Support information

Hierarchically Tetramodal-Porous Zeolite ZSM-5 Monoliths with Template-Free-Derived Intracrystalline Mesopores

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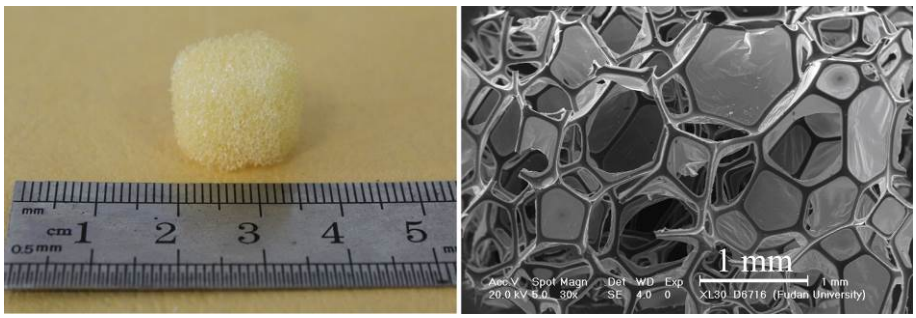

Figure S1. The optical image (left) and SEM image (right) of the commercial PUF scaffolds, showing that it has an open and well-connected macrocellular structure with cell-forming membranes.

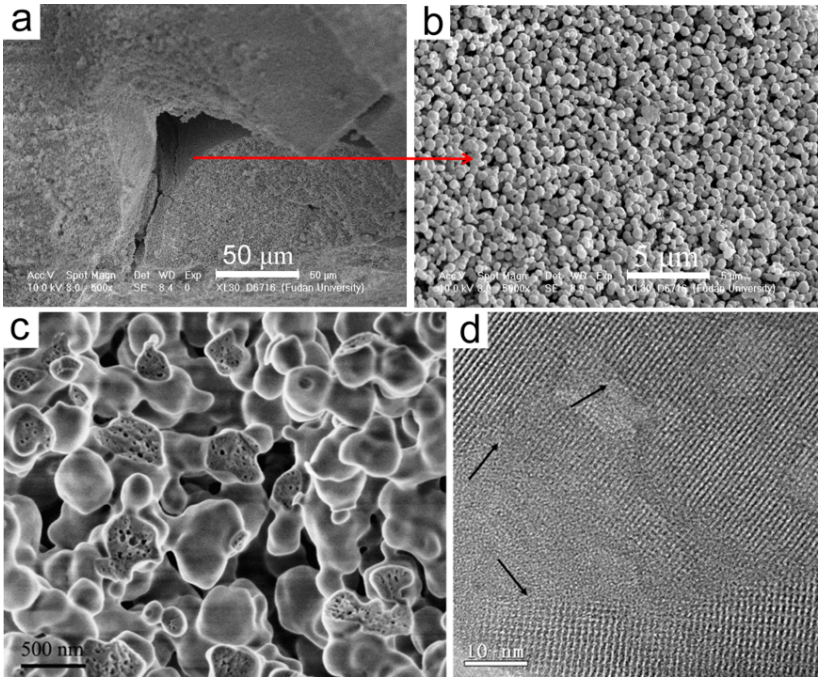

Figure S2. SEM images of (a) the magnified triangular macropore after the removal of the PU skeleton; (b) the regions from the area adjacent to the macropores (denoted by the red arrow), showing the bimodal macropores can be connected; (c) FESEM image of the monolithic zeolites ZSM-5 prepared by using the commercial PUF as a sacrificed scaffold through a SAC method, showing that the monolith is composed of particles and some mesopores are embedded in each zeolite particle; (d) HRTEM image of micro-mesopore in each particle, further demonstrating the interconnectivity between the mesopores and micropores.

