Supporting information

N-doped-carbon encapsulated $FeMo_xO_y$ nanoparticles for efficiently removing Rhodamine B by oxidation of $^1O_2$ generated from H_2O_2.

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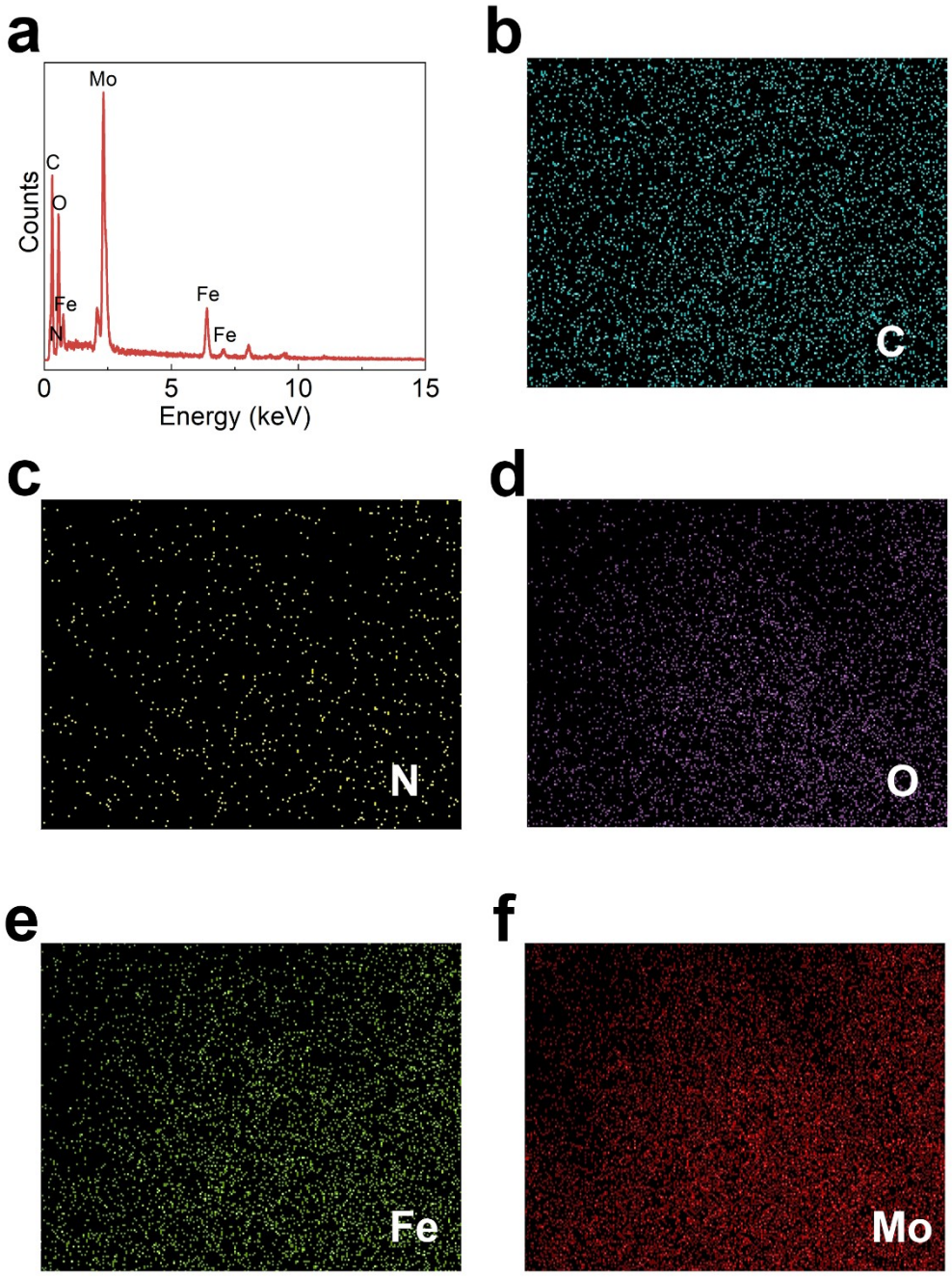


Fig. S1 EDS images of FeMo@NC-973.

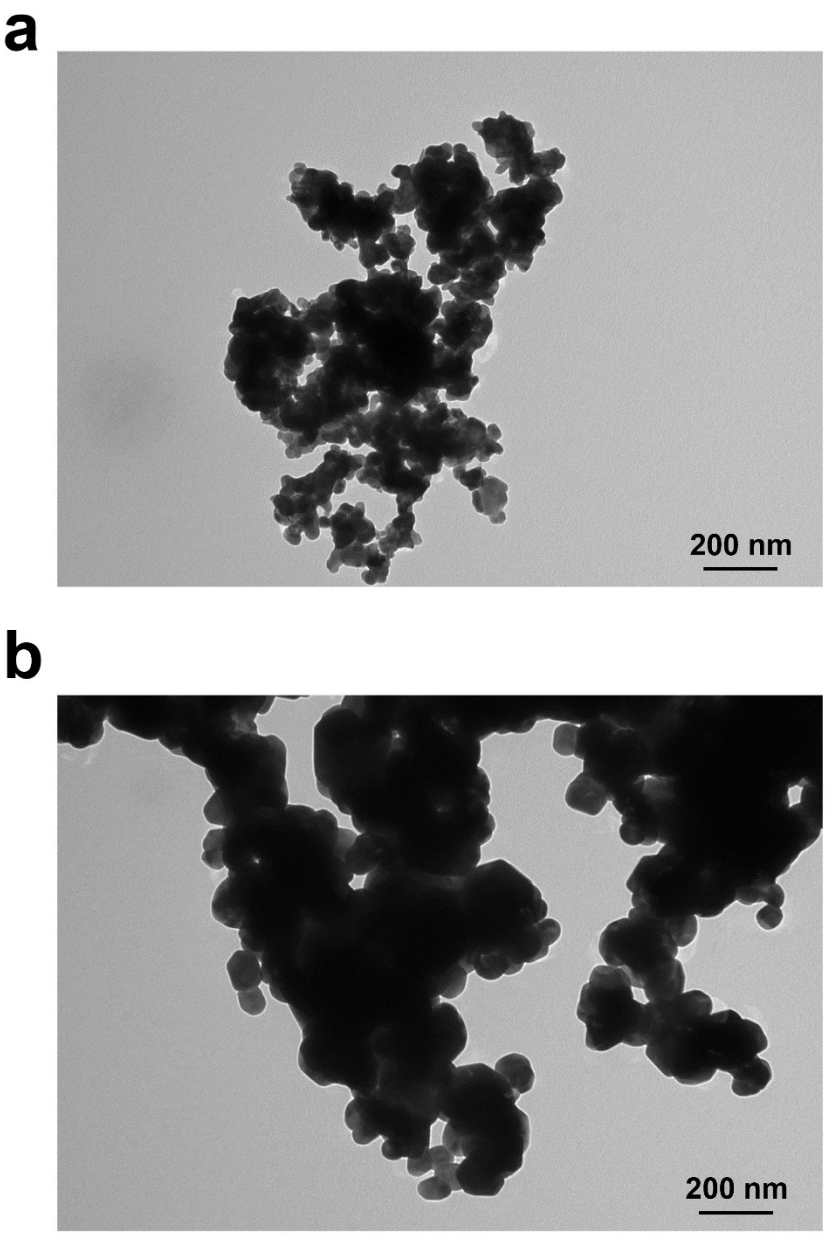


Fig. S2 TEM images of FeMo@NC-973 (a) and FeMo@NC-1023 (b).

