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Editorial

High-Performance Metal–Chalcogen Batteries

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The rapid proliferation in the market for smart devices, electric vehicles, and power grids over the past decade has substantially increased the demand for commercial lithium-ion batteries (LIBs) [1]. However, the development of next-generation secondary batteries has become increasingly urgent due to the high cost and potential geopolitical resource issues of lithium, low capacity, and safety concerns [2].

Metal–chalcogen batteries (MCBs, where M = Li, Na, K, Mg, Ca, Zn, Al, etc.; C = S, Se, and Te) have attracted considerable attention because of their affordability, environment friendliness, and the high theoretical capacities of chalcogen cathodes, as well as the high theoretical capacities of metal anodes [3,4]. Different from the ion-insertion electrochemistry of LIBs, MCBs realize high specific capacities based on reversible redox reactions between chalcogen elements and metal ions [5]. Therefore, high-performance MCBs with chalcogen as the cathode and a metal as the anode have wide-ranging application prospects. According to the different types of electrolytes, MCBs can be divided into organic electrolyte-based systems and aqueous electrolyte-based systems.

For organic electrolyte-based systems, MCBs achieve much higher capacity than LIBs through multistep redox reactions. However, these multistep reactions are complex multiphase and multielectron reactions, accompanied by the formation of a series of electrolyte-soluble intermediate products (polysulfides, polyselenides, and polytellurides) on the cathode side [6]. Such reaction mechanisms trigger the infamous shuttle effect, resulting in capacity attenuation, low rate performance, and low Coulombic efficiency (CE) [7]. The volume changes of chalcogen cathodes during the charging and discharging process result in the proliferation of structure destruction of the cathodes, which seriously affects the battery performance [8]. On the anode side, severe dendrite issues caused by uneven deposition of metal ions may result in short circuits and thermal runaway [9]. Moreover, safety hazards remain due to the toxicity and flammability of organic electrolytes. In the previous decades, tremendous efforts have been attempted to resolve the above problems, but there is still a considerable way to go before the commercialization of MCBs.

For aqueous electrolyte-based systems, MCBs address safety concerns because they employ water-based electrolytes that are flame-retardant, nontoxic, inexpensive, and highly ion-conductive [10]. Therefore, aqueous MCBs possess greater application potential in wearable electronics and large-scale power storage that require higher safety. Most aqueous MCBs are based on solid–solid conversion reaction mechanisms, in which the charge/discharge products are insoluble in aqueous electrolytes, thus suppressing the shuttle effect caused by soluble intermediates in organic electrolytes [11]. However, the solid–solid conversion mechanisms in aqueous electrolytes slow the kinetics of the redox reactions. In addition, the disproportionation reactions and volume changes of chalcogen cathodes during the charging and discharging process also affect the battery performance [12]. On the anode side, the hydrogen evolution, corrosion, passivation, and dendrite growth may lead to further deteriorated electrochemical performance [13]. In the past decade, several efforts have been made to address these challenging problems. It is worth noting that the research on aqueous MCBs is still in the initial stage compared with the organic systems, so further comprehensive and in-depth research on aqueous systems is required.

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This Special Issue, entitled "High-Performance Metal-Chalcogen Batteries", has in view to present the current status of MCBs, propose strategies to solve the aforementioned problems, explore the internal mechanism of ameliorating the performance of MCBs, and ultimately provide a direction to guide the further application and development of MCBs. Potential topics include, but are not limited to:

- High-performance metal-chalcogen batteries;
- Chalcogen cathodes;
- Metal anodes;
- Electrolytes;
- Separators;
- New materials;
- Advanced characterizations;
- Machine learning;
- Theoretical calculations;
- Mechanism studies;
- Full batteries.

This Special Issue invites original research articles, review articles, as well as short communications on the research of MCBs. We firmly believe that the findings of this Special Issue will greatly contribute to providing comprehensive guidelines for researchers and promote the development of MCBs.

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