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Editorial

Editorial for the special issue “Energy Material Chemistry”

Electrochemical storage energy has been considered as the potential alternative for the fossil fuels. The systems for electrochemical storage energy include secondary batteries, fuel cells and so on. Although they have different energy storage and conversion mechanisms, they share some common features, such as electrode/electrolyte interface and ion/electron transport. Moreover, the electrocatalysis also shows the gigantic prospect and meaning considering the serious fossil fuel consumption causes the issues of environments and energy lack. In the past few years, global researchers have done the extensive and intensive studies on enhancing the electrochemical performance and activity.

The themed issue entitled “Energy Material Chemistry” includes 9 carefully selected short communication, reviews, and original research articles that address the most recent developments in metal ion batteries, electrocatalysis and photoelectronic analysis involving the electrode material syntheses, electrocatalyst design, structure characterization, electrochemical storage performance, electrocatalytical activity and the related mechanism.

Due to the capacity limitation of lithium ion batteries (LIBs) caused by traditional graphite as anode, more advanced electrode materials and techniques should be developed to improve the lithium storage. Lian from Jiangsu University applied the in-situ partial phase conversion of Nb_2O_5 to form a monoclinic/orthorhombic (H/T-Nb_2O_5) heterophase homojunction. The unique heterophase interface is demonstrated to play a crucial role in regulating the local electronic environment, resulting in charge redistribution, formation of an internal electric field, and enhanced electron transfer. Moreover, the abundant phase interfaces offer additional reactive sites for Li^+ ion adsorption, thereby enhancing reaction dynamics. Hence, the synergistic effects within the H/T-Nb_2O_5 homojunction render high Li^+ storage capacity (413 mAh g^{-1} at 100 mA g^{-1}), superior rate capability, and cycling stability. Growing energy demands, coupled with safety issues and the limited energy density of LIBs, have catalyzed the transition to all-solid-state lithium batteries (ASSLBs) with higher energy densities and safety. Liang from National Power Battery Innovation Center summarized the recent advances in designing and synthesizing artificial solid-electrolyte interphases for ASSLBs to solve interfacial issues, covering three main preparation methods and their technical routes. Moreover, advanced ex-situ characterization techniques for artificial SEIs are comprehensively summarized. This review provides perspectives on techniques for the interface engineering of artificial SEIs for ASSLBs, with focus on promising methods for industrial applications. While technological innovations in electrode materials and battery performance have been pursued, the environmental threats and resource wastage posed by the resulting surge in used batteries have been overlooked. Wang from University of Wollongong summarizes the pretreatment, pyrometallurgical, and hydrometallurgical processes and technologies, analyzes their applicability and environmental friendliness using industrial examples, highlights their technical shortcomings and problems, and emphasizes the bright future of battery recycling. The review also points out that the recycling process of solid-state batteries (SSB) is different, which requires detailed classification according to various configurations of SSB followed by mechanical crushing, and then further processing by pyrometallurgy or hydrometallurgy based on actual circumstances, which brings challenges to the established battery-recycling enterprise and limitations on flexibility.

More other sophisticated secondary battery techniques should be further exploited to compensate the shortcomings of LIBs. Sodium ion batteries (SIBs) have the similar operation mechanism and receive a broad interests in terms of their available applications from research community. Li from Khalifa University of Science and Technology prepared a self-assembled heterogeneous structure consisting of TiO_2 nanosheets and reduced graphene oxide. The restacking of porous TiO_2 nanosheets and reduced graphene oxide within the heterostructure favors high porosity and excellent conductivity. Benefiting from enhanced electron and Na^+ transfer, as well as improved structural stability, this heterogeneous structure exhibited exceptional Na^+ storage performance, specifically including a long-term cycling stability (217 mAh g^{-1} at 10 C, 5000 cycles) and an ultrahigh rate capability (135 mAh g^{-1}, 40 C). Aqueous Zn-ion batteries (AZIBs) are anther new secondary batteries owing to their characteristics of high safety, high theoretical specific capacity (5851 mA g^{-1}), convenient assembly, and high crustal abundance of Zn. Xiong from Shandong University synthesized VO_2 doped with Ce ions by a simple one-step hydrothermal method and oxygen vacancies are synchronously generated during synthesis. Ce doping changed the local electronic structure of VO_2 and further improved its conductivity. Therefore, as the cathode material for AZIBs, it delivers a capacity of 158.5 mAh g^{-1} at 5 A g^{-1} after 1000 cycles and exhibits an excellent energy density of 312.8 Wh kg^{-1}. The structural modification and prospect of enhancing its conductivity by doping with rare-earth metals and introducing oxygen vacancies may aid in improving the stability of AZIBs in the future.

