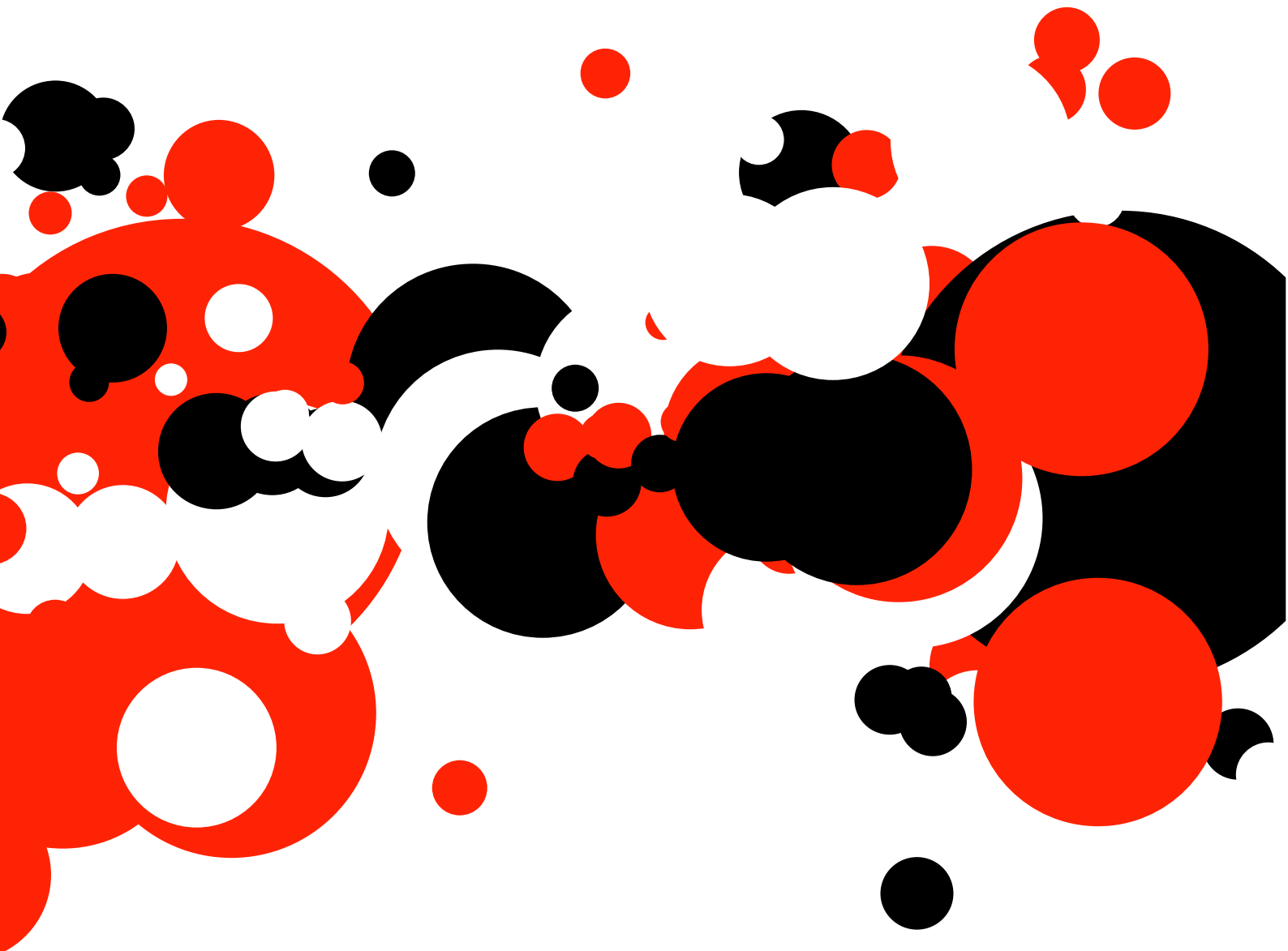




University of Technology Sydney

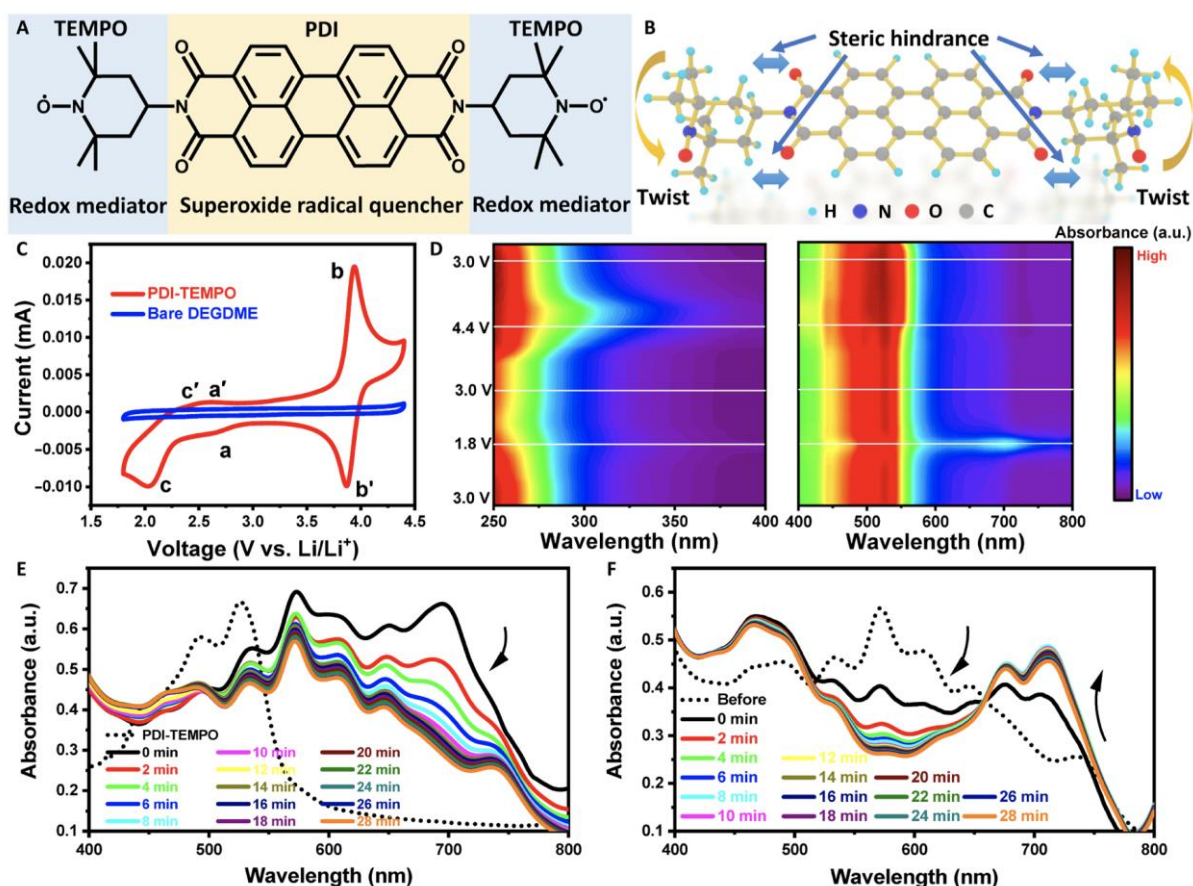
Centre for Clean Energy Technology

Research Highlights in 2022



1. Jinqiang Zhang, Yufei Zhao, Bing Sun, Yuan Xie, Anastasia Tkacheva, Feilong Qiu, Ping He, Haoshen Zhou, Kang Yan, Xin Guo, Shijian Wang, Andrew M. McDonagh, Zhangquan Peng, Jun Lu, **Guoxiu Wang***, “A long-life lithium-oxygen battery via a molecular quenching/mediating mechanism”, **Science Advances**, eabm1899, 8, 2022. IF=14.14. DOI:10.1126/sciadv.abm1899

Abstract: The advancement of lithium-oxygen (Li-O₂) batteries has been hindered by challenges including low discharge capacity, poor energy efficiency, severe parasitic reactions, etc. We report an Li-O₂ battery operated via a new quenching/mediating mechanism that relies on the direct chemical reactions between a versatile molecule and superoxide radical/Li₂O₂. The battery exhibits a 46-fold increase in discharge capacity, a low charge overpotential of 0.7 V, and an ultralong cycle life >1400 cycles. Featuring redox-active 2,2,6,6-tetramethyl-1-piperidinyloxy moieties bridged by a quenching-active perylene diimide backbone, the tailor-designed molecule acts as a redox mediator to catalyze discharge/charge reactions and serves as a reusable superoxide quencher to chemically react with superoxide species generated during battery operation. The all-in-one molecule can simultaneously tackle issues of parasitic reactions associated with superoxide radicals, singlet oxygen, high overpotentials, and lithium corrosion. The molecular design of multifunctional additives combining various capabilities opens a new avenue for developing high-performance Li-O₂ batteries.

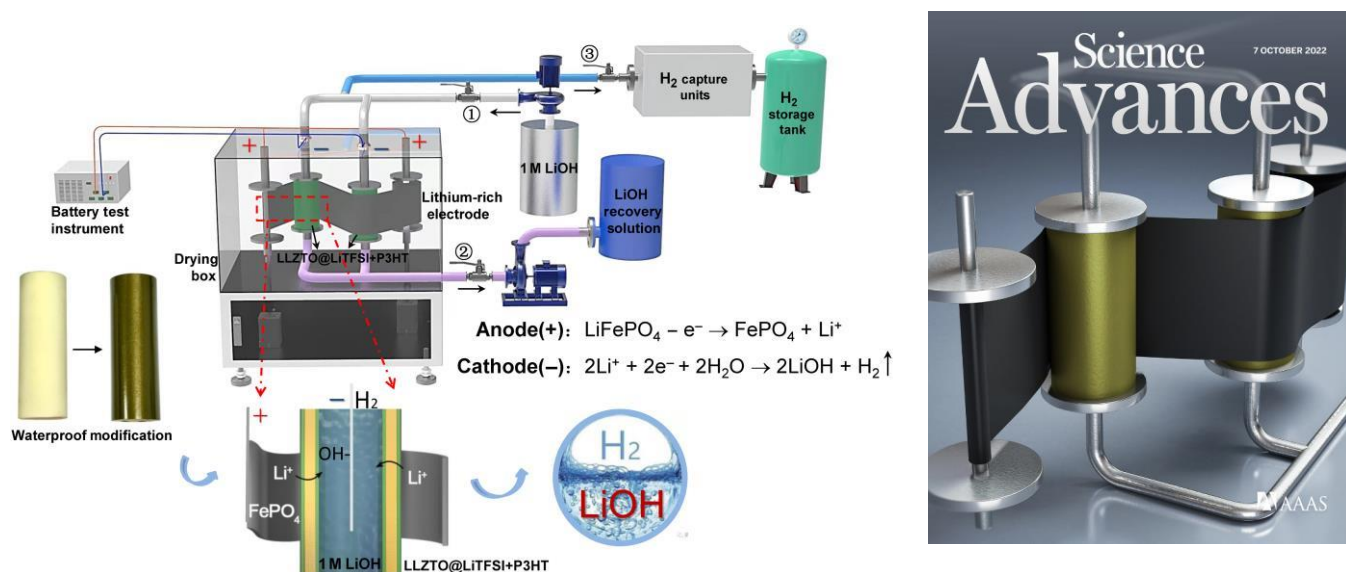


<https://www.science.org/doi/10.1126/sciadv.abm1899>

<https://www.uts.edu.au/news/health-science/its-air-battery-research-takes-charge>