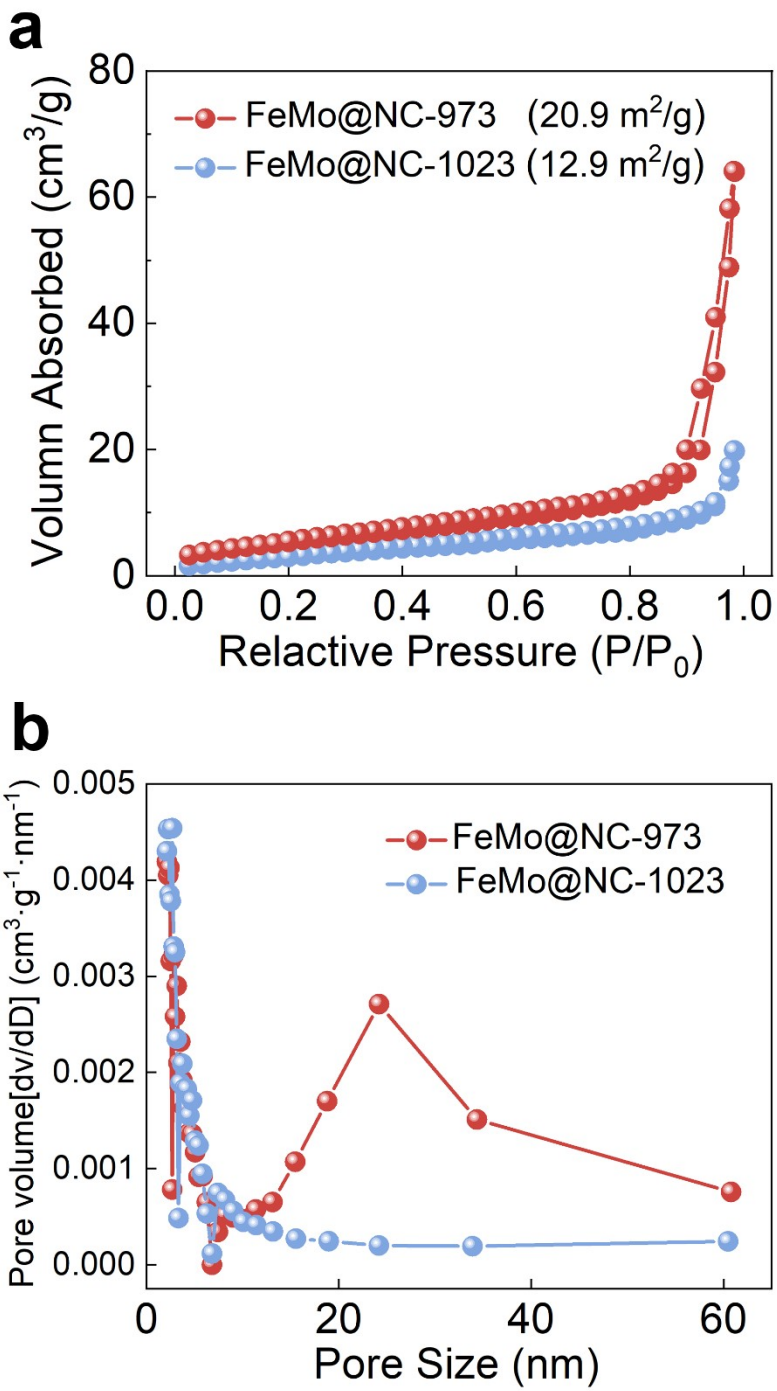


Fig. S3 Adsorption isotherm (a) and pore diameter distribution (b) of materials.

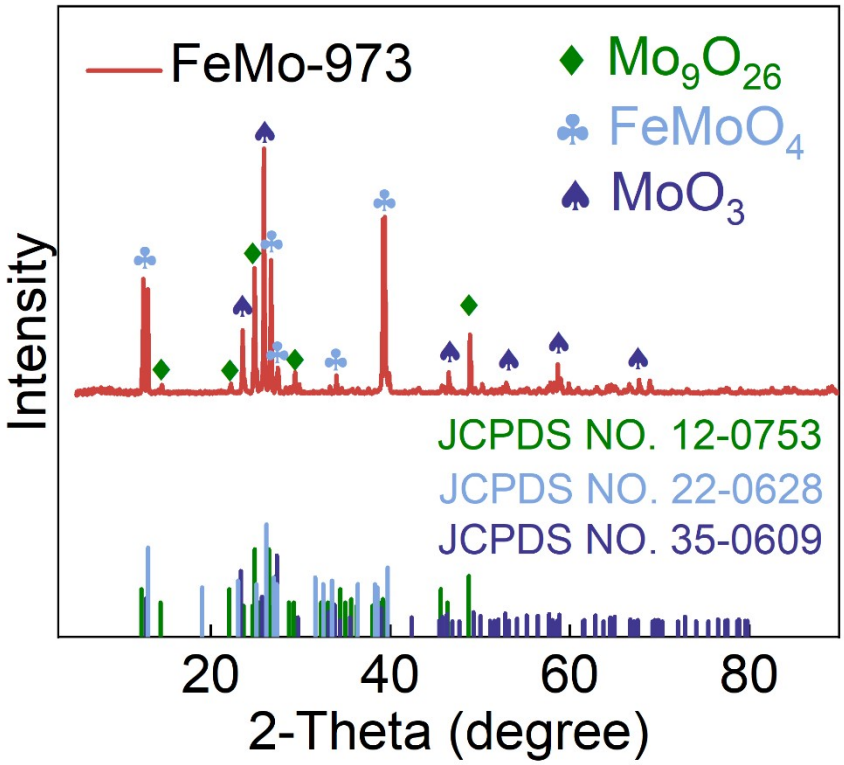


Fig. S4 The XRD pattern of FeMo-973.

