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Improving Efficiencies in Fuel, Chemical and Pharmaceutical Industries

Repetitive branching, a novel and simple synthesis method, produces zeolite crystals with large-pore "highways" that improve transport and utilization of chemicals within the crystal

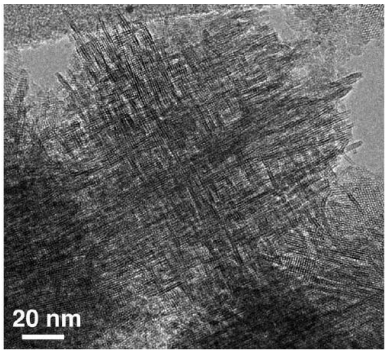
This research was conducted by the group of Michael Tsapatsis at the University of Minnesota and was supported by CCEI. Other materials synthesized were supported from other funding sources.

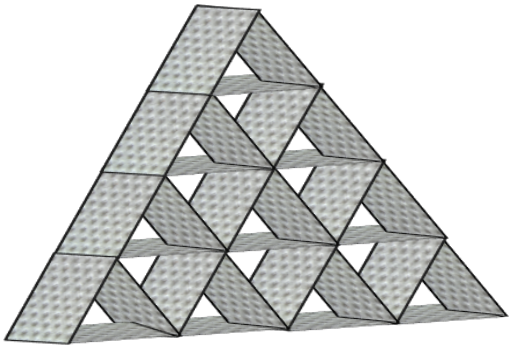
Zeolite catalysts have important application spanning from petrochemicals to pharmaceuticals to renewables. This synthesis method significantly improves the effectiveness of traditional zeolites with no unwanted change in functionality and is the first cost-efficient route that can enable large scale commercialization.

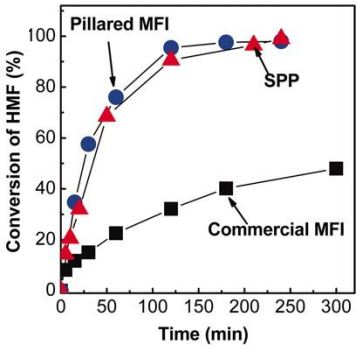
Research Details

- Zeolites derive many of their catalytic properties from pores less than a nanometer in diameter
- The repetitive branching technique stacks thin zeolite sheets at right angles producing a "house of cards" shaped crystal with channels throughout which are 4-14 times larger than the zeolite pores

- Molecules can rapidly pass through these channels to reach the smaller, reactive pores within the crystal
- No complex and costly post-synthesis processing is required







Left: Transmission electron microscopy image of zeolite showing visible channels and barely distinguishable pores. Middle: "House of cards" arrangement of thin zeolite sheets with pores an order of magnitude smaller in diameter than the channels. The channels act like expressways, allowing reacting molecules to route more quickly to individual pores and reducing "traffic" within the zeolite. Right: Comparison of new material (SPP) with Pillared MFI (a similar but higher cost material) and commercial MFI lacking large diffusion channels. A sample reaction for processing of 5-hydroxymethylfurfural, an important biomass compound, shows the channeled zeolites are much more effective catalysts than traditional zeolites.

RELEVANT PUBLICATION:

X. Zhang, D. Liu, D. Xu, S. Asahina, K. A. Cychosz, K. V. Agrawal, Y. Al Wahedi, A. Bhan, S. Al Hashimi, O. Terasaki, M. Thommes and M. Tsapatsis, Synthesis of self-pillared zeolite nanosheets by repetitive branching, Science 336 (6089), 1684-1687 (2012) [DOI:10.1126/science.1221111]

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