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Editorial: Advanced micro/nano materials for electrochemical energy conversion and application

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Editorial on the Research Topic
Advanced micro/nano materials for electrochemical energy conversion and application

Energy crises are serious threats to the survival and development of mankind and global organisms. Scientists are committed to developing new sustainable energy utilization. There is a huge amount of renewable energy in nature, including solar energy, geothermal energy, wind energy, tidal energy, bioenergy, and so on. How to transform and store these natural energies is the key to their wide industrial application, which is also an effective way to alleviate the energy crisis. In view of the rapidly rising global energy demand, efficient using these sustainable energies already become a global concern, and electrochemical energy technologies have become the research hotspots within the last 10 years. As the core of electrochemical energy technologies, materials with different microscopic chemical molecular structure and the physical micro/nano structure have received tremendous interest due to their unique mechanical/electrical and interfacial properties, which are the keys to realize the efficient and effective energy conversion and storage.

From the microscopic design of molecular structure to the specific properties of micro/nano materials, researchers have continually demonstrated the manipulation of macroscopic material properties by controlling the microstructure. However, the existing electrochemical energy conversion systems still have various problems limiting their energy utilization, for example, low efficiency, inferior thermal stability, service life and safety. It is of great significance to develop new micro/nano materials for various electrochemical energy conversion and applications, and solve their inherent defects and problems so as to improve energy crises and environmental problems. This topical issue is a collection of articles that explore the diverse micro/nano materials in the application of efficient energy storage and conversion. Authors from China, the United States, Poland contributed to the collected publications, including two original research articles, one brief research report and one opinion article, which are summarized below:

As a matter of fact, lithium-ion batteries have already realized wide applications in the mobile world from portable electronics to electric vehicles. To meet the demand of high-capacity lithium-ion batteries, it is necessary to develop advanced anode materials with high theoretical capacity. Zeng et al. proposed a Si/Cu composite anode by mixing the micro-scale powder of Cu-Zn alloy, Si and Al-Si *via* a facile solid mechanosynthesis method and wet chemical etching (at HCl solution). Two types of Si/Cu composite (Si/Cu respectively from pure Si and $Al_{80}Si_{20}$) with core-shell structure were synthesized and compared, which delivered specific capacity/retention rate of 608 $mAhg^{-1}$/66.4% and 707 $mAhg^{-1}$/81.1% after 200 cycles, respectively. The high cycling stability of Si/Cu composite (added super P carbon) is believed to be the homogeneity of the composition and small Si size.

Two-dimensional (2D) materials and their based materials also have been proposed as promising candidates of electrode materials in lithium-ion battery due to their unique surface area, pore structure, surface morphology, chemical composition and electrical properties. Wenelska et al. 2022) prepared a three-dimensional (3D) MoS_2/graphene anode material for lithium-ion batteries through a facile and highly reproducible route. In which, the graphene oxide flakes served as the building blocks and the internal cross-linkage of nano-scale spherical MoS_2 sheets and graphene oxide are benefit to prevent their aggregation and ensure structural stability. The resultant GO/MoS_2 electrodes exhibited the large initial charge capacity of 783 $mAhg^{-1}$ at current density of 100 mA/g and Coulombic efficiency of more than 96% from the second cycle on exceeding theoretical capacity of the pristine 2D MoS_2 and graphene.

Thermal energy is widely existing in nature and industrial production. It is considered an available way to reduce energy consumption by converting thermal energy into electric energy through thermoelectric energy conversion technology. Thermogalvanic cells based on redox reactions are not only noise-free and environmentally friendly, but also enable continuous conversion of low-grade heat to electricity, which has made significant progress in recent years. Meng and Gao summarized the latest progress of thermogalvanic cells from their working mechanism and strategies for improving performance, and discussed the potentials and challenges of thermogalvanic cells in further applications. The temperature-dependent redox reaction caused by the temperature gradient between two electrodes is the mechanism of thermoelectric cells. The thermoelectric performance is closely related to the electrolyte (liquid-state, quasi-solid, or solid-state) and electrode materials (metal, carbon or conducting polymer).

Metal-organic frameworks (MOFs), which are the micro/nano materials made by linking inorganic and organic units *via* some strong bonds, possessing ultrahigh porosity (up to 90% free volume) and enormous internal surface areas, have received great interest for potential applications in clean energy and high-capacity adsorbents. This Research Topic also addressed the utilization of MOFs in photocatalysis. Yang et al. synthesized the Ag doped ZnO by using the zinc-based metal-organic framework (MIL-125(Zn)) as precursor *via* absorption and pyrolysis processes. By exploring the photocatalytic activity in degradating of rhodamine (RhB) under UV light irradiation, the authors proved that doped Ag nanoparticles on MIL-125(Zn)-derived ZnO can broaden the UV light absorption ability to the visible light region and can improve the degradation efficiency of RhB, which can be attributed to the synergistic effect of nano-scale Ag particles and ZnO. This result also prove that MOFs have potential application prospects in photocatalyst and will provide experience for other researchers in this field. In summary, this Research Topic showcased the micro/nano materials in efficient energy storage and conversion. With the advent of the electromechanical era (especially new energy vehicles) and the decarbonization of the economy, we believe that in the next decade, significant progress will be made in electrochemical energy conversion materials and technologies.

Author contributions

F. Zhang and F. Zhao drafted and revised the editorial. All authors provided constructive feedback.

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