

In-situ synthesis of a hybrid Fe (Co)/MXene/ZSM-5 catalyst for phenol abatement

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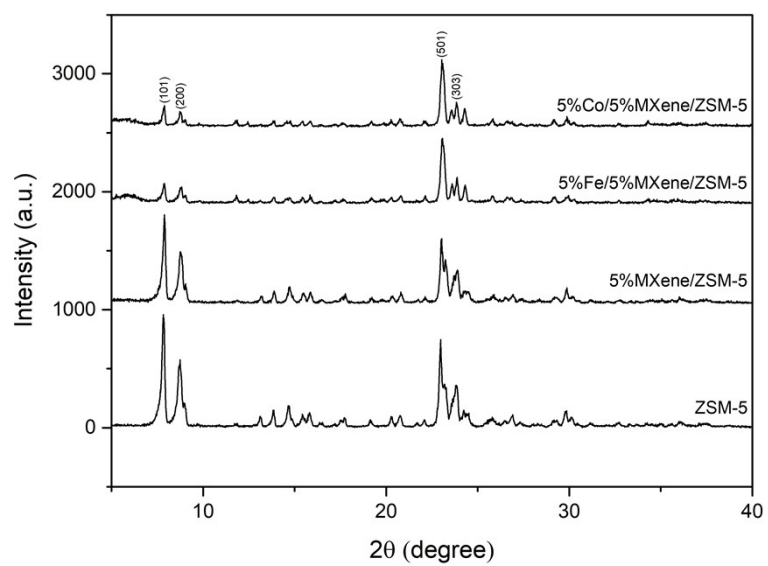


Fig. S1 The XRD patterns of ZSM-5, 5%MXene/ZSM-5, 5%Fe/5%MXene/ZSM-5 and 5%Co/5%MXene/ZSM-5.

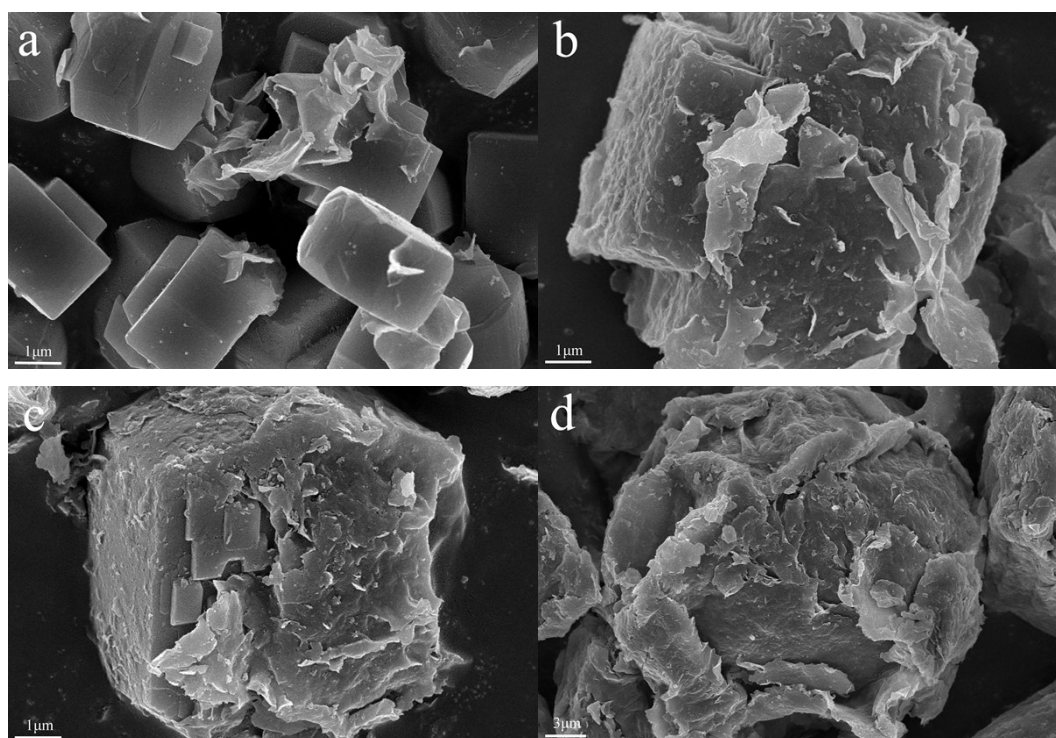


Fig. S2 The SEM images of (a) 1%MXene/ZSM-5, (b) 3%MXene/ZSM-5, (c) 5%MXene/ZSM-5 (c), and (d) 7%MXene/ZSM-5.