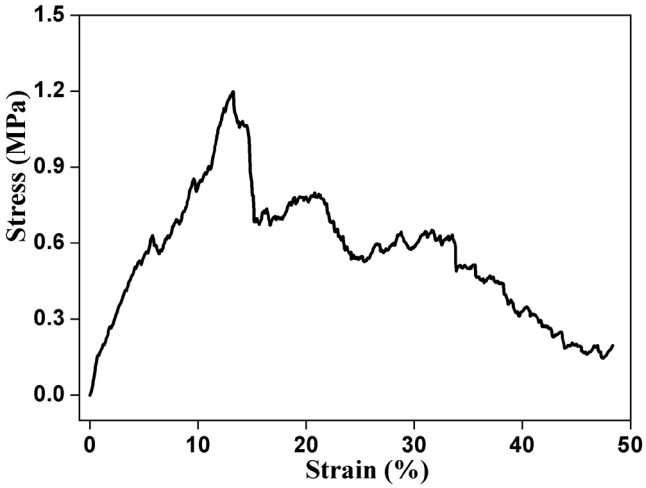

Figure S3. The stress-strain curve of the zeolite monoliths prepared by using the commercial PUF as a sacrificed scaffold through a SAC method, showing that the mechanical strength of the zeolite monolith can reach as high as ~ 1.2 MPa.

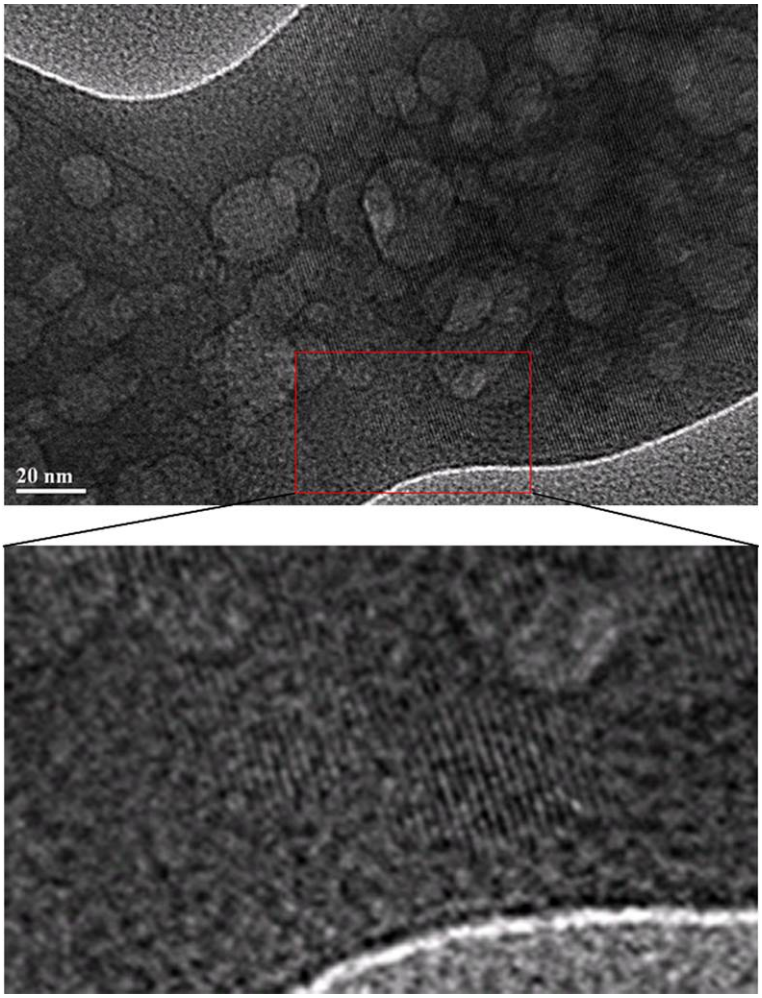

Figure S4. The HRTEM image of the interconnecting part between two intergrown zeolite crystals, suggesting that zeolite crystals are bonded together by the interconnecting amorphous region.

