

Electronic Supplementary Material

The effect of hierarchical single-crystal ZSM-5 zeolites with different Si/Al ratios on its pore structure and catalytic performance

Yuexin Hou^{1*}, Xiaoyun Li^{2*}, Minghui Sun^{1, 3}, Chaofan Li^{1,4}, Syed ul Hasnain Bakhtiar¹, Kunhao Lei¹, Shen Yu¹, Zhao Wang¹, Zhiyi Hu^{1,4}, Lihua Chen (✉)¹, Baolian Su (✉)^{1,3,5}

1 Laboratory of Living Materials at the State Key Laboratory of Advanced Technology for Materials Synthesis and Processing, Wuhan University of Technology, Wuhan 430070, China

2 State Key Laboratory of Silicate Material for Architectures, Wuhan University of Technology, Wuhan 430070, China

3 Laboratory of Inorganic Materials Chemistry (CMI), University of Namur, B-5000 Namur, Belgium

4 Nanostructure Research Centre (NRC), Wuhan University of Technology, Wuhan 430070, China

5 Clare Hall, University of Cambridge, Cambridge, CB3 9AL, UK

E-mails: chenlihua@whut.edu.cn (Chen L); bao-lian.su@unamur.be (Su B)

*These authors contributed equally to this work.

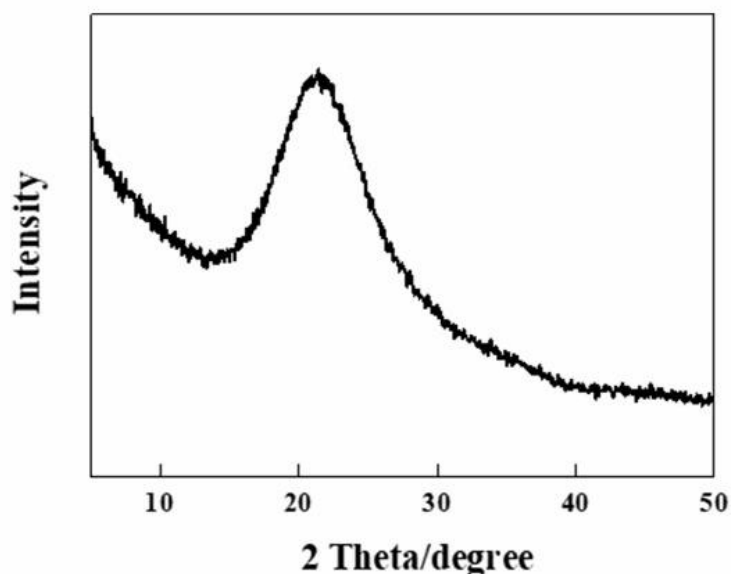


Fig. S1 XRD pattern of SiO₂@PC.

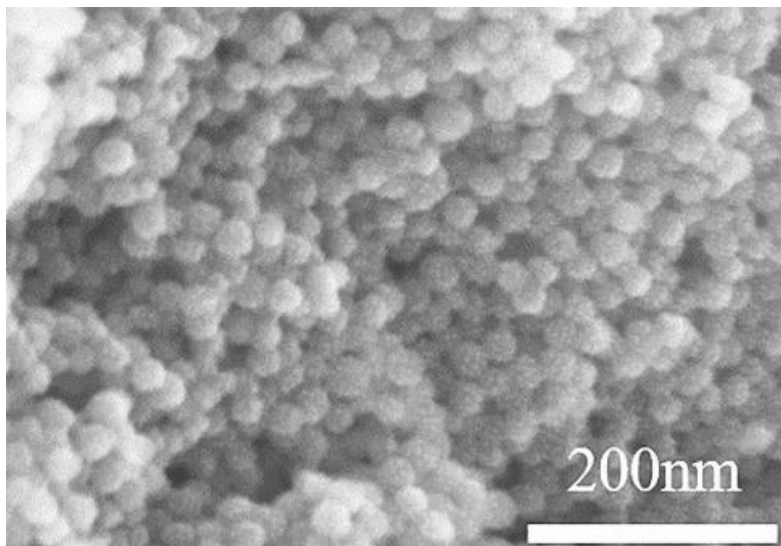


Fig. S2 SEM image of SiO₂@PC.