2. Jing Xu, Yang Jin, Kai Liu, Nawei Lyu, Zili Zhang, Bin Sun, Qianzheng Jin, Hongfei Lu, Huajun Tian, Xin Guo, Devaraj Shanmukaraj, Hui Wu, Meicheng Li, Michel Armand, **Guoxiu Wang***, “A green and sustainable strategy toward lithium resources recycling from spent batteries”, **Science Advances**, eabq794, 8, 2022. IF=14.14. DOI:10.1126/sciadv.abm1899

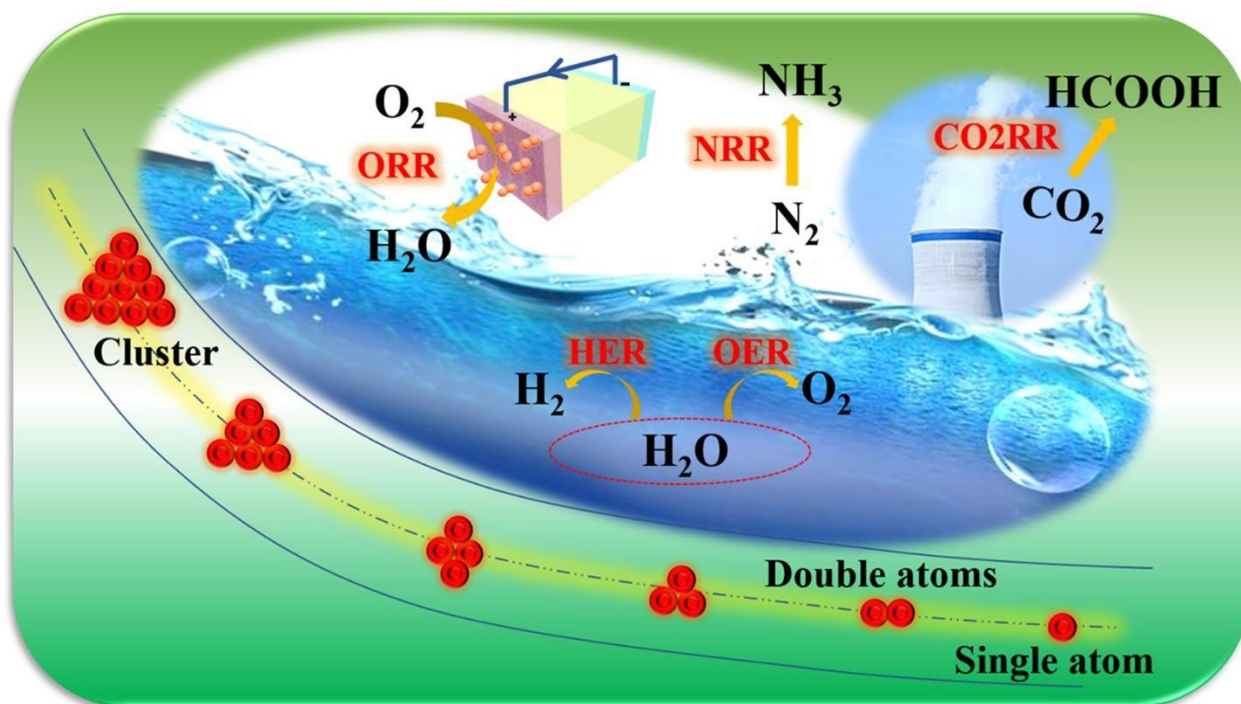
Abstract: Recycling lithium from spent batteries is challenging because of problems with poor purity and contamination. Here, we propose a green and sustainable lithium recovery strategy for spent batteries containing LiFePO₄, LiCoO₂, and LiNi_{0.5}Co_{0.2}Mn_{0.3}O₂ electrodes. Our proposed configuration of “lithium-rich electrode || LLZTO@LiTFSI+P3HT || LiOH” system achieves double-side and roll-to-roll recycling of lithium-containing electrode without destroying its integrity. The LiTFSI+P3HT-modified LLZTO membrane also solves the H⁺/Li⁺ exchange problem and realizes a waterproof protection of bare LLZTO in the aqueous working environment. On the basis of these advantages, our system shows high Li selectivity (97%) and excellent Faradaic efficiency (≥97%), achieving high-purity (99%) LiOH along with the production of H₂. The Li extraction processes for spent LiFePO₄, LiNi_{0.5}Co_{0.2}Mn_{0.3}O₂, and LiCoO₂ batteries is shown to be economically feasible. Therefore, this study provides a previously unexplored technology with low energy consumption as well as high economic and environmental benefits to realize sustainable lithium recycling from spent batteries.



<https://www.science.org/doi/10.1126/sciadv.abq7948>

3. Yongxia Wang, Xiangzhi Cui, Jinqiang Zhang, Jinli Qiao, Haitao Huang, Jianlin Shi, **Guoxiu Wang***, “Advances of atomically dispersed catalysts from single-atom to clusters in energy storage and conversion applications”, **Progress in Materials Science** 128, 100964, 2022. IF=39.67. DOI: 10.1016/j.pmatsci.2022.100964.

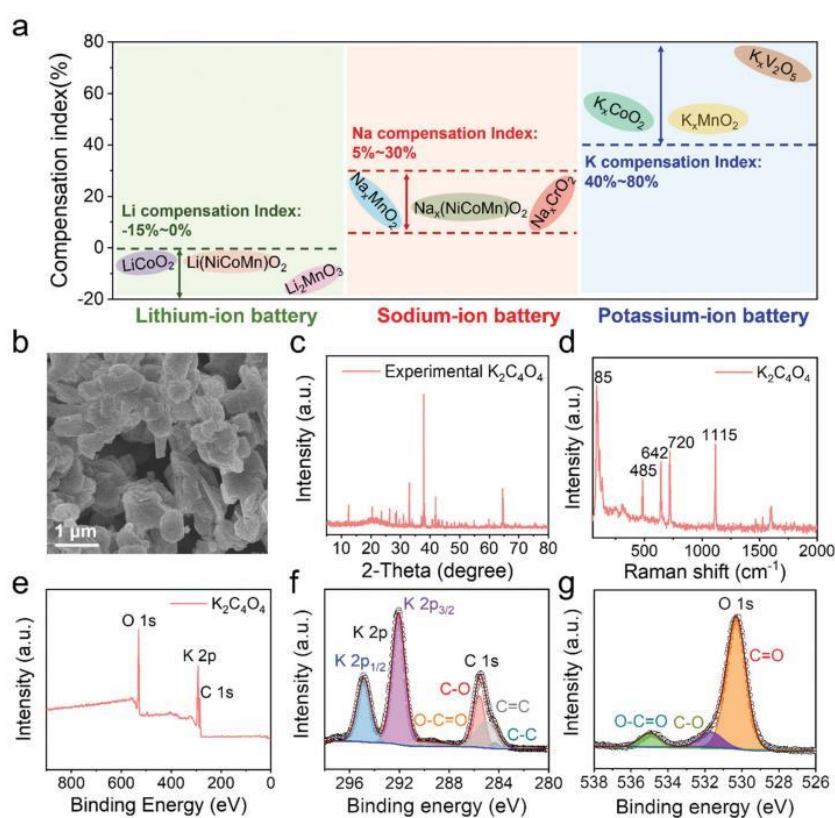
ABSTRACT: Owing to the special structural characteristics and maximized efficiency, atomically dispersed catalysts (ADCs) with different atom sizes ranged from the single atom to clusters can bridge the gap between heterogeneous and homogeneous catalysis. Tremendous progress has been made in ADCs including developing advanced synthesis strategies, promoting electrochemical performance and unraveling the underlying fundamental mechanisms. Herein, the recent progress of ADCs ranged from single-atom to clusters has been systematically reviewed with emphasis on key issues of synthesis methods, stabilization strategies, performance evaluation, mechanistic understanding, integrated experimental and theoretical studies in typical applications of energy storage and conversion, including oxygen reduction reaction in fuel cell and metal-air battery, oxygen evolution and hydrogen evolution reactions in water splitting, hydrogen oxidation reactions, carbon dioxide reduction and nitrogen reduction reaction. Centering on the topics, the most up-to-date results are present, along with the perspectives and challenges for the future development of ADCs.



<https://www.sciencedirect.com/science/article/pii/S0079642522000457#f0005>

4. Shuoqing Zhao, Zhichao Liu, Guanshun Xie, Ziqi Guo, Shuguang Wang, Jinhui Zhou, Xiuqiang Xie, Bing Sun, Shaojun Guo and **Guoxiu Wang***, “High-efficiency cathode potassium compensation and interfacial stability improvement enabled by dipotassium squarate for potassium-ion batteries”, **Energy & Environmental Science**, 15, 3015-3023, 2022. IF= 38.53. DOI: 10.1039/D2EE00833E.

