Hierarchically mesoporous titanium dioxide materials for energy and environmental applications

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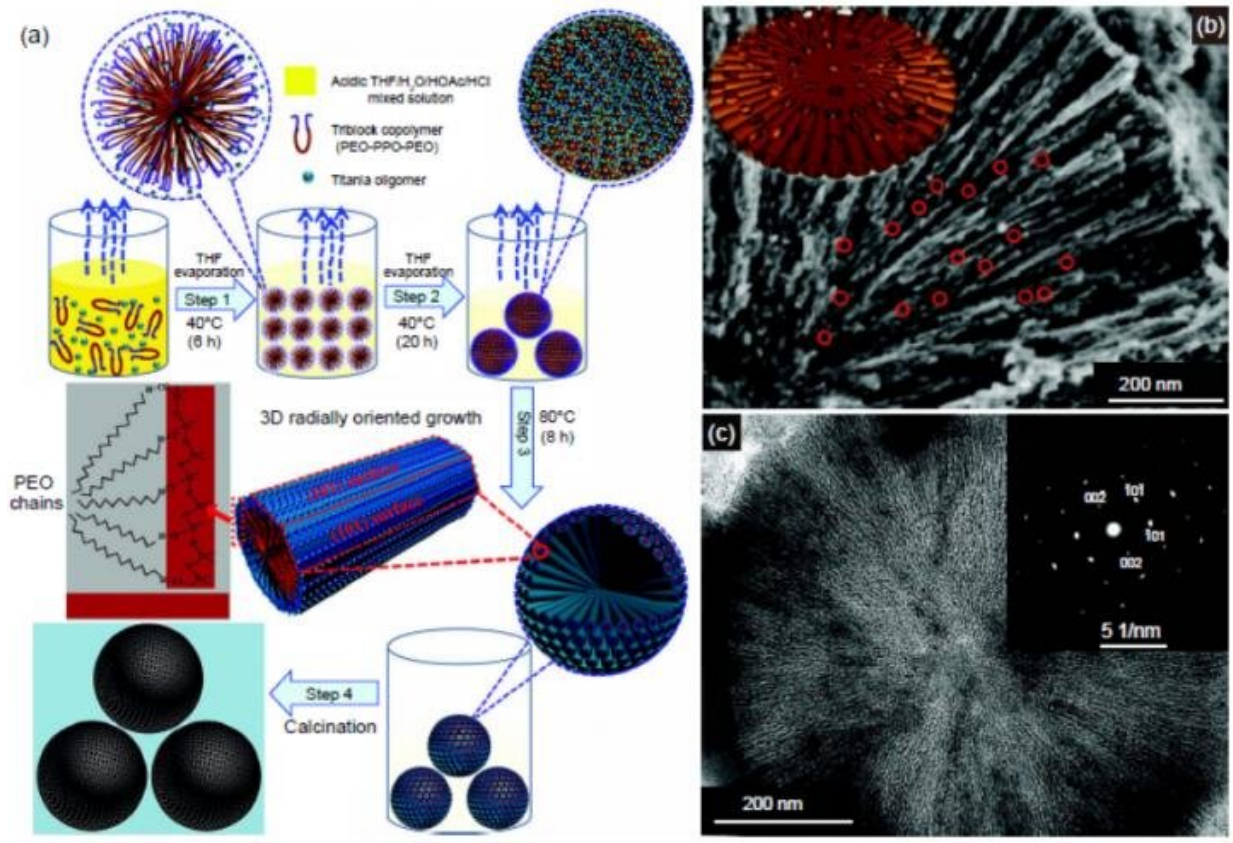

Schematic representation of the formation process of hierarchically mesoporous TiO2 microspheres with single-crystal like pore wall through evaporation-driven oriented assembly (a). SEM image of a single ultramicrotomed, radially-oriented hierarchically mesoporous TiO2 microspheres (b). Inset: Structure models for the radially oriented channels with interchannel pores. TEM image of a single ultramicrotomed, hierarchically mesoporous TiO2 microspheres (c). Inset: The

SAED pattern taken from the cylindrical pore bundles region with [010] incidence. Credit: Science China Press

Since the first discovery of photocatalytic water splitting on a TiO_2 electrode under ultraviolet (UV) light, TiO_2 materials have been widely investigated over the past few decades due to their unique properties such as nontoxicity, abundance, easy availability, and stability. For the moment, TiO_2 materials present great potentials in the applications from the conventional areas (e.g., pigment, cosmetic, and toothpaste) to the latest developed areas including catalysis, energy storage and conversion, biomedicine, environmental remediation and so on. Beyond all question, TiO_2 materials render new candidates to overcome the energy, environment, and health challenges facing humanity today.

Recently, various TiO_2 nanomaterials with different structures have been fabricated and applied in different areas and reveal excellent performances. Among them, mesoporous TiO_2 materials, especially with hierarchically mesoporous structures, have received increasing interest due to their attractive features, such as high surface areas, large pore volumes, tunable pore structures, and nano-confined effects. Those features enable the high performance of hierarchically mesoporous TiO_2 materials in many areas. The high surface area can provide abundant active-sites for surface- or interface-related processes such as adsorption and catalysis. The large pore volume has shown great potential in the loading of guest species and the accommodation of structural change. And the porous structure can facilitate the diffusion of reactants and products, which is benefit for the reaction kinetics.

In a new review published in *National Science Review*, scientists at the Department of Chemistry in Fudan University, China, present the latest advances in the synthesis of hierarchically mesoporous TiO_2 materials

for energy and environmental applications. Co-authors Wei Zhang, Yong Tian, Haili He, Li Xu, Wei Li, and Dongyuan Zhao summarize the general synthetic strategies (template-free, soft-template, and hard-template and multiple-template routes) for hierarchically mesoporous TiO_2 materials firstly.

Subsequently, they review the representative morphologies of hierarchically mesoporous TiO_2 materials (nanofibers, nanosheets, microparticles, films, spheres, core-shell structures, and multi-level architectures), meanwhile, the corresponding synthetic mechanisms and the key factors for the controllable synthesis of hierarchically mesoporous TiO_2 materials with different architectures are highlighted. Moreover, they discuss the applications of hierarchically mesoporous TiO_2 materials in terms of energy storage and environmental protection, including photocatalytic degradation of pollutants, photocatalytic fuel generation, photoelectrochemical water splitting, chemical catalysis, lithium-ion batteries and sodium-ion batteries. Finally, the authors outline the challenges and future directions of research and development in this area.

More information: Wei Zhang et al, Recent advances in synthesis of hierarchically mesoporous TiO2 materials for energy and environmental applications, *National Science Review* (2020). DOI: 10.1093/nsr/nwaa021

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