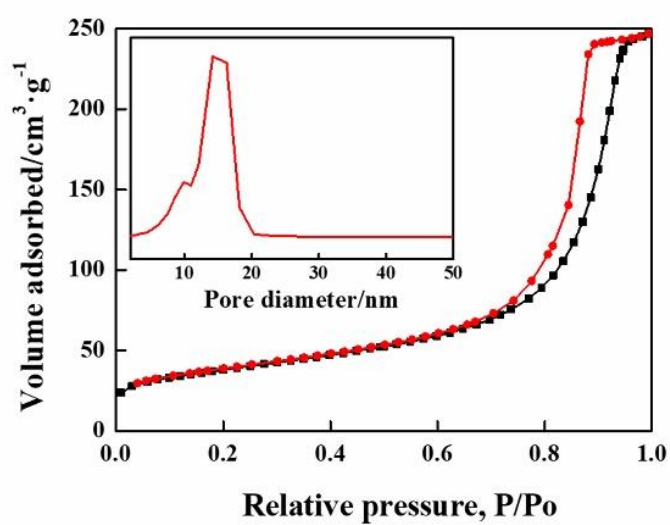


Fig. S3 Nitrogen adsorption-desorption isotherm of SiO₂@PC and the inset is the corresponding mesopore size distribution.

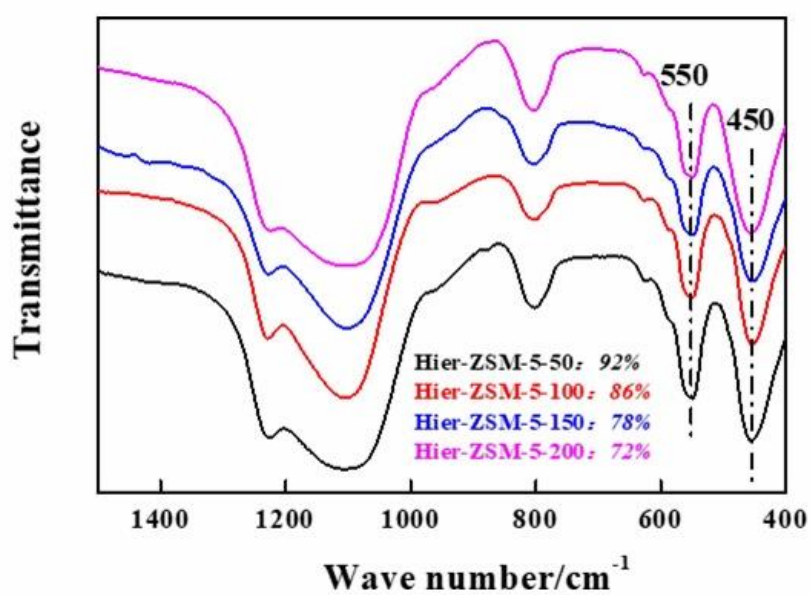


Fig. S4 FT-IR spectra of Hier-ZSM-5-*x*.

