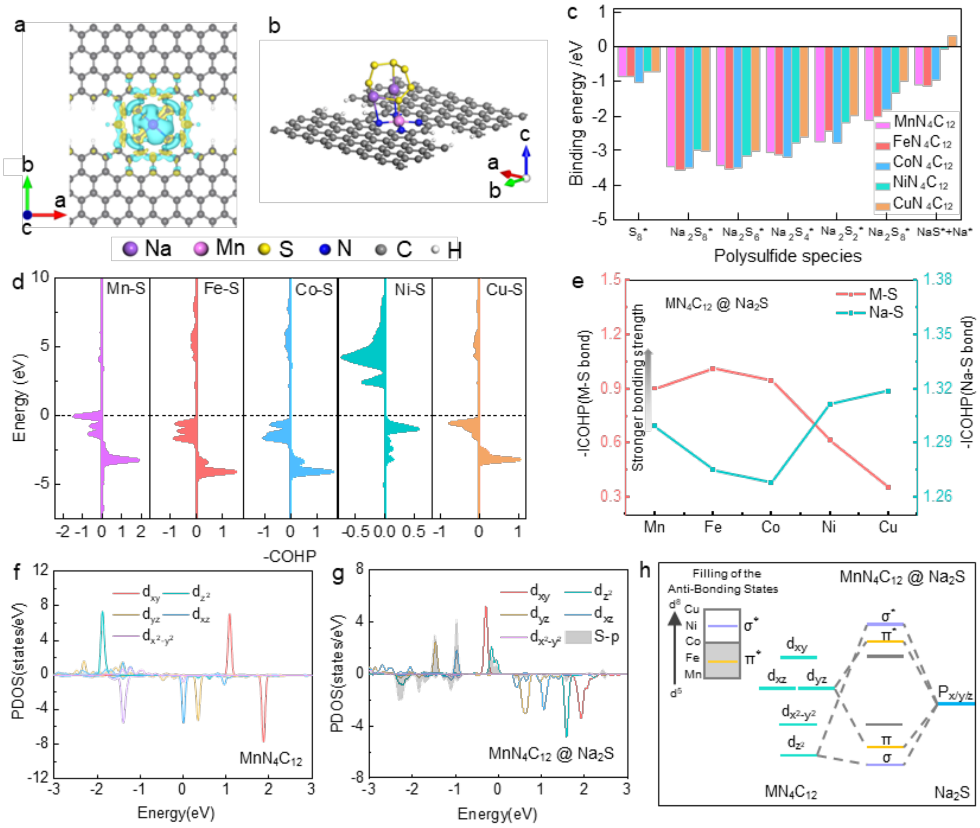
9. Hao Tian†, Yaojie Lei†, Bing Sun†, Cheng-Chieh Yang, Chi-Liang Chen, Tao Huang, Xiaoyue Zhang, Yong Chen, Ailing Song, Le Pang, Hongxia Wang, Chung-Li Dong, Sean C Smith, Wei-Hong Lai, Yun-Xiao Wang*, Xin Tan*, Hao Liu, **Guoxiu Wang***, "P-d orbital hybridization induced by transition metal atom sites for room-temperature sodium-sulfur batteries", **National Science Review**, 2025, nwaf241. IF= 16.3. DOI: 10.1093/nsr/nwaf241.

**ABSTRACT:** For energy storage applications involving sulfur redox reactions, uniformly dispersed metal sites in S hosts serves as an effective approach to facilitate electron transfer during charge and discharge cycles. In this study, we exploited a facile method to construct transitional single-atom catalysts to overcome the kinetic limitations for electron transportation in room-temperature sodium-sulfur (RT Na-S) batteries. By the synergistic effect of polysulfide adsorption and p-d orbital hybridization between catalysts and intermediates, electron-donating and electron-capturing capabilities of different atomic sites towards sulfur redox reactions are systematically revealed. Remarkably, atomic Mn-N4 active moiety structures possess abundant unfilled antibonding orbitals, promoting p-d hybridization and leading to superior S conversion reactions. The work establishes a design paradigm for single-atom catalysts in metal-sulfur batteries by linking atomic-scale electronic features to macroscopic performance. This atomic-level engineering strategy paves the way for high-energy-density RT Na-S batteries, with potential extensions to other multivalent sulfur-based energy storage systems.



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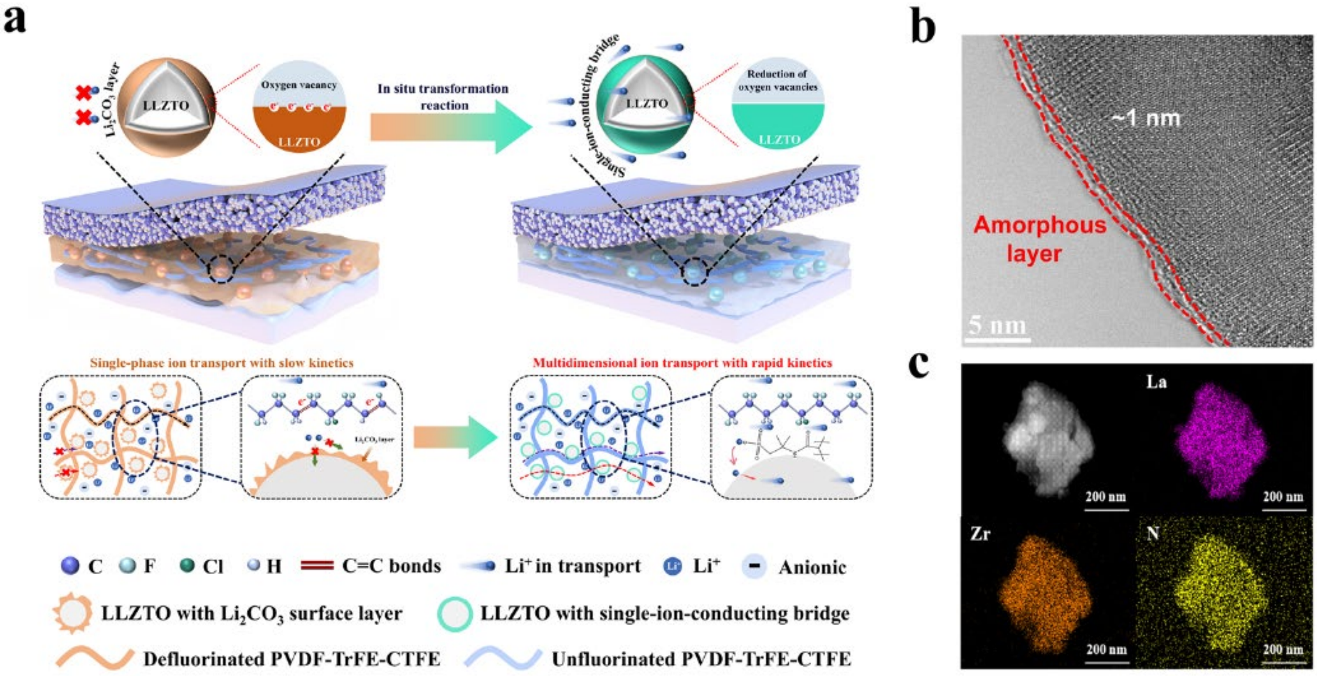
10. Jiajun Gong, Qimin Peng, Shunshun Zhao, Taolue Wen, Haojie Xu, Weiting Ma, Zhicheng Yao, Yong Chen*, **Guoxiu Wang***, and Shimou Chen*, "Built-in single-ion-conducting polymer bridges for superior ion transport enabling long-life and high-voltage lithium–metal batteries", **Energy & Environmental Science**, 18, 5511-5523, 2025. IF=32.4. DOI: 10.1039/D5EE01338K.

**ABSTRACT:** Composite polymer electrolyte (CPE)-based Li metal batteries have emerged as the most promising candidates for next-generation batteries. However, intrinsic incompatibility between composite phases severely compromises electrolyte performance. Herein, we propose a built-in single-ion-conductor bridge that seamlessly links the garnet-type oxide phase with PVDF-based polymer matrixes, enabling excellent composite compatibility and superior $Li^+$ fluxes throughout the bulk electrolyte. The 2-acrylamido-2-methylpropanesulfonic acid molecule is chosen to *in situ* convert the inert surface layer of garnet fast-ion conductors into a molecular single-ion-conducting layer with rapid ionic transport, effectively bridging ion transport among multiple components. The resulting CPE exhibits remarkable long-cycling stability under extreme conditions (*e.g.*, high voltage of 4.5 V, high loading of 10.2 mg cm$^{-2}$, and low temperature of −30 °C). Specifically, the assembled Li‖$LiNi_{0.9}Co_{0.05}Mn_{0.05}O_2$ pouch cells delivered a stable cycling for 1200 cycles at 0.5C. Moreover, the strategy is readily applicable to sodium metal batteries, achieving decay-free performance over 2200 cycles. Thus, it offers a promising approach for fabricating high-performance solid-state batteries.



