New Strategies for Syntheses of Mesoporous Zeolites with High Catalytic Properties

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Zeolites with unique micropores have been widely applied in industry at present, but the relatively small micropores in zeolites significantly influence the mass transport in many catalytic reactions. Recently, mesoporous zeolites have been successfully templated from nanosized carbon materials, but their industrial applications are still limited, because of the cost of these templates, the complexity of synthetic procedures, and the difficulty for dispersion of templates into gels. In this work, we would like to summarize our recent results for syntheses of mesoporous zeolites from a series of new strategies in the following:

(1) Hierarchical mesoporous zeolites templated from cationic polymers. Cationic polymers have obvious advantages such as good hydrothermal stability, strong coulombic interaction with silica species with negative charge in alkaline media, mesoscale size, and low cost, which are very suitable for the templation of mesoporosity in zeolites. Examples are the syntheses of mesoporous Beta and ZSM-5 zeolites. Notably, this route is “one-step” hydrothermal synthesis with simple synthetic process, and these mesoscale templates are homogeneously dispersed into synthetic gel. Very interestingly, these novel zeolites exhibit excellently catalytic properties in the alkylation of benzene with isopropanol, compared with conventional zeolites.

(2) Stable, porous, and bulky particles assembling from zeolite nanocrystals. Generally, the decrease in the crystal size results in high external surface area, fast diffusive rate, and much exposed active sites. However, the preparation of zeolite nanocrystals is relatively complex, compared with micrometer-sized zeolites. Usually, zeolite nanocrystals are obtained from high-speed centrifugation in slurry system, which is difficult to prepare a large amount in industry. We show here an alternative and simple route for one-pot synthesis of stable, porous, and bulky particles with high external surface area and large pore volume from an assembly of zeolite nanocrystals with cationic polymers. Obviously, these zeolite particles combine advantages of both the nanocrystals (high external surface area, large mesopore volume, and fast diffusive rate) and the micrometer-sized crystals (easy filtration and high solid yield).

(3) Mesoporous aluminophosphate zeolites from tetramethylguanidine template. Normally, aluminophosphate zeolites are templated from organic amines. Recently, it is found that tetramethylguanidine is not only a template for the formation of aluminophosphate zeolites but also a linker between zeolite crystals. As a result, mesoporous aluminophosphate zeolites could be formed in the presence of tetramethylguanidine.

(4) Fast synthesis of mesoporous Silicalite-I zeolite under super-critical CO₂. We have successfully synthesized mesoporous Silicalite-I zeolite under super-critical CO₂, and the catalytic tests in Beckmann rearrangement of cyclohexanone oxide into ε-caprolactam, shows that mesoporous silicalite-I is more active than conventional silicalite-I.

Reference: