Electronic Supporting Information

Bimetallic Fe-Cu/Beta zeolite catalysts for direct hydroxylation of benzene to phenol: effect of the sequence of ion exchange for Fe and Cu cations

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Table S1 XPS quantitative analysis of the Fe-containing Beta zeolite catalysts.

Sample	Fe species (%)	
	Fe^{2+}	Fe^{3+}
6Fe	60.3	39.7
6Fe/6Cu	60.1	39.9
6Cu/6Fe	64.5	35.5
6Fe-6Cu	71.2	28.8

Table S2 The elements contents in the liquid and the output solid products for 6Fe/*x*Cu and 6Cu/*y*Fe Beta zeolite catalysts.

Sample	Input			Output solid				Output liquid (ppm)			
	Support	Solution (ppm)	Si/Al	Si/Fe	Si/Cu	Fe (wt.%)	Cu (wt.%)	Si	Al	Cu	Fe
6Fe/1.5Cu	6Fe	$Cu(NO_3)_2$ 145	26	17	121	5.7	0.4	141	16	114	0
6Fe/3Cu		$Cu(NO_3)_2$ 258	24	17	111	5.7	0.4	157	17	223	0
6Fe/6Cu		$Cu(NO_3)_2$ 488	24	17	87	5.7	1.1	153	20	393	0
6Cu/1.5Fe	6Cu	$Fe(NO_3)_3$ 176	16	94	300	1.0	0.3	158	33	130	0
6Cu/3Fe		$Fe(NO_3)_3$ 234	16	38	532	2.2	0.2	165	48	159	0
6Cu/6Fe		$Fe(NO_3)_3$ 520	19	13	676	6.0	0.2	170	101	167	9

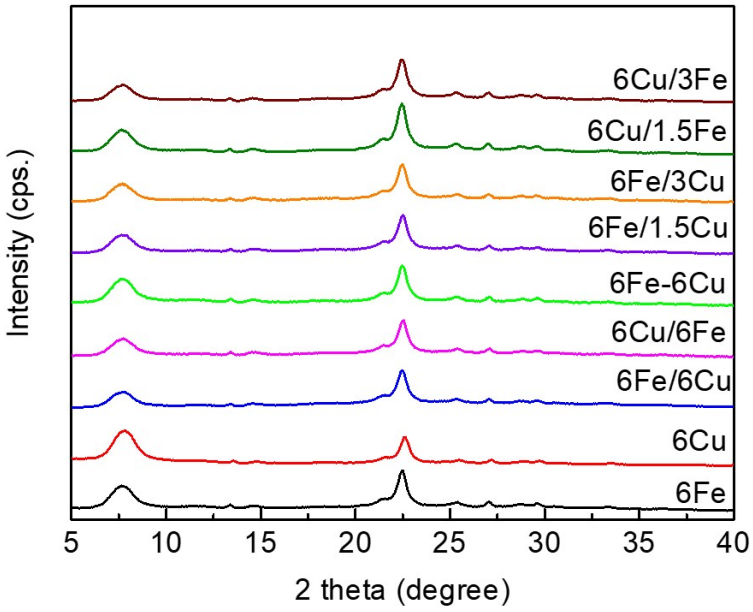

Fig. S1 XRD patterns of (a) the Fe and Cu-containing Beta zeolite catalysts prepared by liquid phase ion exchange.

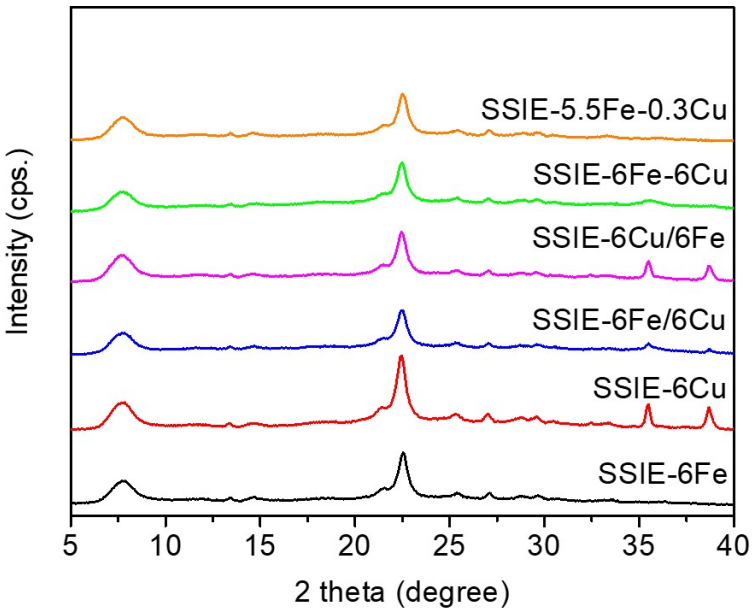

Fig. S2 XRD patterns of the Fe and Cu-containing Beta zeolite catalysts prepared by solid state ion exchange.