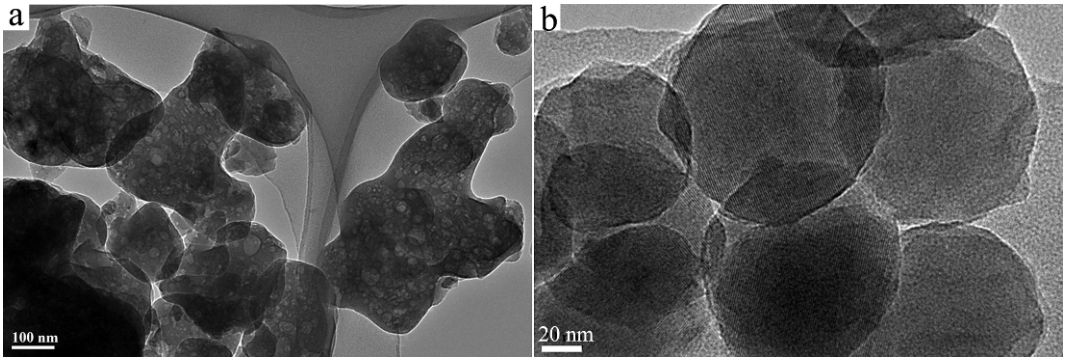

Figure S5. TEM images of (a) the sample prepared by the SAC treatment at 180 °C without PU foam as the scaffolds; (b) the sample prepared by using TEOS as silica source with the SAC treatment at 180 °C.

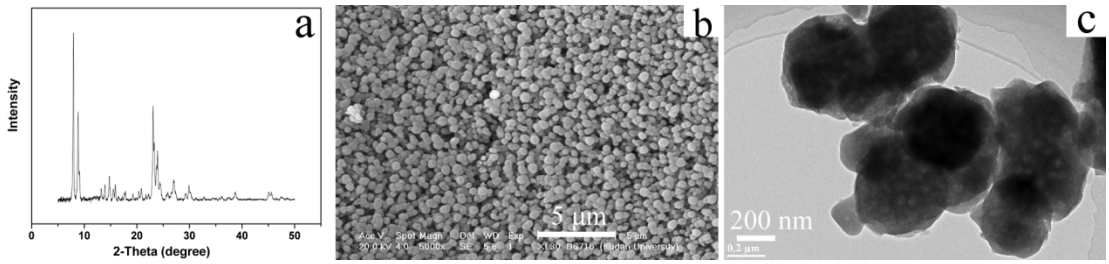

Figure S6. The monolithic ZSM-5 with a Si/Al ratio of 100 (ICP results) after the SAC treatment at 180 °C for 24 h: (a) XRD pattern, (b) SEM image, (c) TEM image, demonstrating that the samples possess a similar morphology and structure with the mainly discussed zeolite with a Si/Al ratio of 153 (ICP results).

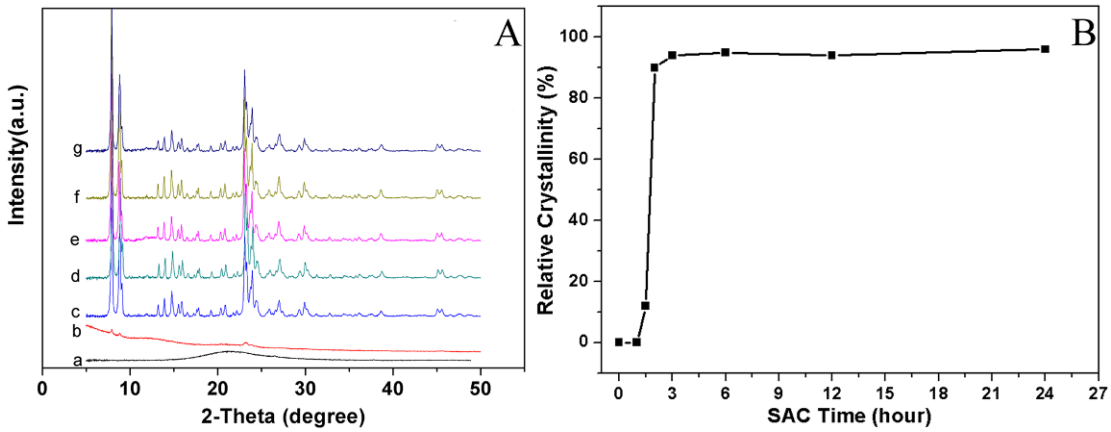

Figure S7. (A) Powder XRD patterns of the ZSM-5 monoliths after the SAC treatment at 180 °C for different time (a) 1, (b) 1.5, (c) 2, (d) 3, (e) 6, (f) 12, (g) 24 h; (B) The relative zeolite crystallinity of the monolithic ZSM-5 products functioned with the SAC treatment time.