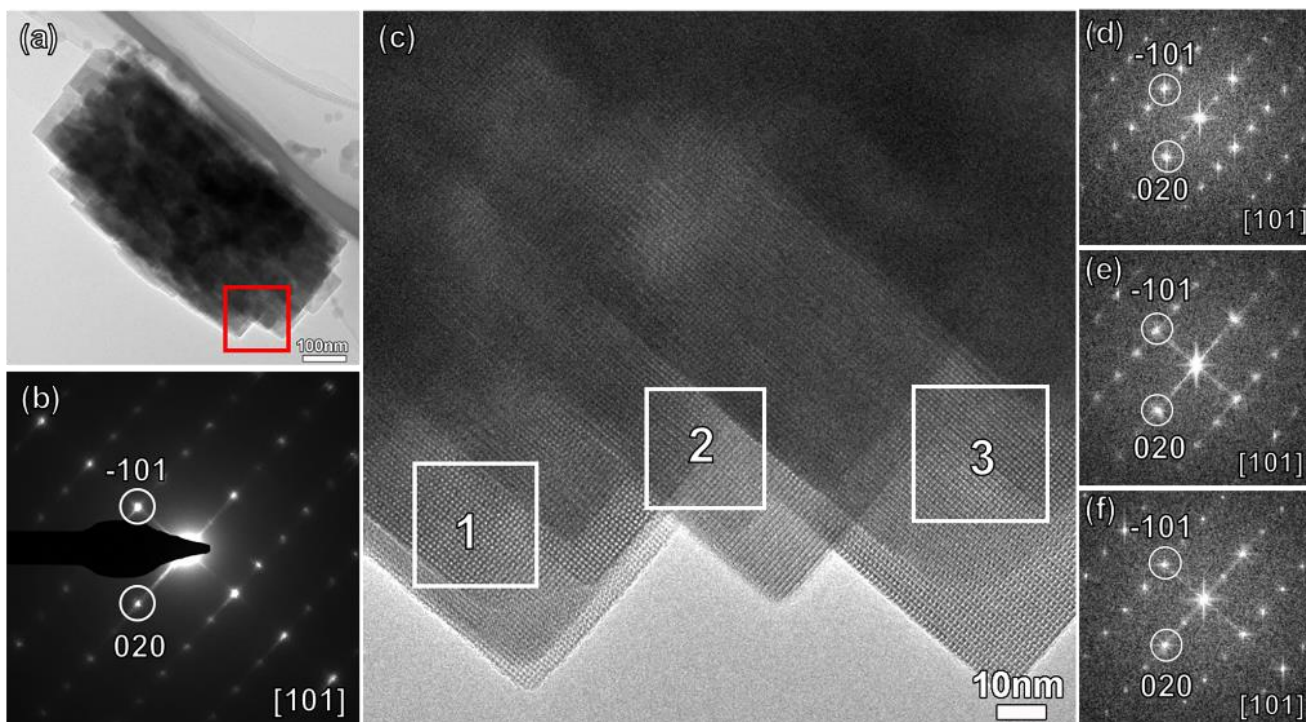


Fig. S5 (a) TEM image of Hier-ZSM-5-100; (b) Corresponding SAED pattern of the area indicated by the red circle in panel (a); (c) HR-TEM image of the area indicated by the red box in panel (a); (d–f) Corresponding FFT patterns from zone 1(d), zone 2(e) and zone 3(f) of (c).

