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Editorial

Advanced Materials for Electrocatalysis and Energy Storage

Qinglin Deng

School of Physics and Materials Science, Guangzhou University, Guangzhou 510006, China; qldeng@gzhu.edu.cn

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Energy problems restrict the sustainable development of human society. New energy sources are urgently needed to replace traditional nonrenewable fossil energy sources. Hydrogen is a highly efficient and green energy, showing huge prospects for applications. Solar energy, wind energy, tidal energy, and geothermal energy are affected by geographical conditions with the characteristics of locality, randomness, regionality, and intermittency, which lead to their limited use. An effective strategy is to develop high-efficiency energy storage and conversion devices to collect and use these scattered energy sources. In addition, the increasing popularity of electronic products and new energy vehicles has put forward higher requirements for energy storage batteries.

In view of these hotspots, we propose this Special Issue titled "Advanced Materials for Electrocatalysis and Energy Storage", designed to bring together researchers to address these issues. The main objective of this Special Issue is to publish relevant scientific papers. Original research articles, reviews, and communications are welcome. This Special Issue will focus on the fundamentals and application areas of advanced materials for electrocatalysis and energy storage, including lithium/sodium/potassium ion batteries, aqueous zinc ion batteries, electrochemical capacitors, electrocatalysis materials and applications, etc.

Lithium-ion batteries (LIBs) are the typical representatives of energy-storage devices and have been extensively studied. Nonetheless, there are still many other topics that urgently require research. Developing high-performance cathode and anode materials is still an important research direction, especially for practical commercial applications [1]. Although great progress has been achieved, there are many research hotspots worthy of our attention, including safety issues associated with lithium dendrite growth, theoretical calculations and predictions, micrometer-dimensional electrodes, self-supported electrodes without additives, electrodes with high mass loading, Li-metal anodes, silicon anodes, high rate performance, effects in high- and low-temperature environments, battery recycling, etc.

Sodium-ion batteries (SIBs) and potassium-ion batteries (PIBs) are already frontier hotspots and development directions in the field of energy storage batteries, which will make up for the shortage of lithium resources in LIBs [2,3]. They show great potential for applications in smart grids and large-scale energy storage systems. SIBs and PIBs have a similar working mechanism to LIBs. Therefore, the problems faced by LIBs are also faced by SIBs and PIBs. Research on cathode materials have mainly focus on layered oxides, polyanionic compounds, and Prussian blue compounds. The anode materials can mainly be classified into three types by the Na/K-storage mechanisms: alloy-type, conversion-type, and intercalation-type. Developing novel and high-performance active materials is one of the most important research directions for SIBs and PIBs. The current research hotspots and directions mainly include the following aspects: structural regulation, morphology optimization, doping modification, carbon coating, synergistic effect, pseudocapacitive effect, theoretical calculation, mechanism exploration, etc.

Supercapacitors (SCs) and batteries each have their respective advantages and disadvantages. SCs have high power density but low energy density, and batteries such as LIBs have the reverse properties. Most SCs work based on aqueous electrolytes; however, their working voltage is limited to the potential of water decomposition. Thus, nonaqueous hybrid supercapacitors (HSCs), with a larger operation window, and which combine the superiority of batteries and SCs, are attracting increasing attention [4]. Activated carbon electrodes have been widely used as cathodes. An important research direction is to develop suitable high-performance battery-type anodes to match the cathode, so as to obtain higher energy density and power density with an outstanding Ragone plot.

Aqueous zinc-ion batteries have the advantages of high energy density, low cost, and high safety, making them promising energy-storage devices. Vanadium oxides, manganese oxides, Prussian blue analogs, and organic electrode materials have become the most widely studied cathode materials in recent years, which will also be the focus of future research. At present, the core problems of zinc-ion batteries are the growth in zinc dendrites and the occurrence of side reactions, which seriously restrict their application development [5]. A major research priority in the future is still zinc protection. In this regard, there are many effective solutions, including the structural design of zinc electrodes, the construction of functional interface layers, and the optimization of electrolyte composition and concentration, all of which can control the dissolution/deposition process of Zn ions, inhibiting the formation of Zn dendrites and improving the Coulombic efficiency [6]. Other types of batteries, such as lithium-sulfur batteries, fuel cells, and solid-state batteries, are also the focuses of this Special Issue.

Electrocatalysis aims to accelerate the reaction by charge transfer at the interface of the electrode and the electrolyte, which involves a redox process. It plays a critical role in energy conversion and storage and low carbon emission, accompanying many important application areas such as oxygen evolution reaction (OER) [7], hydrogen evolution reaction (HER) [8], and carbon dioxide reduction [9]. There are many factors that control the catalytic activity, such as the specific surface area of the active materials, band structure, electronic properties, crystalline phase, and so on. Insufficient activity, poor selectivity, and poor stability of electrocatalysis are the core obstacles for its industrial application. Exploring new electrocatalysts, modifying the activity of existing catalysts, reducing the use of expensive noble metals, studying the synergistic effects, and developing high-temperature and ultra-high-temperature electrocatalysis technologies will be the crucial directions of future research.

We hope that this Special Issue can inspire our readers to achieve more important research findings in the fields of advanced materials for electrocatalysis and energy storage. All published papers will play a positive role in promoting future research. This Special Issue gives us the opportunity to exchange our views and research progress in electrocatalysis and energy storage. Finally, as guest editors, we would like to express our thanks to the contributors of this Special Issue, as well as the readers, editors, and reviewers, for your attention, effort, and feedback.

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