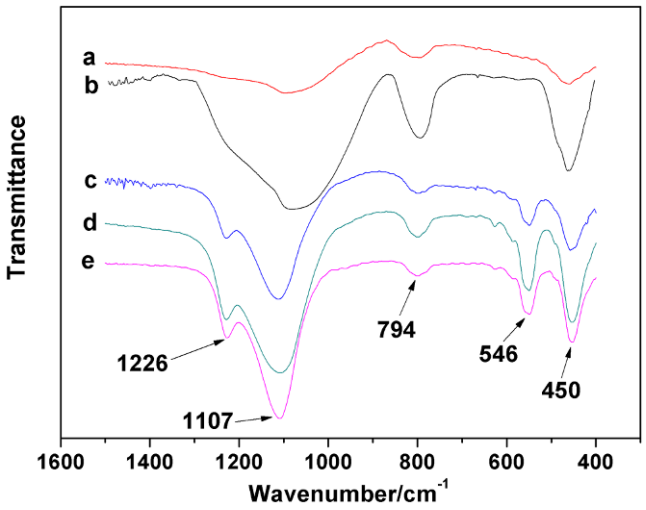

Figure S8. FTIR spectra of the ZSM-5 monoliths after the SAC treatment at 180 °C for different time (a) 0, (b) 1, (c) 1.5, (d) 2, (e) 3 h.

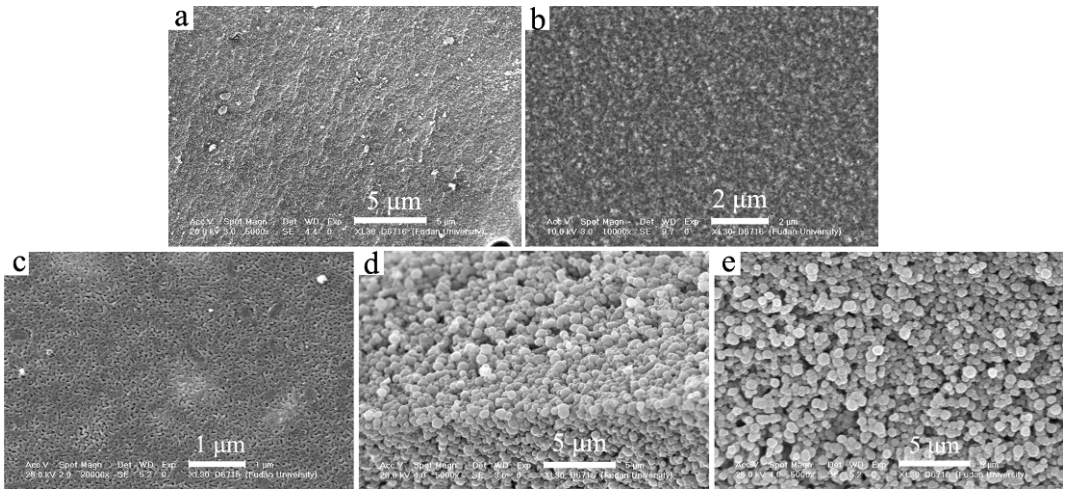

Figure S9. SEM images of the sample after the SAC treatment at 180 °C for different time (a) 0, (b) 1, (c) 1.5, (d) 2, (e) 3 h.

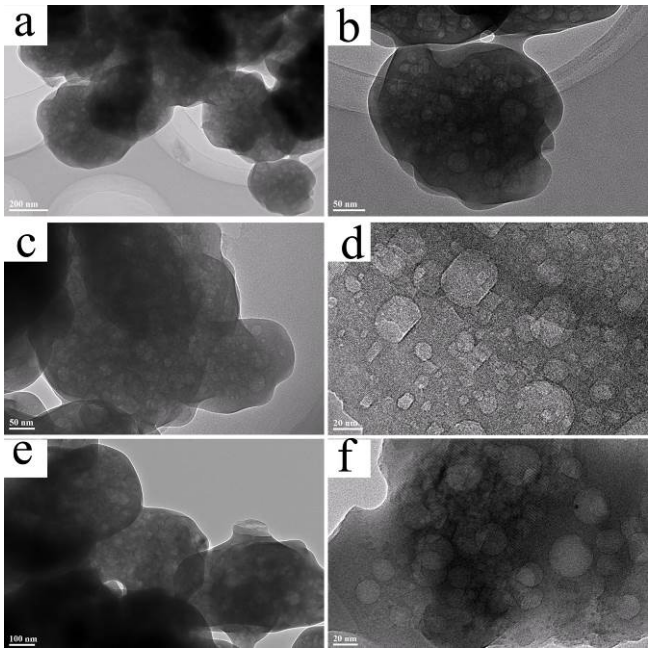

Figure S10. TEM images of the samples after the SAC treatment at 180 °C for different time (a, b) 3, (c, d) 6, (e, f) 12 h.

