Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Organic promoters driven fast synthesis of zeolite Beta and its acceleration mechanism

Dongpu Zhao[a,b], Weifeng Chu[a,b], Yanan Wang[a,b], Xiangxue Zhu[a], Xiujie Li[a], Sujuan Xie[a], Jie An[a], Wenjie Xin[a], Shenglin Liu[a]*, and Longya Xu[a]*

[a] *State Key Laboratory of Catalysis, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Dalian 116023, Liaoning, China*

[b] *University of Chinese Academy of Sciences, Beijing 100049, China*

* *Correspondence to: slliu@dicp.ac.cn, lyxu@dicp.ac.cn*

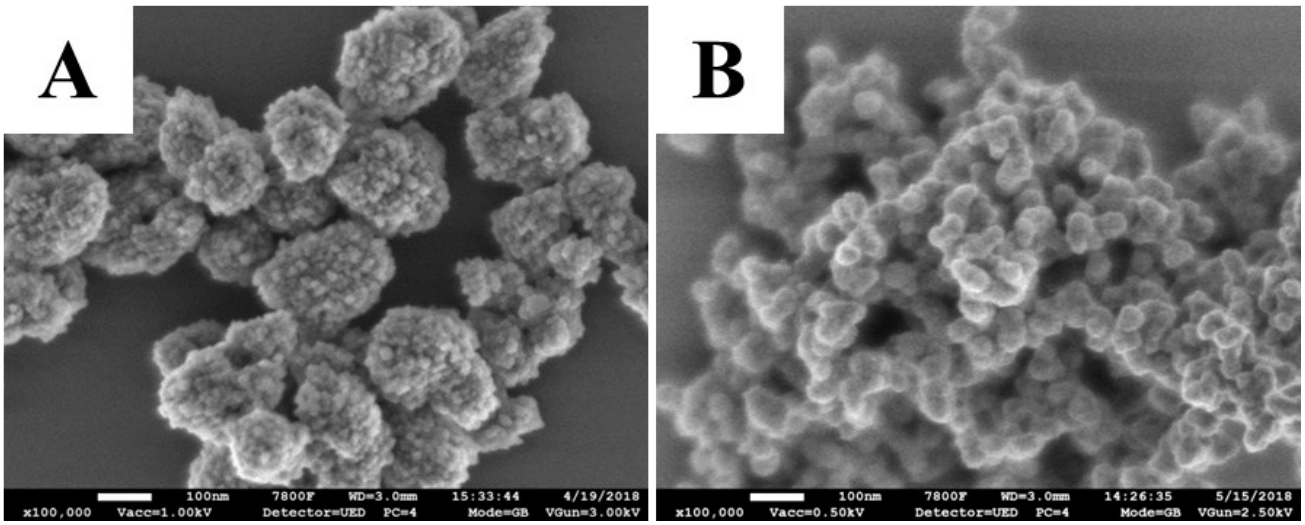


Figure S1. FESEM images of zeolite Beta synthesized with (A) and without (B) NMP at 140 °C for 60 h.

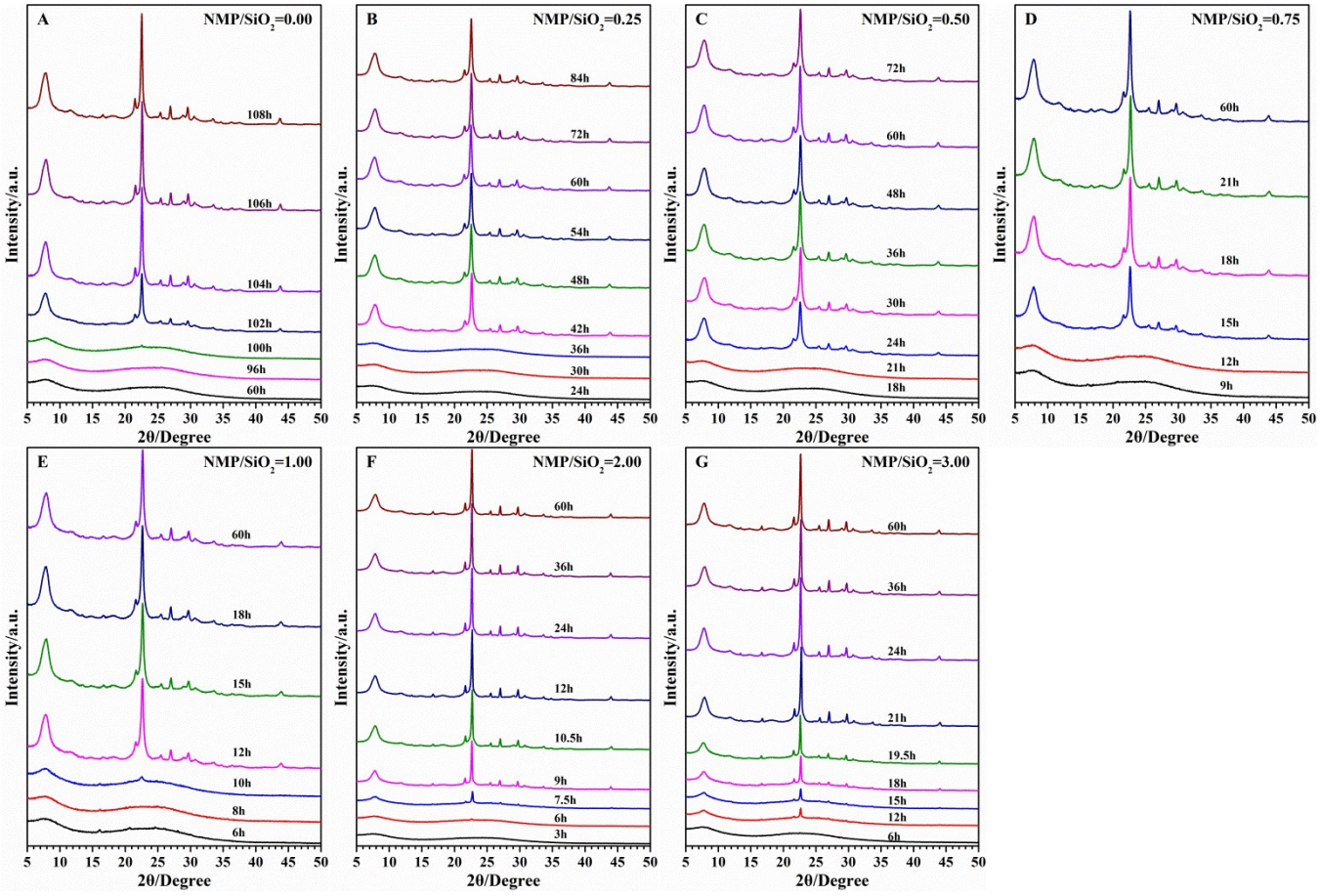


Figure S2. Crystallization process of zeolite Beta synthesized with NMP/SiO_2 molar ratios of 0.00 (A), 0.25 (B), 0.50 (C), 0.75 (D), 1.00 (E), 2.00 (F), and 3.00 (G) at 140 °C.