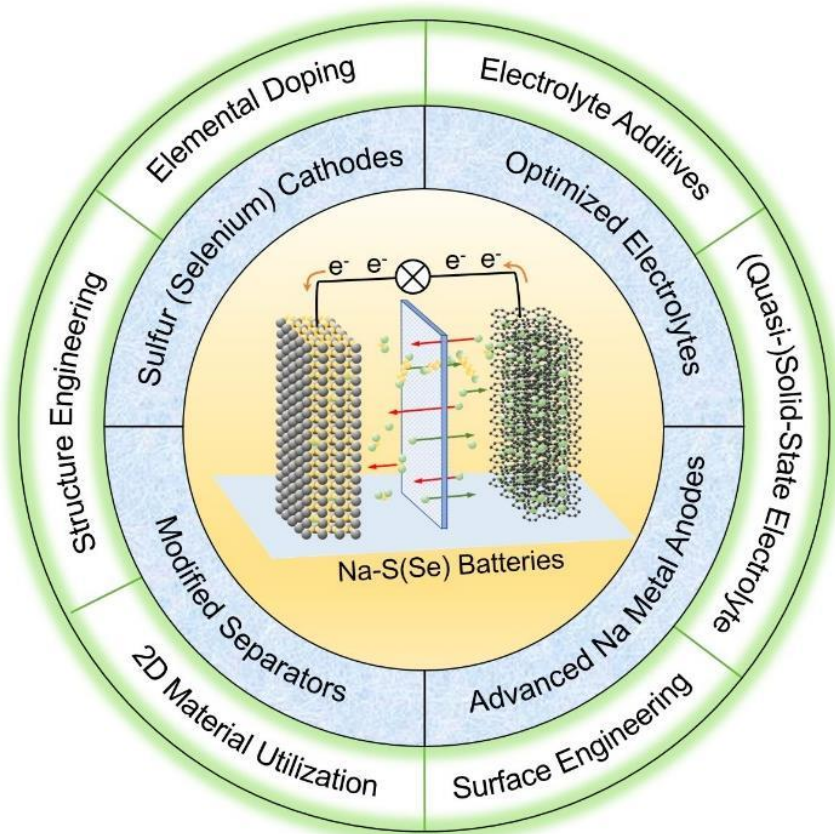
ABSTRACT: Potassium deficiency and irreversible loss of potassium at the initial cycle of potassium-ion batteries inevitably reduce their energy density and cycle life. Cathode pre-potassiation before battery assembling is an efficient method to address these issues but faces problems such as safety risks and high cost. Herein, we report an economic and facile potassium compensation strategy employing a self-sacrificial agent (i.e., $K_2C_4O_4$) at cathodes to improve the performances of potassium-ion batteries. We found that with the addition of $K_2C_4O_4$ in a P3-type $K_{0.5}MnO_2$ cathode, the initial Coulombic efficiency of the electrode can be significantly improved from 53.6% to the reported highest one of 93.5%. Moreover, we demonstrate that the decomposition of $K_2C_4O_4$ during the charge process contributes to the formation of a thin and F-rich cathode electrolyte interphase layer on the surface of the electrode, benefiting for the improved kinetics and interfacial stability of $K_{0.5}MnO_2$ cathodes. As a result, a $K_2C_4O_4$ -assisted potassium-ion full cell shows about three times higher energy density (220 W h kg^{-1}) and much enhanced capacity retention than the $K_2C_4O_4$ -free cell without any pre-potassiation treatment. The potassium compensation strategy provides an effective approach to overcome the existing technical hurdles for the development of potassium-based energy storage systems.



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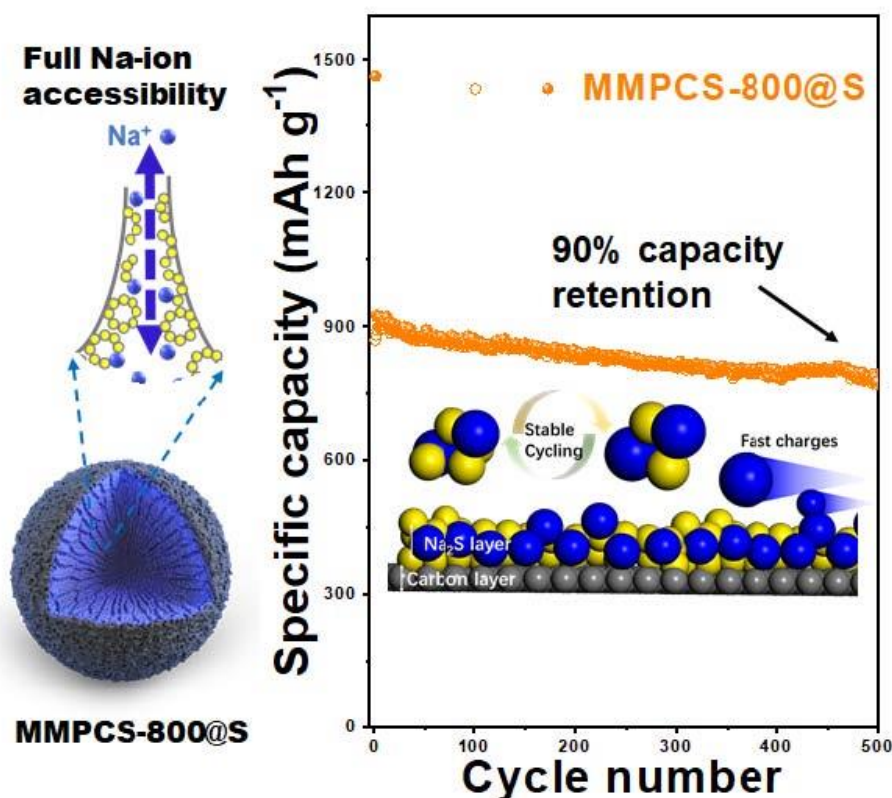
5. Zefu Huang, Pauline Jaumaux, Bing Sun*, Xin Guo*, Dong Zhou, Devaraj Shanmukaraj, Michel Armand*, Teofilo Rojo*, **Guoxiu Wang***, “High-energy room-temperature sodium-sulfur and sodium-selenium batteries for sustainable energy storage”, **Electrochemical Energy Reviews**, accepted in July, 2022. IF=32.804.

ABSTRACT: Rechargeable room-temperature sodium-sulfur (Na-S) and sodium-selenium (Na-Se) batteries are gaining extensive attention for potential large-scale energy storage applications, owing to their low cost and high theoretical energy density. The optimization of electrode materials and investigations of mechanisms are essential to achieve high-energy-density and long-term cycling stability of Na-S(Se) batteries. Herein, we provide a comprehensive review of the recent progress on Na-S(Se) batteries. We elucidate the Na storage mechanisms and improvement strategies for battery performance. In particular, we discussed the advances in the development of battery components, including high-performance sulfur cathodes, optimized electrolytes, advanced Na metal anodes and modified separators. Combined with current research achievements, this review outlines remaining challenges and clear research directions for the future development of practical high-performance Na-S(Se) batteries.



6. Can Wu, Yaojie Lei, Laura Simonelli, Dino Tonti, Ashley Black, Xinxin Lu, Wei-Hong Lai, Xiaolan Cai, Yun-Xiao Wang, Qinfen Gu, Shu-Lei Chou, Hua-Kun Liu, **Guoxiu Wang***, Shi-Xue Dou, “Continuous carbon channels enable full Na-ion accessibility for superior room-temperature Na-S batteries”, **Advanced Materials**, 34, 2108363, 2022. IF= 32.09. DOI: 10.1002/adma.202108363.

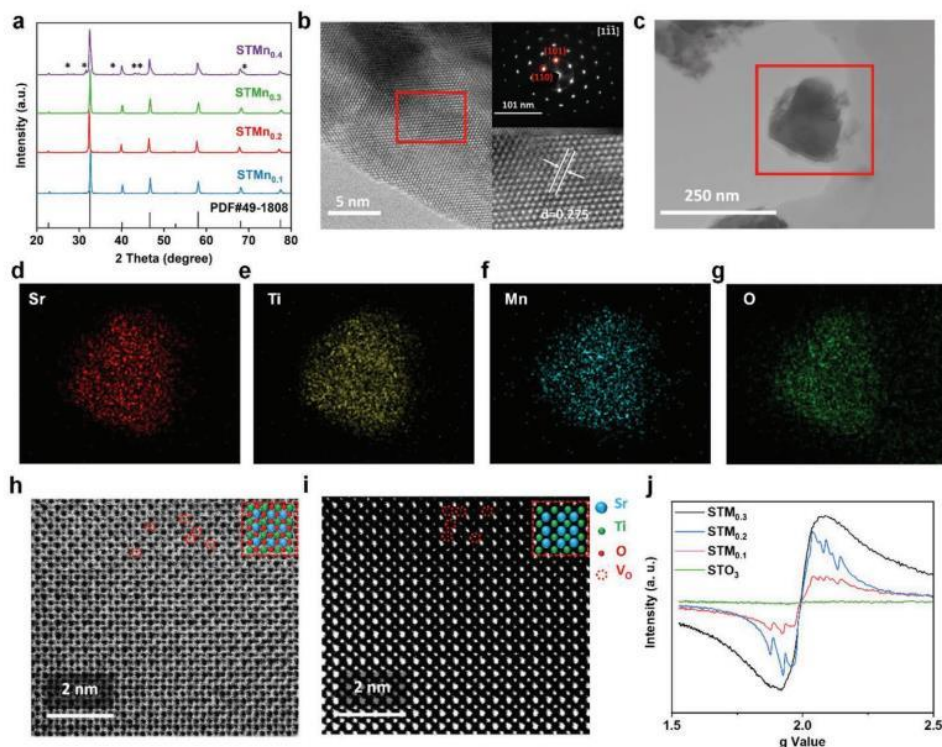
ABSTRACT: Porous carbon has been widely used as an efficient host to encapsulate highly active molecular sulfur (S) in Li-S and Na-S batteries. However, for these sub-nanosized pores, it is a challenge to provide fully accessible sodium ions with unobstructed channels during cycling, particularly for high sulfur content. It is well recognized that solid interphase with full coverage over the designed architectures plays critical roles in promoting rapid charge transfer and stable conversion reactions in batteries, whereas constructing a high-ionic-conductivity solid interphase in the pores is very difficult. Herein, unique continuous carbonaceous pores are tailored, which can serve as multifunctional channels to encapsulate highly active S and provide fully accessible pathways for sodium ions. Solid sodium sulfide interphase layers are also realized in the channels, showing high Na-ion conductivity toward stabilizing the redox kinetics of the S cathode during charge/discharge processes. This systematically designed carbon-hosted sulfur cathode delivers superior cycling performance (420 mAh g⁻¹ at 2 A g⁻¹ after 2000 cycles), high capacity retention of ≈90% over 500 cycles at current density of 0.5 A g⁻¹, and outstanding rate capability (470 mAh g⁻¹ at 5 A g⁻¹) for room-temperature sodium-sulfur batteries.



<https://onlinelibrary.wiley.com/doi/10.1002/adma.202205634>

7. Wenshuo Hou, Pingli Feng, Xin Guo, Zhenhua Wang, Zhe Bai, Yu Bai, **Guoxiu Wang***, Kening Sun, “Catalytic Mechanism of Oxygen Vacancies in Perovskite Oxides for Lithium–Sulfur Batteries”, **Advanced Materials**, 34, 2202222, 2022. IF= 32.09. DOI: 10.1002/adma.202202222.

