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$CoMoO_4$ as a novel heterogeneous catalyst of peroxymonosulfate activation for the degradation of organic dyes

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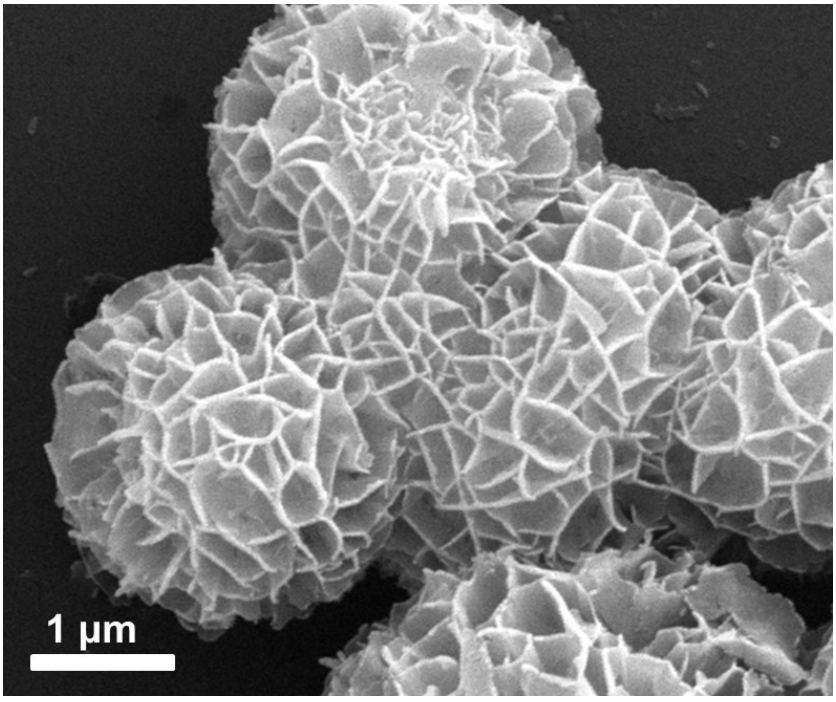

Fig S1 SEM pattern of uncalcined precursor.

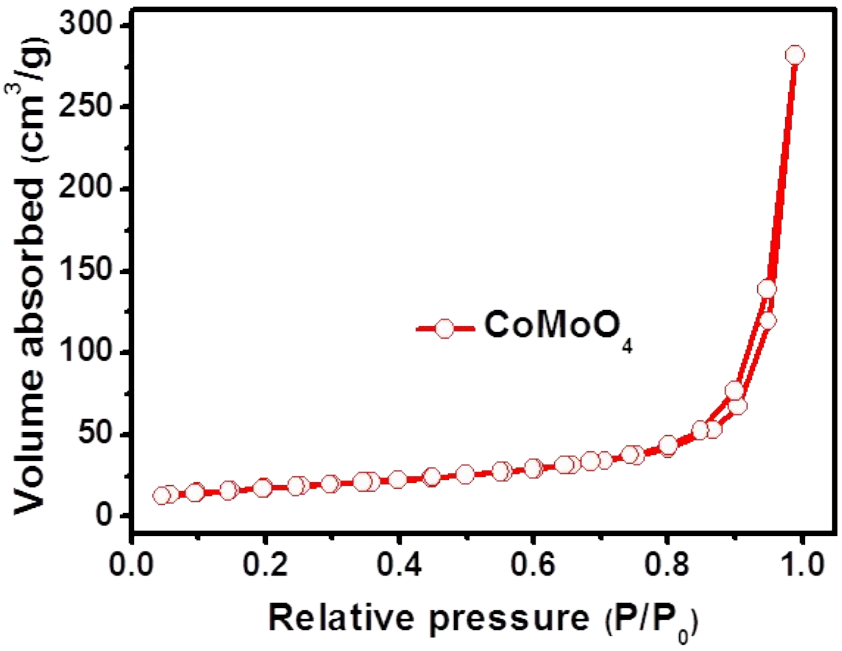

Fig S2 N_2 adsorption/desorption isotherm of $CoMoO_4$.