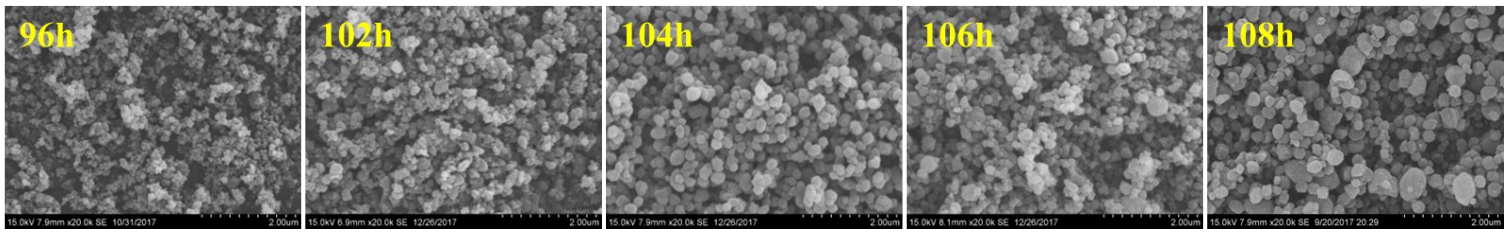


Figure S3. SEM images of the products (with NMP/SiO_2 molar ratio of 0.00) synthesized at 140 °C for different periods of time.

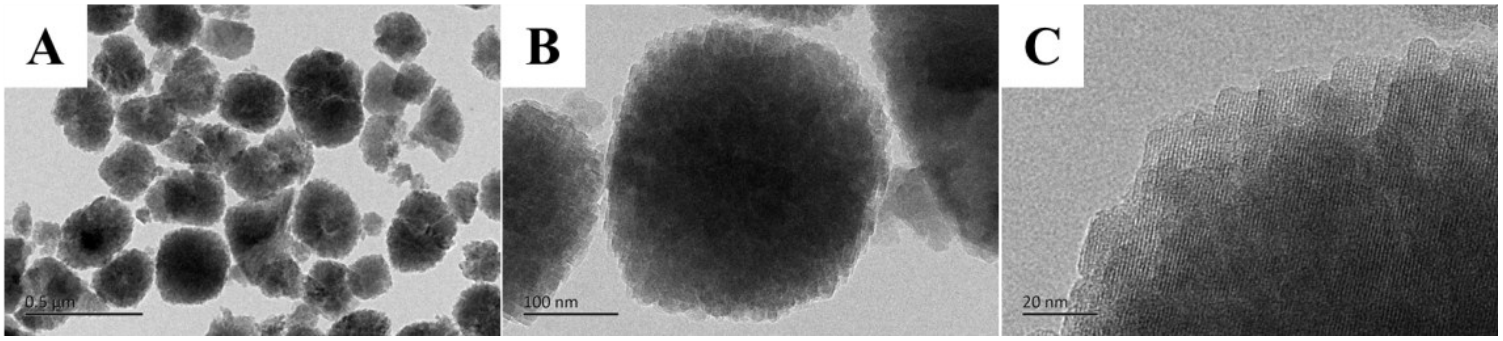


Figure S4. TEM images (A, B) and HRTEM image (C) of the zeolite Beta (with NMP/SiO_2 molar ratio of 0.00) synthesized at 140 °C for 108 h.

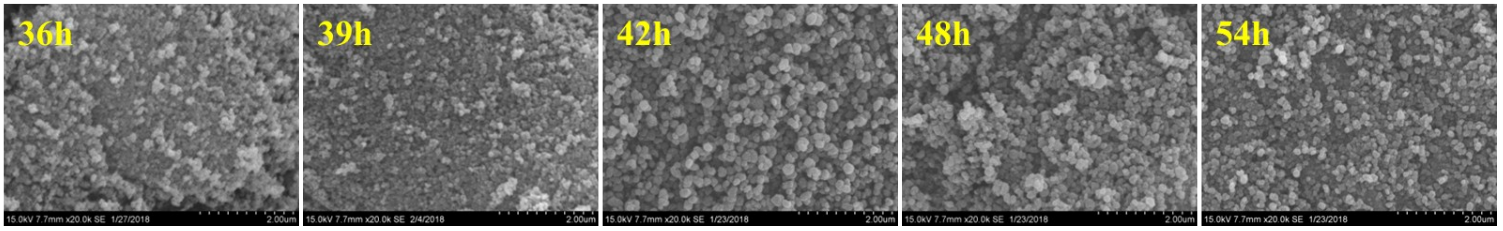


Figure S5. SEM images of the products (with NMP/SiO_2 molar ratio of 0.25) synthesized at 140 °C for different periods of time.

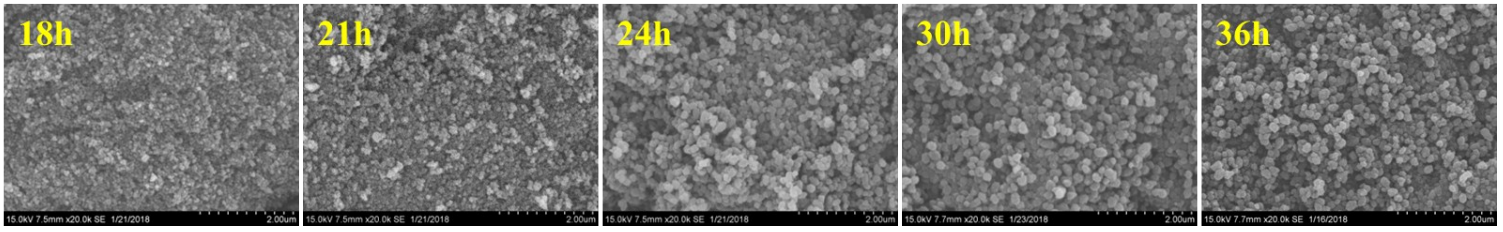


Figure S6. SEM images of the products (with NMP/SiO_2 molar ratio of 0.50) synthesized at 140 °C for different periods of time.