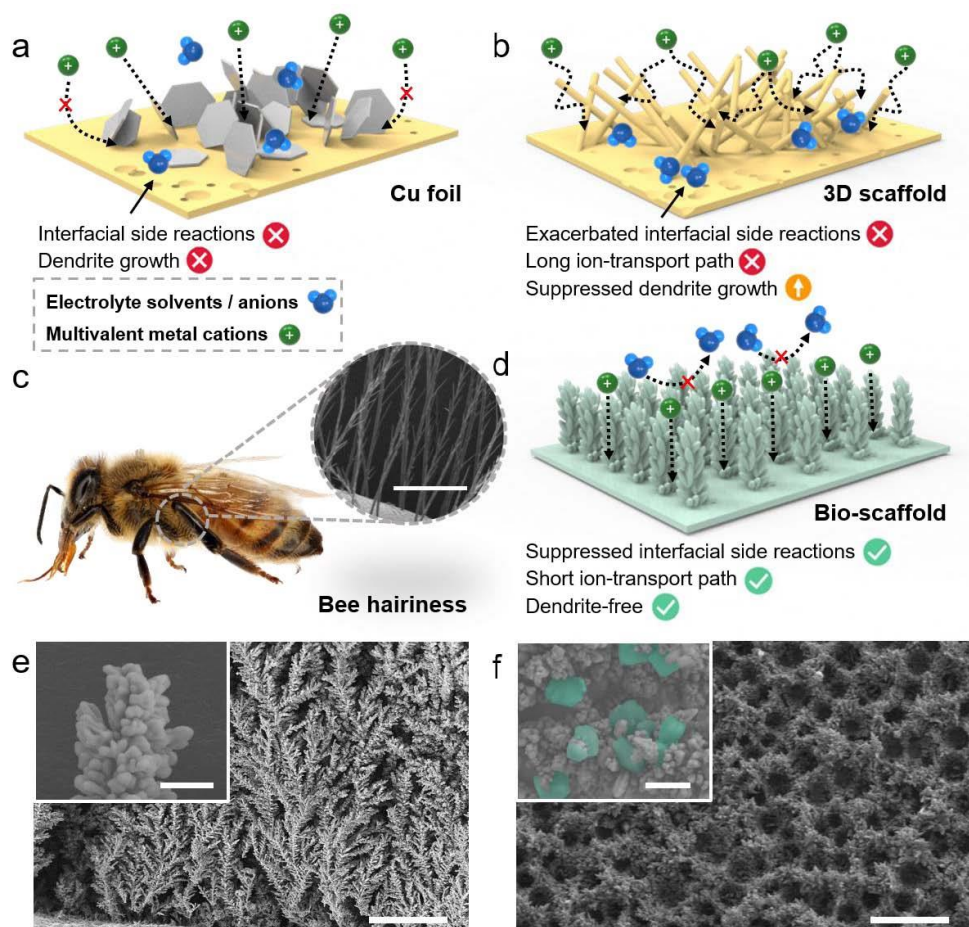
ABSTRACT: Defective materials have been demonstrated to possess adsorptive and catalytic properties in lithium–sulfur (Li–S) batteries, which can effectively solve the problems of lithium polysulfides (LiPSs) shuttle and sluggish conversion kinetics during charging and discharging of Li–S batteries. However, there is still a lack of research on the quantitative relationship between the defect concentration and the adsorptive-catalytic performance of the electrode. In this work, perovskites $\text{Sr}_{0.9}\text{Ti}_{1-x}\text{Mn}_x\text{O}_{3-\delta}$ (STMn_x) ($x = 0.1–0.3$) with different oxygen-vacancy concentrations are quantitatively regulated as research models. Through a series of tests of the adsorptive property and electrochemical performance, a quantitative relationship between oxygen-vacancy concentration and adsorptive-catalytic properties is established. Furthermore, the catalytic mechanism of oxygen vacancies in Li–S batteries is investigated using density functional theory calculations and in situ experiments. The increased oxygen vacancies can effectively increase the binding energy between perovskite and LiPSs, reduce the energy barrier of LiPSs decomposition reaction, and promote LiPSs conversion reaction kinetics. Therefore, the perovskite $\text{STMn}_{0.3}$ with high oxygen-vacancy concentrations exhibits excellent LiPSs adsorptive and catalytic properties, realizing high-efficiency Li–S batteries. This work is helpful to realize the application of the quantitative regulation strategy of defect engineering in Li–S batteries.



<https://onlinelibrary.wiley.com/doi/abs/10.1002/adma.202202222>

8. Zhijia Zhang, Xu Yang, Peng Li, Yao Wang, Xin Zhao, Javad Safaei, Hao Tian, Dong Zhou, Baohua Li, Feiyu Kang, **Guoxiu Wang***, “Biomimetic dendrite-free multivalent metal batteries”, **Advanced Materials**, 34, 2206970, 2022. IF= 32.09. DOI: 10.1002/adma.202206970.

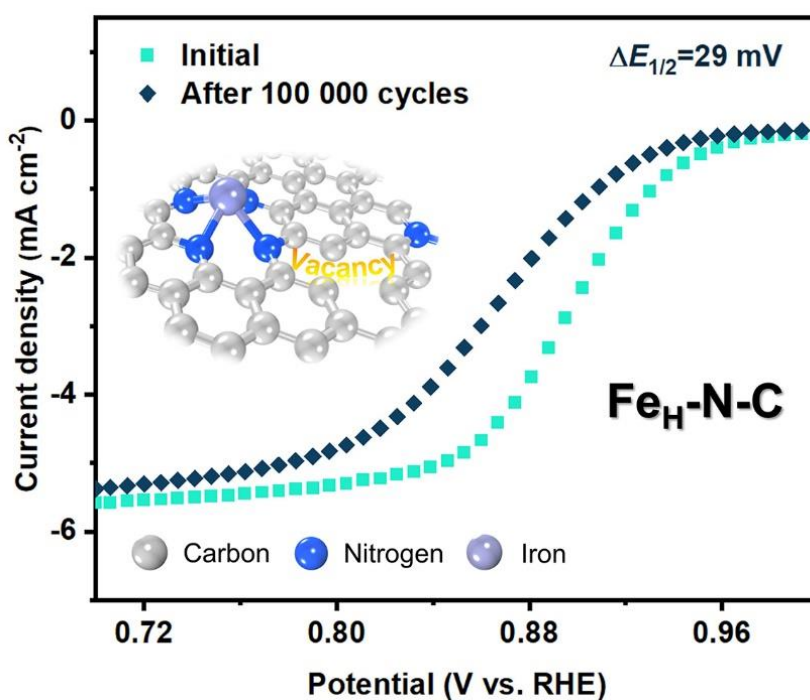
ABSTRACT: Rechargeable multivalent metal (e.g., zinc (Zn) and aluminum (Al)) batteries are ideal choices for large-scale energy storage owing to their intrinsic low cost and safety. However, the poor compatibility between metallic anodes and electrolytes strongly hampers their practical applications. Herein, we demonstrate that confining multivalent metals in a biomimetic scaffold (Bio-scaffold) can achieve highly efficient multivalent metal plating/stripping. This Bio-scaffold is well-tailored through the synergy of a parallel-aligned array of fractal copper branches and a CaTiO_3 (CTO)-based coating layer. By virtue of this design strategy, the as-developed Bio-scaffold-based Zn and Al metal anodes exhibited dendrite-free morphologies with high reversibility and long lifespan, as well as excellent performance for Zn and Al full batteries. Theoretical modeling and experimental investigations reveal that the fractal copper array not only facilitates multivalent ion diffusion and electrolyte wetting, but also effectively reduces the local current densities during cycling; Meanwhile, the CTO-based coating layer effectively blocks interfacial side reactions and enables a homogeneous ionic flux. This work opens a new avenue for developing multivalent metal batteries.



<https://onlinelibrary.wiley.com/doi/full/10.1002/adma.202206970>

9. Hao Tian, Ailing Song, Peng Zhang, Kaian Sun, Jingjing Wang, Bing Sun, Qiaohui Fan, Guangjie Shao, Chen Chen, Hao Liu, Yadong Li, **Guoxiu Wang***, “High durability of Fe-N-C single atom catalysts with carbon vacancies towards oxygen reduction reaction in alkaline media”, **Advanced Materials**, 35, 2210714, 2023. IF= 30.85. DOI: 10.1002/adma.202210714.

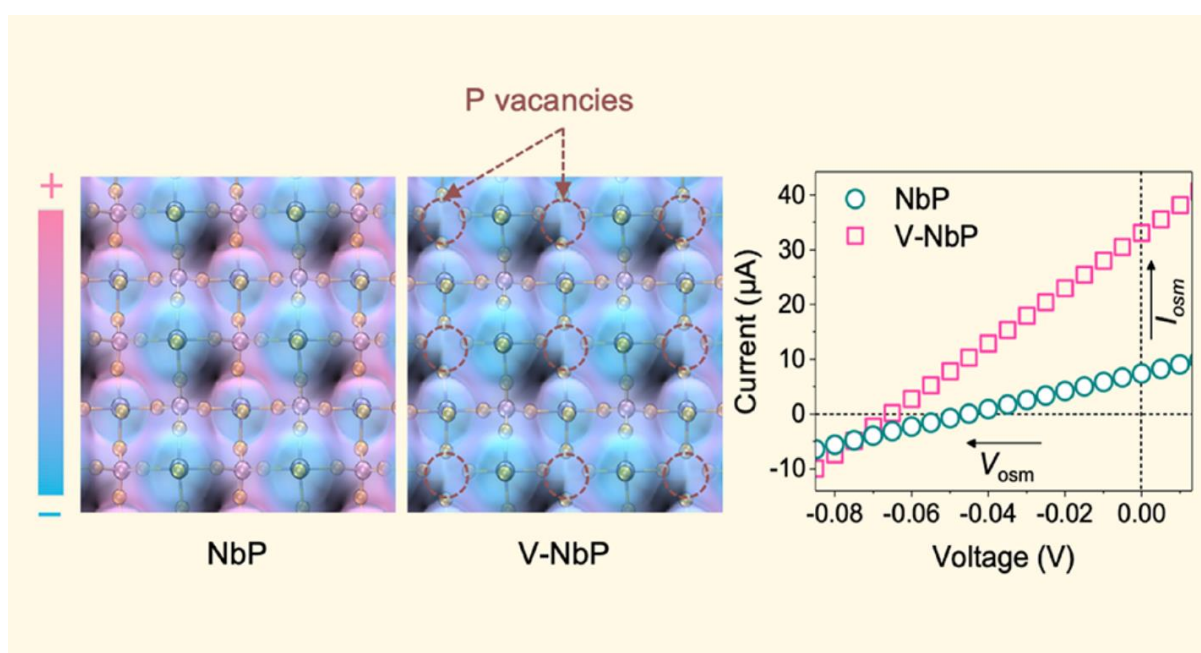
ABSTRACT: Single atom catalysts (SACs) have attracted extensive interest to catalyze the oxygen reduction reaction (ORR) in fuel cells and metal-air batteries. However, the development of SACs with high selectivity and long-term stability is a great challenge. In this work, we practically designed and synthesized carbon vacancy modified Fe-N-C SACs ($\text{Fe}_\text{H}\text{-N-C}$) through microenvironment modulation, achieving high-efficient utilization of active sites and optimization of electronic structures. The $\text{Fe}_\text{H}\text{-N-C}$ catalyst exhibited a half-wave potential ($E_{1/2}$) of 0.91 V and sufficient durability of 100,000 voltage cycles with 29 mV $E_{1/2}$ loss. Density functional theory calculations confirmed the vacancies around metal- N_4 sites can reduce the adsorption free energy of OH^* , and hinder the dissolution of metal centre, significantly enhancing the ORR kinetics and stability. Accordingly, $\text{Fe}_\text{H}\text{-N-C}$ SACs presented a high-power density and long-term stability over 1200 h in rechargeable zinc-air batteries. This work will not only guide for developing highly active and stable SACs through rational modulation of metal- N_4 sites, but also provide an insight into the optimization of the electronic structure to boost electro-catalytical performances.