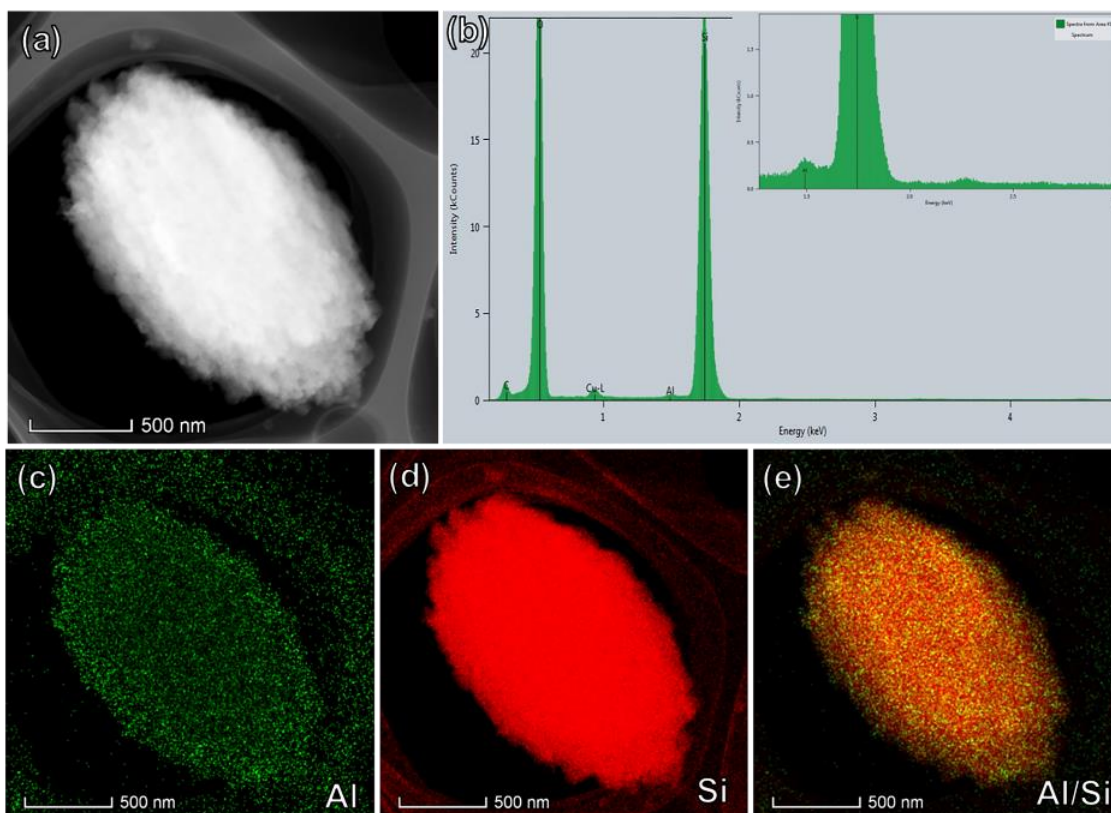


Fig. S6 (a) HAADF-STEM image of Hier-ZSM-5-100; (b) Corresponding EDX spectrum of Hier-ZSM-5-100; (c–e) Corresponding EDX elemental maps: Al (c, green), Si (d, red), and the mass fraction (e).

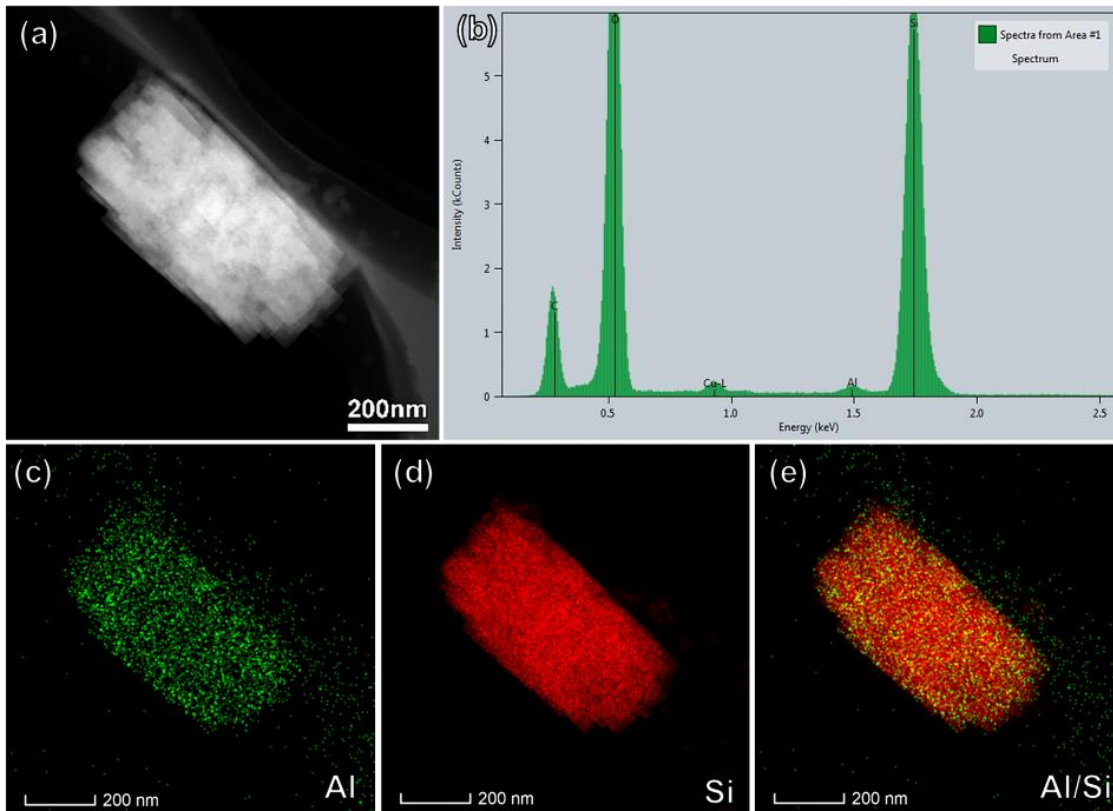


Fig. S7 (a) HAADF-STEM image of Hier-ZSM-5-100; (b) Corresponding EDX spectrum of Hier-ZSM-5-100; (c–e) Corresponding EDX elemental maps: Al (c, green), Si (d, red), and the mass fraction (e).