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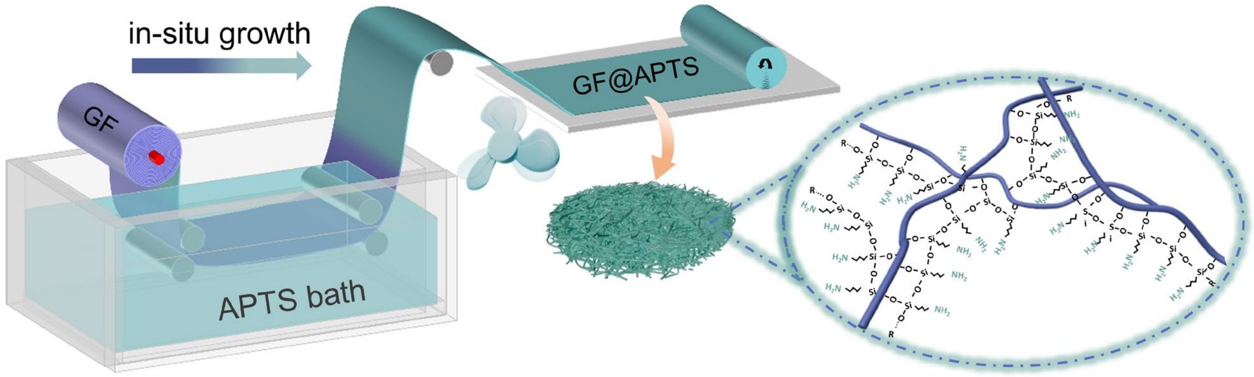
11. Mengcheng Huang[‡], Yaojie Lei[‡], Yajun Hu, Wei-Hong Lai, Yun-Xiao Wang, Chunyu Liu, Shengli Zhai* and **Guoxiu Wang***, “Interfacial Ionic and Thermal Regulation for Highly Reversible and Ultra-Reliable Zinc-Ion Batteries”, **Energy & Environmental Science**, 2025, IF=32.4. DOI:10.1039/D5EE01635E

**ABSTRACT**: Prevalent glass fiber separators in aqueous Zn-ion batteries (ZIBs) offer inadequate control over interfacial reactions, contributing to the rapid growth of Zn dendrites and aggravated parasitic reactions. Moreover, the stability of ZIBs under extreme operating conditions remains a critical yet often overlooked issue. Here, we present a novel silane-decorated glass fiber separator with engineered physical structures and surface chemistry, facilitating highly reversible and ultra-reliable ZIBs. Silane strengthens the separator, resists stress, and forms heat-insulating char layers under flame, ensuring reliability in extreme conditions. Silane networks also function as fillers that enhance pore uniformity for even $Zn^{2+}$ flux. The amino groups in silane demonstrate comprehensive management of interfacial anions, cations, water transfer and reaction kinetics. This capability induces $Zn^{2+}$ to concentrate at the interface, accelerates $Zn^{2+}$ transfer, reduces deposition barriers, and obstructs water molecules and sulfate ions from participating in parasitic reactions. Consequently, dendrite-free Zn plating/stripping is achieved with 99.4% Coulombic efficiency over 250 cycles, stable charge/discharge performance for 7000 hours, and remarkable cycling stability and flame resistance for Zn//V full batteries. This strategy demonstrates versatility across various separator materials and battery chemistry, offering a promising route to more reliable and higher-performing energy storage systems.



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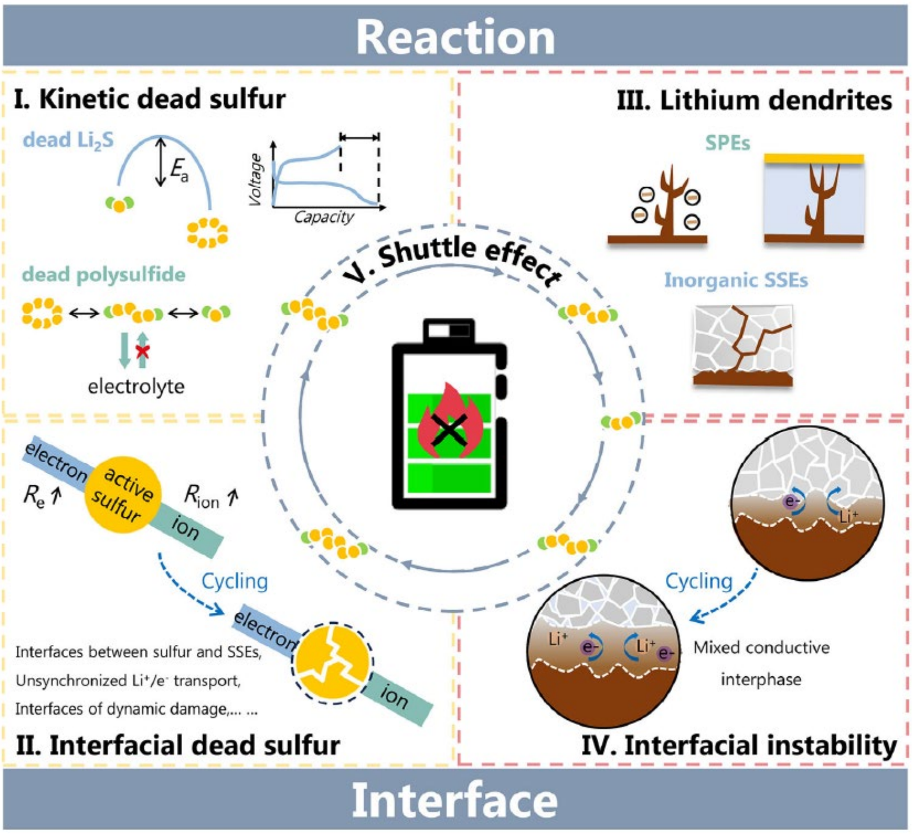
12. Ru Xiao, Zhuoyan Qu, Junxing Ren, **Guoxiu Wang***, Zhenhua Sun, Feng Li, "Current Status and Future Prospects of Solid-State Lithium–Sulfur Batteries: A Focus on Reaction and Interface Engineering", **Advanced Energy Materials**, 2501926, 2025. IF=24.4. DOI: 10.1002/aenm.202501926.

**ABSTRACT:** The burgeoning development of solid-state electrolytes significantly improves the safty and practicality of solid-state lithium–sulfur batteries (LSBs). Based on mature solid-state electrolytes, challenges in electrochemical performance remain, largely due to complex reactions and interfacial issues on both sulfur and lithium sides. This review comprehensively examines the fundamental challenges and recent progress from the perspectives of reaction and interface. From a reaction standpoint, it discusses the trade-off between shuttle effect and redox kinetics, as well as the irreversible accumulation of kinetically dead sulfur across different electrolytes, which were often overlooked. Regarding interfaces, it discusses the formation of interfacial dead sulfur within the cathode and strategies to enhance the across-interface transport of charge carriers. It also analyzes mechanisms underlying lithium dendrite formation and interface failure, along with current solutions to mitigate dead lithium and extend lithium anode lifespan. In pursuit of meeting commercial demands for solid-state LSBs, engineering parameters targeting high energy density are specified by formulations, and differences in parameter design principles among different electrolyte systems are systematically analyzed. Finally, to bridge fundamental insights with practical applications, future research directions are proposed, emphasizing reaction and interface engineering for high-performance solid-state LSBs.