<https://onlinelibrary.wiley.com/doi/abs/10.1002/adma.202210714>

10. Javad Safaei, Yifu Gao, Mostafa Hosseinpour, Xiuyun Zhang, Yi Sun, Xiao Tang, Zhijia Zhang, Shijian Wang, Xin Guo, Yao Wang, Zhen Chen, Dong Zhou, Feiyu Kang, Lei Jiang, **Guoxiu Wang***, “Vacancy Engineering for High-Efficiency Nanofluidic Osmotic Energy Generation”, **Journal of the American Chemical Society**, 2023. IF=16.383. DOI: 10.1021/jacs.2c12936.

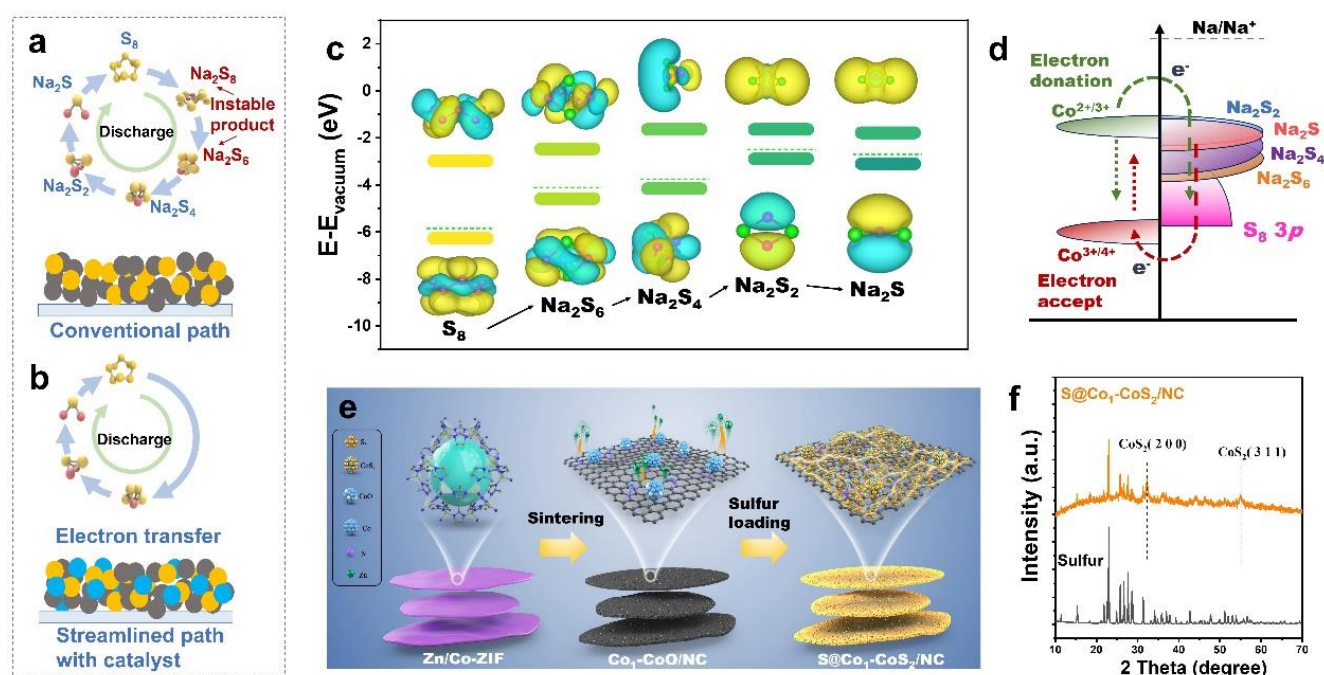
ABSTRACT: Two-dimensional (2D) nanofluidic membranes have shown great promise in harvesting osmotic energy from the salinity difference between seawater and fresh water. However, the output power densities are strongly hampered by insufficient membrane permselectivity. Herein, we demonstrate that vacancy engineering is an effective strategy to enhance the permselectivity of 2D nanofluidic membranes to achieve high-efficiency osmotic energy generation. Phosphorus vacancies were facilely created on NbOPO₄ (NbP) nanosheets, which remarkably enlarged their negative surface charge. As verified by both experimental and theoretical investigations, the vacancy-introduced NbP (V-NbP) exhibited fast transmembrane ion migration and high ionic selectivity originating from the improved electrostatic affinity of cations. When applied in a natural river water|seawater osmotic power generator, the macroscopic-scale V-NbP membrane delivered a record-high power density of 10.7 W m⁻², far exceeding the commercial benchmark of 5.0 W m⁻². This work endows the remarkable potential of vacancy engineering for 2D materials in nanofluidic energy devices.



<https://pubs.acs.org/doi/abs/10.1021/jacs.2c12936>

11. Yaojie Lei, Can Wu, Xinxin Lu, Weibo Hua, Shaobo Li, Yaru Liang, Hanwen Liu, WeiHong Lai, Qinfeng Gu, Xiaolan Cai, Nana Wang, Yun-Xiao Wang, Shu-Lei Chou, Hua-Kun Liu, **Guoxiu Wang***, Shi-Xue Dou, “Streamline sulfur redox reactions to achieve efficient roomtemperature sodium-sulfur batteries”, **Angewandte Chemie International Edition**, e202200384, 2022. IF= 15.34. DOI: 10.1002/anie.202200384.

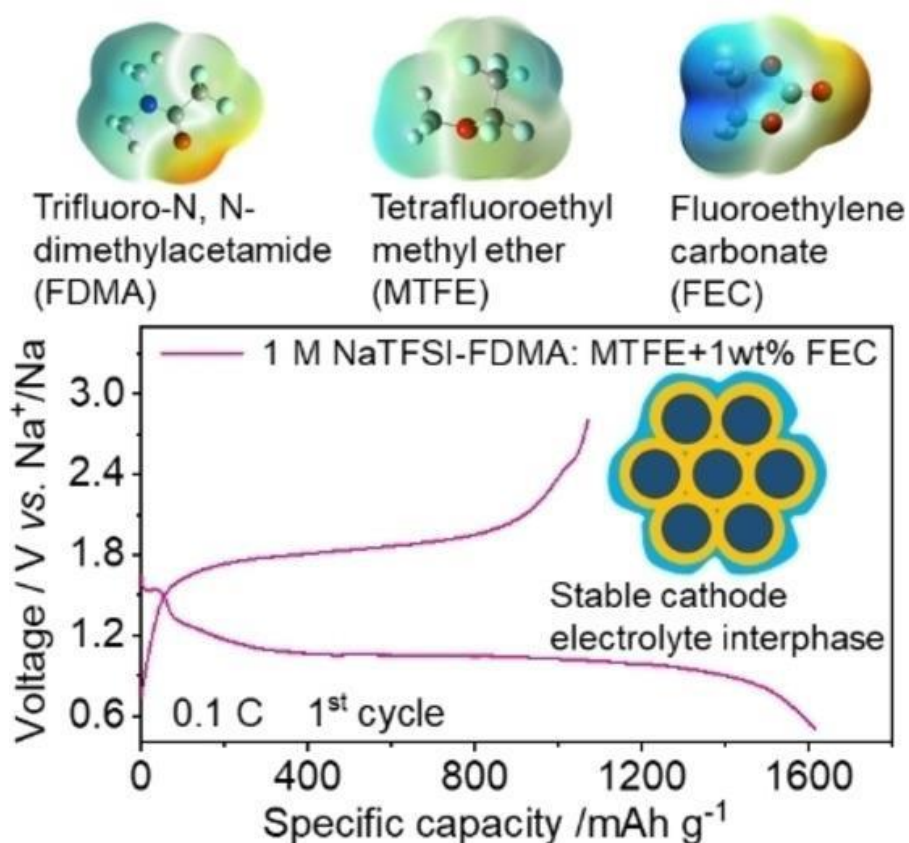
ABSTRACT: Engineering CoS_2 as electron reservoirs overcomes the limited length of the electron diffusion tunnel over an insulating sulfur cathode and thus achieves fast reaction kinetics in sodium-sulfur batteries. With the assistance of Co_1 single atoms, this strategy provides streamlined redox paths, which reduce the formation of unstable polysulfides and enable stable sodium-sulfur batteries.



<https://onlinelibrary.wiley.com/doi/10.1002/anie.202200384>

12. Junru Wu, Yao Tian, Yifu Gao, Ziyao Gao, Yuefeng Meng, Yao Wang, Xia Wang, Dong Zhou, Feiyu Kang, Baohua Li, **Guoxiu Wang***, “Rational Electrolyte Design toward Cyclability Remedy for Room-Temperature Sodium–Sulfur Batteries”, **Angewandte Chemie International Edition**, e202205416, 2022. IF= 15.34. DOI: 10.1002/anie.202205416.