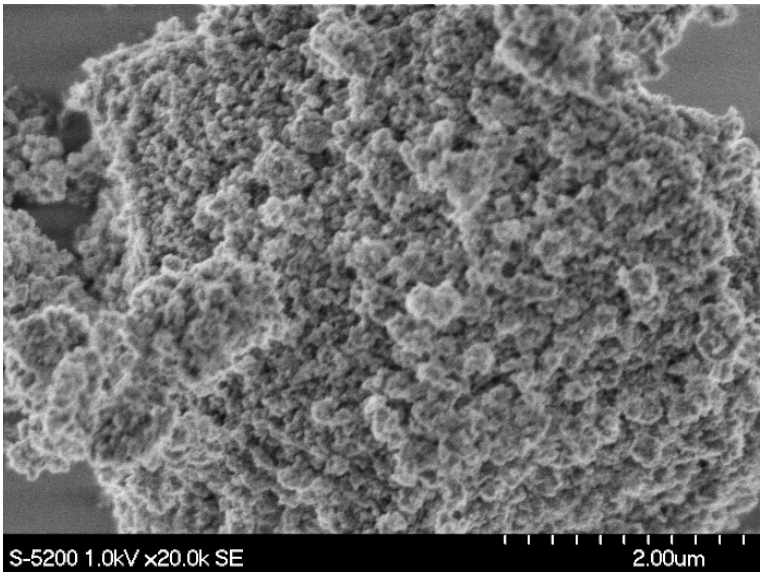

Fig. S3 SEM image of parent Beta zeolite.

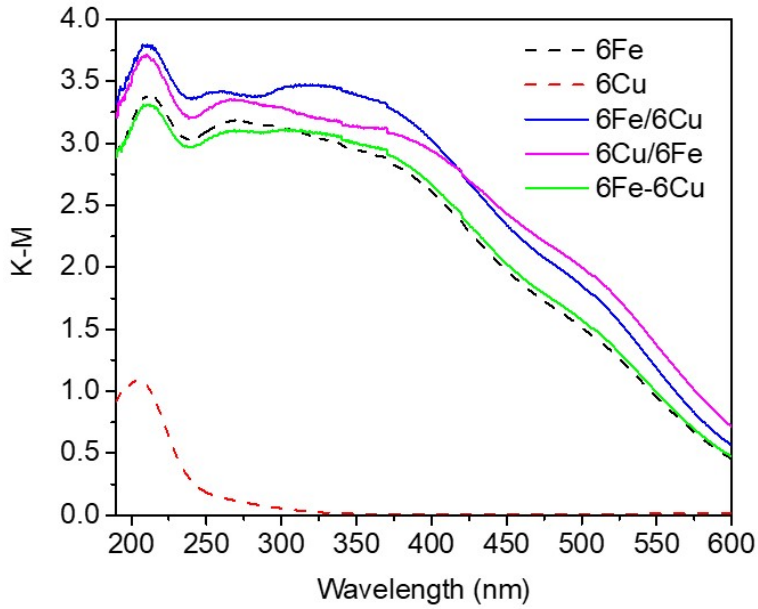

Fig. S4 UV-vis spectra of the Fe and Cu-exchanged Beta zeolite catalysts.