The utilization of renewable energy sources and efficient energy conversion are pivotal in addressing the present energy issues. For the electrochemical catalysis technology, CO_2 can be electrically converted into high-value chemicals. Zhang from Shandong University developed a rapid thermal shock method, Joule heating, to load various metal nanoparticles onto carbon supports. Compared to conventional pyrolysis processes, Joule heating enables rapid heating within a short period, effectively preventing the migration and aggregation of metal atoms. When used as electrocatalysts for electrocatalytic CO_2 reduc-

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tion, bismuth-, indium-, and tin/carbon-carrier-based catalysts exhibit excellent Faraday efficiencies of 92.8%, 86.4%, and 73.3%, respectively, for formate generation in flow cells. Fuel cells have long been developed as an ideal solution for future vehicles but their practical performance is severely restricted by the sluggish cathodic oxygen reduction reaction (ORR). Zhang from Qingdao University and Yuan from Zhejiang University used a direct epitaxial growth strategy to prepare a heterostructure of Pd nanocrystals (PdNCs) on N-doped Ag nanowires (NWs). The PdAg bimetallic heterostructure showed the highest mass activity among reported PdAg-based ORR electrocatalysts and exhibited excellent stability, with only a 1.5 mV decay in the half-wave potential even after 20000 cycles of continuous testing. Hydrogen preparation by electrolytic water has become a potential green energy source because of its high conversion efficiency and environmental compatibility. However, sluggish kinetics (especially the oxygen evolution reaction (OER) involving a four-electron process), bottleneck water electrolysis. Wang from Qingdao University and Changzhou University prepared Fe-doped $Ni_{0.85}Se$ nanoparticles anchored on NF ($FeNi_{0.85}Se$/NF). The addition of iron altered the coordination environment of the nickel species along with the catalyst's morphology, creating additional active sites. Notably, the synergistic interaction between the bimetallic components augmented the built-in activity and accelerated reaction kinetics. $FeNi_{0.85}Se$/NF electrocatalysts demonstrated remarkable catalytic activity for OER, with an acceptable overpotential of 276 mV and a Tafel slope of 58.1 mV dec^{-1} at 100 mA cm^{-2}. Surface-enhanced Raman spectroscopy (SERS) is a commonly used analytical technique in chemistry, and medical science because of its nondestructive nature, rapid analysis capabilities, and high sensitivity. Xi from Chinese Academy of Inspection and Quarantine synthesized ultrathin C_{60} nanosheets with two-dimensional structures using chemical vapor deposition and used as SERS substrates. Owing to the combined effects of the expanded specific surface area and matched interfacial charge transport paths, the substrate has a minimum detection limit of 10^{-11} for rhodamine 6G and a Raman enhancement factor of 107. In addition, the C_{60} nanosheets exhibited good stability and uniformity as SERS substrates.

This special issue is targeted to encompass the recent achievements in the field of energy storage materials and techniques, including LIBs, SIBs, AZIBs, electrocatalysis and so on. We hope to give a broad perspective for large readers to learn about the state-of-the-art research developments in energy storage materials and techniques, and acquire their future potential and challenges. Finally, the guest editors would like to thank all the authors, and reviewers for their great efforts and enthusiastic contributions to this themed issue.

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