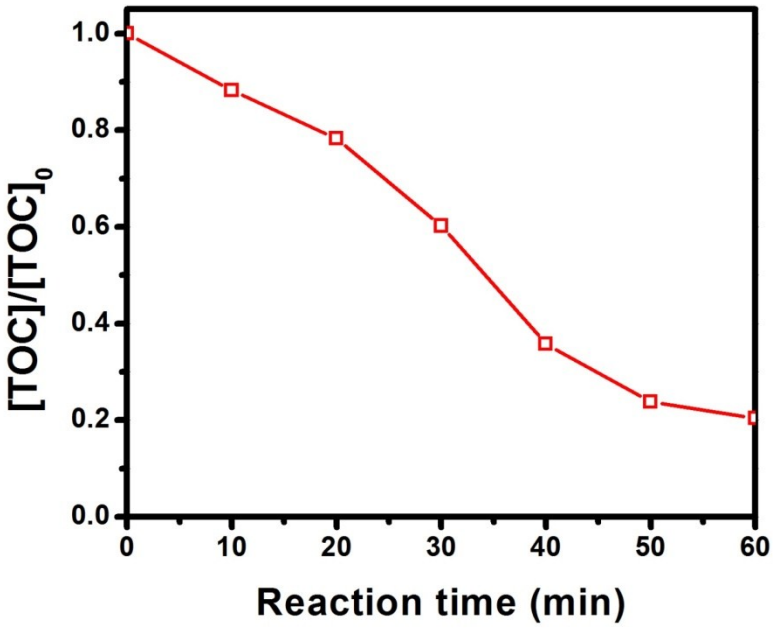

Fig S3 TOC removal in MB degradation catalyzed by $CoMoO_4$/PMS systems. Conditions: $[MB]_0$ = 100 mg/L, volume (MB) = 50 mL, [Oxone] = 2 mM, catalyst amount = 0.05 g (0.10 g/L), temperature=25°C, without pH adjustment.

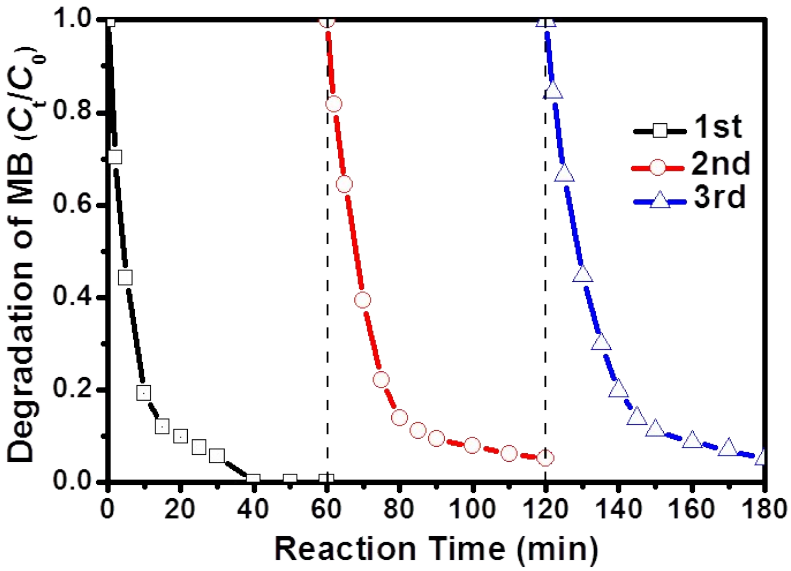

Fig S4 Degradation of MB in $CoMoO_4$/PMS system for catalyst recycling experiment. Conditions: $[MB]_0$ = 100 mg/L, volume (MB) = 50 mL, [Oxone] = 2mM, catalyst amount = 0.05 g (0.10 g/L), temperature=25°C, without pH adjustment.