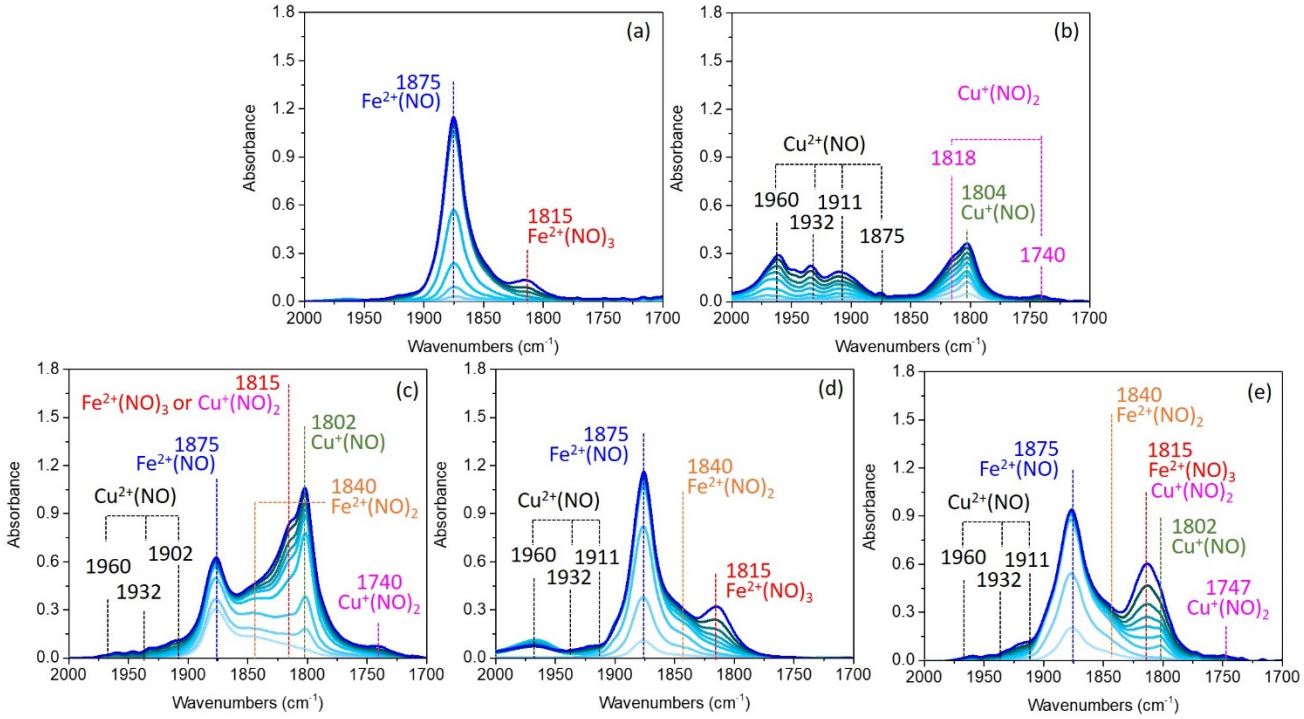

Fig. S5 NO adsorption of FTIR spectra (P_{NO}=5-1000 Pa) for (a) 6Fe, (b) 6Cu, (c) 6Fe/6Cu, (d) 6Cu/6Fe and (e) 6Fe-6Cu Beta zeolite catalysts.

