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Editorial: Micro/nano materials for energy storage and conversion

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Editorial on the Research Topic

Micro/nano materials for energy storage and conversion

The demand for energy is increasing dramatically at an alarming rate, resulting from rapid economic development and the ever-increasing requirements of energy-based appliances. With energy usage increasing, concerns about environmental Research Topic and the social problems associated with the consumption of conventional fossil fuels are becoming serious (Yu D. et al., 2014; Fang R. et al., 2017). As a cutting-edge approach, nanotechnology has opened new frontiers in the field of materials science and engineering to meet the challenge by designing novel materials, especially micronanometer, subnano, and even atomic scale materials, for efficient energy storage and conversion. Recently, the applications of micro/nano materials in energy storage and conversion fields, including lithium batteries, metal-ion batteries, water splitting, photocatalytic reactions, and electrochemical catalysis, have been widely investigated (Dai L. et al., 2015; Hao J. et al., 2020; Zhang S. et al., 2022). However, the practical application of micro/nano materials is still far from being satisfactory, as it is mainly impeded by costs and efficiency. Therefore, the design of cost-saving and highly efficient micro/nano materials in the field of energy storage and conversion is still very significant. Numerous papers have been reported in this Research Topic, and herein we introduce the representative advances in the collected papers that discuss how micro/nano materials work in the area of energy conversion and storage.

Currently, the highest energy density of lithium-ion batteries (LIBs) is approaching its limitation but is still unable to satisfy the growing requirements of electric vehicles. Furthermore, the high cost and safety Research Topic severely limit their large-scale practical application for renewable energy storage systems. It is urgent to develop an innovative and highly efficient battery system to meet the ever-increasing demands for energy. Cao et al. reported one electrospinning approach to synthesize a novel nanocompound, namely, the FeS₂ nanoparticles encapsulated in S/N co-doped three-dimensional multi-channel structural carbon nanofibers (FeS₂@CNFs). The FeS₂@CNFs electrode exhibited an excellent rate property and cyclic stability as cathode materials for LIBs. The electrode also showed a high initial capacity of 1,336.7 mAh g⁻¹,

and it still had a capacity of 856.5 mAh g⁻¹ remaining at 0.02 A g⁻¹ after 100 cycling tests. Li et al. fabricated a new ZnO@CZIF-8 nanocompound comprising the hierarchical ZnO nanospheres coated with inherently derived ZIF-8 porous carbon shells, which could provide sufficient active sites, facilitate rapid electronic migration, and effectively restrain the volume expansion of electrode materials. Finally, the ZnO@CZIF-8 nanospheres electrode exhibited a high capacity of 316 mAh g⁻¹ at a current density of 1 A g⁻¹ after 50 cycles and a satisfactory rate capacity used as the anode material for the Ni-Zn secondary battery using a commercial Ni(OH)₂ cathode. Iron–chromium redox flow batteries (ICRFBs) possessed the advantages of long cycling performance, flexible design, and high safety, as well as affordable maintenance costs. Su et al. reported one method to prepare an indium ions composite electrode by introducing the indium ions into graphite felt surfaces, which exhibited dramatically enhanced electrochemical properties after In³⁺ modification.

It is worth noting that the aqueous metal-ion batteries with high safety and economical costs show promising opportunity for the development of an efficient large-scale energy storage system. Gan et al. summarized the main factors of the cyclic stability attenuation of cathode materials and the strategies of how to optimize the stability of cathode materials for aqueous zinc-ion batteries, including introducing vacancy, doping, combination engineering, and object modification. Besides these, the applicable material system and corresponding mechanisms of the relevant optimization strategies were provided, and finally, perspectives of further research directions and development prospects were proposed for practical industrial application. Sodium-ion batteries (SIBs) have attracted much attention as potential alternatives to LIBs owing to their high abundance, environmental friendliness, and low cost. Wang et al. reviewed the significant research progress on Sb₂S₃-based nanomaterials for SIB, mainly focusing on Sb₂S₃, Sb₂S₃/carbon composites, Sb₂S₃/graphene composites, and the Sb₂S₃/M_xS_y composites structure. Sb₂S₃-based micro/nano materials displayed promising potential for developing high-performance SIBs.

Besides the batteries energy system, supercapacitors are a significant device because of their many advantages, such as high power density, good charge/discharge rate performance, and long cycling stability. Liu et al. synthesized a flower-like MnO₂/G microsphere by optimizing the TE-G/KMnO₄ ratio of carbon and KMnO₄ in the redox reaction. The MnO₂/G electrode demonstrated a superior rate performance with a specific capacitance of 500 F g⁻¹ at the current density of 1 A g⁻¹, and the capacitance retention was kept at 85.3% after 5,000 cycles tests, which was much better than the optimized MnO₂/rGO electrode. Wu et al. reported a hybrid Ti₃C₂Tx/C nanosphere microsupercapacitor structure through aerosol jet printing technology. The planar devices were manufactured by the hybrid spherical nanostructures, which showed excellent areal capacitance performance. This design provided a straightforward and effective technique on how to build up a 3D-structured MXene with suppressed self-stacking in order to achieve microenergy storage devices with high electrochemical performances.