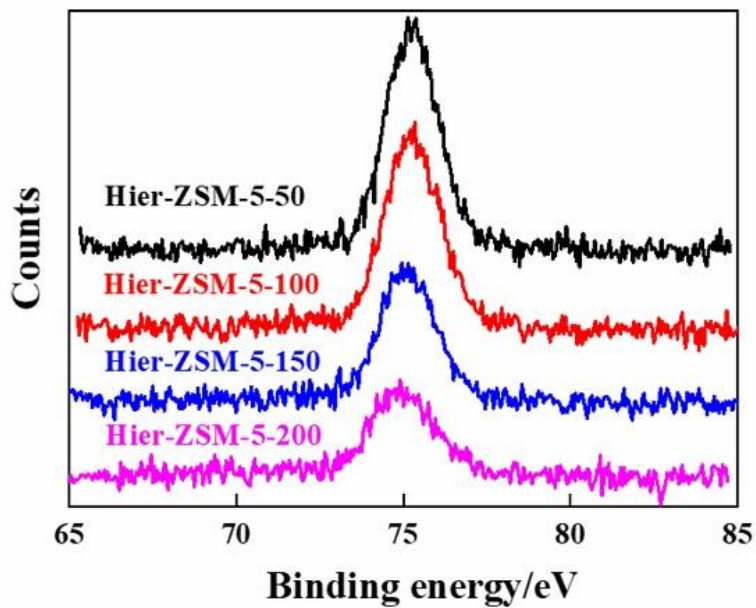


Fig. S8 Al XPS spectra of Hier-ZSM-5-*x*.

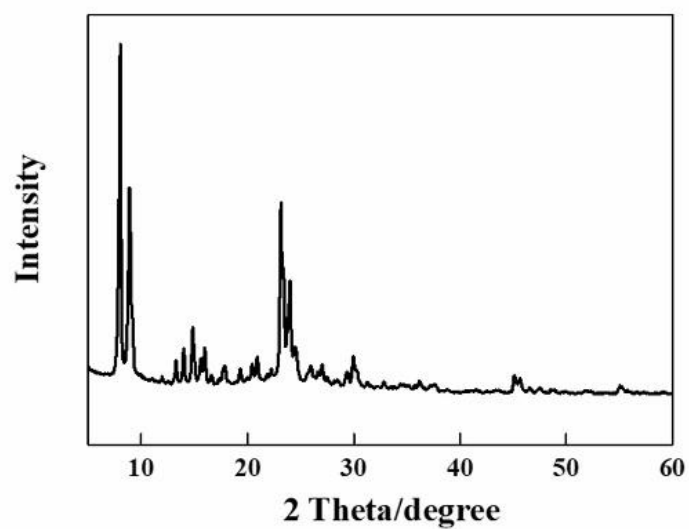


Fig. S9 XRD pattern of Com-ZSM-5.