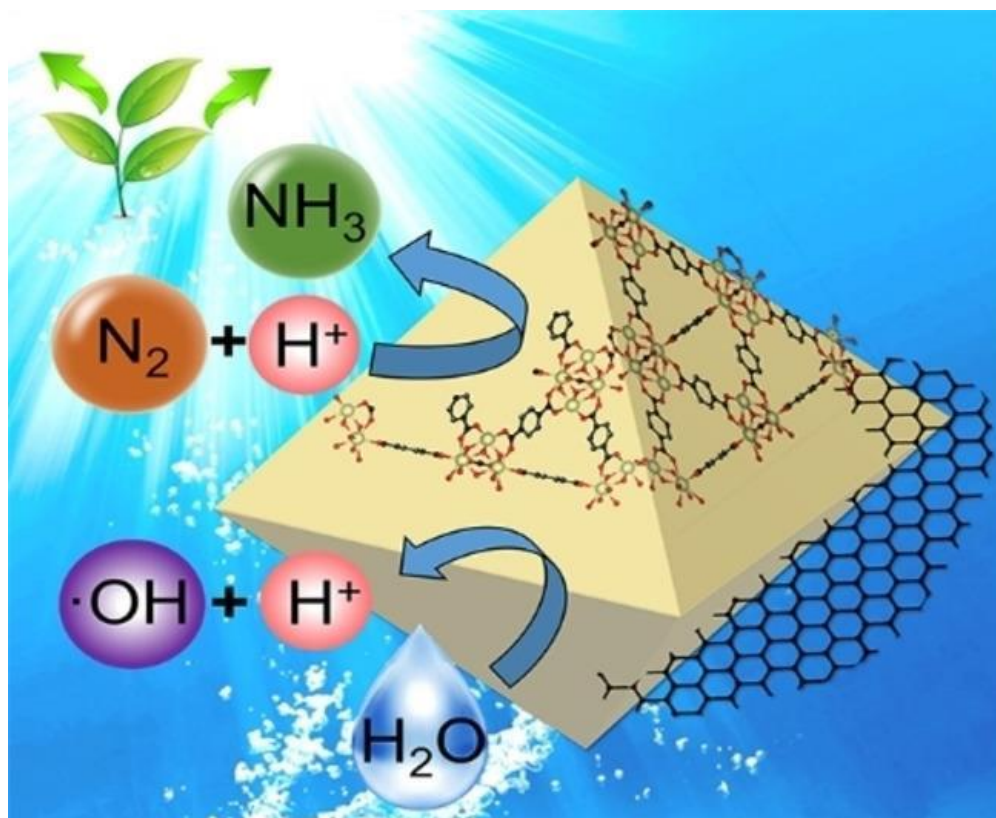
ABSTRACT: An all-fluorinated electrolyte is demonstrated to enable a quasi-solid-phase conversion via controllable nucleophilic reactions to improve the performance of room-temperature sodium–sulfur batteries. The fluorinated ether as anti-solvent further minimizes polysulfides solubility, and simultaneously stabilizes the Na anode. The as-developed batteries achieved high capacity, long lifespan, and enhanced safety.



<https://onlinelibrary.wiley.com/doi/abs/10.1002/anie.202205416>

13. Sixiao Liu, Zhenyuan Teng, Hang Liu, Tianyi Wang, **Guoxiu Wang**, Qiang Xu, Xiuyun Zhang, Min Jiang, Chengyin Wang, Wei Huang, Huan Pang, "A Ce-UiO-66 Metal–Organic Framework-Based Graphene-Embedded Photocatalyst with Controllable Activation for Solar Ammonia Fertilizer Production", **Angewandte Chemie International Edition**, e202207026, 2022. IF= 15.34. DOI: 10.1002/anie.202207026.

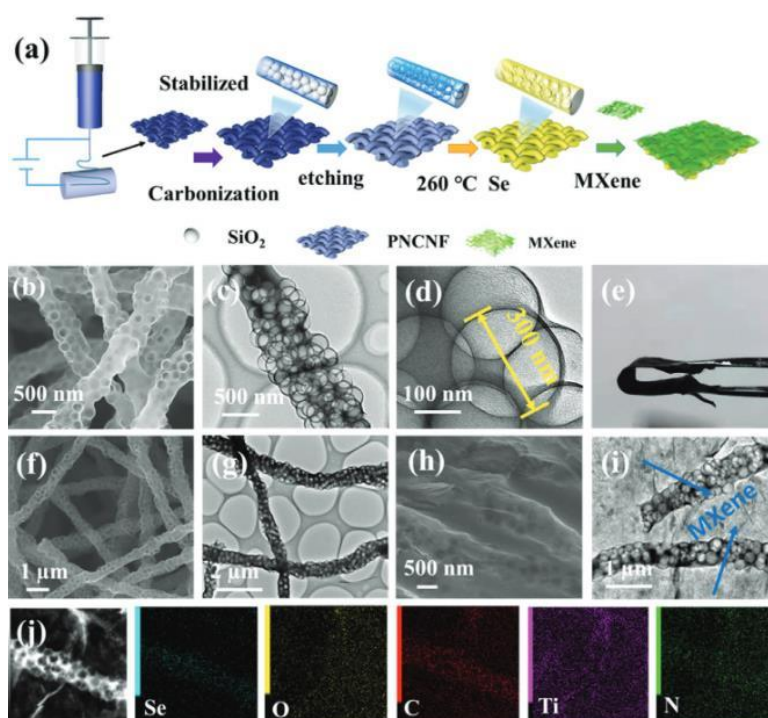
ABSTRACT: Activated graphene-embedded Ce-UiO-66 catalysts showed a remarkable nitrogen fixation apparent quantum efficiency (AQE) of 9.25 % under 365 nm light and high stability as solar nitrogen fertilizer. Ce-UiO-66 is activated by the breakage of benzene-C bonds and forms effective active sites. Graphene embedding controlled bond breakages and improved photocatalytic performance.



<https://onlinelibrary.wiley.com/doi/abs/10.1002/ange.202207026>

14. Jiayi Li, Jianjun Song, Linqi Luo, Hongwei Zhang, Junan Feng, Xiaoxian Zhao, Xin Guo, Hanghang Dong, Shuangqiang Chen, Hao Liu, Guangjie Shao, Thomas. D. Anthopoulos, Yaqiong Su, Fengyun Wang, **Guoxiu Wang***, “Synergy of MXene with Se Infiltrated Porous N-Doped Carbon Nanofibers as Janus Electrodes for High-Performance Sodium/Lithium–Selenium Batteries”, *Advanced Energy Materials*, 2200894, 2022. IF= 29.70. DOI: 10.1002/aenm.202200894.

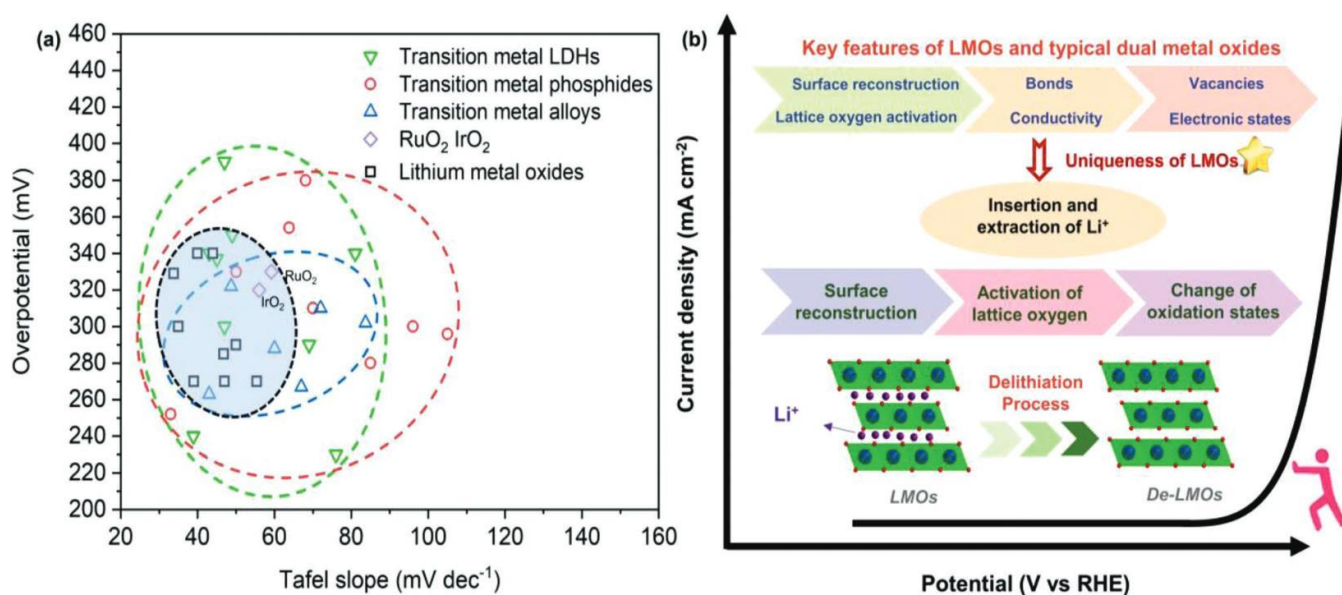
ABSTRACT: Metal–selenium (M–Se) batteries are considered promising candidates for next-generation battery technologies owing to their high energy density and high-rate capability. However, Se cathode suffers from poor cycling performance and low Coulombic efficiency, owing to the shuttle effect of polyselenides. Herein, it is reported the incorporation of $\text{Ti}_3\text{C}_2\text{T}_x$ MXene onto Se infiltrated porous N-doped carbon nanofibers (PNCNFs) to construct free-standing Janus PNCNFs/Se@MXene cathodes for high-performance Na–Se and Li–Se batteries. The increase of pyrrolic-N content and the porous structure of the PNCNFs is conducive to enhancing the adsorption of Na_2Se and alleviating the shuttle effect. Meanwhile, density functional theory (DFT) calculations have proven that 2D $\text{Ti}_3\text{C}_2\text{T}_x$ MXene with polar interfaces enables the effective chemical immobilization and physical blocking of polyselenides to suppress the shuttle effect. The unique architecture with $\text{Ti}_3\text{C}_2\text{T}_x$ MXene built on top of interlinked nanofiber ensures the continuous electron transfer for redox reaction. As a result, the novel Janus PNCNFs/Se@MXene electrodes deliver robust rate capabilities and superior long-term cycling stability in both Na–Se and Li–Se batteries. The incorporation of 2D MXene to construct Janus electrodes provides a competitive advantage for selenium-based cathode materials and highlights a new strategy for developing high-performance batteries.



<https://onlinelibrary.wiley.com/doi/full/10.1002/aenm.202200894>

15. Siqi Jiang, Hongli Suo, Xiaobo Zheng, Teng Zhang, Yaojie Lei, Yun-Xiao Wang, Weihong Lai and **Guoxiu Wang***, "Lightest Metal Leads to Big Change: Lithium-Mediated Metal Oxides for Oxygen Evolution Reaction", *Advanced Energy Materials*, 2201934, 2022. IF= 29.70. DOI: 10.1002/aenm.202201934.