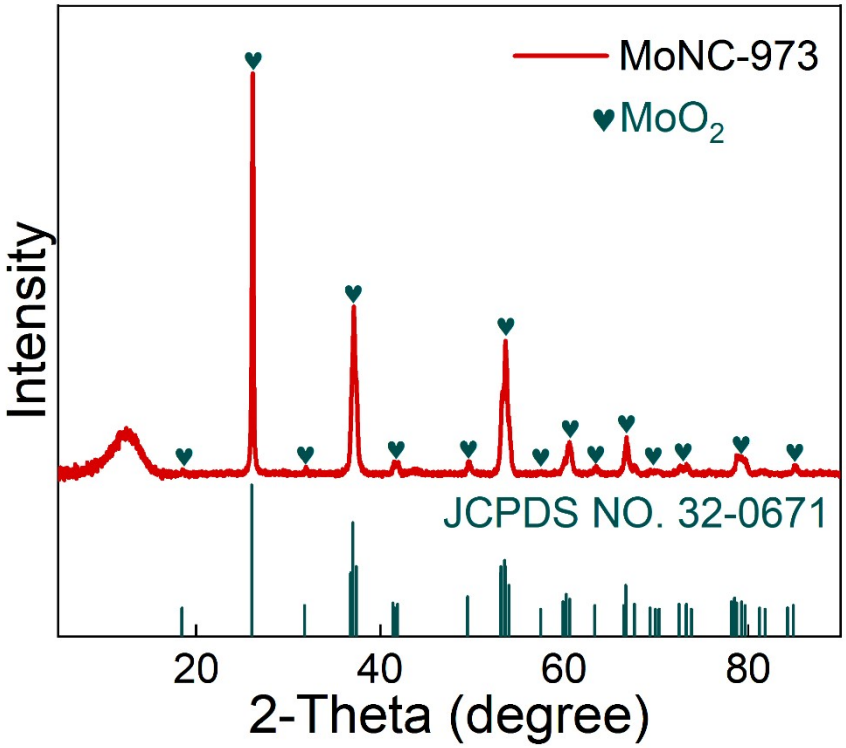


Fig. S5 The XRD pattern of MoNC-973.

Fig. S6 (a) The solution of MoNC-973 and RhB after stirring for 15 minutes. (b) The filtrates of (a). (c) The solution of used MoNC-973 and ethanol. (d) The eluted solution of used MoNC-973 by ethanol.

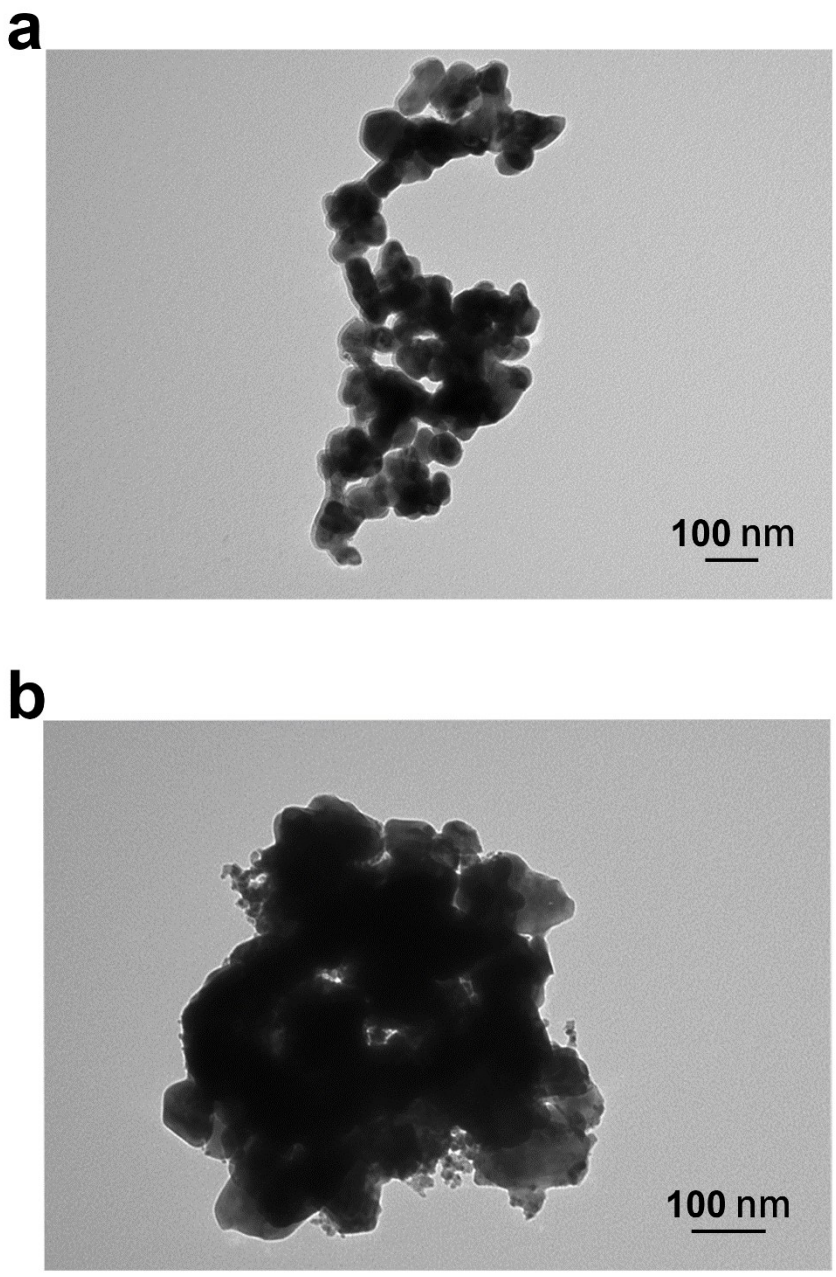


Fig. S7 TEM images of FeMo@NC-973 of Fe/Mo=0.29/1 (a) and 1.15/1 (b).