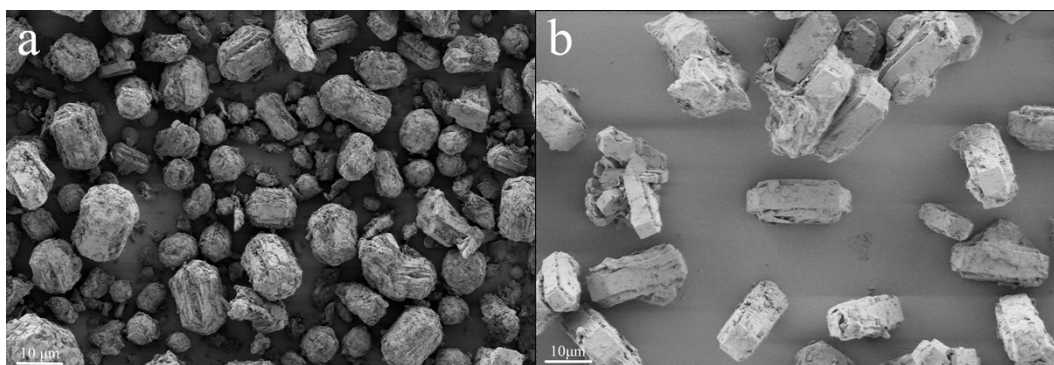


Fig. S3 The SEM images of (a) 5%Fe/5%MXene/ZSM-5, and (b) 5%Co/5%MXene/ZSM-5.

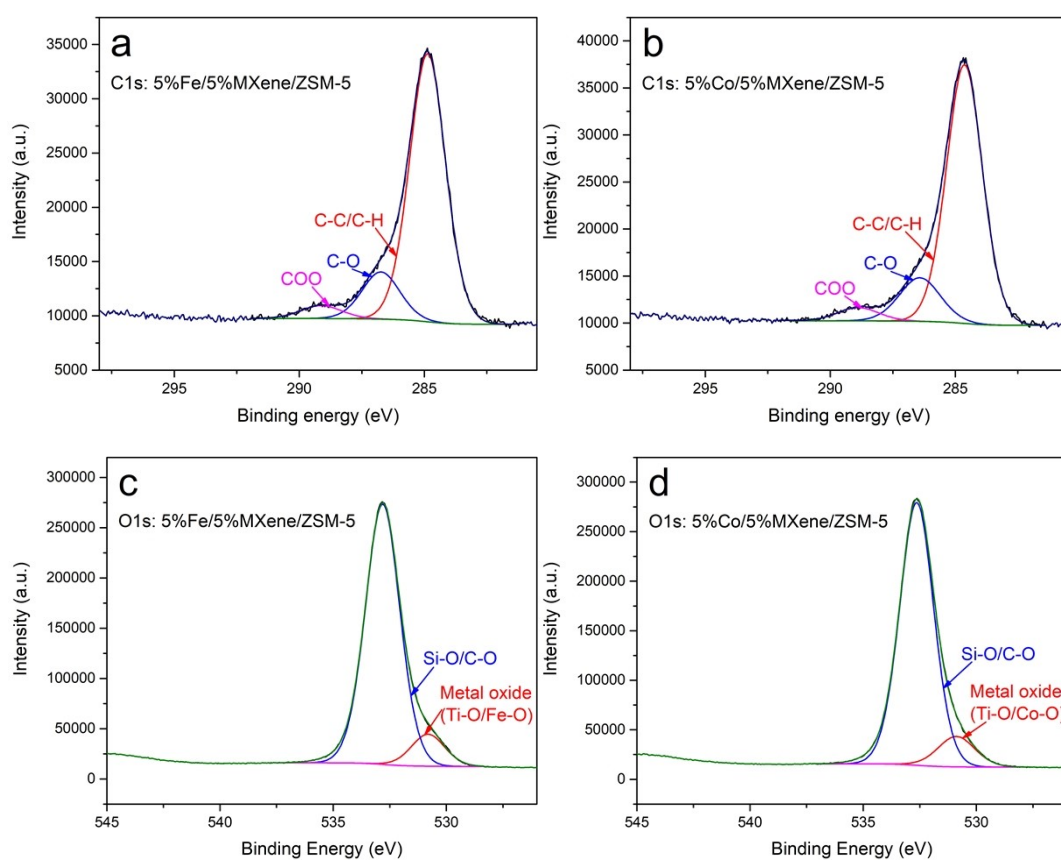


Fig. S4 (a, b) C1s spectra of 5%Fe/5%MXene/ZSM-5 and 5%Co/5%MXene/ZSM-5. (c, d) O1s spectra of 5%Fe/5%MXene/ZSM-5 and 5%Co/5%MXene/ZSM-5.