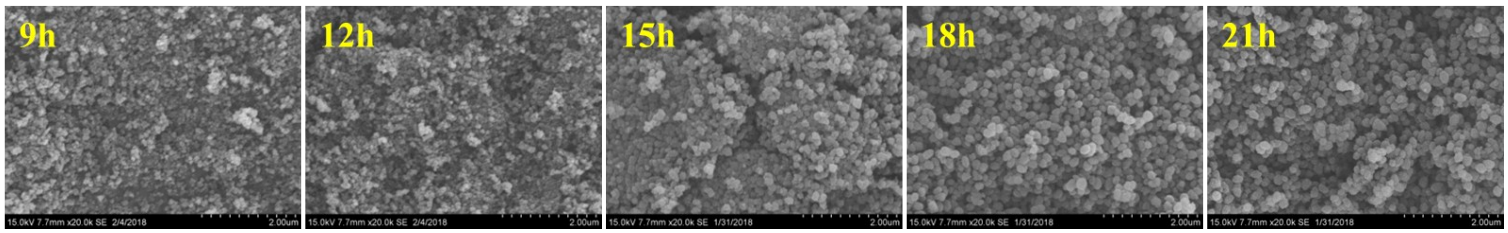


Figure S7. SEM images of the products (with NMP/SiO_2 molar ratio of 0.75) synthesized at 140 °C for different periods of time.

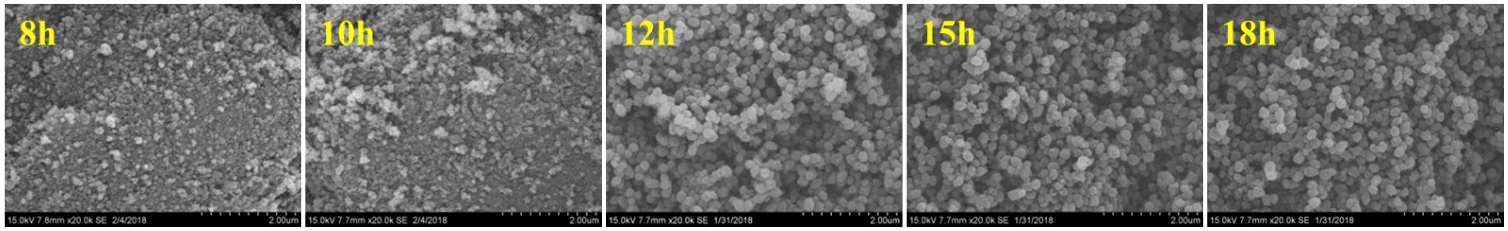


Figure S8. SEM images of the products (with NMP/SiO_2 molar ratio of 1.00) synthesized at 140 °C for different periods of time.

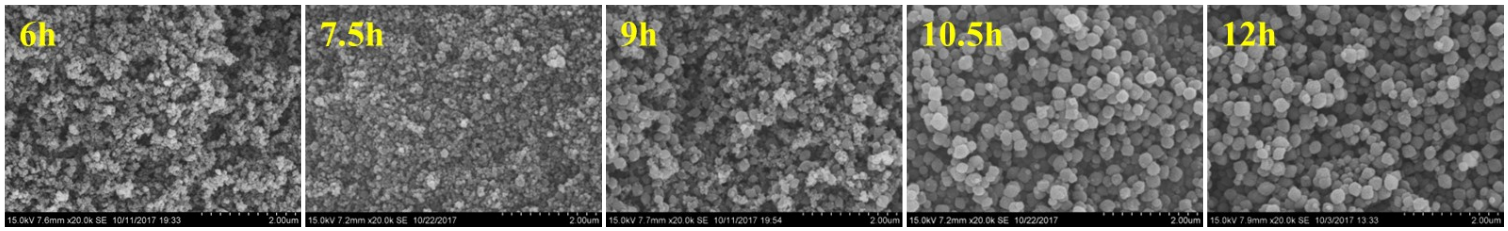


Figure S9. SEM images of the products (with NMP/SiO_2 molar ratio of 2.00) synthesized at 140 °C for different periods of time.

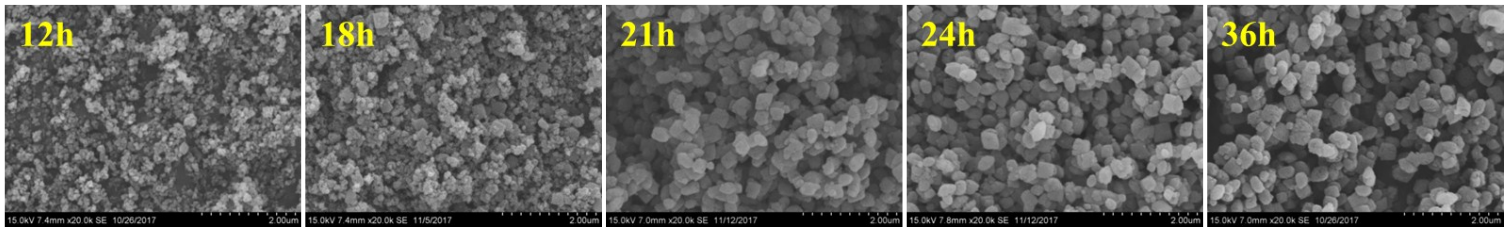


Figure S10. SEM images of the products (with NMP/SiO_2 molar ratio of 3.00) synthesized at 140 °C for different periods of time.