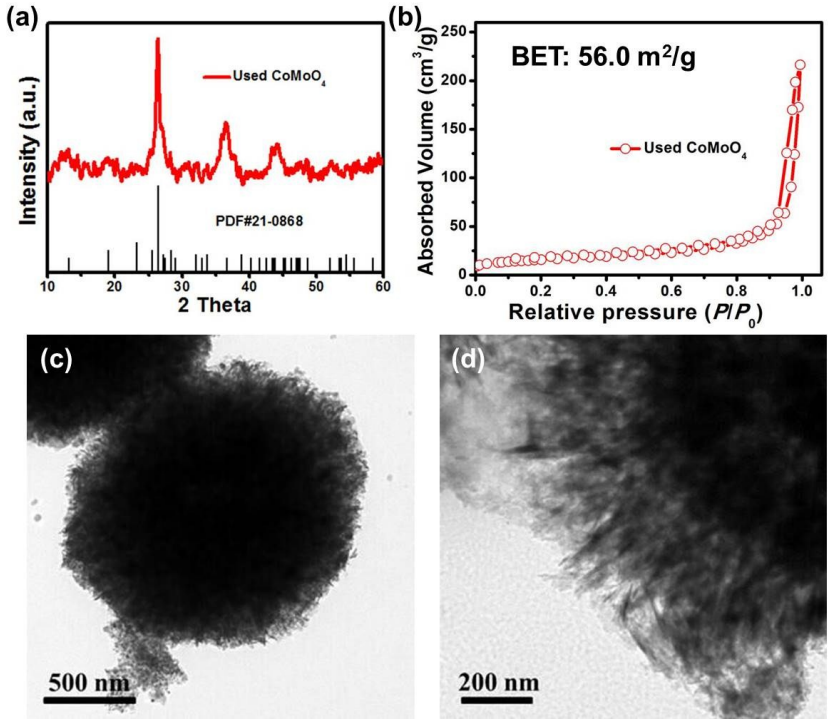

Fig S5 XRD pattern (a), N_2 adsorption/desorption isotherm (b), TEM images (c and d) of the used $CoMoO_4$.

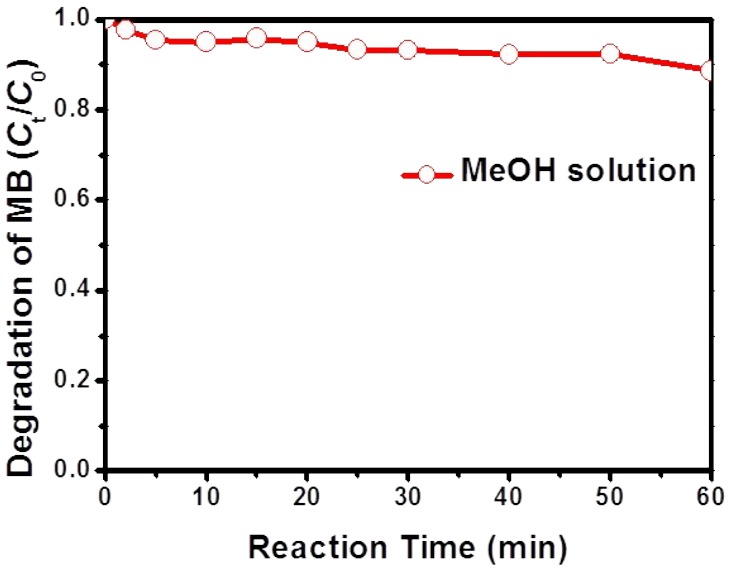

Fig S6 MB degradation in MeOH solution. Conditions: $[MB]_0$ = 100 mg/L, volume (MB) = 50 mL, [Oxone] = 2mM, catalyst amount = 0.05 g (0.10 g/L), temperature=25°C, without pH adjustment.

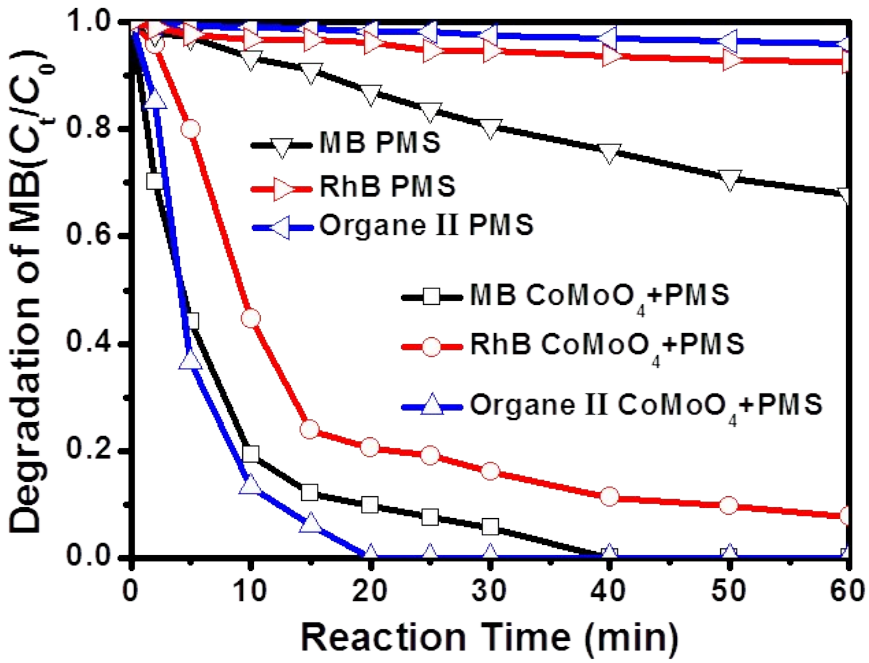

Fig S7 Degradation in various dyes by $CoMoO_4$/PMS system. Conditions: $[dye]_0$ = 100 mg/L, volume (dye) = 50 mL, [Oxone] = 2mM, catalyst amount = 0.05 g (0.10 g/L), temperature=25°C, without pH adjustment.