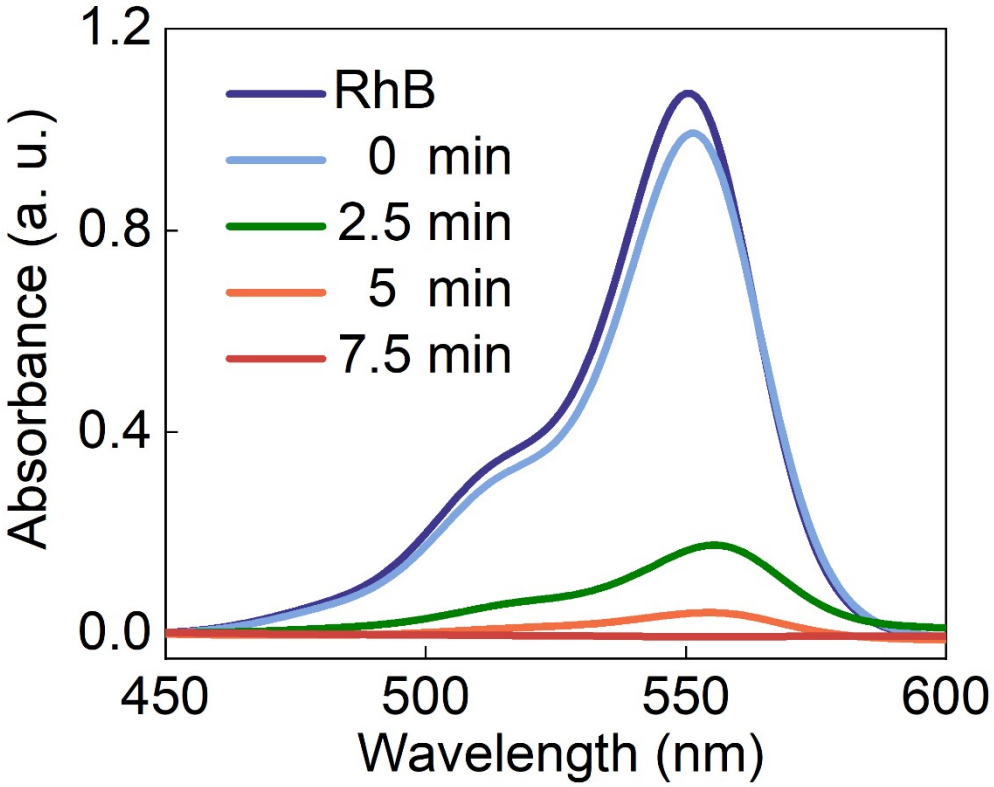


Fig. S8 UV-vis spectra of the solution in different reaction time.

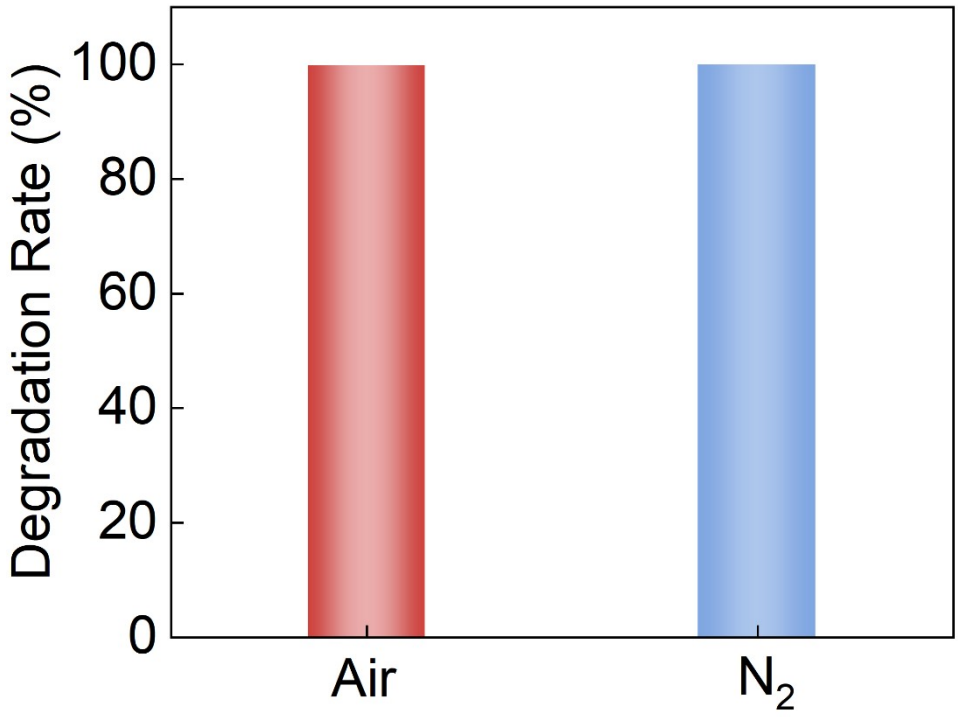


Fig. S9 Degradation rate of RhB by FeMo@NC-973/H_2O_2 system under air and N_2 atmosphere.

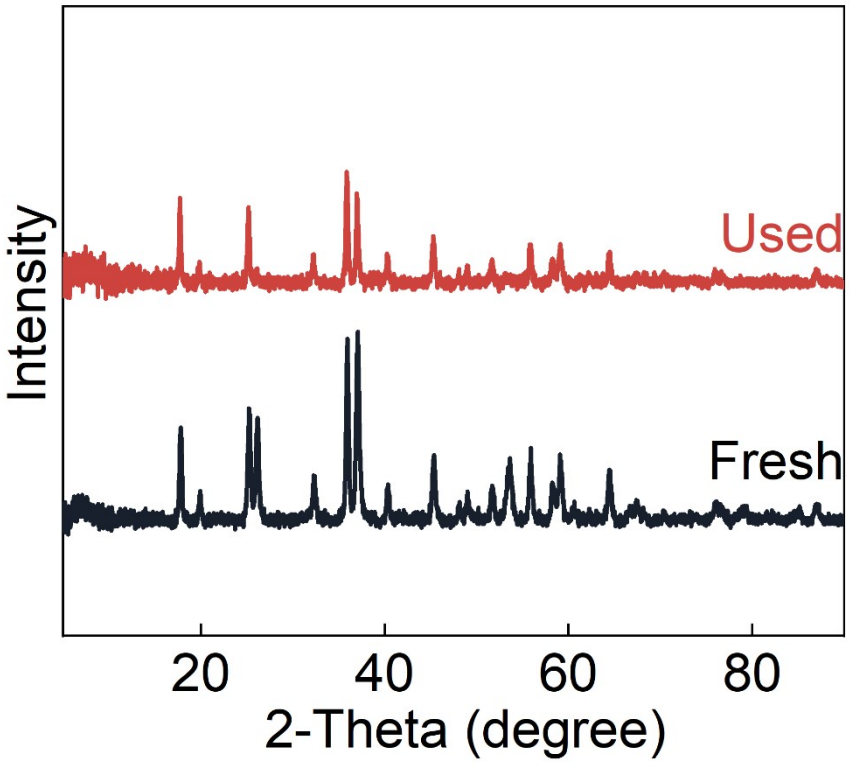


Fig. S10 XRD patterns of fresh and used catalysts.