Table S1. Synthesis conditions, Si/Al ratio and N_2 adsorption data of the samples

Sample	NMP/SiO_2	Time/Temperature(°C)	Si/Al (XRF)	S_{BET}	V_{micro}	S_{ext}	V_{meso}

Beta	0.00	108 h/140	12.03	728	0.215	180	0.283
Beta	0.50	60 h/140	13.20	682	0.195	195	0.554
Beta	1.00	60 h/140	14.81	725	0.201	216	0.584
Beta	2.00	60 h/140	18.08	736	0.222	175	0.365
Beta	3.00	60 h/140	18.25	737	0.232	147	0.285

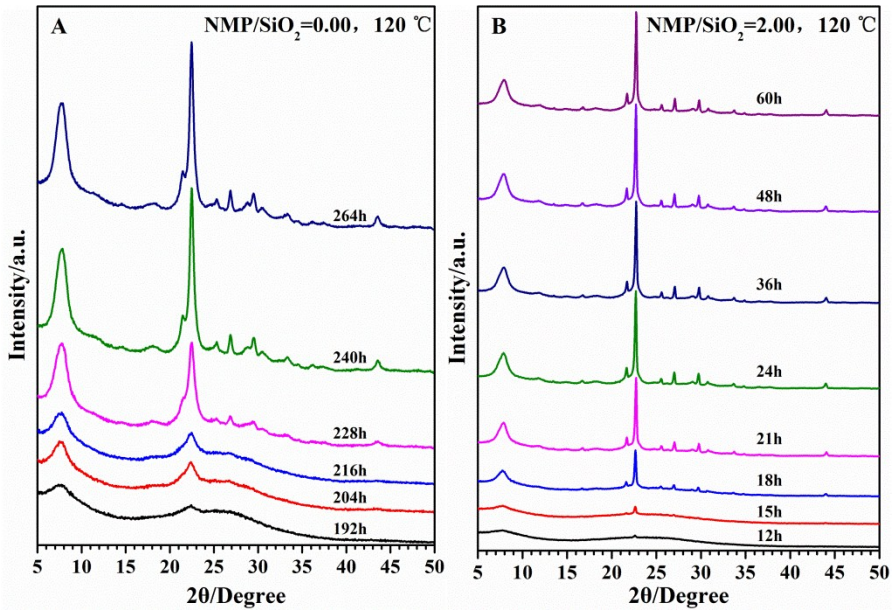


Figure S11. Crystallization process of the products synthesized without (A) and with (B) NMP at 120 °C.

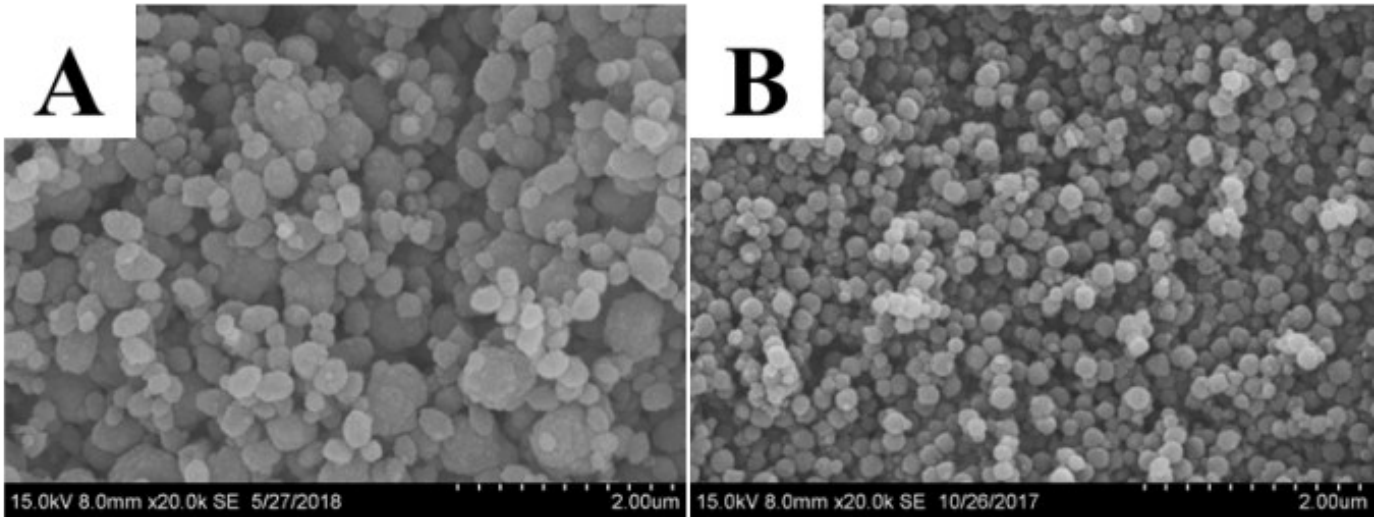


Figure S12. SEM images of zeolite Beta synthesized without (A, 240 h) and with (B, 24 h) NMP at 120 °C.

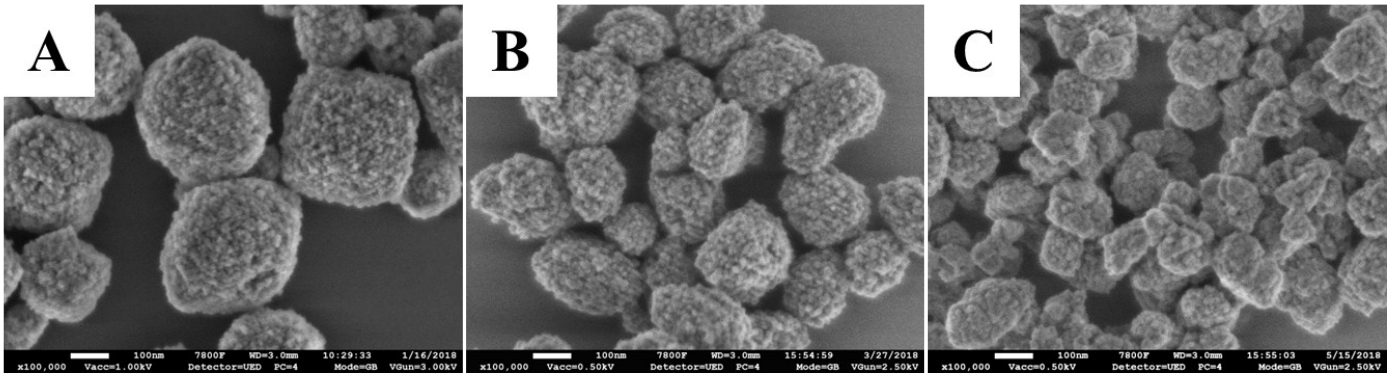


Figure S13. FESEM images of zeolite Beta (P/SiO_2 = 0.50) synthesized by using 2-pyrrolidinone (A: 18 h), NEP (B: 21 h) and NPP (C: 120 h) as promoter.