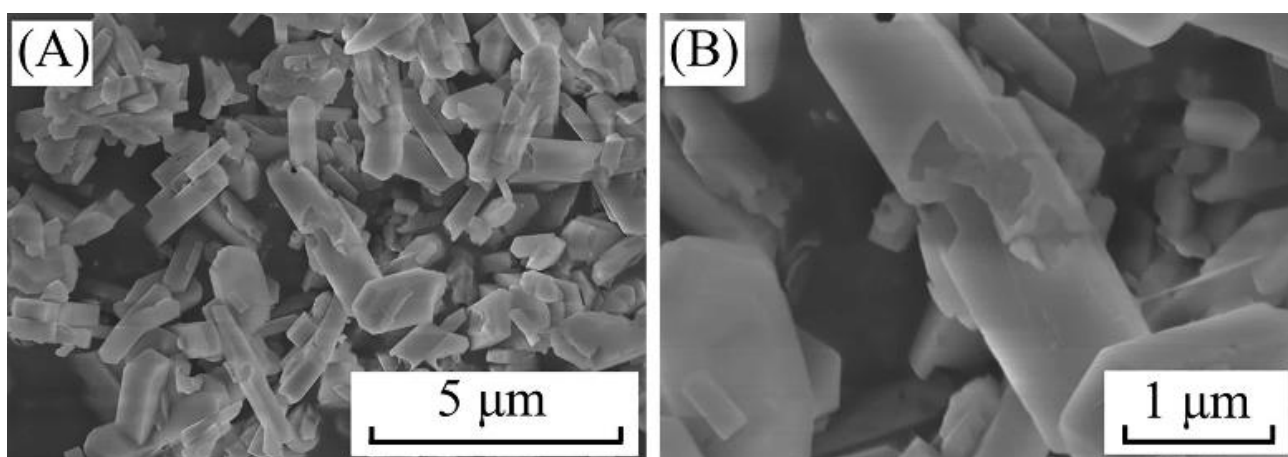


Fig. S10 SEM images of Com-ZSM-5.

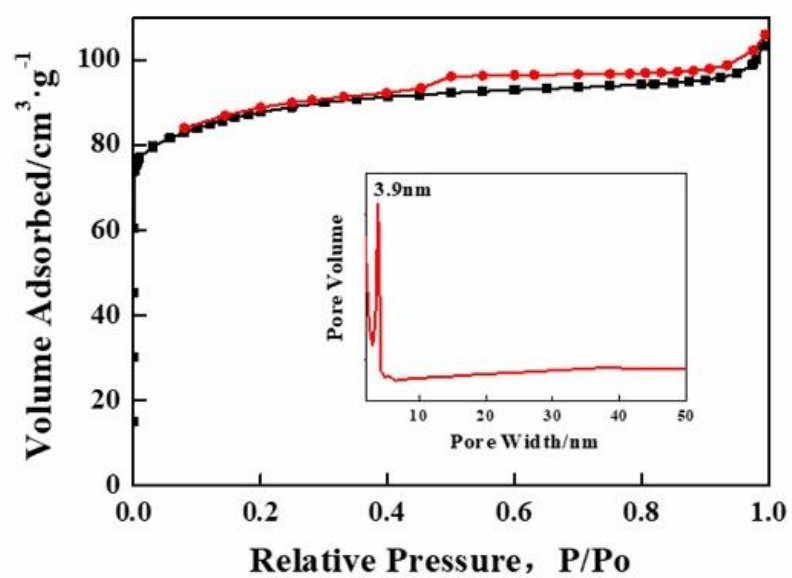


Fig. S11 Nitrogen adsorption-desorption isotherm of Com-ZSM-5 and the inset is the mesopore size distribution.

Table S1 Textural properties for Hier-ZSM-5-100 with hydrothermal stability test

Sample	$S_{BET}^{a)}$	$S_{micro}^{b)}$	$V_{total}^{c)}$
Hier-ZSM-5-100(I)	364	227	0.30
Hier-ZSM-5-100(II)	341	230	0.27
Hier-ZSM-5-100(III)	260	146	0.47

Hier-ZSM-5-100 with different stability tests: (I) crushed with a pressure of 50 MPa, (II) heated at 100 °C for 2 days in Teflon-lined stainless-steel autoclave, (III) treated with steam at 700 °C for two hours. a) BET surface area of the samples (m²/g). b) Micropore surface area of the samples (m²/g). c) Single point adsorption total pore volume at P/P₀ = 0.99 (cm³/g).

Table S2 Distribution of acid sites of Hier-ZSM-5-x

Sample	Distribution of acid sites		
	weak	moderate	strong
Hier-ZSM-5-50	0.37	0.12	0.39
Hier-ZSM-5-100	0.27	0.13	0.33
Hier-ZSM-5-150	0.27	0.10	0.21
Hier-ZSM-5-200	0.20	0.10	0.20

The relative amount of acid sites of Hier-ZSM-5-x was obtained by calculating the corresponding peaks area.