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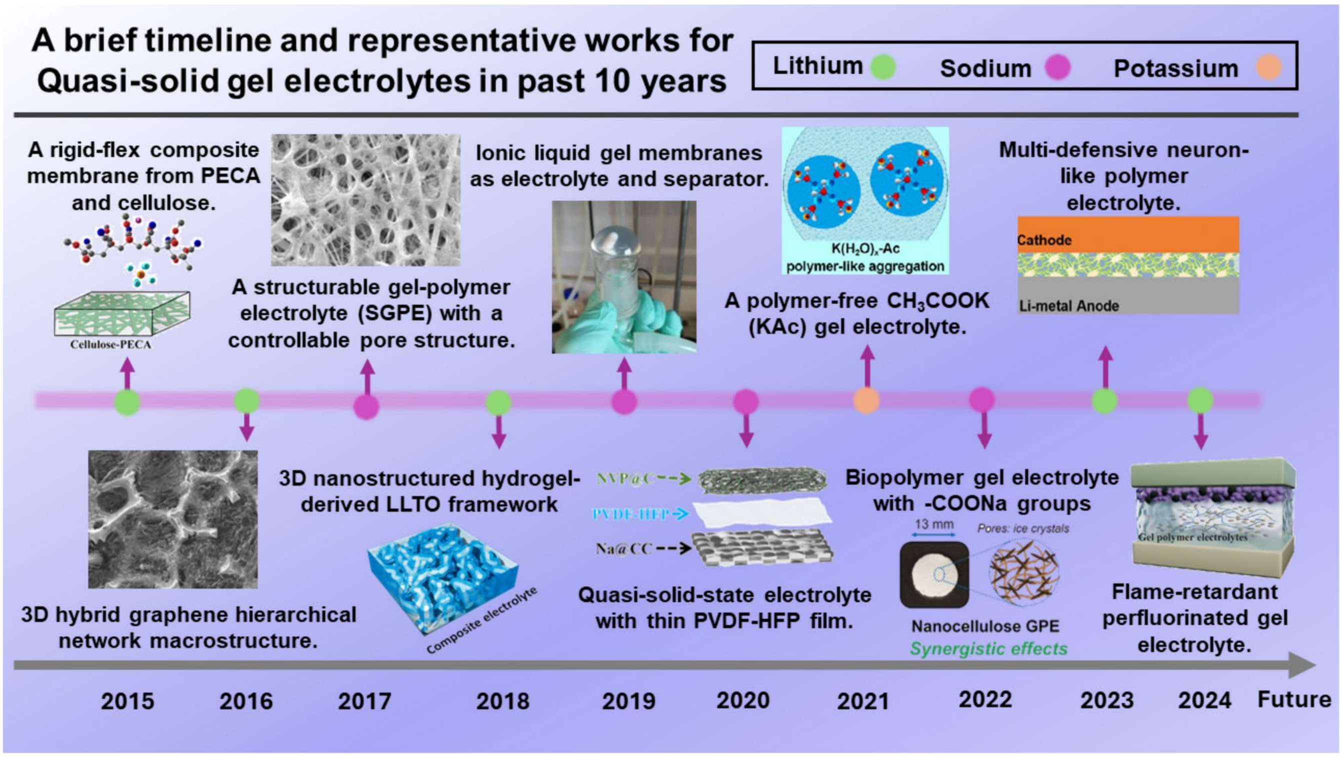
13. Jiahui Lu, Yingying Chen, Yaojie Lei, Pauline Jaumaux, Hao Tian*, **Guoxiu Wang***, "Quasi-solid Gel Electrolytes for Alkali Metal Battery Applications", **Nano-Micro Lett.** 17, 194, 2025. IF=31.6. DOI: 10.1007/s40820-024-01632-w.

**ABSTRACT:** Alkali metal batteries (AMBs) have undergone substantial development in portable devices due to their high energy density and durable cycle performance. However, with the rising demand for smart wearable electronic devices, a growing focus on safety and durability becomes increasingly apparent. An effective strategy to address these increased requirements involves employing the quasi-solid gel electrolytes (QSGEs). This review focuses on the application of QSGEs in AMBs, emphasizing four types of gel electrolytes and their influence on battery performance and stability. First, self-healing gels are discussed to prolong battery life and enhance safety through self-repair mechanisms. Then, flexible gels are explored for their mechanical flexibility, making them suitable for wearable devices and flexible electronics. In addition, biomimetic gels inspired by natural designs are introduced for high-performance AMBs. Furthermore, biomass materials gels are presented, derived from natural biomaterials, offering environmental friendliness and biocompatibility. Finally, the perspectives and challenges for future developments are discussed in terms of enhancing the ionic conductivity, mechanical strength, and environmental stability of novel gel materials. The review underscores the significant contributions of these QSGEs in enhancing AMBs performance, including increased lifespan, safety, and adaptability, providing new insights and directions for future research and applications in the field.



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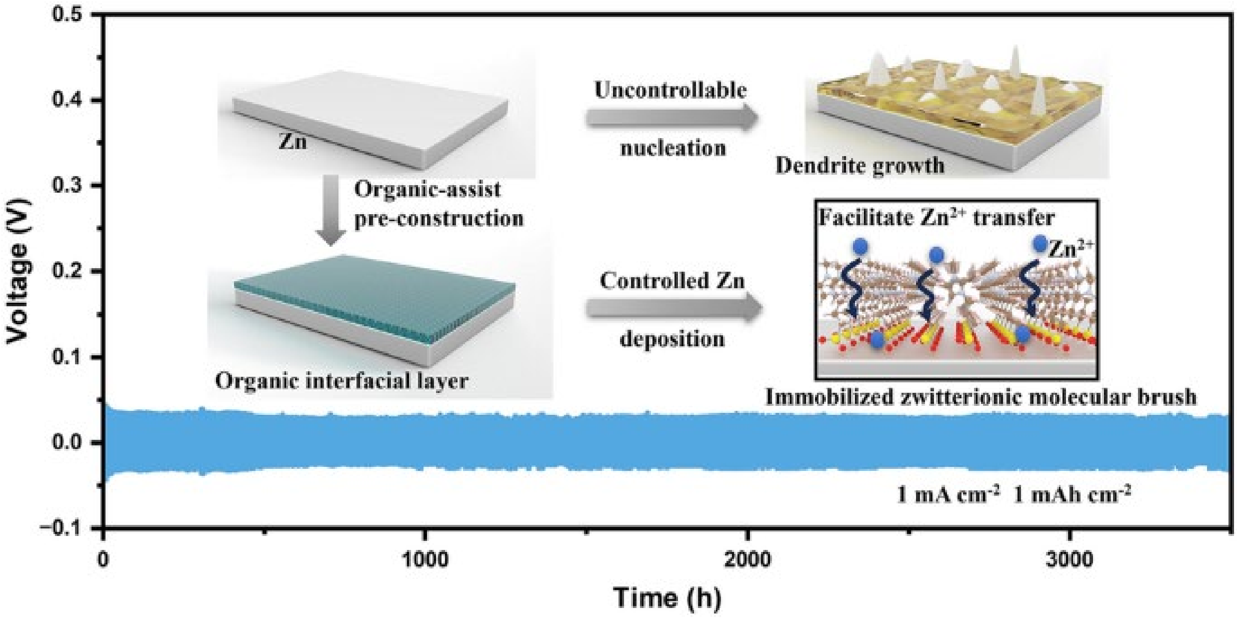
14. Limeng Sun, Xianjun Cao, Li Gao, Jiayi Li, Chen Qian, Jinhu Wu, Xinming Nie*, Hong Gao, Peng Huang*, Yufei Zhao*, Yong Wang, Jinqiang Zhang*, **Guoxiu Wang**, Hao Liu*, "Immobilizing Zwitterionic Molecular Brush in Functional Organic Interfacial Layers for Ultra-Stable Zn-Ion Batteries", **Nano-Micro Letters**, 17, 262, 2025. IF=31.6. DOI: 10.1007/s40820-025-01782-5.

**ABSTRACT:** Rechargeable zinc-ion batteries have emerged as one of the most promising candidates for large-scale energy storage applications due to their high safety and low cost. However, the use of Zn metal in batteries suffers from many severe issues, including dendrite growth and parasitic reactions, which often lead to short cycle lives. Herein, we propose the construction of functional organic interfacial layers (OIL) on the Zn metal anodes to address these challenges. Through a well-designed organic-assist pre-construction process, a densely packed artificial layer featuring the immobilized zwitterionic molecular brush can be constructed, which can not only efficiently facilitate the smooth Zn plating and stripping, but also introduce a stable environment for battery reactions. Through density functional theory calculations and experimental characterizations, we verify that the immobilized organic propane sulfonate on Zn anodes can significantly lower the energy barrier and increase the kinetics of $Zn^{2+}$ transport. Thus, the Zn metal anode with the functional OIL can significantly improve the cycle life of the symmetric cell to over 3500 h stable operation. When paired with the $H_2V_3O_8$ cathode, the aqueous Zn-ion full cells can be continuously cycled over 7000 cycles, marking an important milestone for Zn anode development for potential industrial applications.