Figure S14. Photograph of the supernatant of the sample (P/SiO_2 = 0.50) synthesized by using NPP as promoter.

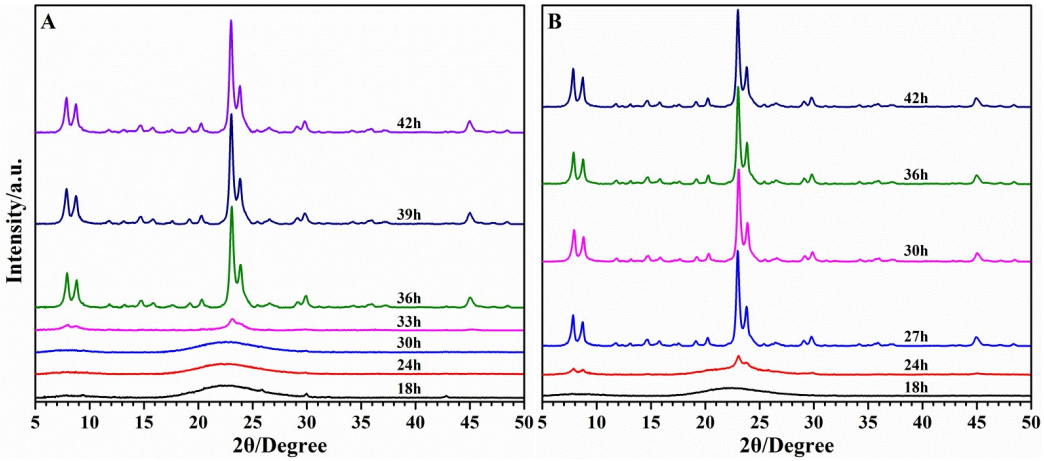


Figure S15. Crystallization process of ZSM-11 synthesized without (A) and with (B) NMP at 150 °C. Molar gel composition: *x* NMP/1.0 SiO_2/0.15 Na_2O/0.016 Al_2O_3/0.2 TBABr/40 H_2O (*x* = 0.00 and 1.00).

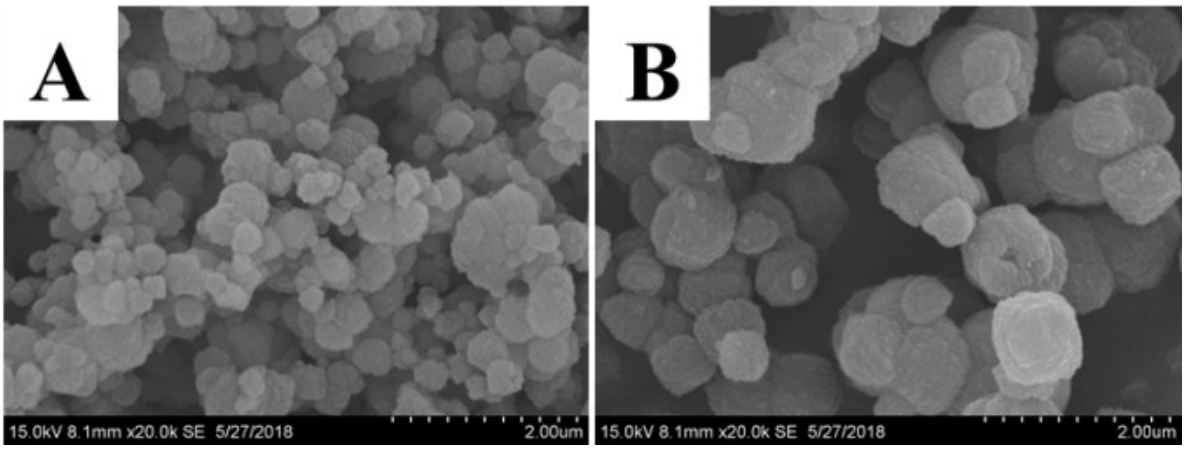


Figure S16. SEM images of ZSM-11 synthesized without (A, 39 h) and with (B, 27 h) NMP at 150 °C.

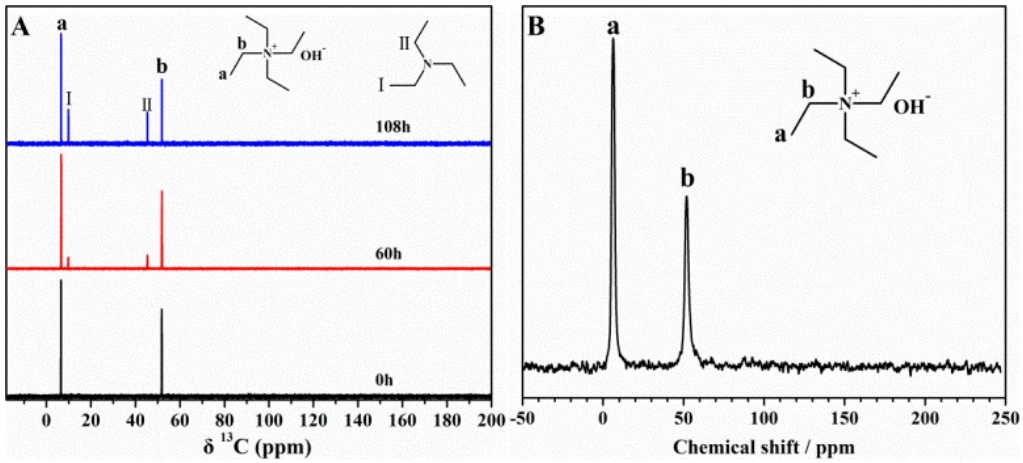
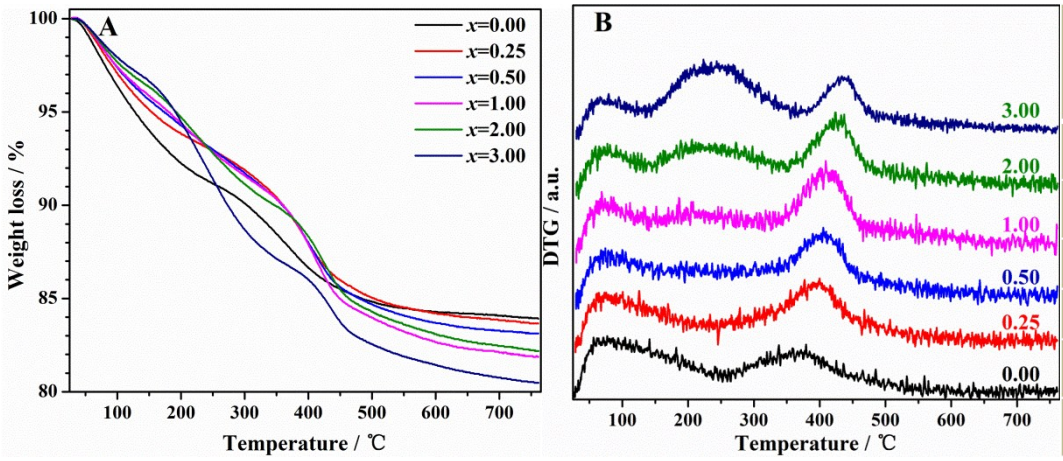