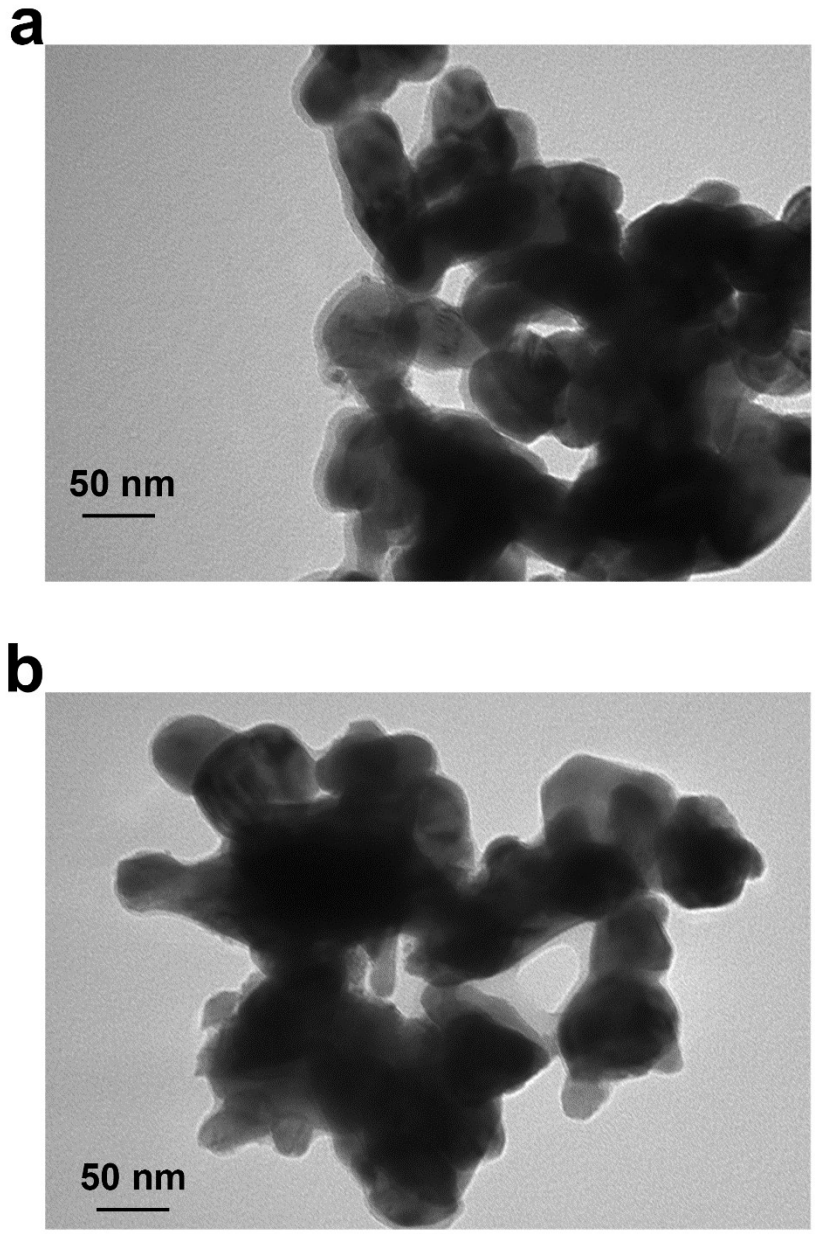
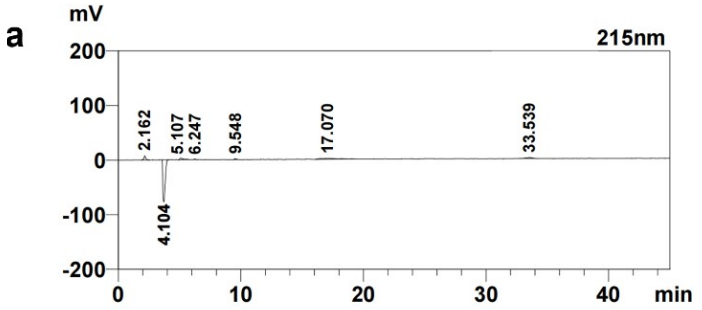
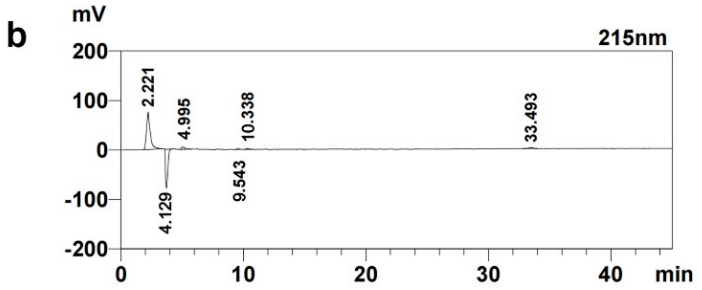


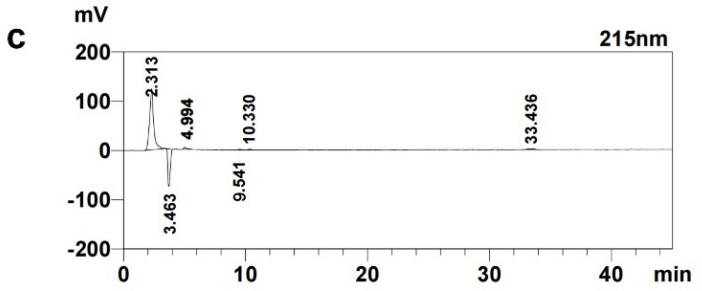
Fig. S11. TEM images of fresh (a) and used catalysts (b).



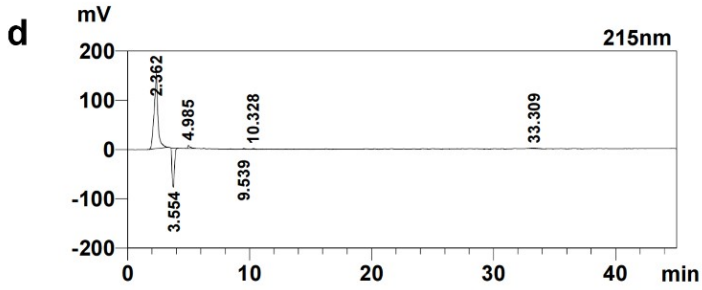
Retention Time	Peak area
2.162	77016
4.104	-105118
5.107	57324
6.247	5430
9.548	14628
17.070	144096
33.539	65373



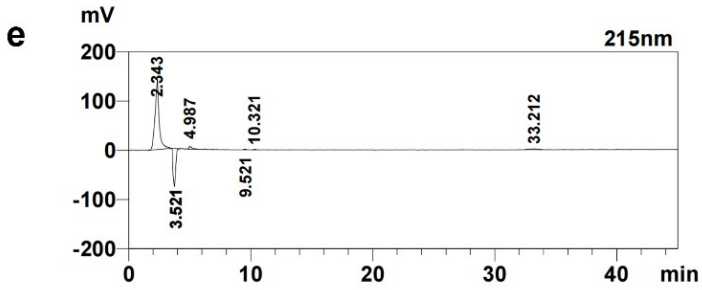
Retention Time	Peak area
2.221	1570758
4.129	-993732
4.995	101392
9.543	16353
10.338	22075
33.493	58694