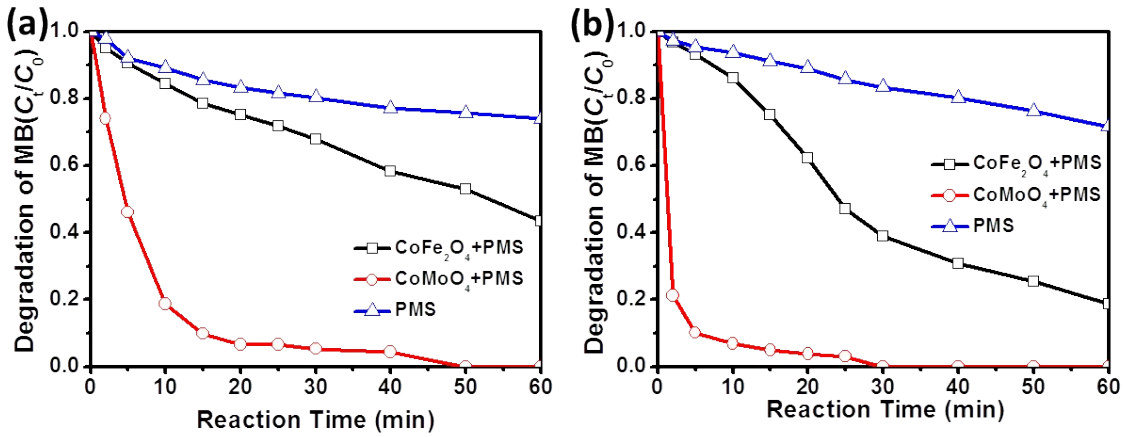

Fig S8 MB degradation by $CoMoO_4$/PMS system under some actual water background: tap water (a), surface water (b). Conditions: $[MB]_0$ = 100 mg/L, volume (MB) = 50 mL, [Oxone] = 2mM, catalyst amount = 0.05 g (0.10 g/L), temperature=25°C, without pH adjustment.

Tables

Table S1 The performances of various catalysts in PMS activation for MB degradation.

Catalyst	MB (mg/L)	PMS (mM)	Cat. dosage (g/L)	MB:PMS:Cat. (mg/L:mM:g/L)	Time[a] (min)	REF
Co_3O_4-Bi_2O_3	7.50	0.50	0.05	1:0.0670:0.0067	10	1
activated RGO	10.0	1.64	0.06	1:0.1640:0.0060	60	2
Co_3O_4/titanate	10.0	0.50	0.50	1:0.0500:0.0500	10	3
RGO-CO_2	10.0	3.29	0.05	1:0.3290:0.0050	175	4
$CuFe_2O_4$/AC	20.0	6.50	0.50	1:0.3250:0.0025	60	5
Fe_3O_4@OMS-2	20.0	2.63	0.40	1:0.1315:0.0200	15 (95.0%)	6
Fe_3O_4/Mn_3O_4/rGO	50.0	1.97	0.10	1:0.0394:0.0020	30 (93.5%)	7
Fe_3O_4@MnO_2	30.0	20.0	0.30	1:0.6670:0.0100	30	8
Co/IBA	37.4	2.00	1.00	1:0.0535:0.0267	10	9
$NiCo_2O_4$	18.7	0.50	0.20	1:0.0267:0.0107	40	10
Cu/Fe_3O_4	7.50	2.50	0.10	1:0.3333:0.0133	30	11
PPy/CNTs-$CoFe_2O_4$	100.0	4.00	1.00	1:0.0400:0.0100	60 (95.0%)	12
Cobalt phosphonate	93.5	5.00	0.10	1:0.4810:0.0011	25	13
$CoMoO_4$	**100.0**	**2.00**	**0.10**	**1:0.0200:0.0010**	**40**	**Herein**

[a] Time required for complete degradation of MB.

References

[1] Y. B. Ding, L. H. Zhu, A. Z. Huang, X. R. Zhao, X. Y. Zhang and H. Q. Tang. A heterogeneous Co_3O_4–Bi_2O_3 composite catalyst for oxidative degradation of organic pollutants in the presence of peroxymonosulfate. *Catal. Sci. Technol.*, 2012, **2**, 1977-1984.