Figure S17. (A) Liquid-state ^{13}C NMR spectra of the supernatants. (B) Solid-state ^{13}C NMR spectrum of the final product (at 140 °C for 108 h).



NMP/SiO_2	TEA^+ weight loss (wt%)
0.00	7.24
0.25	9.31
0.50	12.22
1.00	14.27
2.00	14.38
3.00	16.43

Figure S18. TG (A) and DTG (B) curves of the samples synthesized with different NMP/SiO_2 molar ratios after 3 h of heating at 140 °C. The table gave the corresponding weight loss assigned to TEA^+.

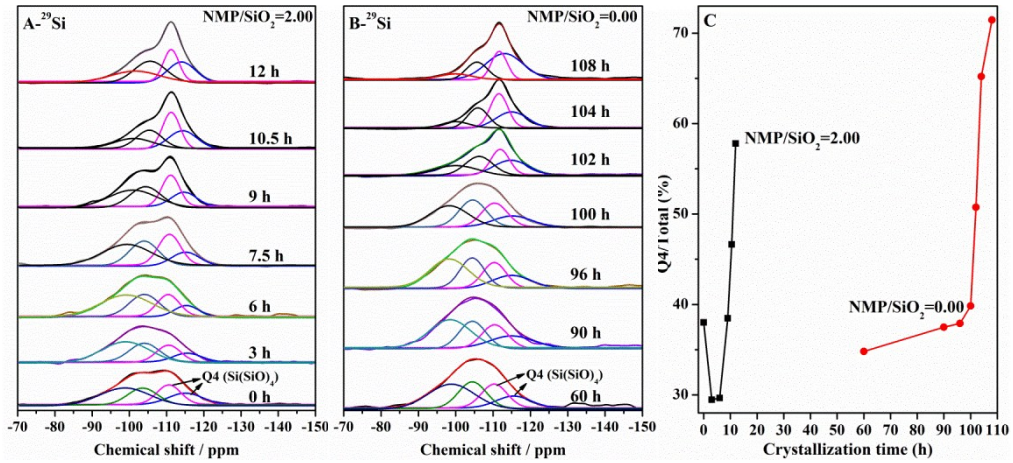


Figure S19. Deconvoluted ^{29}Si MAS NMR spectra of the samples synthesized with (A) and without (B) NMP, crystallization-time dependence of relative concentration of Q4 ($Si(SiO)_4$) species (from ^{29}Si MAS NMR).

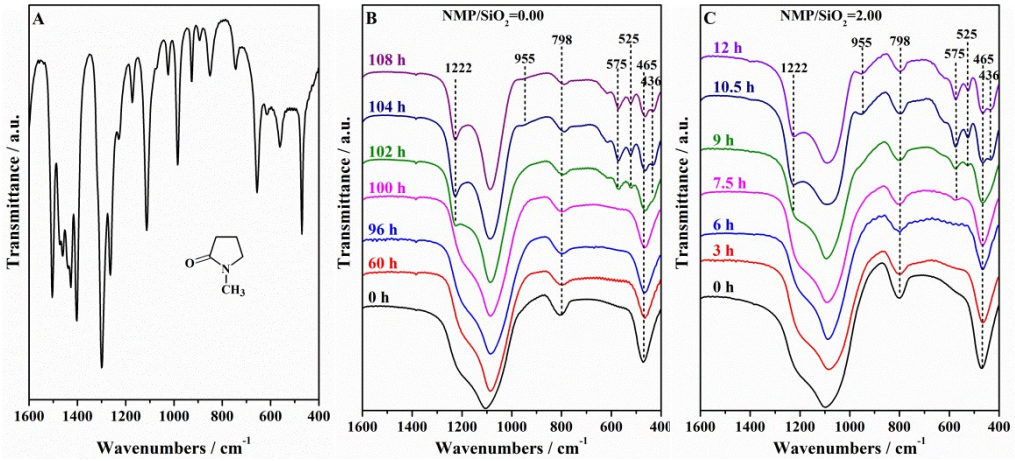
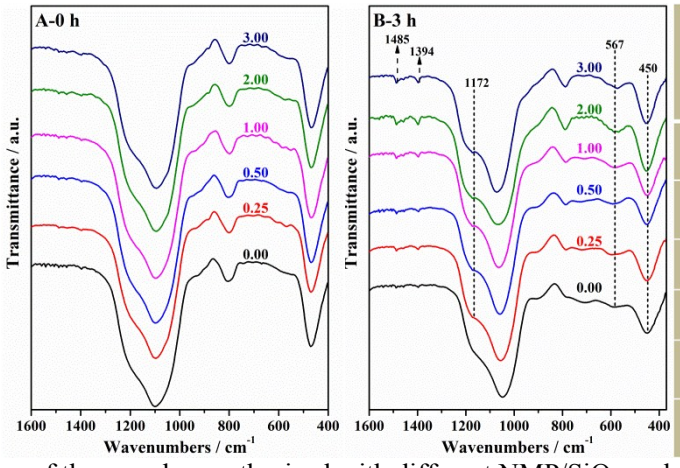


Figure S20. FT-IR spectra of NMP (A), and the calcined samples synthesized without (B: NMP/SiO_2 = 0.00) and with (C: NMP/SiO_2 = 2.00) NMP.