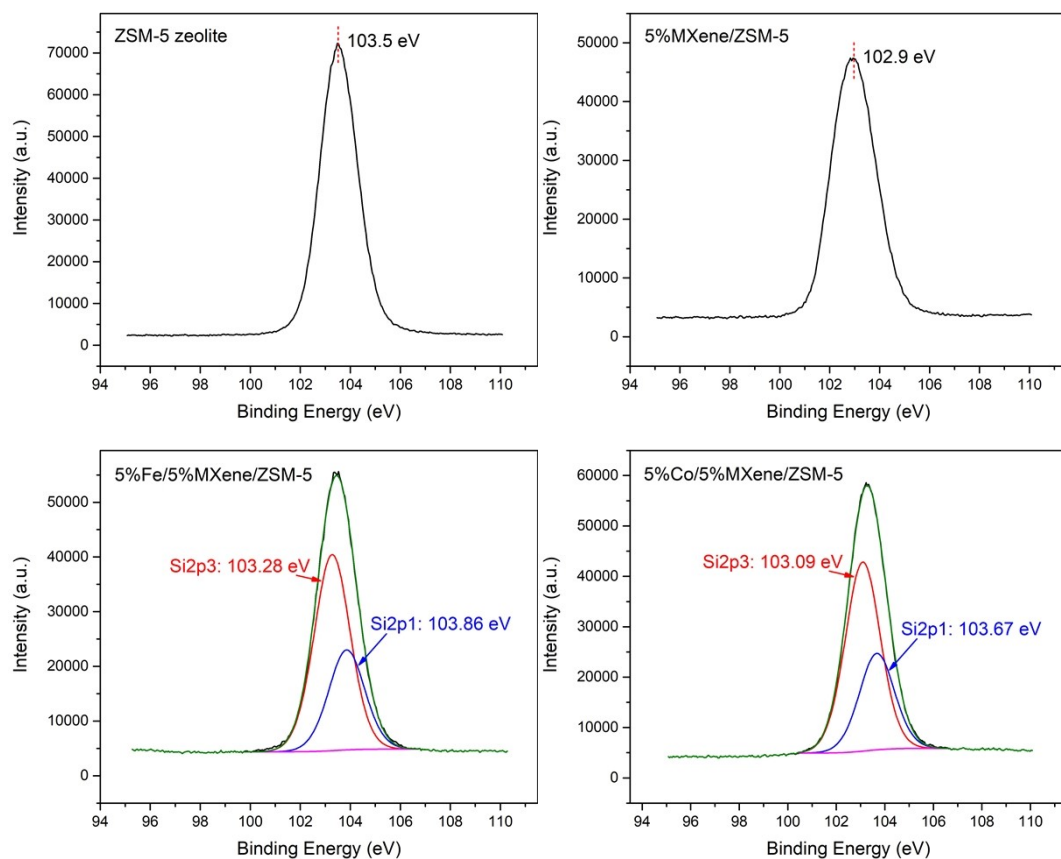


Fig. S5 The Si2p spectra of ZSM-5, 5%MXene/ZSM-5, 5%Fe/5%MXene/ZSM-5, and 5%Co/5%MXene/ZSM-5.