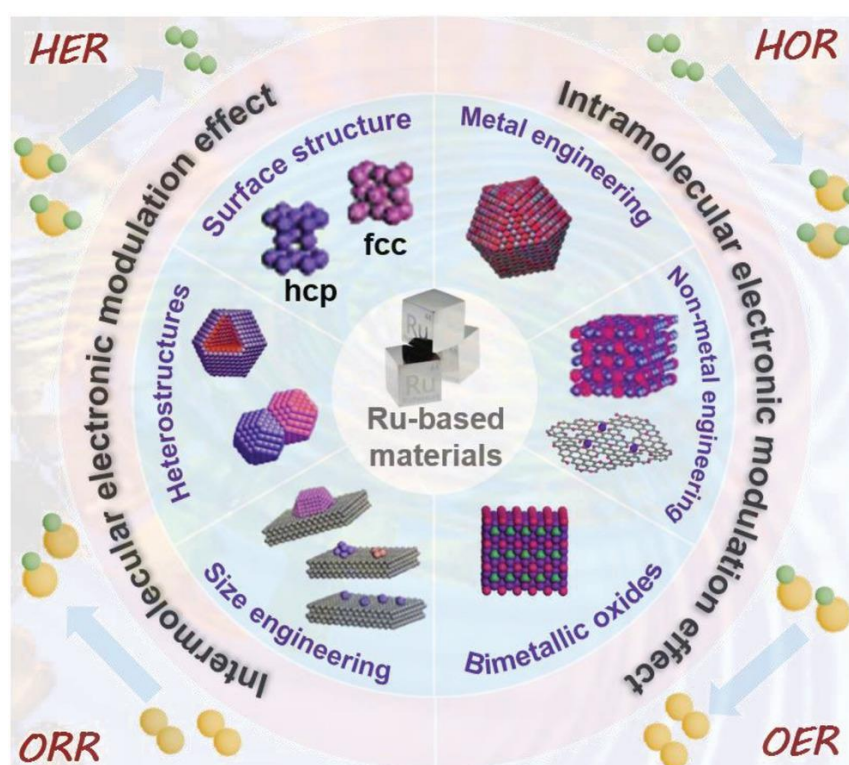
ABSTRACT: As the lightest metal, the reversible insertion/extraction properties of lithium have been key findings in lithium metal oxide chemistry. Lithium has been widely used in the oxygen evolution reaction (OER), and the reaction mechanism of lithium-mediated metal oxides has both similarities and uniqueness compared to typical dual metal oxides. Notably, the insertion/extraction of lithium during the OER is also crucial for the construction of novel surface reconstruction models. This review aims to provide the concepts of general OER pathways and key features of dual metal oxides for the OER. As a comparison then the development of lithium metal oxides for the OER is introduced and the chemistry underlying lithium metal oxide catalysts is unveiled. This review also examines the challenges remaining for the relevant catalysts, with prospects for further improving their OER activities.



<https://onlinelibrary.wiley.com/doi/full/10.1002/aenm.202201934>

16.Xianjun Cao, Juanjuan Huo, Lu Li, Junpeng Qu, Yufei Zhao, Weihua Chen, Chuntai Liu, Hao Liu, and **Guoxiu Wang***, “Recent Advances in Engineered Ru-Based Electrocatalysts for the Hydrogen/Oxygen Conversion Reactions”, **Advanced Energy Materials**, 2022, 119, 2022. IF= 29.70. DOI: 10.1002/aenm.202202119.

ABSTRACT: The application of renewable energy conversion devices is considered as one of the effective ways to alleviate the energy shortage and environmental pollution. Designing electrocatalysts with excellent performance and affordable price is promising to accelerate the reaction process and large-scale application. At present, ruthenium (Ru)-based nanomaterials have shown similar catalytic activity but superior price demand compared to commercial Pt/C. This undoubtedly makes Ru-based nanomaterials a perfect candidate to replace advanced Pt catalysts. Significant progress is made in the rational design of Ru-based electrocatalysts, but an in-depth understanding of the engineering strategies and induced effects is still at an early stage. This review summarizes the modification strategies for enhancing the catalytic activity of Ru, including surface structure, metal element, nonmetal element, size, bimetallic oxides, and heterostructure engineering strategies. Then the induced electronic modulation effects generated by the intramolecular and intermolecular of the Ru-based nanomaterials are elucidated. Further, the application progress of engineered Ru-based nanomaterials for hydrogen and oxygen conversion reactions is highlighted, and the correlations of engineering strategies, catalytic activity, and reaction pathways are elaborated. Finally, challenges and prospects are presented for the future development and practical application of Ru-based nanomaterials.



<https://onlinelibrary.wiley.com/doi/full/10.1002/aenm.202202119>

17. Tianyi Wang, Di He, Hang Yao, Xin Guo, Bing Sun, and **Guoxiu Wang***, “Development of Proteins for High-Performance Energy Storage Devices: Opportunities, Challenges, and Strategies”, *Advanced Energy Materials*, 2202568, 2022. IF= 29.70. DOI: 10.1002/aenm.202202568.

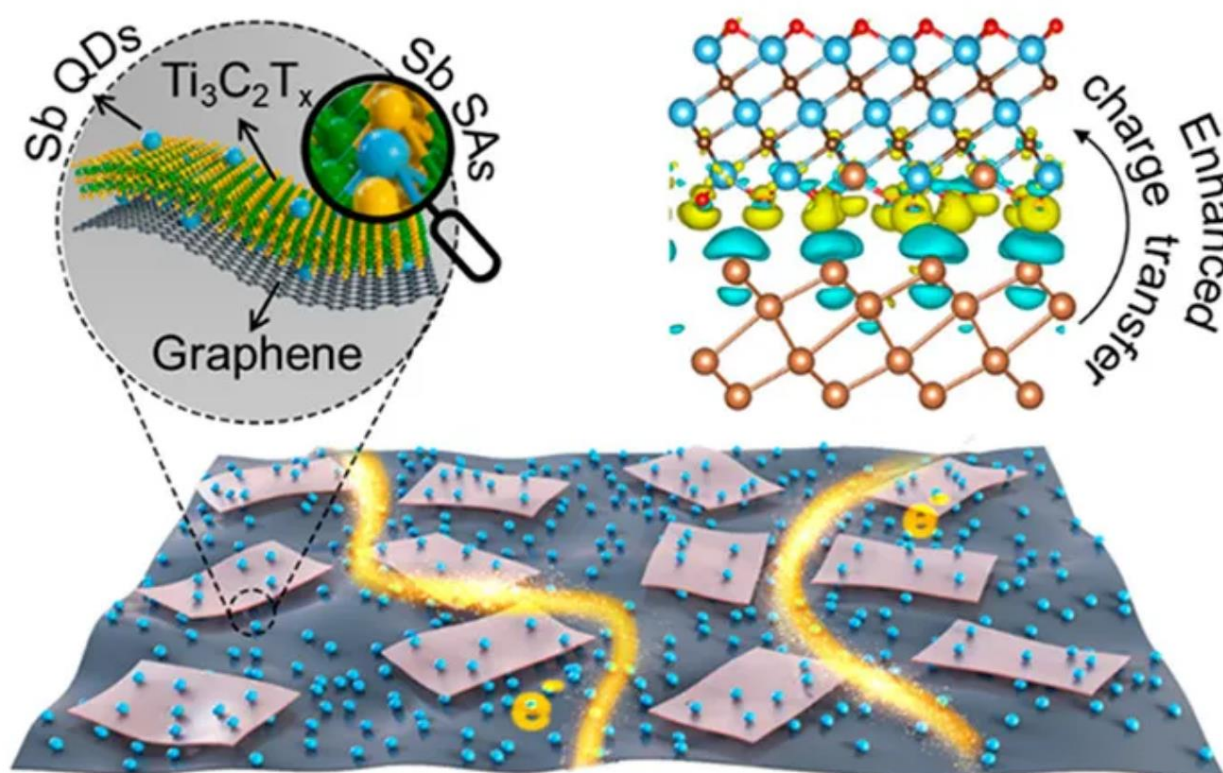
ABSTRACT: In pursuit of reducing environmental impact during battery manufacture, the utilization of nontoxic and renewable materials is essential for building a sustainable future. As one of the most intensively investigated biomaterials, proteins have recently been applied in various high-performance rechargeable batteries. In this review, the opportunities and challenges of using protein-based materials for high-performance energy storage devices are discussed. Recent developments of directly using proteins as active components (e.g., electrolytes, separators, catalysts or binders) in rechargeable batteries are summarized. The advantages and disadvantages of using proteins are compared with the traditional counterparts, and the working mechanisms when using proteins to improve the electrochemical performances of rechargeable batteries are elucidated. Finally, the future development of applying biomaterials to build better batteries is predicted.



<https://onlinelibrary.wiley.com/doi/full/10.1002/aenm.202202568>

18. Xin Guo, Hong Gao, Shijian Wang, Guang Yang, Xiuyun Zhang, Jinqiang Zhang, Hao Liu, **Guoxiu Wang***, “MXene-Based Aerogel Anchored with Antimony Single Atoms and Quantum Dots for High-Performance Potassium-Ion Batteries”, **Nano Letters** 22, 1225–1232, 2022. IF=11.19. DOI: 10.1021/acs.nanolett.1c04389.

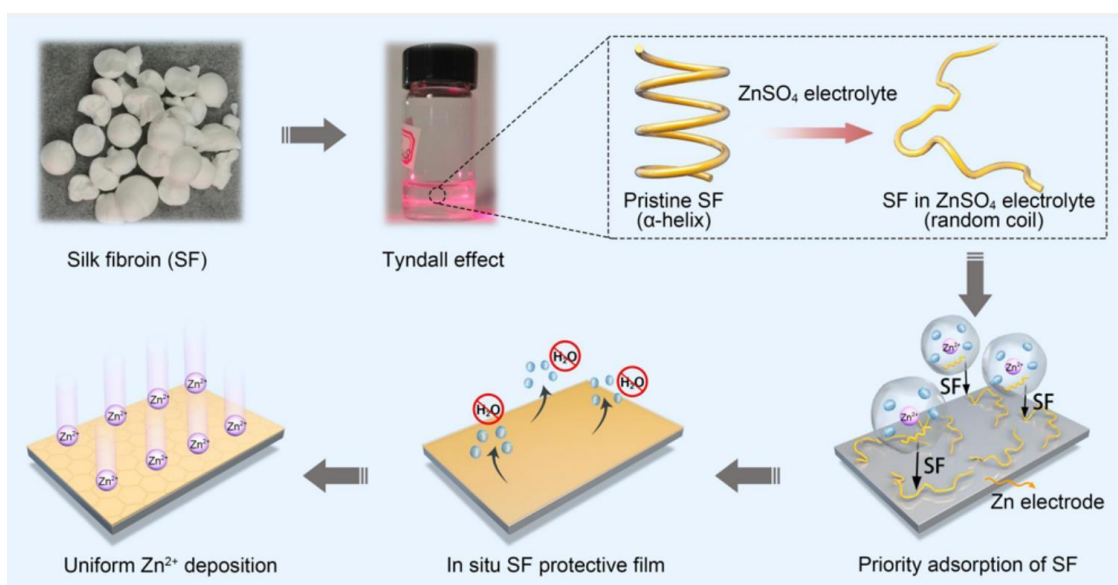
ABSTRACT: Rationally electronic structure engineering of nanocomposite electrodes shows great promise for enhancing the electrochemical performance of rechargeable batteries. Herein, we report antimony single atoms and quantum dots (~ 5 nm) codecorated $\text{Ti}_3\text{C}_2\text{T}_x$ MXene-based aerogels (Sb SQ@MA) for high-performance potassium-ion batteries (PIBs). We found that the atomically dispersed Sb could modify the electronic structure of the Sb/ $\text{Ti}_3\text{C}_2\text{T}_x$ composite, improve the charge transfer kinetics, and enhance the potassium storage capability at the heterointerfaces. Additionally, the MXene-based aerogel with rich surface functional groups and defects provides abundant anchoring sites and endows the composite reinforced structural stability and highly efficient electron transfer. The high loading of Sb (~ 60.3 wt %) with short ionic transport pathways is desired potassium reservoirs. These features synergistically enhance the rate and cycling performance of the Sb SQ@MA electrodes in PIBs. This work has demonstrated an enlightening technique to tailor the interface activity of heterostructured electrodes for electrochemical applications.