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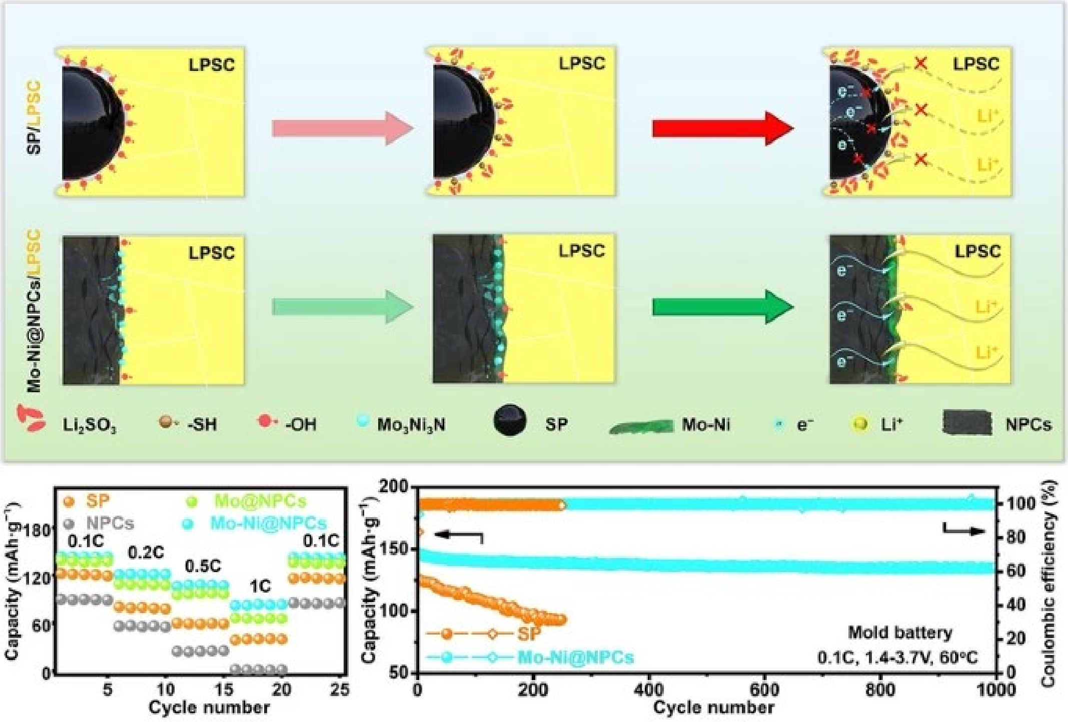
15. Xin Gao, Ya Chen, Zheng Zhen, Lifeng Cui, Ling Huang, Xiao Chen, Jiayi Chen, Xiaodong Chen, Duu-Jong Lee, **Guoxiu Wang***, "Construction of Multifunctional Conductive Carbon-Based Cathode Additives for Boosting $Li_6PS_5Cl$-Based All-Solid-State Lithium Batteries", **Nano-Micro Letters**, 17, 140, 2025. IF=31.6. DOI: 10.1007/s40820-025-01667-7.

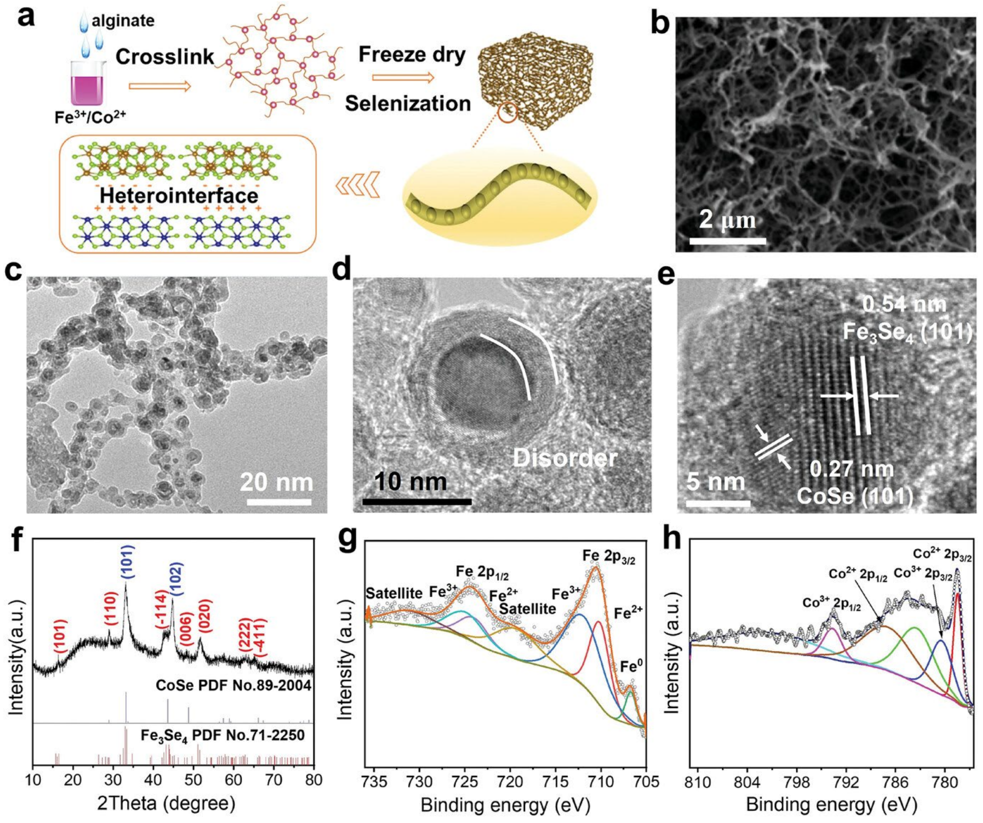
**ABSTRACT:** The electrochemical performance of all-solid-state lithium batteries (ASSLBs) can be prominently enhanced by minimizing the detrimental degradation of solid electrolytes through their undesirable side reactions with the conductive carbon additives (CCAs) inside the composite cathodes. Herein, the well-defined Mo3Ni3N nanosheets embedded onto the N-doped porous carbons (NPCs) substrate are successfully synthesized (Mo-Ni@NPCs) as CCAs inside $LiCoO_2$ for $Li_6PSC_5Cl$ (LPSCl)-based ASSLBs. This nano-composite not only makes it difficult for hydroxide groups (–OH) to survive on the surface but also allows the in situ surface reconstruction to generate the ultra-stable MoS2-Mo3Ni3N heterostructures after the initial cycling stage. These can effectively prevent the occurrence of OH-induced LPSC decomposition reaction from producing harmful insulating sulfates, as well as simultaneously constructing the highly-efficient electrons/ions dual-migration pathways at the cathode interfaces to facilitate the improvement of both electrons and $Li^+$ ions conductivities in ASSLBs. With this approach, fine-tuned Mo-Ni@NPCs can deliver extremely outstanding performance, including an ultra-high first discharge-specific capacity of 148.61 mAh $g^{-1}$ (0.1C), a high Coulombic efficiency (94.01%), and a capacity retention rate after 1000 cycles still attain as high as 90.62%. This work provides a brand-new approach of "conversion-protection" strategy to overcome the drawbacks of composite cathodes interfaces instability and further promotes the commercialization of ASSLBs.



https://link.springer.com/article/10.1007/s40820-025-01667-7

16. Chunrong Ma, Xiao Tang, Haoxi Ben, Wei Jiang, Xinyu Shao, **Guoxiu Wang***, Bing Sun, “Promoting Reaction Kinetics and Boosting Sodium Storage Capability via Constructing Stable Heterostructures for Sodium-Ion Batteries”, **Advanced Functional Materials**, 35, 2412879, 2025. IF=18.5. DOI: 10.1002/adfm.202412879

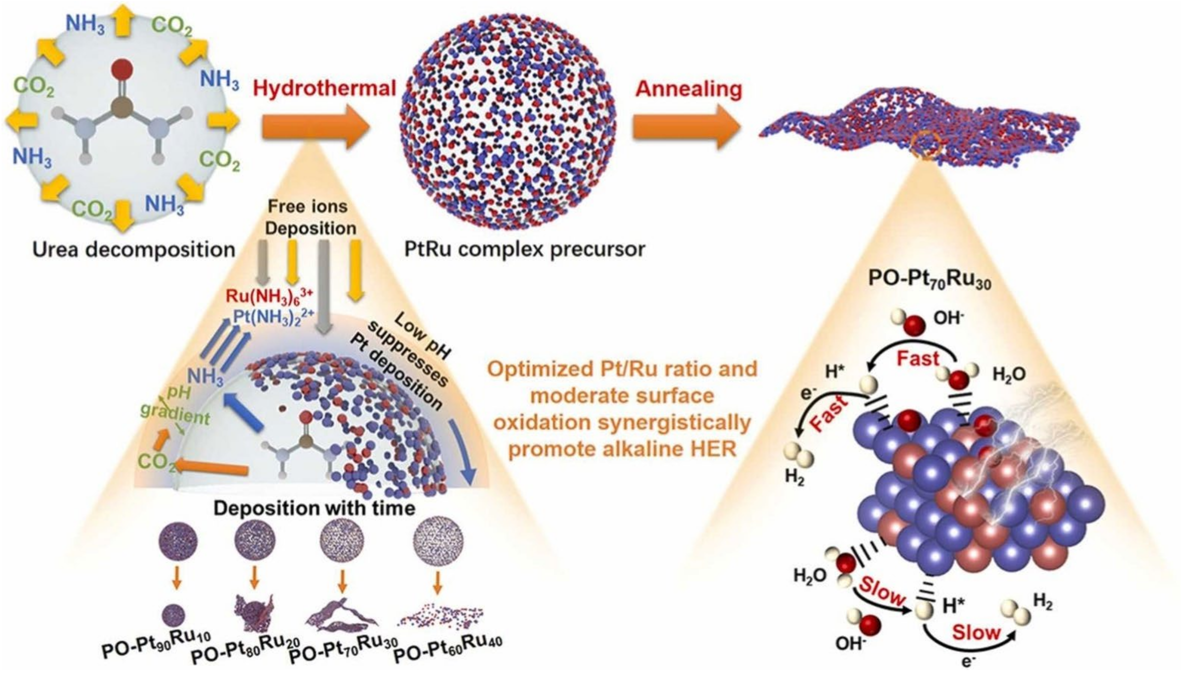
**ABSTRACT:** Constructing heterostructures containing multiple active components is proven to be an efficient strategy for enhancing the sodium storage capability of anode materials in sodium-ion batteries (SIBs). However, performance enhancement is often attributed to the unclear synergistic effects among the active components. A comprehensive understanding of the reaction mechanisms on the interfaces at the atomic level remains elusive. Herein, the carbon-coated $Fe_3Se_4$/CoSe (Fe3$Se_4$/CoSe-C) anode material as a model featuring atomic-scale contact interfaces is synthesized. This unique heterogeneous architecture offers an adjustable electronic structure, which facilitates rapid reaction kinetics and enhances structural integrity. In situ microscopic and ex situ spectral characterization techniques, along with theoretical simulations, confirm that the heterointerface with strong electric fields promotes $Na^+$ ion migration. Based on solid-state nuclear magnetic resonance (NMR) analysis, an interface charge storage mechanism is revealed, resulting in the enhanced specific capacity of the anode materials. When employed as an anode in SIBs, the Fe3Se4/CoSe-C electrode demonstrates excellent rate capabilities (218 mAh $g^{-1}$ at 7 A $g^{-1}$) and prolonged cycling stability (258 mAh $g^{-1}$ at 5 A $g^{-1}$ after 1000 cycles). This work highlights the significance of heterointerface engineering in electrode material design for rechargeable batteries.



