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Editorial: Interface and structure designs of electrode materials for advanced electrochemical energy storage

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Editorial on the Research Topic
Interface and structure designs of electrode materials for advanced electrochemical energy storage

The increasing demand for mobile power supplies in electric vehicles has motivated intense research efforts into developing high-performance electrochemical energy storage (EES) devices. However, current EES technologies do not meet the requirements for various applications of improved performance and safety and reduced cost and environmental footprint. Advanced materials, including active anode and cathode materials, inactive carbon and binding additives, metal current collectors, separators, and electrolytes, play essential roles in supporting battery operations. Particularly, the interface engineering of distinct phases or components in composite electrodes and electrolytes, as well as the hierarchical structure design for each component or multi-component device, can address many fundamental Research Topic associated with the charge transport kinetics, electrochemical characteristics, and chemical/physical/mechanical properties. Therefore, it is possible to improve the energy storage performance, reliability, and safety by investigating the interface and structure.

This Research Topic aims to highlight recent progress and advances in interface, material, and structure designs for electrochemical energy storage. It focuses on studying and understanding the interface properties, electrode and electrolyte materials, and hierarchical structure designs for electrochemical energy storage devices, including lithium-ion batteries, lithium metal batteries, all-solid-state batteries, sodium-ion batteries, multivalent batteries, water-based batteries, flow batteries, supercapacitors, hybrid energy storages, and other innovative systems. Two papers in this Research Topic highlight achievements in potassium-ion batteries, covering novel approaches to fabricate high-performance anode materials. Two papers report recent progress in lithium-sulfur batteries, focusing on quasi/all-solid-state electrolytes and porous carbon nanofiber electrodes.

Xiao et al. developed hierarchically porous carbon nanofibers (HPCNFs) as a freestanding sulfur host *via* an electrospinning process. The interconnected porous structure can offer fast electron and ion transport pathways, the mesopores can provide a high level of sulfur loading (76.4 wt%), and the micropores can inhibit the shuttle effects of the sulfur cathode during the discharge/charge process. As a result, the HPCNF electrode delivered a high specific discharge capacity of 787 $mAhg^{-1}$ for over 150 cycles.

Yang et al. reviewed recent progress on solid-state electrolytes to address many critical challenges for lithium-sulfur batteries, such as large volume change of sulfur cathodes, shuttle effects of polysulfides, and the lithium dendrite Research Topic. This review paper summarized various solid-state electrolytes, including polymer electrolytes, inorganic solid electrolytes, and hybrid electrolytes. This work highlighted the future perspective for lithium–sulfur solid-state batteries and major challenges in full-lifespan management, including materials, synthesis, manufacturing of batteries, operation process, and recycling.

For batteries other than lithium-ion, potassium-ion batteries (PIBs) have received increasing research interest because of their natural abundance and low cost. Liu et al. reported a new flour-derived porous phosphorus-doped carbon (PPDC) strategy as an anode for high-performance potassium-ion batteries. This work demonstrated a PPDC anode with a hierarchically porous structure and rich P-doping, which offers fast transport of K^+ and electrons for long cycling performance and provides sufficient inner space to buffer large volume changes of active electrode materials. Thus, the as-prepared PPDC anode enables high reversible capacity, excellent cyclic stability, and enhanced rate performance. Xiao et al. reviewed the recent progress and perspective of electrospun carbon nanofibers-based binder-free anodes for high-performance PIBs due to their good conductivity, large surface areas, and structural stability. This mini-review summarized the effects of porous structure, doping heteroatoms, and composite designs on the specific surface area, conductivity, lattice distance, potassium storage performance, and industrial application of electrospun carbon nanofiber electrodes for potassium ion storage.

In conclusion, the investigations on the interfaces and structure designs of the advanced electrode and electrolyte materials facilitate the development of various energy storage technologies. In addition to materials synthesized at the laboratory scale, the scale-up manufacturing processes and recycling of battery electrodes, electrolytes, and devices are urgently needed in the battery community for future research and development that can move one step further toward practical applications.

Author contributions

HS, JL, and JZ wrote the manuscript.

Conflict of interest

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