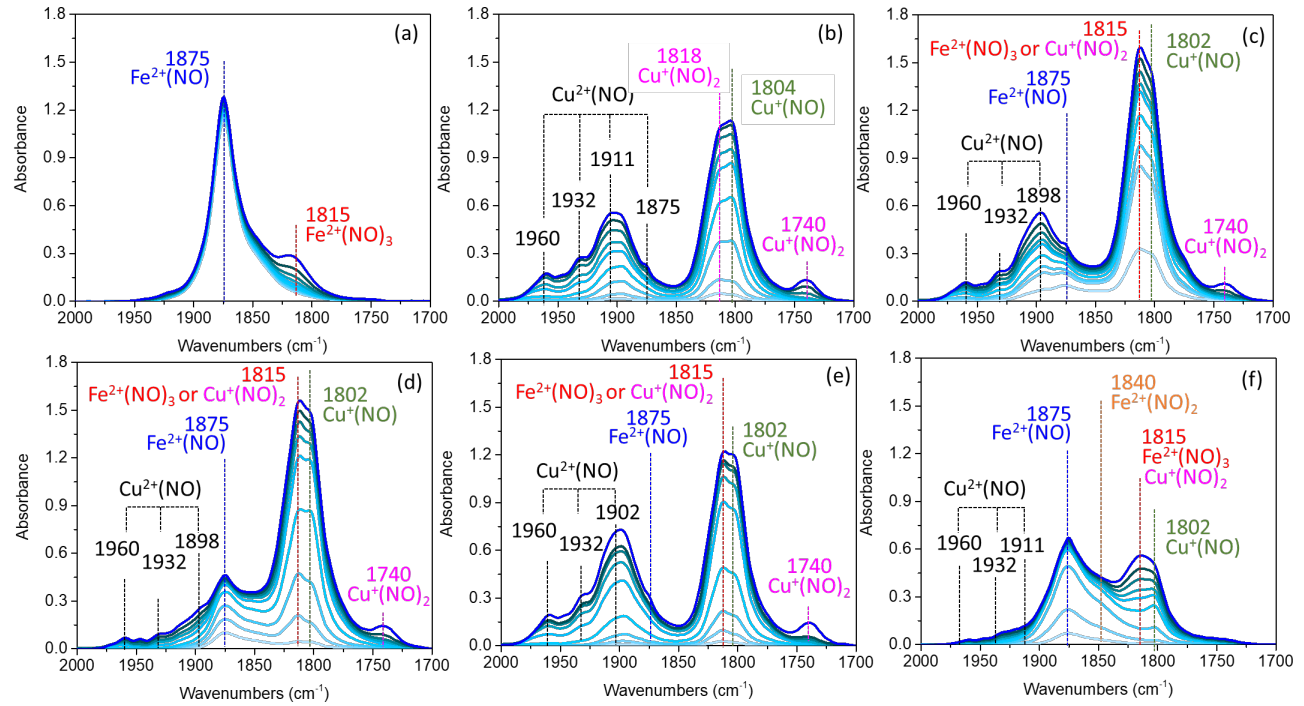

Fig. S6 NO adsorption of FTIR spectra (P_{NO}=5-1000 Pa) for (a) SSIE-6Fe, (b) SSIE-6Cu, (c) SSIE-6Fe/6Cu, (d) SSIE-6Cu/6Fe, (e) SSIE-6Fe-6Cu and (f) SSIE-5.5Fe-0.3Cu Beta zeolite catalysts.

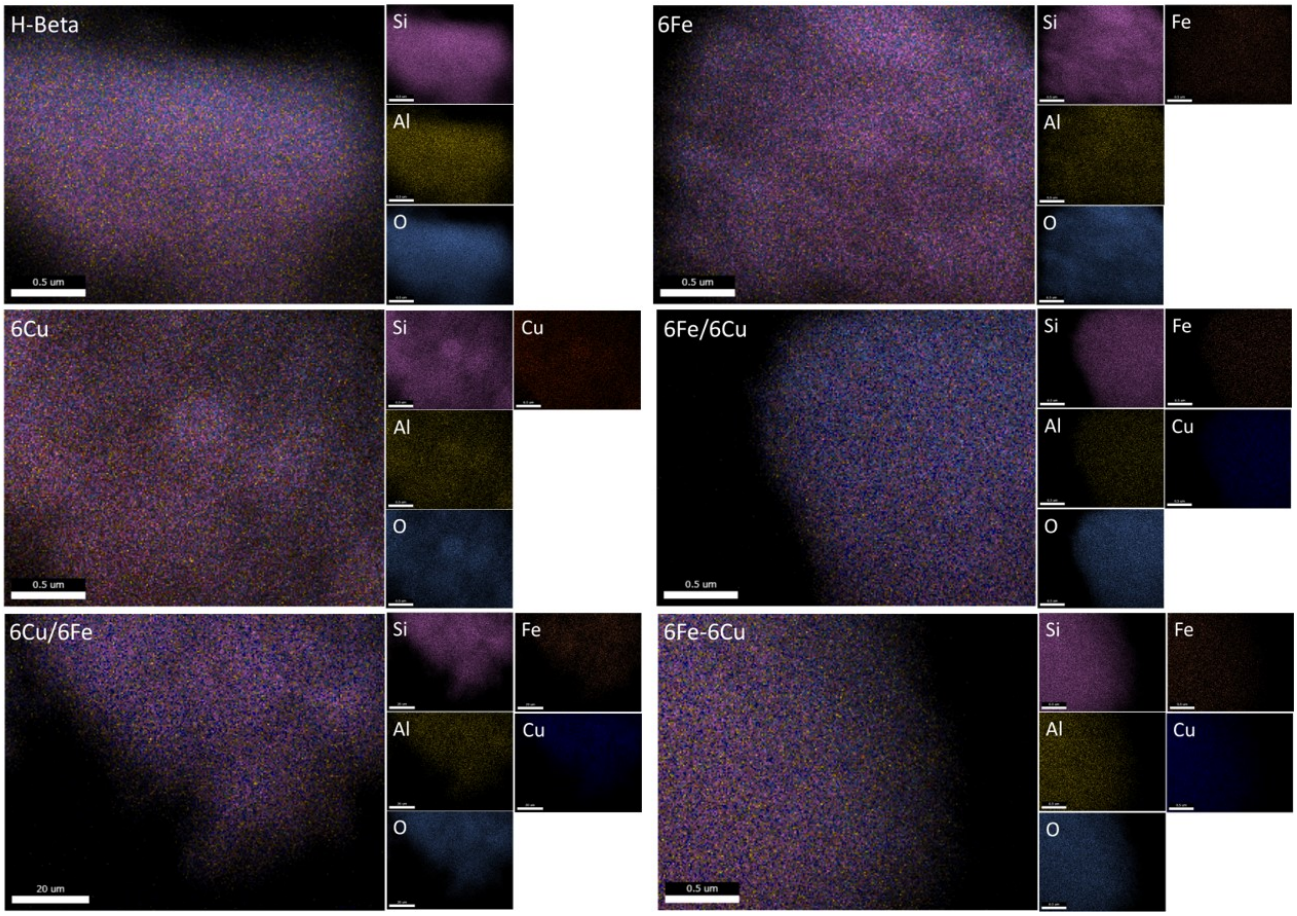

Fig. S7 EDX elemental mapping images of the Beta zeolite catalysts prepared by the ion exchange method.