https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.202412879

17. Xianjun Cao, Limeng Sun, Fengying Pan, Zeliang Wu, Dongfang Li, Xinming Nie*, Xiaoyan Li, Peng Huang*, Li Gao, Cheng Gong, Yufei Zhao*, Qiong Cai, Jinqiang Zhang*, **Guoxiu Wang**, Hao Liu*, “Revealing the roles of oxidation states and constituents of the alloy in alkaline hydrogen evolution reaction”, **Applied Catalysis B: Environment and Energy**, 375, 125415, 2025. IF=20.3. DOI: 10.1016/j.apcatb.2025.125415

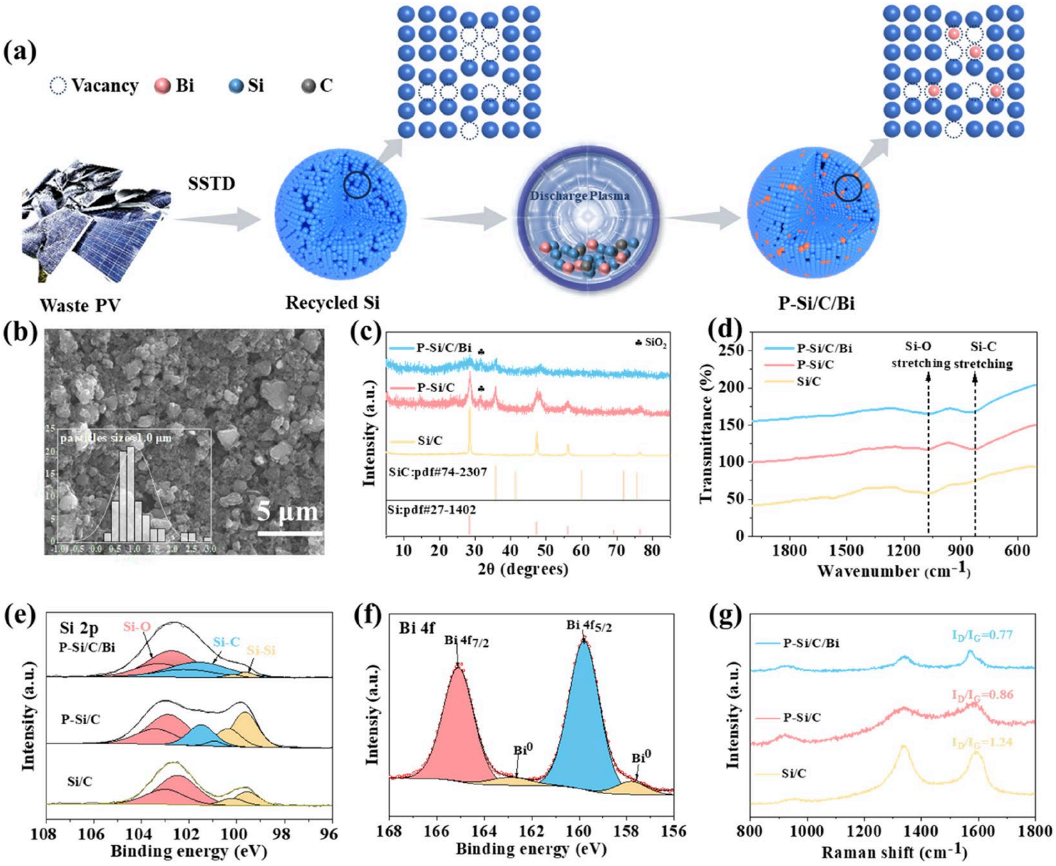
**ABSTRACT:** Precious metal Pt has exhibited excellent catalytic performance in numerous electrocatalytic applications. However, the slow water dissociation kinetics hinder its alkaline hydrogen evolution reaction (HER) activity. Herein, we design the partially oxidized PtRu alloys with fine-tuned structure which can significantly enhance the alkaline HER. Theoretical calculations reveal that the alteration of Pt/Ru ratio and surface oxidation state of PtRu materials can effectively tune the water and hydrogen adsorption capability, thus impacting the alkaline HER performance. We dentify $Pt_{70}Ru_{30}$ with 3 O surface coverage with optimized adsorption energy to be the most suitable candidate for alkaline HER. Inspired by theoretical predictions, we prepare partially oxidized PtRu with tunable composition and structure via a facile urea-assisted method, with a “capture and release” reaction mechanism by generating complexing agents and pH gradients. The as-synthesized partially oxidized $Pt_{70}Ru_{30}$ electrode exhibits excellent HER catalytic activity and stability in the alkaline electrolyte, achieving an overpotential of only 11 mV at 10 mA $cm^{-2}$ and a Tafel slope of 28 mV $dec^{-1}$, outperforming that of Pt/C ($\eta_{10}$ = 29 mV, Tafel slope = 52 mV $dec^{-1}$). *In-situ* spectral measurements show that the partially oxidized Pt and Ru species in $Pt_{70}Ru_{30}$ can facilitate breaking the O-H bonds and improve the alkaline HER kinetics. This work unravels the influence of Pt/Ru ratio and surface partial oxidation on water dissociation and hydrogen adsorption, which provide guidelines for the rational design of highly efficient electrocatalysts.



https://www.sciencedirect.com/science/article/pii/S0926337325003984?via%3Dihub

18. Dingyi Zhang, Hong Gao*, Jiayi Li, Yiwen Sun, Zeshen Deng, Xinyao Yuan, Congcong Li, Tianxiao Chen, Xingwang Peng, Chao Wang, Yi Xu, Lichun Yang*, Xin Guo, Yufei Zhao, Peng Huang*, Yong Wang, **Guoxiu Wang**, Hao Liu*, "Plasma-enhanced vacancy engineering for sustainable high-performance recycled silicon in lithium-ion batteries", **Energy Storage Materials**, 77, 104231, 2025. IF=18.9. DOI: 10.1016/j.ensm.2025.104231

**ABSTRACT:** Silicon, renowned for its exceptional theoretical capacity, is a promising lithium-ion battery (LIB) anode material, yet its practical application is hindered by severe lithiation-induced volume expansion, structural instability, and high production costs. This study introduces a sustainable strategy to address these challenges by repurposing recycled photovoltaic (PV) silicon through a plasma-assisted vacancy engineering approach. By combining dielectric barrier discharge plasma-assisted milling with bismuth (Bi) modification, controlled vacancy defects are introduced into silicon microparticles, enhancing ion transport and mitigating internal stress. Bi further stabilizes the anode by absorbing mechanical stress and facilitating lithium-ion accommodation at vacancy sites. The resulting plasma induced silicon/carbon/bismuth composite demonstrates outstanding cycling stability and high-rate performance, retaining 1442 mA h g$^{-1}$ after 300 cycles at 0.5 A g$^{-1}$ and 525 mA h g$^{-1}$ after 1000 cycles at 7 A g$^{-1}$. This scalable and eco-friendly method not only overcomes the inherent limitations of silicon anodes but also transforms PV waste into high-performance LIB materials, advancing sustainable energy storage technologies.