Retention Time	Peak area
2.313	2812730
3.463	-1047564
4.994	59128
9.541	17902
10.330	22899
33.436	70210



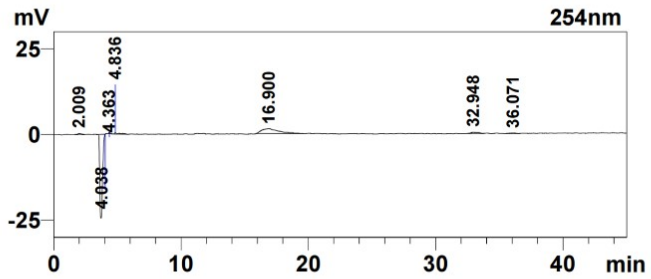
Retention Time	Peak area
2.362	3196142
3.554	-1058495
4.985	98094
9.539	12574
10.328	9546
33.309	55847



Retention Time	Peak area
2.343	3248908
3.521	-1129823
4.987	105124
9.521	12787
10.321	14568
33.212	60728

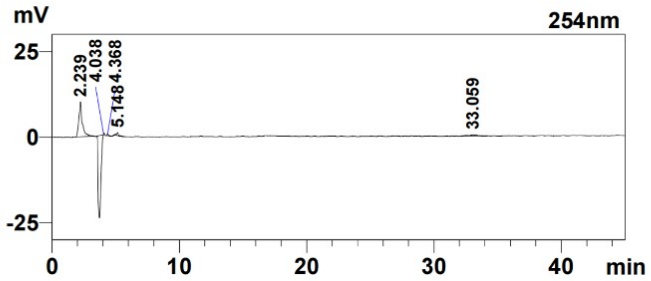
Fig. S12. LC spectra in the different reaction time at the 215 nm. (a) RhB; (b) 2.5 min; (c) 5 min; (d) 7.5 min and (e) 10 min.

a



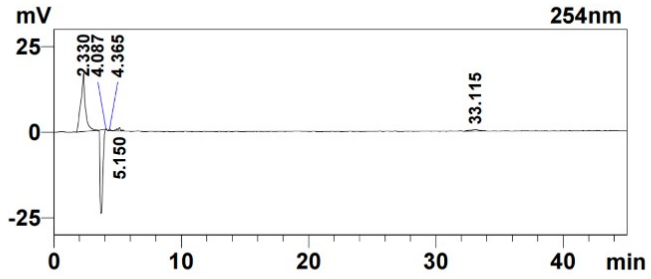
Retention Time	Peak area
2.009	7253
4.038	-351757
4.363	2762
4.836	8813
16.900	135754
32.948	15043
36.071	4879

b



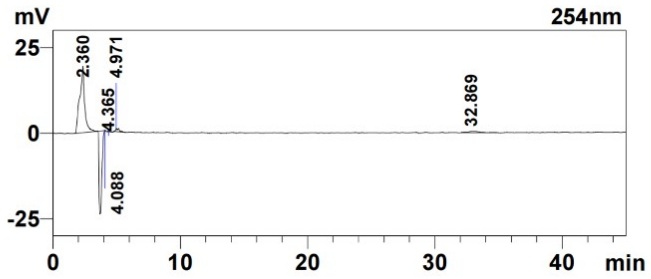
Retention Time	Peak area
2.239	188914
4.038	-361448
4.368	3343
5.148	8720
33.059	16131

c



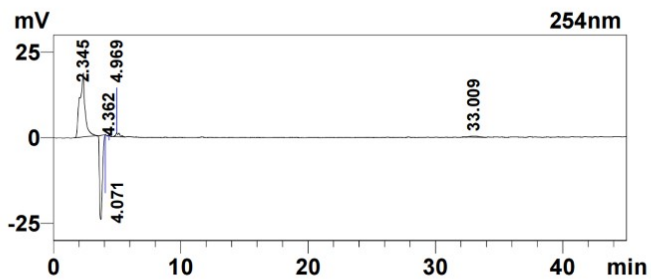
Retention Time	Peak area
2.33	418111
4.087	-361620
4.365	3501
5.15	17993
33.115	20776

d



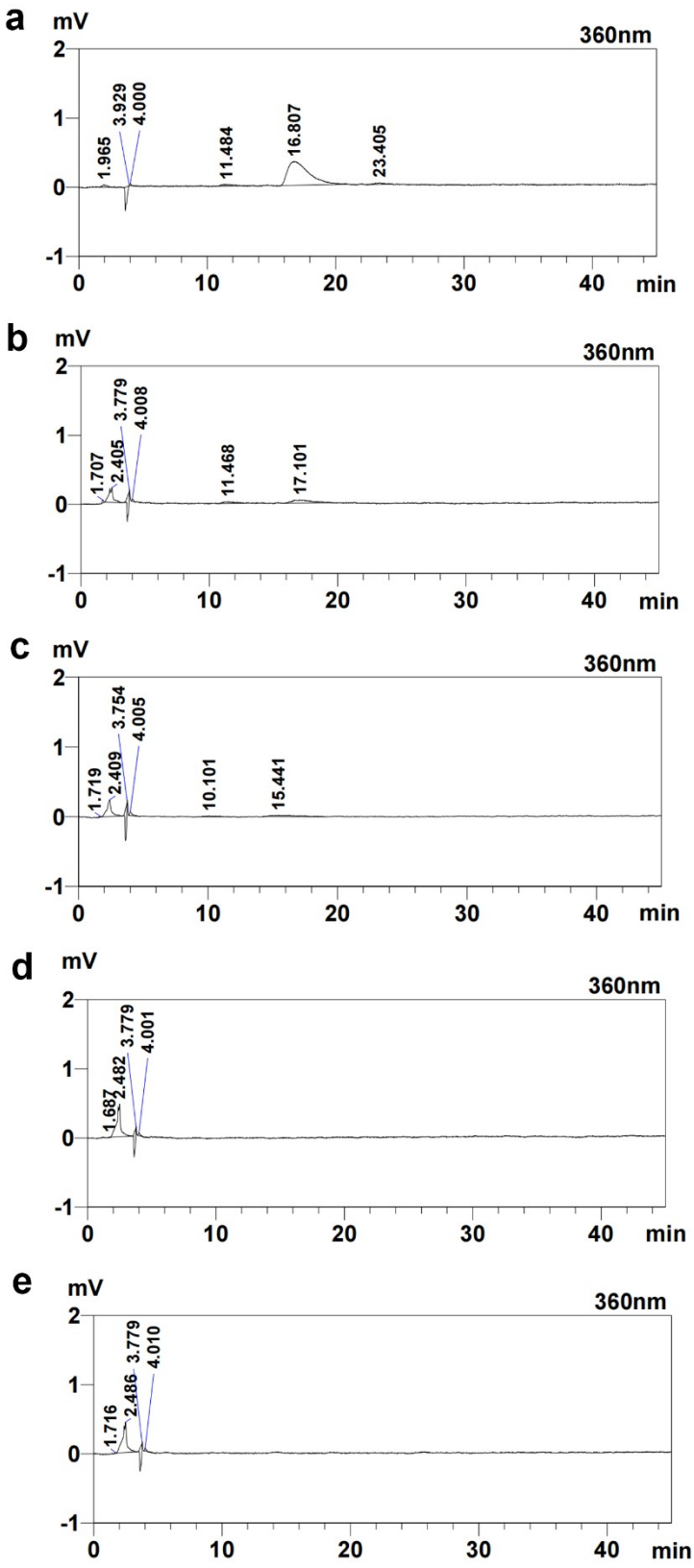
Retention Time	Peak area
2.36	519829
4.088	-358342
4.365	4448
4.971	20401
32.869	24502