NMP/SiO_2	S_{567}/S_{450}
3.00	0.145
2.00	0.191
1.00	0.185
0.50	0.135
0.25	0.127
0.00	0.080

Figure S21. FT-IR spectra of the samples synthesized with different NMP/SiO_2 molar ratios after 0 h (A) and 3 h (B) of heating

at 140 °C. The table quantified the 5Rs concentration in the samples (at 140 °C for 3 h) by comparing the peak area of 5Rs (at 567 cm^{-1}) with that of T-O bending vibration (at 450 cm^{-1}).

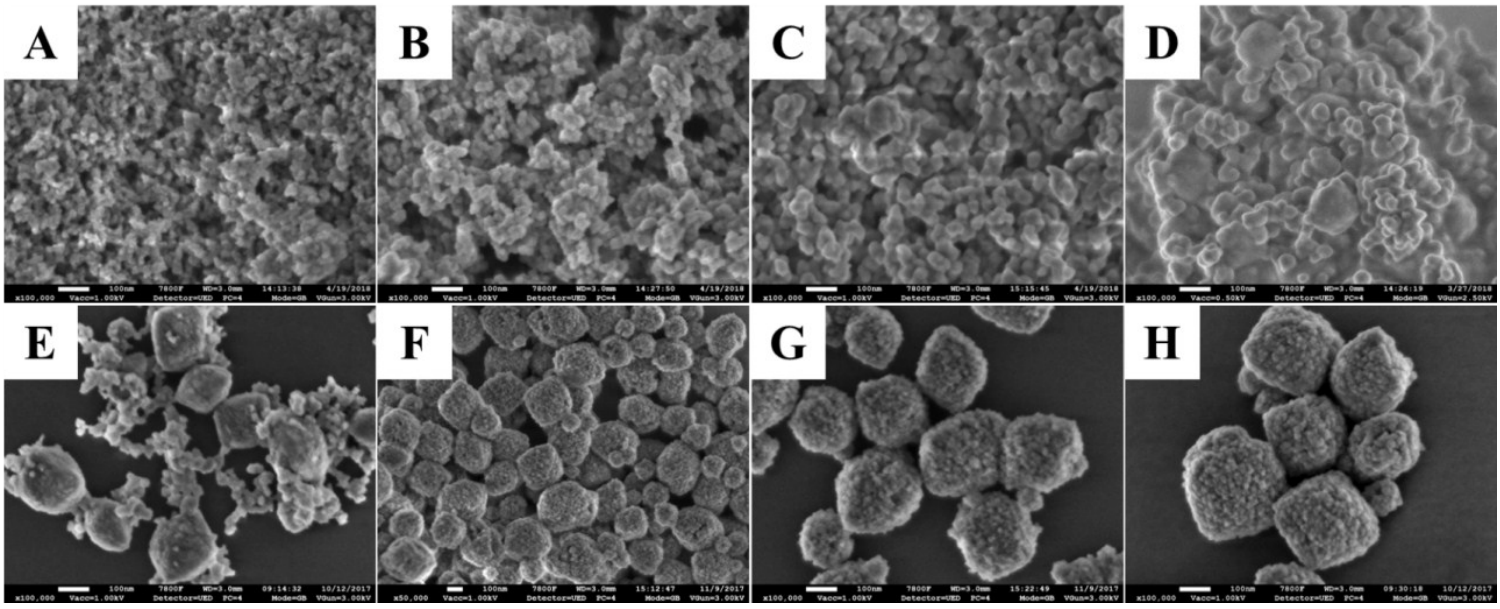


Figure S22. FESEM images of the products (with NMP/SiO_2 molar ratio of 2.00) synthesized at 140 °C for different periods of time: (A) 0 h, (B) 3 h, (C) 6 h, (D) 7.5 h, (E) 9 h , (F and G) 10.5 h, and (H) 12 h.

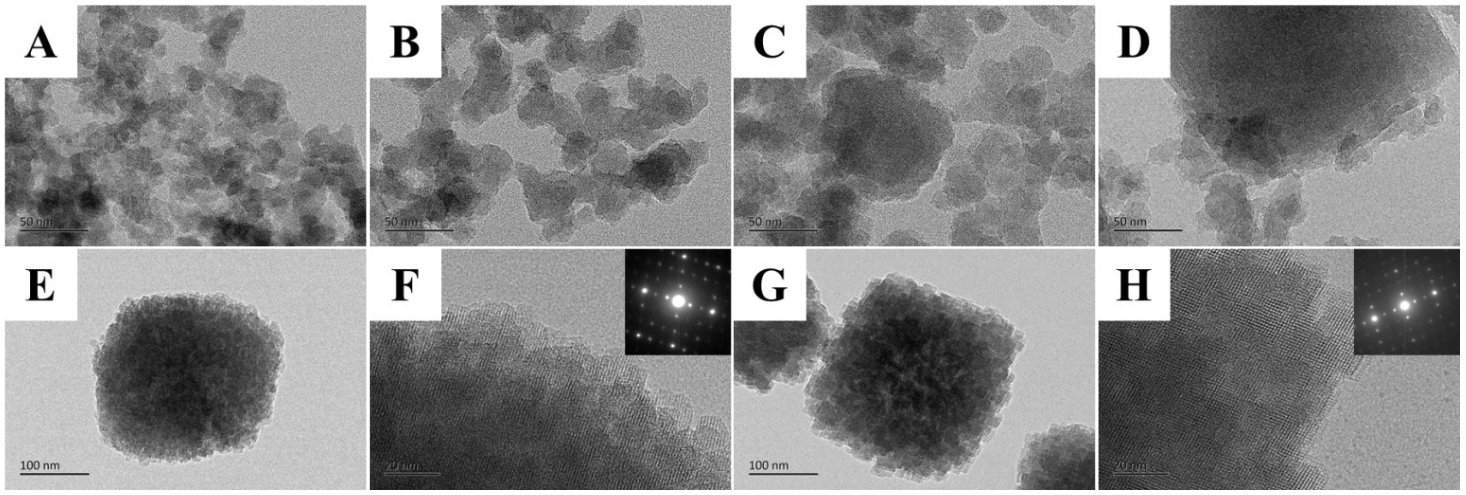


Figure S23. TEM images of the products (with NMP/SiO_2 molar ratio of 2.00) synthesized at 140 °C for different periods of time: (A) 0 h, (B) 3 h, (C) 6 h, (D) 9 h, (E) 10.5 h, and (G) 12 h. HRTEM images of the products obtained at 10.5 h (F), and 12 h (H).