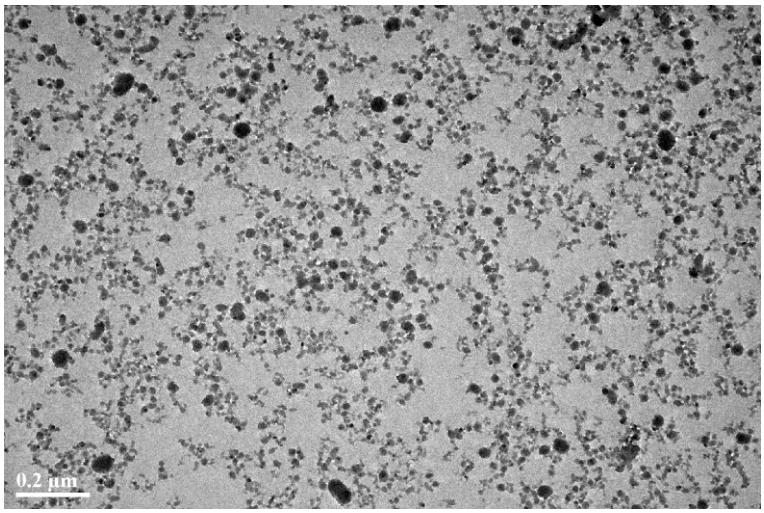

Figure S11. The TEM image of the zeolite precursor after aging for 24 h at room temperature, showing that some particles are dispersed in the solution.

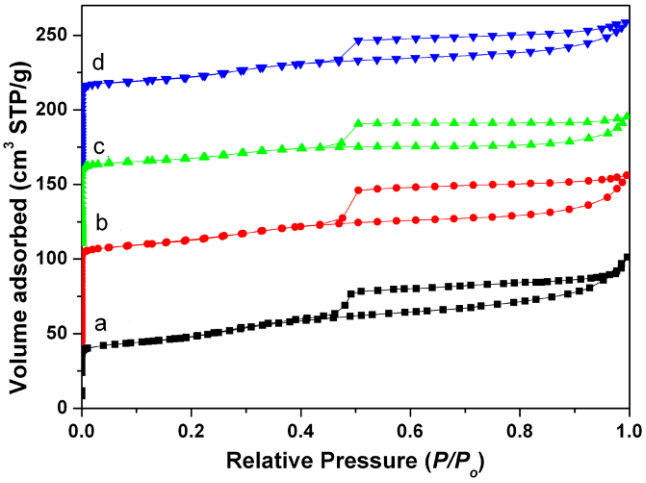

Figure S12. Nitrogen sorption isotherms of the ZSM-5 monoliths after the SAC treatment at 180 °C for different time (a) 2, (b) 3, (c) 6, (d) 12 h.

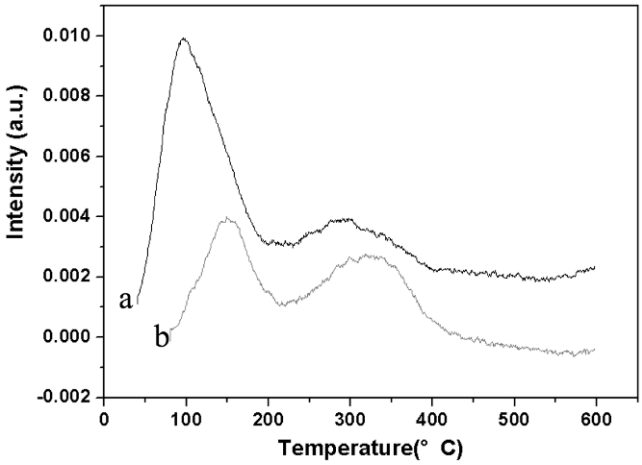

Figure S13. NH_3-TPD curves of the ZSM-5 monolith (a) prepared by using PUF scaffold after the SAC treatment at 180 °C for 24 h and the powder sample prepared according to the reference (b).