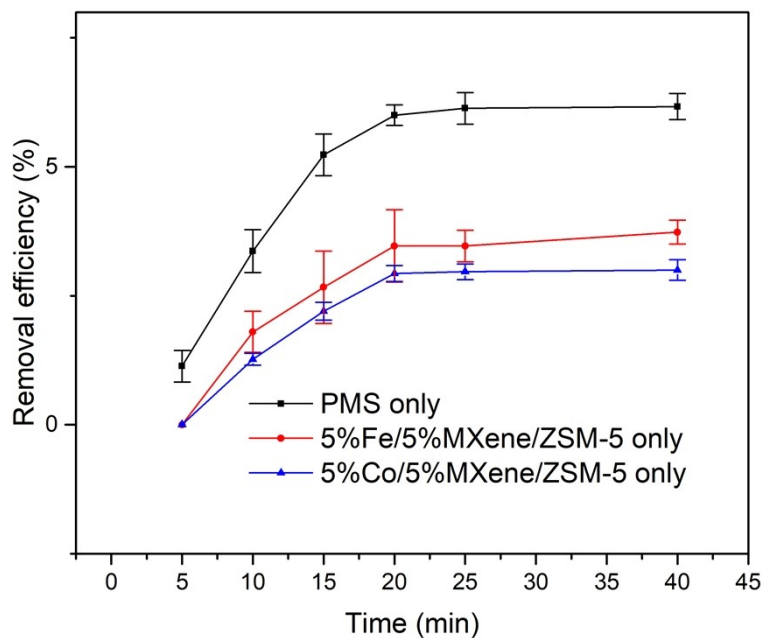


Fig. S6 The effects of PMS alone, 5%Fe/5%MXene/ZSM-5 alone, and 5%Co/5%MXene/ZSM-5 alone on the phenol removal.

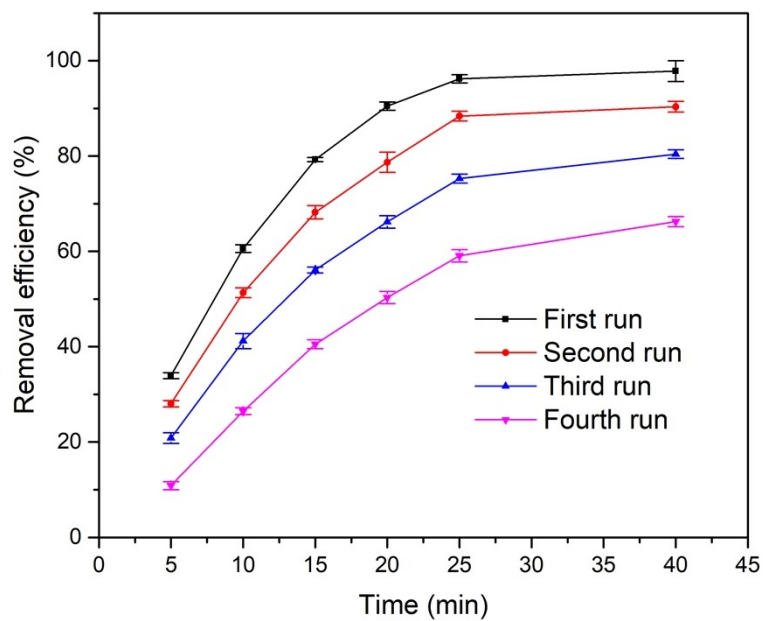


Fig. S7 Consecutive runs of the catalytic activity of 5%Fe/5%MXene/ZSM-5 on phenol removal efficiency.

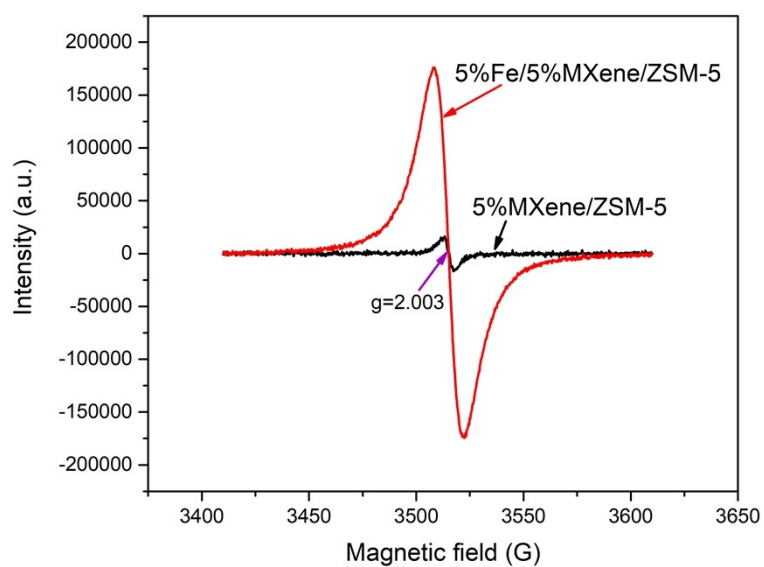


Fig. S8 EPR spectra of 5%MXene/ZSM-5 and 5%Fe/5%MXene/ZSM-5.