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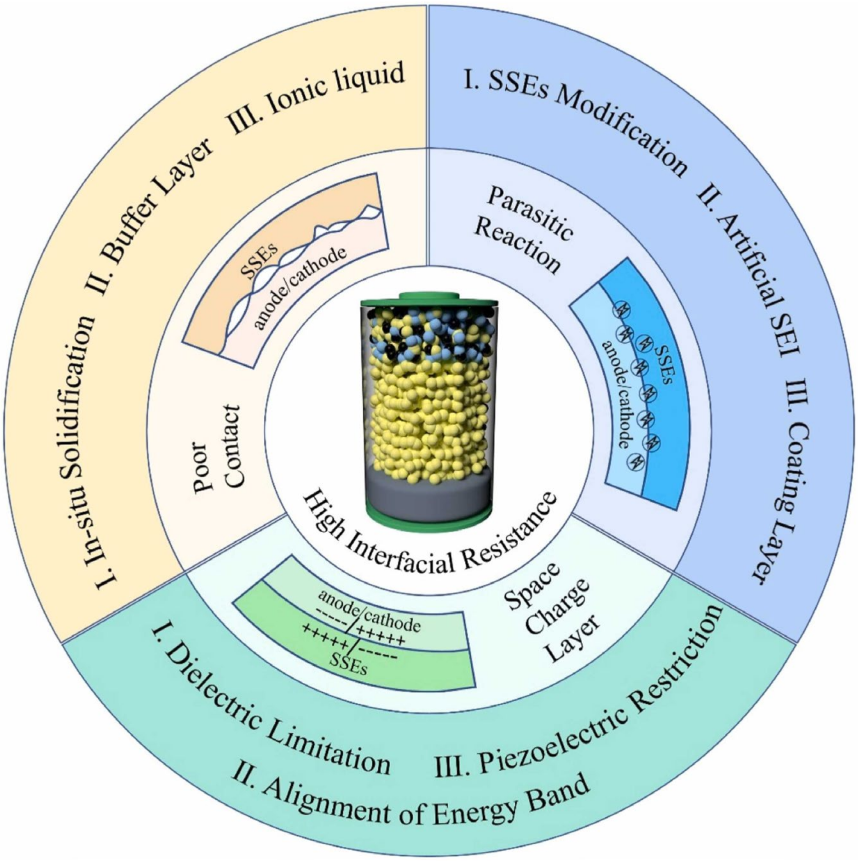
19. Ming Liu, Ailing Song, Xinyi Zhang, Jie Wang, Yuqian Fan, **Guoxiu Wang***, Hao Tian, Zhipeng Ma, Guangjie Shao, “Interfacial lithium-ion transportation in solid-state batteries: Challenges and prospects”, **Nano Energy**, 136, 110749, 2025. IF=16.8. DOI: 10.1016/j.nanoen.2025.110749.

**ABSTRACT:** Solid-state lithium-ion batteries (SSBs) have gained widespread attention due to their enhanced safety and energy density over conventional liquid electrolyte systems. However, their practical application is hindered by significant polarization during cycling, primarily caused by increased interface impedance. To address the challenges of slow lithium-ion diffusion, optimizing interfacial kinetics has emerged as a key strategy to improve the electrochemical performance of SSBs. However, the mechanisms behind battery failure, especially interface polarization, are not fully understood and require further investigation. This review explores the origins of interfacial polarization, including poor contact, parasitic reactions, and space charge layer, supported by theoretical calculations, experimental data, and advanced characterizations. Then, the latest progress categorized as in-situ solidification, buffer layer, ionic liquid, solid-state electrolytes modification, artificial solid electrolyte interphases, coating layers, dielectric additives, and piezoelectric additives are summarized to elucidate the underlying mechanisms of Li$^+$ transport across interfaces. Finally, the integration of mechanical behavior with outstanding interfacial engineering is emphasized as a key factor for advancing SSBs performance and stability, providing insights for the development of next-generation lithium-based batteries.



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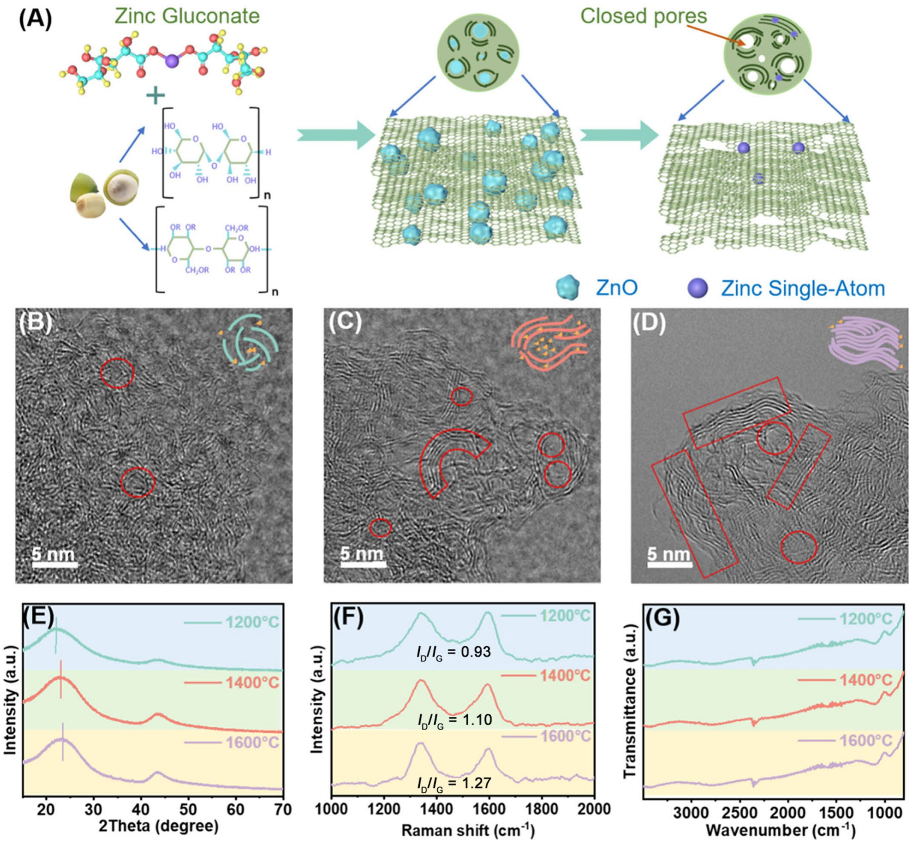
20.Guilai Zhang, Hong Gao*, Dingyi Zhang, Jun Xiao, Limeng Sun, Jiayi Li, Congcong Li, Yiwen Sun, Xinyao Yuan, Peng Huang*, Yi Xu*, Xin Guo, Yufei Zhao, Yong Wang, Yao Xiao, **Guoxiu Wang***, Hao Liu*, "Transformative Catalytic Carbon Conversion Enabling Superior Graphitization and Nanopore Engineering in Hard Carbon Anodes for Sodium-Ion Batteries", **Carbon Energy**, e713, 2025. IF=19.5. DOI:10.1002/cey2.713

