Rationally designing hierarchical zeolites for better diffusion and catalyst efficiency

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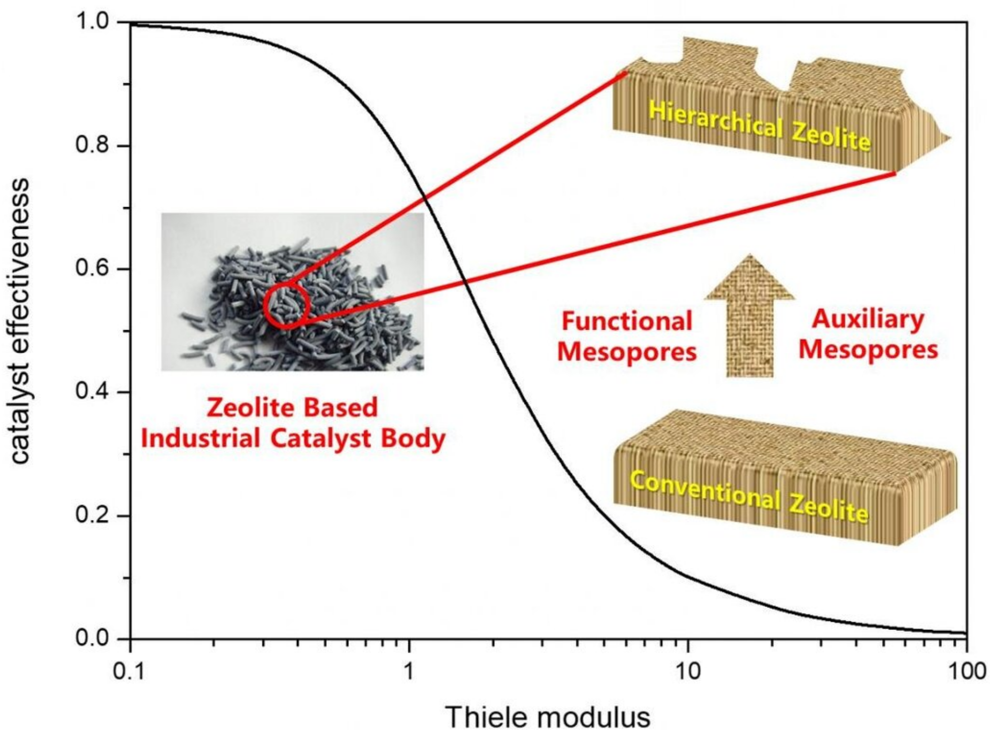

Hierarchical structures at both zeolitic component and industrial catalyst levels Credit: Science China Press

Thanks to various crystalline topologies, tunable chemical composition, high (hydro)thermal stability, and controllable surface acidity/basicity, zeolites are widely used in petroleum refining, petrochemical manufacture, fine chemical synthesis, biomedicine, environmental chemistry, etc. However, for many zeolite-catalyzed reactions, the molecular diameters of the reaction species involved are often larger than the pore apertures of the zeolites. This leads to undesired diffusion resistance between the bulk phase and the active centers of the catalyst, thereby significantly reducing the catalyst efficiency.

Alleviating diffusion resistance and improving catalyst efficiency of the zeolite-based catalyst is always one of the most concerned issues in academia and industry. Within the past decades, tools for integrating hierarchical micro-/mesoporous structures into zeolites for better diffusion and catalyst efficiency have been greatly enriched.

However, in the real industrial catalysis processes, even if zeolitic component contains hierarchically porous structure, it is just one of the components of the multi-component industrial catalyst. The zeolite-based industrial catalyst is essentially hierarchical structure composed of microporous zeolitic and macroporous non-zeolitic components. When the hierarchically porous structure is integrated, the catalyst also has a micro-/meso-/macroporous trimodal hierarchical structure. Obviously, the hierarchical pore structure of industrial zeolite-based catalysts exists in two levels: 'inside the zeolitic component' and 'between the components of the industrial catalyst.'

In a new review paper published in the Beijing-based *National Science Review*, scientists at the China University of Petroleum in Qingdao, China (Peng Peng, Zi-Feng Yan), China National Petroleum Company in Beijing, China (Xiong-Hou Gao), and French National Center for Scientific Research (CNRS) in Caen, France (Svetlana Mintova) analyzed the state-of-the-arts in rational design of hierarchical micro-/mesoporous structures from catalytic reaction engineering point of view.