e



Retention Time	Peak area
2.345	537184
4.071	-371850
4.362	2480
4.969	24091
33.009	15179

Fig. S13. LC spectra in the different reaction time at the 254 nm. (a) RhB; (b) 2.5 min; (c) 5 min; (d) 7.5 min and (e) 10 min.



Retention Time	Peak area
1.965	878
3.929	-3333
4	226
11.484	1319
16.807	39859
23.405	1128

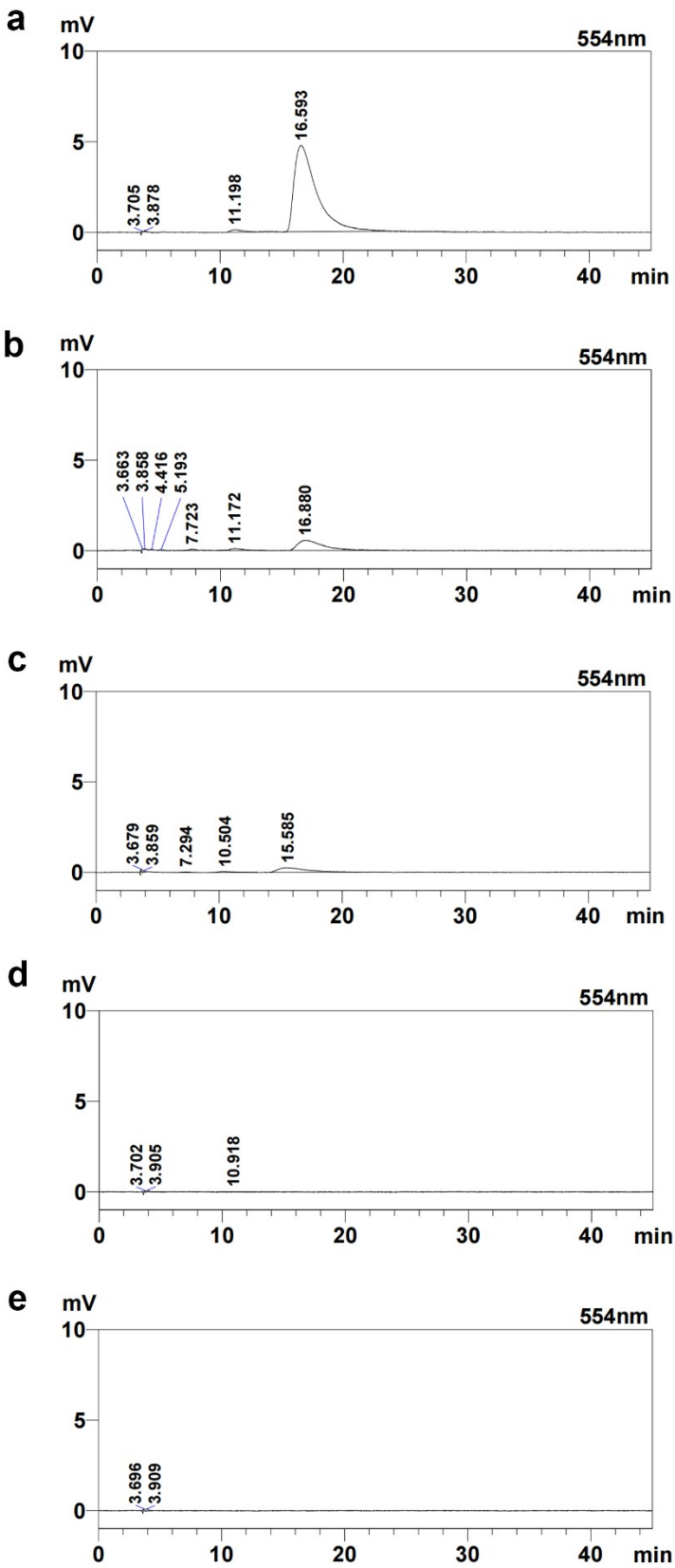
Retention Time	Peak area
1.707	246
2.405	4901
3.779	-3105
4.008	264
11.468	1544
17.101	4853

Retention Time	Peak area
1.719	102
2.409	5673
3.754	-3478
4.005	829
10.101	794
15.441	2718

Retention Time	Peak area
1.687	35
2.482	10489
3.779	-2805
4.001	423

Retention Time	Peak area
1.716	42
2.486	10348
3.779	-3080
4.01	451

Fig. S14. LC spectra in the different reaction time at the 360 nm. (a) RhB; (b) 2.5 min; (c) 5 min; (d) 7.5 min and (e) 10 min.



Retention Time	Peak area
3.705	-689
3.878	592
11.198	9086
16.593	609204

Retention Time	Peak area
3.663	-787
3.858	312
4.416	338
5.193	914
7.723	2910
11.172	8617
16.880	83495

Retention Time	Peak area
3.679	-955
3.859	938
7.294	1089
10.504	4654
15.585	42271

Retention Time	Peak area
3.702	-787
3.905	1702
10.918	589

Retention Time	Peak area
3.696	-856
3.909	1715

Fig. S15. LC spectra in the different reaction time at the 554 nm. (a) RhB; (b) 2.5 min; (c) 5 min; (d) 7.5 min and (e) 10 min.

