Preface

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Published online: 13 July 2020

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The International Union of Pure and Applied Chemistry (IUPAC) classifies porous materials into three categories according to their pore sizes: microporous (<2 nm), mesoporous (2–50 nm), and macroporous (>50 nm). Since the exciting discovery of ordered mesoporous silicates in the 1990s (MCM-41, SBA-15, etc.), functional mesoporous materials have attracted increasing interest owing to their fascinating properties such as tunable large pore sizes, high surface areas, large pore volumes, alternative mesostructures, as well as their wide range of promising applications in catalysis, adsorption, separation, sensors, water treatment, energy conversion and storage, biomedicine, and nanodevices. In the past three decades, the family of functional mesoporous materials has expanded to include a wide range of compositions, such as silica, carbon/polymer, metal, metal oxide, and organic–inorganic hybrid. With the development of nanotechnology, tremendous progress has also been made in the synthesis of nanosized mesoporous materials with a variety of morphologies, such as nanofibers, nanorods, nanosheets, core@shell nanoparticles, and asymmetric nanocomposites.

Generally, the approaches for the synthesis of ordered mesoporous materials can be classified into hard-templating and soft-templating routes. The hard-templating route involves nano-casting using pre-synthesized mesoporous solids or colloidal crystals as a sacrificial mold. In the soft-templating route, surfactant or/and amphiphilic block copolymer molecules and guest species can assemble with polymerizable precursors or/and oligomers into ordered mesostructured composites. The conventional methods, such as hydrothermal synthesis, sol–gel co-assembly, and evaporation induced self-assembly (EISA), are soft-templating routes. Many new methods have also been developed in recent years, including evaporation-induced aggregating assembly (EIAA),

emulsion-induced interfacial assembly, and liquid–liquid bi-phase assembly, which widened the scope of mesoporous material manufacturing.

The functional mesoporous materials have shown great potential in many fields, especially in catalysis, adsorption, separation, energy conversion and storage, and biomedicine. For catalysis, functional mesoporous materials can not only provide the ultra-stable carrier and support for catalytic active sites but also facilitate the mass transfer of large-sized guests through highly accessible mesopore channels as a nano-reactor. Mesoporous materials also offer infinite opportunities in energy conversion and storage applications, such as batteries and supercapacitors. The extraordinarily high surface areas, large pore channels, and pore volumes can improve the performance of materials in terms of energy and power density, lifetime, and stability. One of the most investigated biological applications of mesoporous materials is biomedicine. The functional mesoporous materials can be used for therapeutics, bioimaging agents, biosensors, vaccine adjuvants, and so on because the large mesopore channels can provide ideal storage space for the bio-functional guests.

In summary, a range of new synthetic methods and mesoporous materials have been developed after decades of toil. The applications have also been extended from conventional catalysis, adsorption, and separation to the emergent fields of biomedicine, energy conversion and storage, sensing, etc. However, despite such scientific and technological developments, substantial challenges remain, including understanding the detailed formation mechanism of mesostructures at the microscopic scale, the precise synthesis of mesoporous materials with different mesostructures, compositions, morphologies, and surface properties, and the accurate structure–activity relationship in the applications. Therefore, we organized this special issue to collect the recent development and progress regarding the synthesis, characterizations, and applications of mesoporous materials. We strongly believe that this issue will help the multidisciplinary community to identify a key direction for the development of advanced mesoporous materials.

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