[2] W. C. Peng, S. Z. Li, H. Q. Sun, Y. J. Yao, L. J. Zhi and S. B. Wang. Synthesis of porous reduced graphene oxide as metal-free carbon for adsorption and catalytic oxidation of organics in water. *J. Mater. Chem. A*, 2013, **1**, 5854-5859.

[3] Z. L. Chen, S. H. Chen, Y. H. Li, X. L. Si, J. Huang, S. Massery and G. L. Chen. A recyclable and highly active Co3O4 nanoparticles/titanate nanowire catalyst for organic dyes degradation with peroxymonosulfate. *Mater. Res. Bull.*, 2014, **57**, 170-176.

[4] S. Z. Liu, W. C. Peng, H. Q. Sun and S. B. Wang. Physical and chemical activation of reduced graphene oxide for enhanced adsorption and catalytic oxidation. *Nanoscale*, 2014, **6**, 766-771.

[5] W. D. Oh, S. K. Lua, Z. L. Dong and T. K. Lim. Performance of magnetic activated carbon composite as peroxymonosulfate activator and regenerable adsorbent via sulfate radical-mediated oxidation processes. *J. Hazard. Mater.*, 2015, **284**, 1-9.

[6] M. Y. Wei, Y. Ruan, S. L. Luo, X. X. Li, A. H. Xu and P. Zhang. The facile synthesis of a magnetic OMS-2 catalyst for decomposition of organic dyes in aqueous solution with peroxymonosulfate. *New J. Chem.*, 2015, **39**,

6395-6403.
[7] B. Yang, Z. Tian, B. Wang, Z. B. Sun, L. Zhang, Y. P. Guo, H. Z. Li and S. Q. Yan. Facile synthesis of Fe_3O_4/hierarchical-Mn_3O_4/graphene oxide as a synergistic catalyst for activation of peroxymonosulfate for degradation of organic pollutants. *RSC Adv.*, 2015, **5**, 20674-20683.
[8] S. W. Zhang, Q. H. Fan, H. H. Gao, Y. S. Huang, X. Liu, J. X. Li, X. J. Xu and X. K. Wang. Formation of Fe_3O_4@MnO_2 ball-in-ball hollow spheres as a high performance catalyst with enhanced catalytic performances. *J. Mater. Chem. A*, 2016, **4**, 1414-1422.
[9] Y. B. Wang, Y. Xie, S. M. Yin, R. Xu and R. Lau. Municipal solid waste incineration bottom ash supported cobalt oxide catalysts for dye degradation using sulfate radical. *J. Taiwan Inst. Chem. E.*, 2016, **68**, 246-253.
[10] W. W. Zhang, Y. Su, X. M. Zhang, Y. Yang and X. H. Guo. Facile synthesis of porous $NiCo_2O_4$ nanoflakes as magnetic recoverable catalysts towards the efficient degradation of RhB. *RSC Adv.*, 2016, **6**, 64626-64633.
[11] G. Nie, J. Huang, Y. Z. Hu, Y. B. Ding, X. Y. Han and H. Q. Tang. Heterogeneous catalytic activation of peroxymonosulfate for efficient degradation of organic pollutants by magnetic Cu^0/Fe_3O_4 submicron composites. *Chinese J. Catal.*, 2017, **38**, 227-239.
[12] X. L. Li, H. J. Lu, Y. Zhang and F. He. Efficient removal of organic pollutants from aqueous media using newly synthesized polypyrrole/CNTs-$CoFe_2O_4$ magnetic nanocomposites. *Chem. Eng. J.*, 2017, **316**, 893-902.
[13] Y. P. Zhu, T. Z. Ren and Z. Y. Yuan. Hollow cobalt phosphonate spherical hybrid as high-efficiency Fenton catalyst. *Nanoscale*, 2014, **6**, 11395-11402.

Table S2 Kinetic rate constants of MB degradation at different temperature.

Temperature	15°C	25°C	30°C	35°C
K/min^{-1}	0.05627	0.14387	0.23567	0.42979

Table S3 Parameters of actual water bodies

	Tap water	Surface water
TOC (mg/L)	5.62	6.46
TN (mg/L)	1.39	1.50
Al (mg/L)	0.450	0.272
Ca (mg/L)	10.532	24.457
Cu (mg/L)	0.016	0.004
Fe (mg/L)	0.075	0.023
Mg (mg/L)	1.566	6.157
Mn (mg/L)	0.005	0.002