Moreover, photocatalysis technology has attracted wide attention recently due to its good performance in degrading series of toxic compounds. It can provide an efficient approach

to solve environmental problems. Lu et al. synthesized a ZnO-reduced graphene oxide (rGO) solid catalyst through a one-step electrodeposition method, with lithium perchlorate (LiClO₄) as the supporting electrolyte on the FTO substrate. Thanks to the cooperative effect between rGO and ZnO, the as-obtained ZnO-rGO structure showed a much-enhanced photocatalytic degradation performance. The degradation rate of methylene blue could reach up to 99.1% in 2 h through optimizing the ZnO-rGO composite structure by adjusting the electrodeposition process, which confirmed the effectiveness of the hierarchical approach. Yin et al. fabricated periodic epitaxial junctions utilizing Sb₂Te₃ nanoblades serialized by Te nanowires (Sb₂Te₃/Te) through a one-step hydrothermal epitaxial growth method. The as-obtained product possessed a good crystal shape and heterojunction construction, resulting in a very fast photo response owing to the efficient separation of photogenerated carriers. The responsivity and detectivity were 9.5 × 10¹¹ μAW⁻¹ and 1.22 × 10¹¹ Jones at 50 K, respectively, thus exhibiting a better detection ability than other Te-based photodetector devices.

Micro/nano materials also play a significant role in the field of electrocatalysis. Zhang et al. reported one facile organic–inorganic hybridization approach to synthesize Co-N-C_x catalysts, which showed excellent hydrogen evolution reaction (HER) performances, achieving a low overpotential of 145 mV to reach 10 mA cm⁻² in 0.5 M sulfuric acid. This Co-N-C catalyst greatly facilitated the charge transfer to enhance the HER kinetics, and it also improved the durability during the long cycling tests. Cao et al. reported a feasible molecular self-assembly method to fabricate Pt/Mo carbide/multi-walled carbon nanotubes (Pt/MoC_x/MWCNTs) as an active electrode for ethanol electrooxidation reaction (EOR) in acid media. The composite catalyst demonstrated high catalytic activity and a prominent anti-CO poisoning ability. As described in the paper, the abundant exposure of the active sites and the synergistic effect between Pt and MoC contributed to the superior EOR performance.

Besides experimental methods, simulation and numerical analysis are very powerful tools to design and develop a novel energy storage and conversion system. Fahim et al. reported a numerical analysis that was performed to enhance the heat transmission in the receiver of a parabolic solar collector by introducing perforated barriers. In this work, the flow and thermal characteristics of a solar collector were investigated. Moreover, it also analyzed the beneficial effects of using perforated baffles to improve the heat transfer. The position and perforation number were optimized to achieve the best heat transfer. How to achieve efficient heat transfer and energy storage is still a key problem for engineers and industrialists. Adnan et al. studied the energy storage efficiency between (Al₂O₃-CuO-Cu/H₂O)_{mhnf} and (Al₂O₃-CuO/H₂O)_{hnf} under the condition of novel viscous dissipation effects. The results confirmed that the third generation of heat transfer fluids (Al₂O₃-CuO-Cu/H₂O)_{mhnf} possessed a much higher thermal energy storage efficiency than that of the traditional nano and hybrid nanofluids. Overall, the new insights in heat transfer are promising and could help deal with the requirements of energy storage that must be met in the modern technological world.

We sincerely hope that this Research Topic will inspire and provide new ideas for the design and fabrication of novel micro/nano materials for energy storage and conversion. All the collected works have

contributed significantly to novel micro/nano materials design and synthesis. Furthermore, all the manuscripts have innovatively provided new approaches for the field of energy storage and conversion, covering experimental and theoretical calculations. Moreover, some suggestions have been provided with respect to the development of the field of energy conversion and storage. The realization of a heterostructure is a significant and promising means to improve the performance of micronanostructures in energy storage and conversion; this deserves more research efforts. This heterogeneous structure can achieve a good synergistic effect, combining different performance advantages so as to enhance the overall performance and open up different applications in different fields. Finally, we sincerely thank all the authors, reviewers, and editors who have highly contributed to this Research Topic.

Author contributions

SZ: Writing—original draft. HW: Review and Editing. AR: Review and Editing. FG: Review and Editing. DY: Review and Editing. JL: Supervision, Review and Editing.

References

- Dai, L., Xue, Y., Qu, L., Choi, H.-J., and Baek, J. (2015). Metal-free catalysts for oxygen reduction reaction. *Chem. Rev.* 115 (11), 4823–4892. doi:10.1021/cr5003563
- Fang, R., Zhao, S., Sun, Z., Wang, D., Cheng, H., Li, F., et al. (2017). More reliable lithium-sulfur batteries: Status, solutions and prospects. *Adv. Mater.* 29 (48), 1606823. doi:10.1002/adma.201606823
- Hao, J., Li, B., Li, X., Zeng, X., Zhang, S., Yang, F., et al. (2020). An in-depth study of Zn metal surface Chemistry for advanced aqueous Zn-ion batteries. *Adv. Mater.* 32 (34), 2003021. doi:10.1002/adma.202003021

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- Yu, D., Goh, K., Wang, H., Wei, L., Jiang, W., Zhang, Q., et al. (2014). Scalable synthesis of hierarchically structured carbon nanotube-graphene fibres for capacitive energy storage. *Nat. Nanotechnol.* 9 (7), 555–562. doi:10.1038/NNANO.2014.93

- Zhang, S., Hao, J., Li, H., Zhang, P., Yin, Z., Li, Y., et al. (2022). Polyiodide confinement by starch enables shuttle-free Zn-iodine batteries. *Adv. Mater.* 34 (23), 2201716. doi:10.1002/adma.202201716