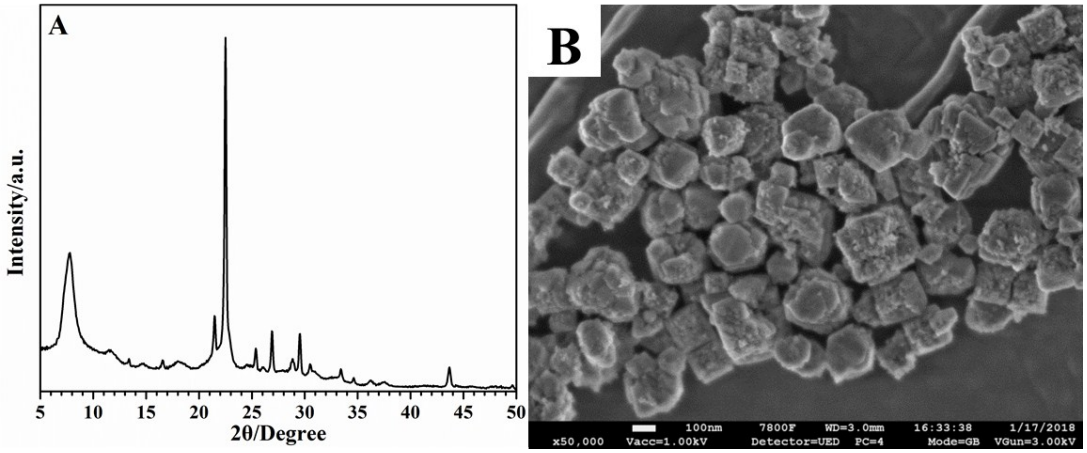


Figure S24. XRD pattern (A) and SEM image (B) of C-Beta.

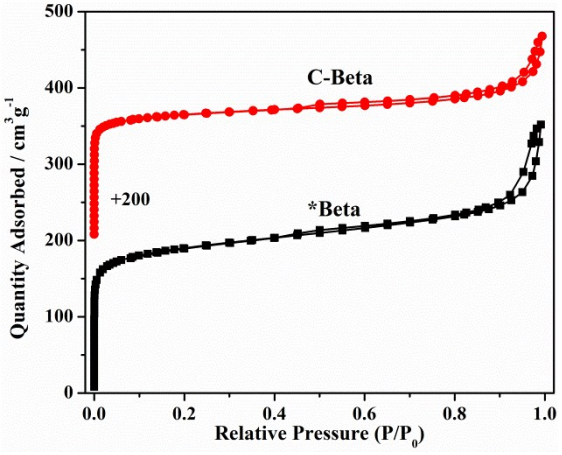


Figure S25. N_2 sorption isotherms for *Beta and C-Beta.

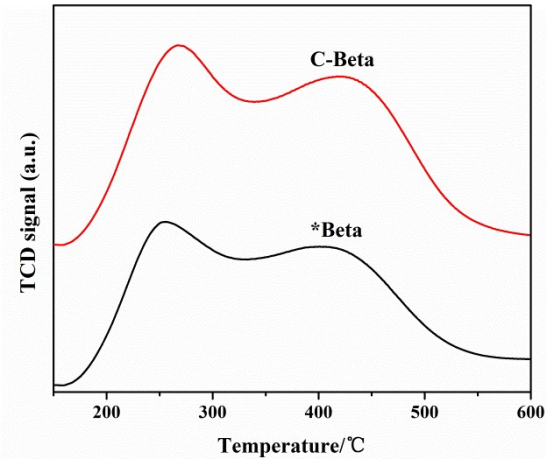


Figure S26. NH_3-TPD profiles for *Beta and C-Beta.

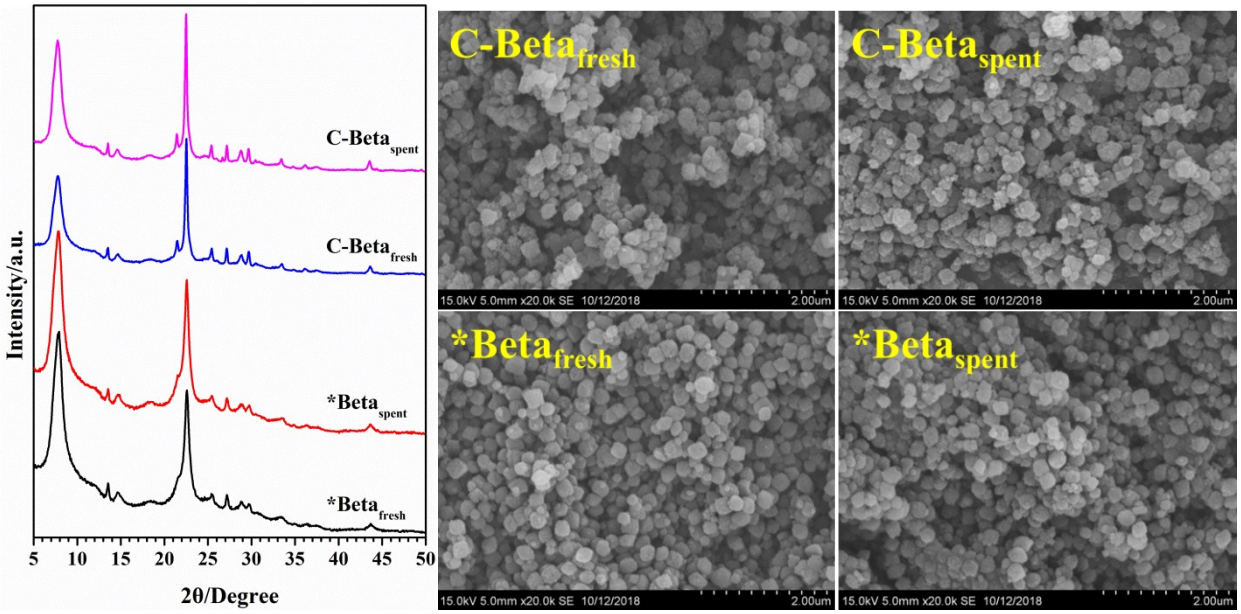


Figure S27. XRD patterns and SEM images of fresh (H-form) and spent samples.