<https://pubs.acs.org/doi/abs/10.1021/acs.nanolett.1c04389>

19. Jing Xu*, Wenli Lv, Wang Yang, Yang Jin, Qianzheng Jin, Bin Sun, Zili Zhang, Tianyi Wang, Linfeng Zheng, Xiaolong Shi*, Bing Sun, and **Guoxiu Wang***, “*In Situ* Construction of Protective Films on Zn Metal Anodes via Natural Protein Additives Enabling High-Performance Zinc Ion Batteries”, **ACS Nano** 16, 11392–11404, 2022. IF= 18.03. DOI: 10.1021/acsnano.2c05285.

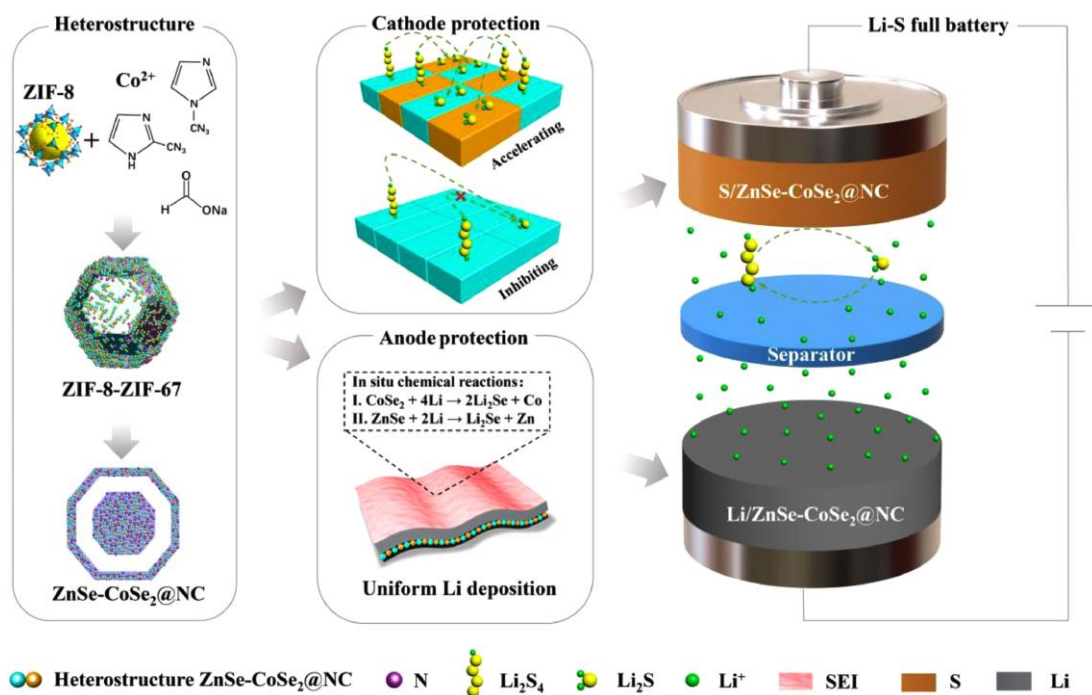
ABSTRACT: The strong activity of water molecules causes a series of parasitic side reactions on Zn anodes in the aqueous electrolytes. Herein, we introduce silk fibroin (SF) as a multifunctional electrolyte additive for aqueous zinc-ion (Zn-ion) batteries. The secondary structure transformation of SF molecules from α -helices to random coils in the aqueous electrolytes allows them to break the hydrogen bond network among free water molecules and participate in Zn^{2+} ion solvation structure. The SF molecules released from the $[\text{Zn}(\text{H}_2\text{O})_4(\text{SF})]^{2+}$ solvation sheath appear to be gradually adsorbed on the surface of Zn anodes and in situ form a hydrostable and self-healable protective film. This SF-based protective film not only shows strong Zn^{2+} ion affinity to promote homogeneous Zn deposition but also has good insulating behavior to suppress parasitic reactions. Benefiting from these multifunctional advantages, the cycle life of the Zn||Zn symmetric cells reaches over 1600 h in SF-containing ZnSO_4 electrolytes. In addition, by adopting a potassium vanadate cathode, the full cell shows excellent cycling stability for 1000 cycles at 3 A g^{-1} . The in-situ construction of a protective film on the Zn anode from natural protein molecules provides an effective strategy to achieve high-performance Zn metal anodes for Zn-ion batteries.



<https://pubs.acs.org/doi/10.1021/acsnano.2c05285>

20. Jing Xu, Liangliang Xu, Zili Zhang, Bin Sun, Yang Jin, Qianzheng Jin, Hao Liu, **Guoxiu Wang***, “Heterostructure ZnSe-CoSe₂ embedded with yolk-shell conductive dodecahedral as Two-in-one hosts for cathode and anode protection of Lithium–Sulfur full batteries”, **Energy Storage Materials** 47, 223-234, 2022. IF=16.28. DOI: 10.1016/j.ensm.2022.02.010.

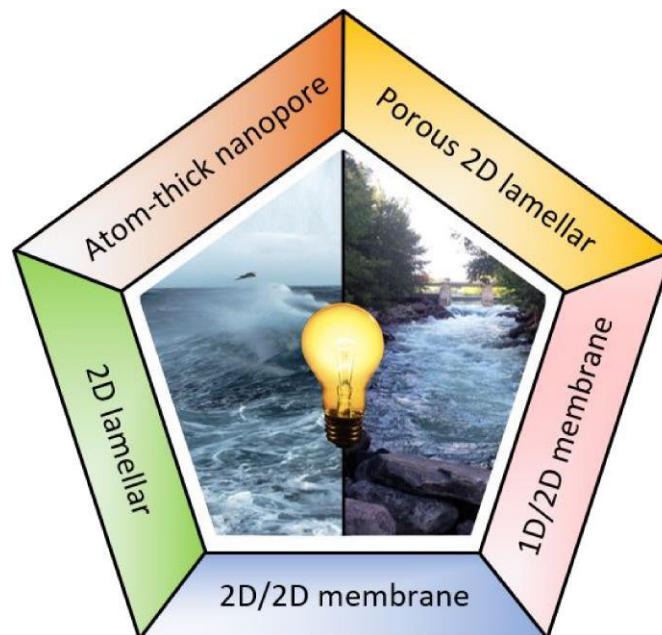
ABSTRACT: Simultaneously realizing the cathode and anode protection is critical for developing practical lithium sulfur (Li-S) batteries. Currently, many efforts have been devoted to solving problems related to either shuttle effect on sulfur cathode or dendrite growth on lithium anode. However, dual side protection is rarely reported. Herein, we rationally designed and synthesized yolk-shell nitrogen doped carbon frameworks embedded with heterostructures ZnSe-CoSe₂ (ZnSe-CoSe₂@NC), working as “two-in-one” hosts for both the sulfur cathode and lithium anode protection. As an anode host, the in situ formed Li₂Se phase contributes to the Li⁺ transfer. Co and Zn guides a homogenous growth of Li within the 3D framework, thus effectively suppressing Li dendrite growth. Meanwhile, the heterostructure ZnSe-CoSe₂ endows the cathode host with superior electronic conductivity, strong polysulfide chemisorption and efficient catalytic activity for polysulfide redox when compared with single metal selenides. Combined with these advantages, this Li-S full cell exhibits ultralong cycle life over 1000 cycles at 2 C. Even with a high sulfur loading (6.08 mg cm⁻²) and lean electrolyte (4.1 μL mg⁻¹), the full cell achieves a high areal capacity of 4.16 mA h cm⁻² after 100 cycles at 0.2 C. This work not only provides a new approach for the structure design of Li-S full battery, but also improves the utilization of active electrode materials.



<https://www.sciencedirect.com/science/article/pii/S2405829722000800>

21. Javad Safaei, **Guoxiu Wang***, “Progress and prospects of two-dimensional materials for membrane-based osmotic power generation”, **Nano Research Energy** 1, e9120008, 2022. DOI: 10.26599/NRE.2022.9120008.

ABSTRACT: The electrical energy that can be harnessed from the salinity difference across the sea water and river water interface can be one of the sustainable and clean energy resources of the future. This energy can be harnessed via the nanofluidic channels that selectively permeate ions. The selective diffusion of cations and anions can produce electricity through reverse electrodialysis. Two-dimensional (2D) materials are a class of nanomaterials that hold great promise in this field. Several breakthrough works have been previously published which demonstrate the high electrical power densities of 2D membranes. The ion transportation can be either through the nano-sized in-plane pores or interlayer spacings of 2D materials. This review article highlights the progress in 2D materials for salinity gradient power generation. Several types of 2D membranes with various nano-architectures are discussed in this review article. These include atom-thick 2D membranes with nanopores, 2D lamellar membranes, 2D lamellar membranes with nanopores, 2D/one-dimensional (1D), and 2D/2D hybrid membranes. The fabrication techniques, physical characteristics, ion transportation properties, and the osmotic power generation of these 2D membranes are elaborated in this review article. Finally, we overview the future research direction in this area. It is envisioned that the research on 2D materials can make practical salinity gradient power generation one step closer to reality.



<https://www.sciopen.com/article/10.26599/NRE.2022.9120008>