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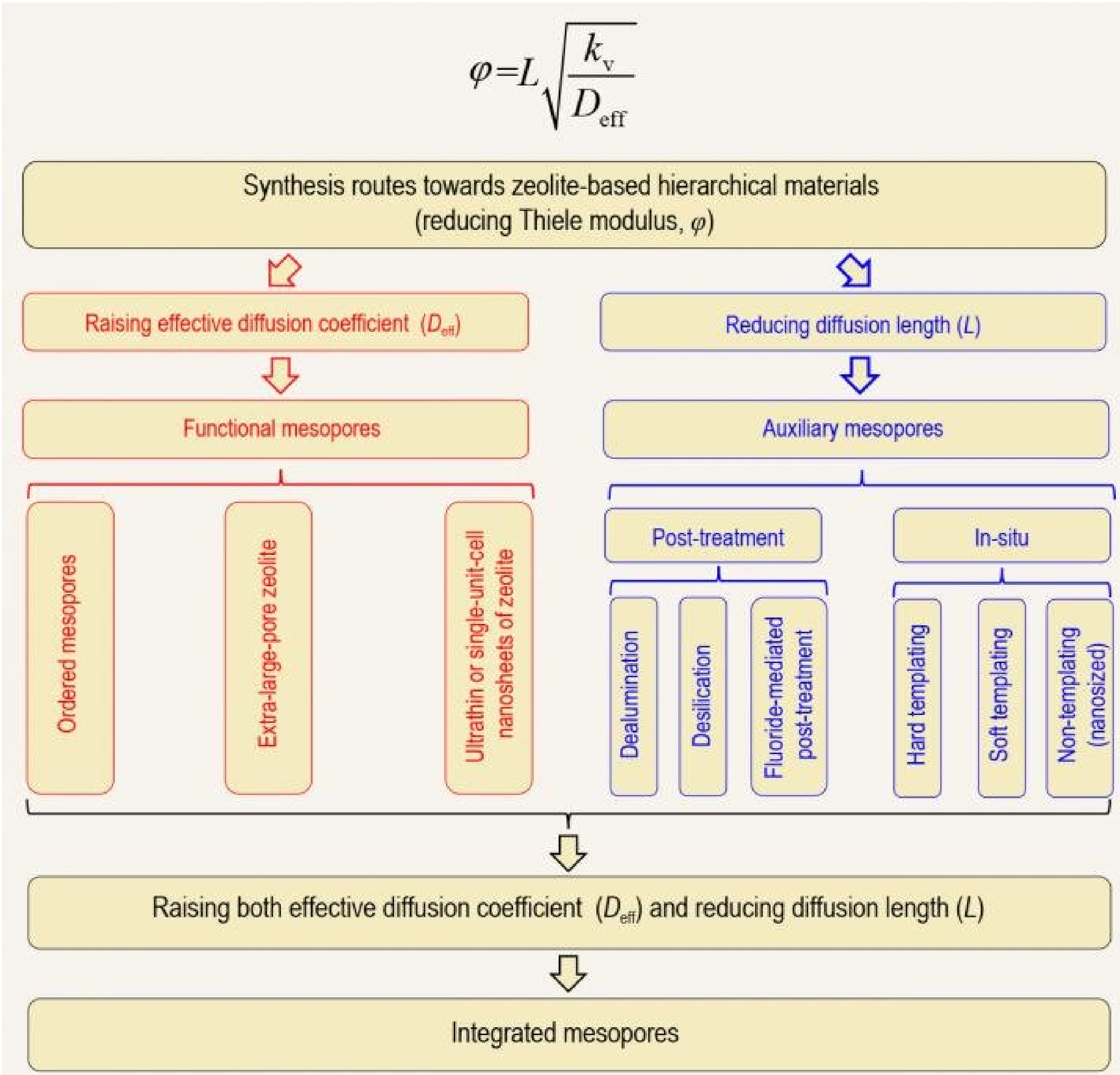

Overview of the synthesis routes toward zeolite-based hierarchical materials. Credit: ©Science China Press

From the perspective of catalytic reaction engineering, the quantitative indicators for evaluating catalyst efficiency are catalyst effectiveness factor (η) and Thiele modulus (φ). If the catalyst system undergoes strong diffusion resistance (η