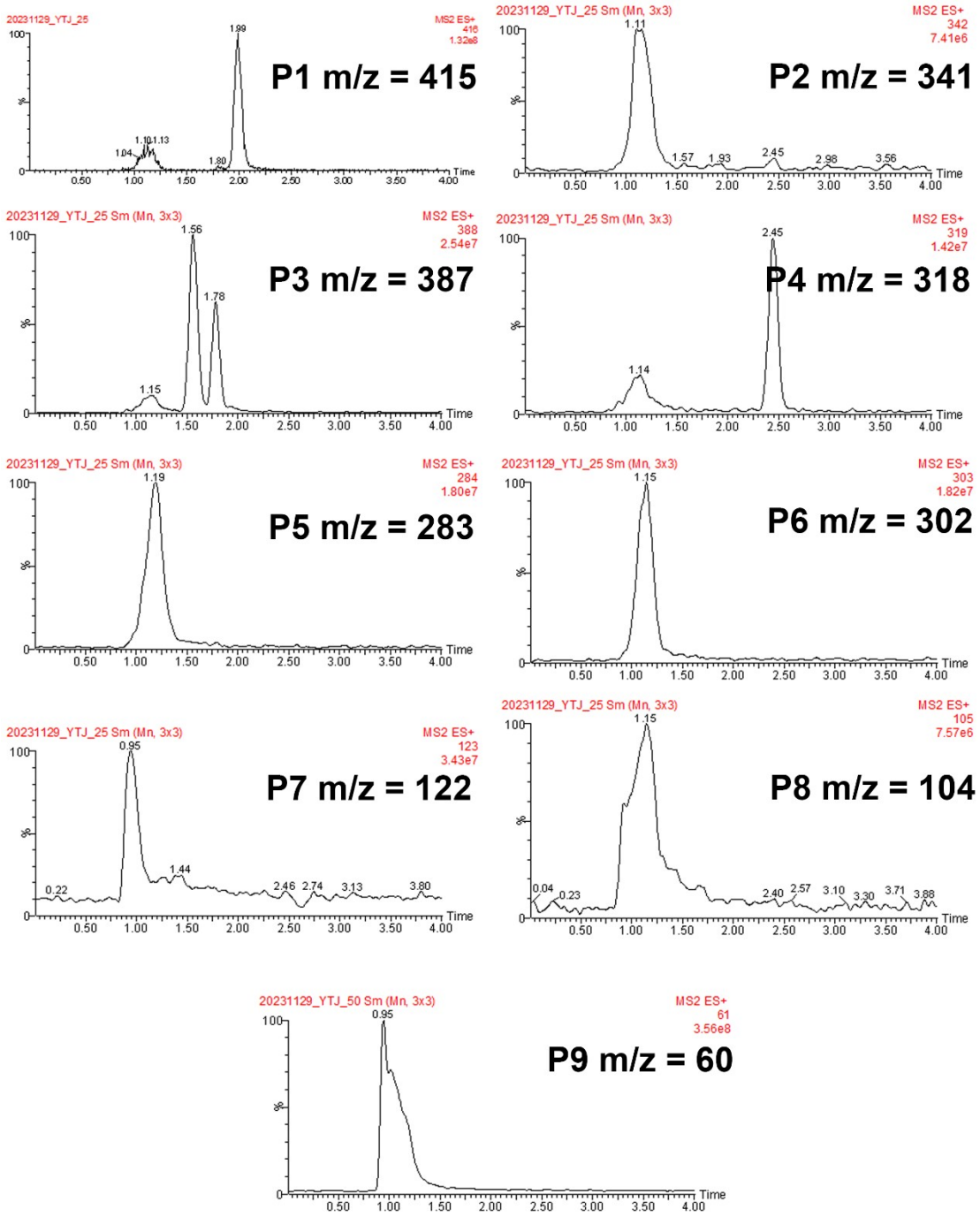


Fig. S16. HPLC-MS spectra of the main products in RhB degradation.

Table S1 Comparison of this work with reported ones literature.

No.	Systems	RhB (mg/L)	Cat. (g/L)	H_2O_2 (mM)	Time (min)	Degra.(%)	Ref.
1	FeMo@NC	10	0.9	25	7.5	~100	This work
2	FMCNe-t	10	0.9	100	15	>99	1
3	Cu–Fe_3O_4 MNPs	4.79	0.5	80	120	>99	2
4	$BiFeO_3$ MNPs	4.79	0.5	10	90	95.2	3
5	Fe_3O_4	4.79	0.5	40	120	97.8	4
6	SrO/Co_3O_4	5	1	1500	6	~96	5
7	$LaTi_{0.4}Cu_{0.6}O_3$	8	1.4	20	120	~94	6
8	Cu/Al_2O_3	10	1	30	30	98.5	7
9	$CoFe_2O_4$	20	0.5	10	90	95.5	8
10	$ZnCr_2$	20	3	150	90	99.8	9
11	Cu-cysteamine	24	0.5	50	15	~99	10
12	$FeCeO_x$	100	1.5	80	150	~98	11
13	Cu/Fe-Al-MCM-41	400	1	40	50	~96	12

Cat. - the dose of catalysts, Degra.- the degradation rate of RhB.

Reference

1. H. Kong, H. Li, H. Wang, S. Li, B. Lu, J. Zhao and Q. Cai, *Applied Surface Science*, 2023, **610**, 155544.
2. W. Du, R. Huang, X. Huang, R. Chen and F. Chen, *Environmental Science and Pollution Research*, 2021, **28**, 19959-19968.
3. W. Luo, L. Zhu, N. Wang, H. Tang, M. Cao and Y. She, *Environmental science & technology*, 2010, **44**, 1786-1791.
4. F. Chen, S. Xie, X. Huang and X. Qiu, *Journal of Hazardous Materials*, 2017, **322**, 152-162.
5. W. Xu, B. Cao, H. Lin, W. Cheng, C. Luo, H. Peng and C. Duan, *Journal of Materials Science*, 2019, **54**, 8216-8225.
6. L. Zhang, Y. Nie, C. Hu and J. Qu, *Applied Catalysis B: Environmental*, 2012, **125**, 418-424.
7. Y. Sheng, Y. Sun, J. Xu, J. Zhang and Y. F. Han, *AIChE Journal*, 2018, **64**, 538-549.
8. D. Liu, D. Chen, Z. Hao, Y. Tang, L. Jiang, T. Li, B. Tian, C. Yan, Y. Luo and B. Jia, *Chemosphere*, 2022, **307**, 135935.
9. N. T. Thao, H. T. P. Nga, N. Q. Vo and H. D. K. Nguyen, *Journal of Science: Advanced Materials and Devices*, 2017, **2**, 317-325.
10. N. Pandey, H. Li, L. Chudal, B. Bui, E. Amador, M. Zhang, H. Yu, M. Chen, X. Luo and W. Chen, *Materials Today Physics*, 2022, **22**, 100587.
11. N. Zhang, E. P. Tsang, J. Chen, Z. Fang and D. Zhao, *Journal of colloid and*

interface science, 2020, **558**, 163-172.

12. S. Li, S. Wang, Q. Chen, S. Jiang and S. Sun, *Water Science and Technology*, 2021, **83**, 1878-1892.