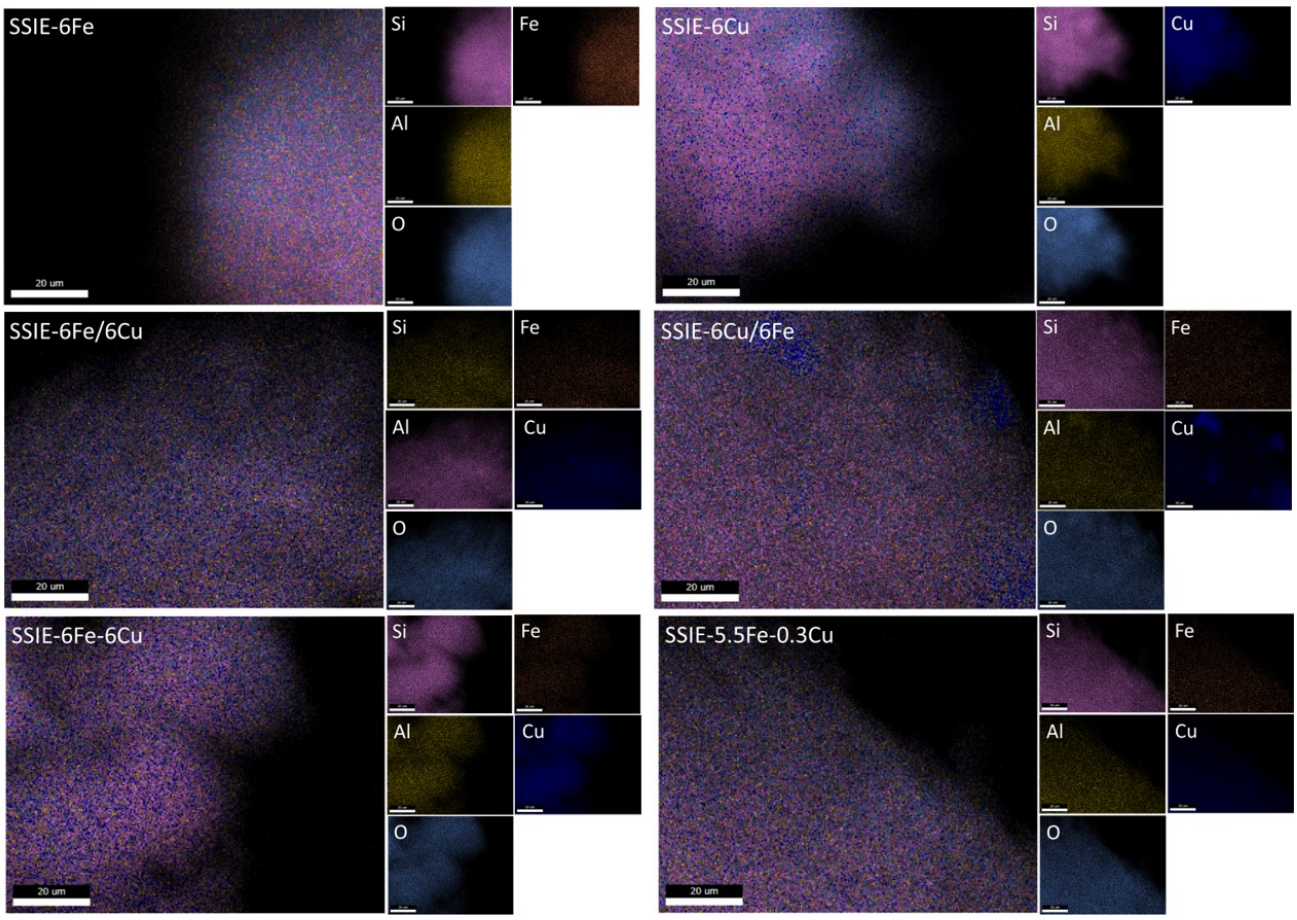

Fig. S8 EDX elemental mapping images of the Beta zeolite catalysts prepared by “solid state ion exchange (SSIE) method”.