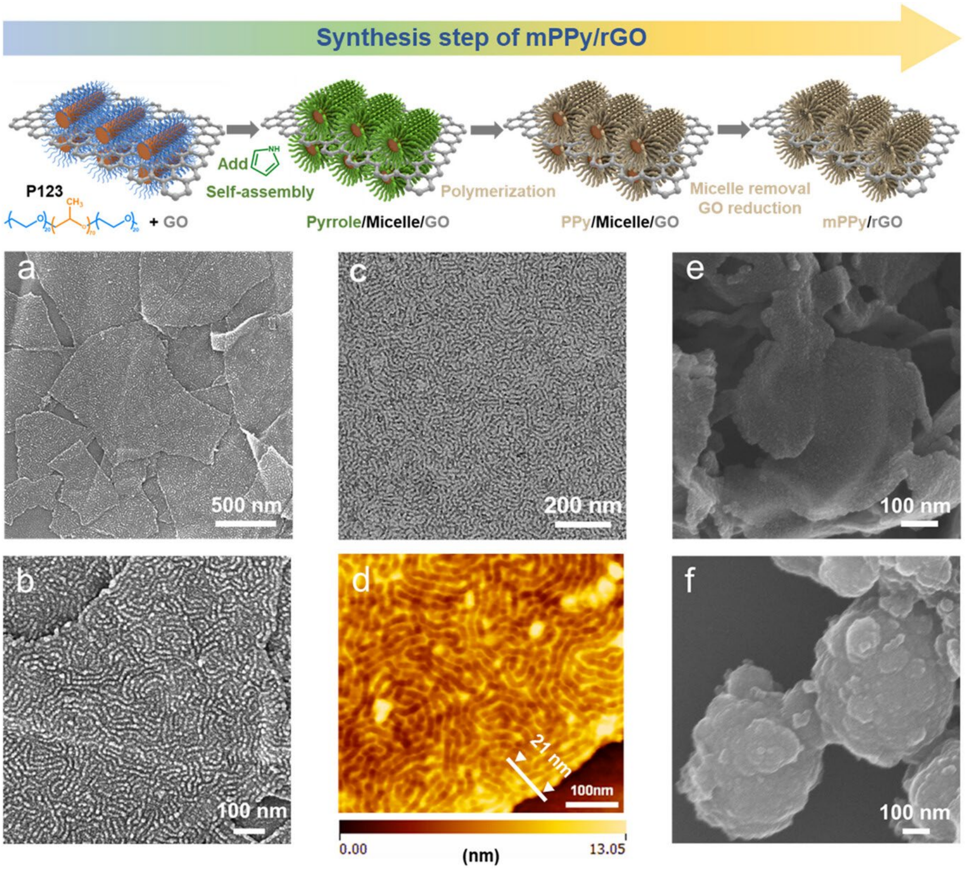
**ABSTRACT:** Hard carbons are promising anode materials for sodium-ion batteries (SIBs), but they face challenges in balancing rate capability, specific capacity, and initial Coulombic efficiency (ICE). Direct pyrolysis of the precursor often fails to create a suitable structure for sodium-ion storage. Molecular-level control of graphitization with open channels for Na$^+$ ions is crucial for high-performance hard carbon, whereas closed pores play a key role in improving the low-voltage (<0.1V) plateau capacity of hard carbon anodes for SIBs. However, creation of these closed pores presents significant challenges. This work proposes a zinc gluconate-assisted catalytic carbonization strategy to regulate graphitization and create numerous nanopores simultaneously. As the temperature increases, trace amounts of zinc remain as single atoms in the hard carbon, featuring a uniform coordination structure. This mitigates the risk of electrochemically irreversible sites and enhances sodium-ion transport rates. The resulting hard carbon shows an excellent reversible capacity of 348.5mAhg$^{-1}$ at 30mAg$^{-1}$ and a high ICE of 92.84%. Furthermore, a sodium storage mechanism involving "adsorption–intercalation–pore filling" is elucidated, providing insights into the pore structure and dynamic pore-filling process.



https://onlinelibrary.wiley.com/doi/10.1002/cey2.713

21. Chen Tang, Hongli Chen, Qian Li, Changle Li, Ying Li, Azhar Alowasheeir, Zeinhom M El-Bahy, **Guoxiu Wang**, Chongyin Zhang, Yusuke Yamauchi, Xingtao Xu, "Directional Ion Transport Through Nanoarchitected 1D Mesochannels: 2D Polymer Interfacial Engineering for High-Efficiency Capacitive Deionization", **Advanced Science**, e04527, 2025. IF=14.3. DOI:10.1002/advs.202504527

**ABSTRACT:** The development of high-performance capacitive deionization (CDI) electrodes demands innovative materials that integrate rapid ion transport, high salt adsorption capacity (SAC), and oxidative stability. This challenge is addressed through a surface nanoarchitectonics strategy, constructing 2D mesochannel polypyrrole/reduced graphene oxide heterostructures (mPPy/rGO) with ordered 1D mesochannels (~8 nm) parallel to the graphene surface. By confining the self-assembly of cylindrical polymer brushes on freestanding rGO substrates, directional ion highways are simultaneously engineered that significantly reduce transport tortuosity. In addition, corrosion-resistant polymer interfaces block oxygen penetration, and strong interfacial interactions between PPy and rGO ensure efficient electron transfer. The mPPy/rGO-based CDI cell achieves breakthrough performance: ultrahigh SAC of 84.1 mg g$^{-1}$ (4.5× activated carbon, the salt concentration: 2 g L$^{-1}$), and 96.8% capacity retention over 100 cycles in air-equilibrated saline solution (the salt concentration: 500 mg L$^{-1}$). This interfacial confinement methodology establishes a universal paradigm for designing polymer-based desalination materials with atomically precise transport pathways.



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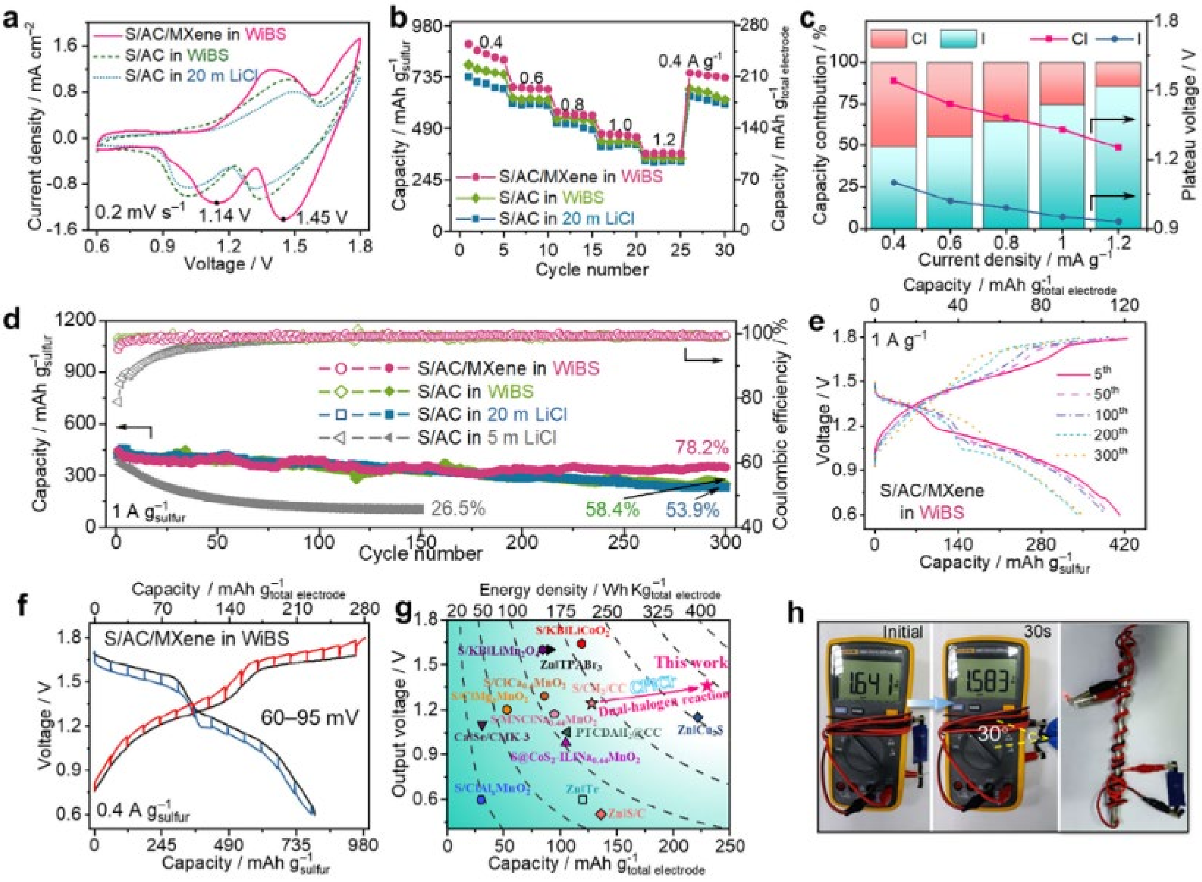
22.Ronghuan Liang, Yan Wang, Chuanlong Wei, Xiao Tang,* Timing Fang, Zhezheng Ding,Qing Wang, Rui Wang, Jianjun Song, Bing Sun,* Xiaomin Liu,* and **Guoxiu Wang***, "A Highly Reversible Aqueous Sulfur-Dual-Halogen BatteryEnabled by a Water-in-Bisalt Electrolyte", **Small**, 2502228, 2025. IF=13. DOI: 10.1002/smll.202502228

**ABSTRACT:** The chlorine-based redox reaction applied in aqueous rechargeable batteries (ARBs) has attracted extensive attention owing to the high theoretical capacity and redox potential. However, it generally suffers from low reversibility and poor Coulombic efficiency due to the evolution of toxic $Cl_2$ gas and the decomposition of aqueous electrolytes. Herein, an aqueous sulfur-dual halogen chemistry is demonstrated by employing highly-concentrated water-in-bisalt (WiBS) electrolyte, sulfur anode, and iodine composite electrodes. The freestanding iodine/carbon cloth cathode and $Cl^-$-containing WiBS electrolyte not only enable the continuous $I^+/I^0$ reaction by forming $[ICl_x]^{1-x}$ interhalogens but also achieve the oxidation of $Cl^-$ in $[ICl_x]^{1-x}$ at higher redox potential and immobilize $Cl^0$ species via $I^+$-$Cl^0$ chemical bonds. Therefore, the as-assembled aqueous sulfur-dual halogen batteries (ASHBs) based on the dual-halogen conversion on the cathode and the $S/S_x^{2-}$ redox reaction on the anode deliver a high energy density of 304 Wh $kg^{-1}$ with an average output voltage of 1.32 V. These key findings open an avenue for the development of low-cost and high-performance ARBs for energy storage applications.



