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RESEARCH HIGHLIGHT

Miniature structures meticulously replicated in carbon

Petra E de Jongh

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Zeolites are crystalline solids, usually aluminosilicates, with ordered microporosity, for which more than two hundred different structures are known. They play a crucial role in present-day society; for instance, as catalysts in the oil refining and petrochemical industry.[1] In future energy systems conductive porous carbon materials are expected to play a key role, as battery electrode materials, supercapacitors, and in fuel cells and electrolyzers.[2,3] However, preparing well-defined ordered microporous carbon materials has been a long-standing challenge. Prof Ryoo and his team describe in *Nature* a new strategy to prepare these materials with unprecedented precision.[4]

Carbon mesostructures can be prepared by filling the ordered mesopores (diameter larger than 2 nm) of silica scaffolds, and removing the silica afterwards.[5] However, common carbon precursors such as sucrose or furfuryl alcohol are too large to easily diffuse in the 0.5–1.3 nm-sized pores of zeolites. Smaller precursor molecules such as ethylene decompose only at high temperatures, resulting in incomplete pore filling and carbon structures being formed outside the zeolite pores. Ryoo *et al.*[5] demonstrate that the use of lanthanum, yttrium or calcium catalysts lowers the decomposition temperature of ethylene by 200 °C. Although the exact catalytic mechanism remains unclear, this results in carbon formation *exclusively inside* the zeolite pores in which the catalyst is present (see Figure 1). After zeolite removal, a well-defined, ordered and interconnected microporous carbon structure is obtained.

The same strategy is applied to several different zeolite structures, with pores down to 0.71 nm. Three-dimensional open zeolite porosity leads to interconnected carbon networks. Interestingly, also well-defined carbon quantum dots with intriguing optical properties can be formed. The materials are prepared on the scale of several grams, and are electronically conducting, very important for application as energy materials. However, the limited mechanical robustness seems to be a great disadvantage. Structures faithfully replicating zeolite micropores are intrinsically fragile, but perhaps this problem might be circumvented by introducing additional mesopores in the zeolites, resulting in a robust nanoscale carbon backbone after templating.

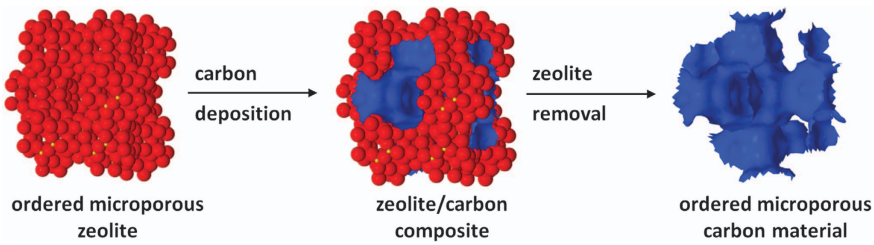

Figure 1 Schematic illustration of the templating process in which first carbon (indicated in dark blue) is deposited onto the pore walls of the zeolite structure (oxygen atoms of the structure indicated in red), followed by an additional heating step and removal of the zeolite, resulting in an interconnected ordered microporous carbon structure.

In short, the exciting findings reported in this paper enable the preparation of ordered microporous carbon materials with a wide range of structures, and will hopefully be followed by a series of papers providing more insight into the catalytic mechanism and exploring the wide range of new functional materials and their optical and electronic properties.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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Debye Institute for Nanomaterials Science, Utrecht University, Utrecht, The Netherlands
E-mail: P.E.deJongh@uu.nl