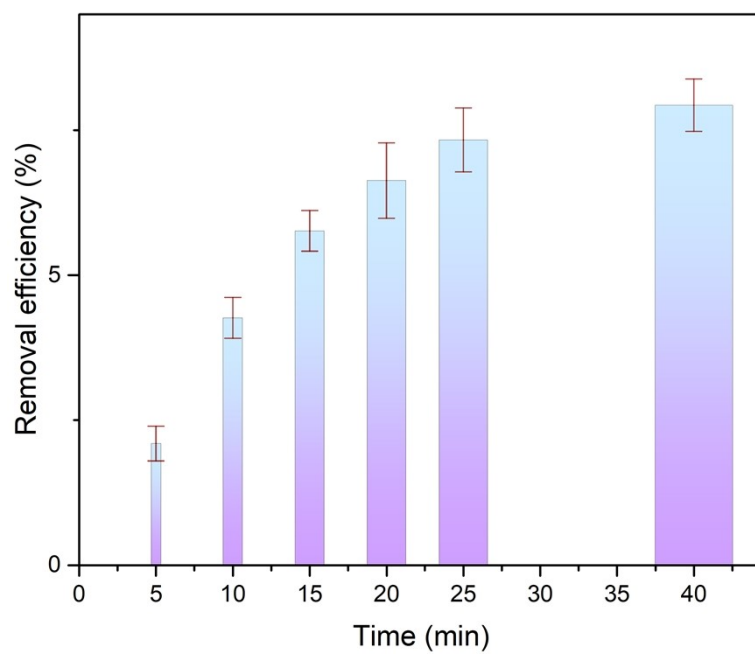


Fig. S9 The phenol removal efficiency under the dark condition.

Table S1 The binding energy peaks of metallic element in 5%Fe/5%MXene/ZSM-5 and 5%Co/5%MXene/ZSM-5.

	Peak	Binding Energy (eV)	Chemical state	AC%	
5%Fe/5%MXene/ZSM-5	Ti2p3/2	459.25	Ti(IV)	100	
	Ti2p1/2	464.95			
	Fe2p3/2	710.20	Fe (II)	38.79/61.21	
	Fe2p1/2	723			
	Fe2p3/2	712.2	Fe (III)		
	Fe2p1/2	725.7			
	O1s-1	530.81	Metal oxide (Ti-O/Fe-O)		10.68/89.32
	O1s-2	532.81	Si-O/C-O		
5%Co/5%MXene/ZSM-5	Ti2p3/2	458.89	Ti(IV)	100	
	Ti2p1/2	464.79			
	Co2p3/2	781.59	Co (II)	100	
	Co2p3/2-multiplet split	783.78			
	sat.	787.5			
	sat.	790.39			
	O1s-1	530.88	Metal oxide (Ti-O/Co-O)	11.17/88.83	
	O1s-2	532.63	Si-O/C-O		

Table S2 The fitting straight line of the estimated band gaps by Taucs relationship.

Sample	Fitting linear equation	R ²	Band gap (eV)
5%MXene/ZSM-5	$y = 7.78833x - 26.00099$	0.99995	3.34
5%Co/5%MXene/ZSM-5	$y = 5.4442x - 13.79593$	0.99966	2.53
5%Fe/5%MXene/ZSM-5	$y = 10.0671x - 20.33098$	0.99992	2.02

Table S3 Experiment conditions of the effect of pH, reaction temperature, PMS concentration and initial phenol concentration.

Experiment	pH	Reaction temperature (K)	PMS concentration (g/L)	Initial phenol concentration (mg/L)	Time (min)
1	1	313.15	0.3	20	5
	3				10
	5				15
	7				20
	9				25
	11				40
2	7	313.15	0.3	20	5
					10
					15
					20
					25
					40
		303.15			5
					10
					15
					20
					25
					40
		323.15			5
					10
					15
20					
25					
40					
3	7	313.15	0.1	20	5
					10
					15
					20
					25
					40
			0.5		5
					10
					15
					20
					25
					40

4	7	313.15	0.3	10	5
					10
					15
					20
					25
					40
				40	5
					10
					15
					20
					25
					40
					40