

Supporting Information

N-methyl-2-pyrrolidone assisted synthesis of hierarchical ZSM-5 with house-of-cards-like structure

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Raw materials

All reagents were used without any further purification. Fumed silica (SiO₂) was purchased from Shenyang Chemical Company (China). Sodium hydroxide (NaOH) and aluminum sulfate (Al₂(SO₄)₃·18H₂O) were supplied by Beijing Chemical Reagent Company (China). N-methyl-2-pyrrolidone (NMP) was obtained from Tianjin Chemical Reagent Company (China).

Synthesis

House-of-cards-like ZSM-5 (HCL-ZSM-5) was prepared via a one-pot hydrothermal process. The homogeneous gel with a molar composition of 0.2 Na₂O: 0.025 Al₂O₃: SiO₂: 17.8 H₂O: 0.808 NMP was firstly obtained. Then the mixture was transferred into an autoclave and crystallized at 140 °C for 6-72 h. The product was collected by filtration, washed with deionized water and dried at 70 °C. For comparison, template free ZSM-5 was prepared with the same procedure used for HCL-ZSM-5, but in the absence of NMP. H form ZSM-5 was obtained through ion exchange with 1 M NH₄NO₃ solution under 80 °C before calcination (550 °C, 6 h).

Characterizations

X-ray diffraction (XRD) data were recorded on a Rigaku D/MAX-2550 diffractometer (50 kV, 200 mA) with Cu K α . Radiation ($\lambda=1.5418$ Å). The morphologies of samples were examined on a JEOL JSM-6700F scanning electron microscopy (SEM) and JEOL JSM-3010 transmission electron microscopy (TEM). The spectra of solid-state ²⁷Al NMR and liquid-state ¹³C NMR were collected on Varian Infinity Plus 400 and Bruker Avance 500 spectrometers, respectively. Nitrogen absorption-desorption isotherms were performed on a Micromeritics ASAP 2020M instrument at 77 K. The specific surface area was evaluated using the Brunauer-Emmett-Teller (BET) equation, and the external surface area was calculated from t-plot analysis. The pore size distribution was obtained by non-local density functional theory (NLDFT) model.

The amounts of Si and Al in zeolites were quantified by inductively coupled plasma (ICP) with a Perkin-Elmer 3300 DV spectrometer. Temperature-programmed desorption of ammonia (TPD-NH₃) curve was measured on a Micromeritics Auto Chem II 2920 automated chemisorption analysis unit with a thermal conductivity detector (TCD).

Catalytic tests

Cumene and 1, 3, 5-triisopropylbenzene (TIPB) cracking evaluations of the catalysts were performed in a micro-fixed bed reactor by pulse injection under atmospheric pressure at 300 °C and 350 °C, respectively. Nitrogen was used as carrier gas. 0.05 g of catalyst was firstly placed in the fixed reactor, then 0.4 µL of reactant (cumene or TIPB) was injected for each run. The reaction products were analyzed by an on-line gas chromatograph (Shimadzu GC-8A) equipped with a thermal conductivity detector (TCD).

Supporting Figures

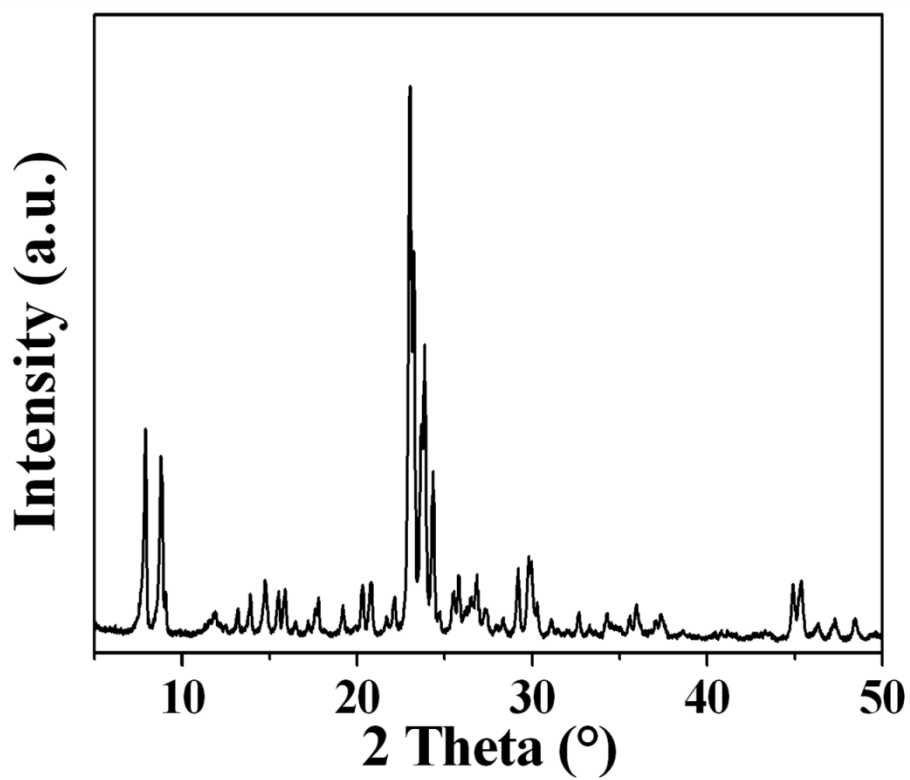


Figure S1. XRD pattern of template free ZSM-5.

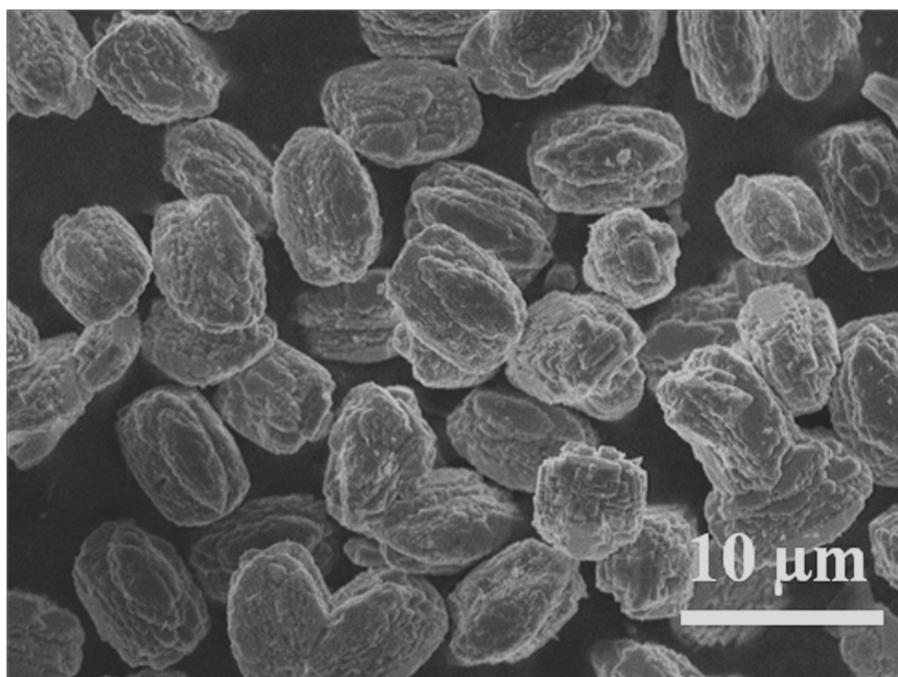


Figure S2. SEM image of template free ZSM-5.