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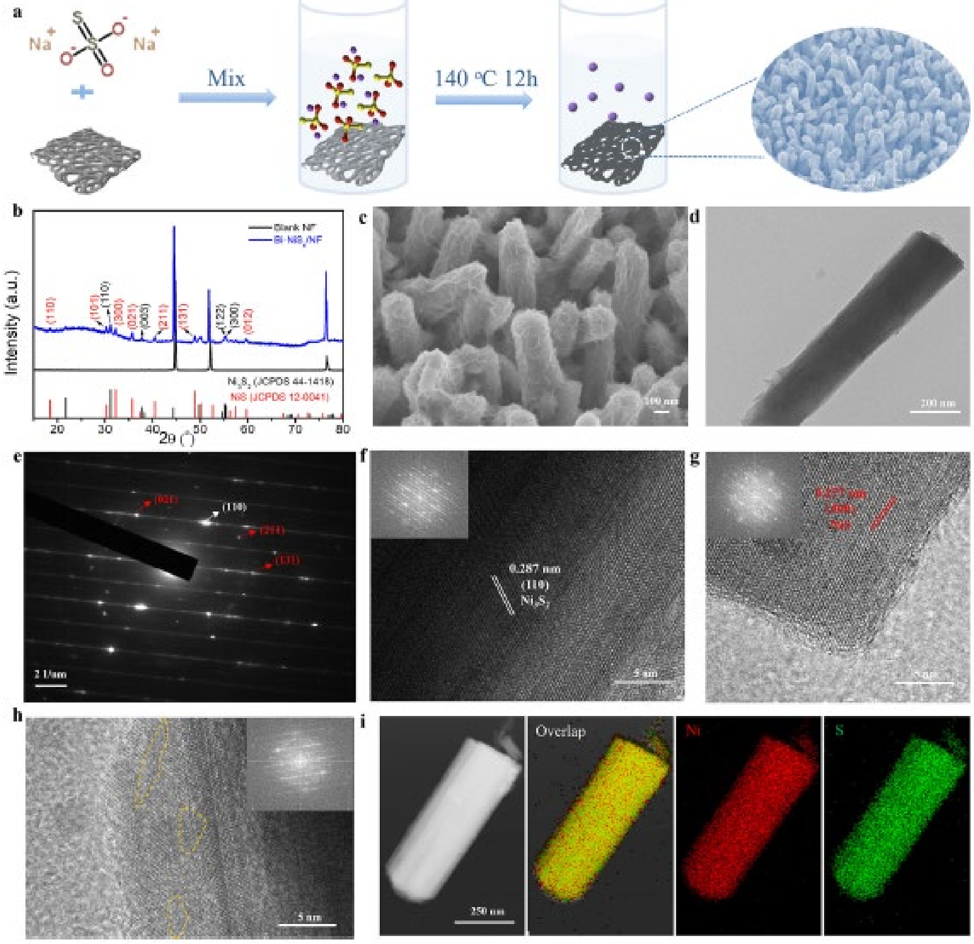
23. Xingxing Yu, Xiaochun Gao, Kang Yan, Shengwen Liu, **Guoxiu Wang***, Yang Yang, “Phase-Mixed Nickel Sulfide Nanoarrays for Electrochemical Water Oxidation at Low Overpotential”, **Small**, 2503194, 2025. IF=13. DOI:1002/smll.202503194

**ABSTRACT:** Transition metal sulfide materials have demonstrated exceptional electrocatalytic activities for the hydrogen evolution reaction (HER); however, their efficacy for the oxygen evolution reaction (OER) remains limited, particularly in alkaline environments. This study introduces a novel nanoarray structure composed of phase-mixed nickel sulfides, specifically rhombohedral NiS and $Ni_3S_2$, directly grown on nickel foam (denoted as bi-NiSx/NF) through a straightforward hydrothermal method. The optimized bi-$NiS_x$/NF catalyst achieves an impressive overpotential of only 43 mV to reach a current density of 10 mA $cm^{-2}$ in 1 m KOH electrolyte. The stability test of bi-NiSx/NF under alkaline conditions uncovers that the intrinsic sulfur-rich surface plays an important role in its superior OER activity. Additionally, annealing treatments demonstrate that OER performance is closely linked to sulfur retention, further affirming the significance of this structural sulfur-rich characteristic. These findings provide valuable insights into the design of phase-mixed catalysts and the intrinsic OER activity of transition metal sulfides, paving the way for future advancements in electrocatalytic materials.



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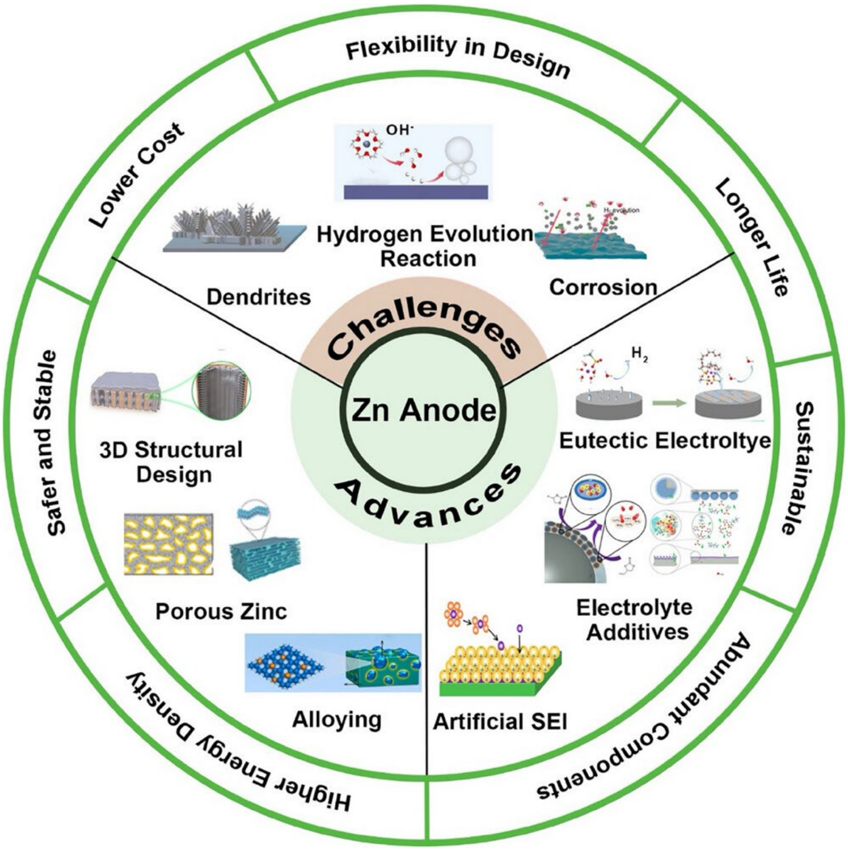
24. Hajra Khan, Chenyu Zhao, Karim Khan, Ayesha Khan Tareen, Asif Shahzad, Steven J. Langford, Hao Liu, Asif Mahmood, **Guoxiu Wang***, “Challenges and Design Strategies for Stable Zinc Anodes in Rechargeable Zinc Batteries”, **Small**, 2504170, 2025, IF=13. DOI: 10.1002/smll.202504170

**ABSTRACT:** Zinc-ion batteries (ZIBs) are increasingly recognized as promising candidates for large-scale energy storage due to their high energy density, safety, low cost, and the natural abundance of zinc. However, the widespread adoption of ZIBs is limited by fundamental issues associated with the zinc metal anode, including dendrite formation, hydrogen evolution reaction (HER), passivation, self-corrosion, and poor cycling stability. In recent years, substantial efforts have been made to address these challenges through approaches such as 3D current collector design, alloying, surface modification, and electrolyte engineering. This review provides a systematic, Zn-anode-focused summary of these advances, with emphasis on structural engineering, interface stabilization, and electrolyte tailoring to improve $Zn^{2+}$ deposition behavior. Uniquely, this work integrates recent progress in advanced characterization techniques such as in situ/operando imaging and spectroscopy, to provide deeper insights into the failure mechanism of Zn anode materials. These details are critical in real-time probing of interfacial and morphological evolutions upon charge/discharge. Finally, the review outlines the key future research directions are proposed to support the development of durable and high-performance Zn-based energy storage systems.



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