

Supplementary Material

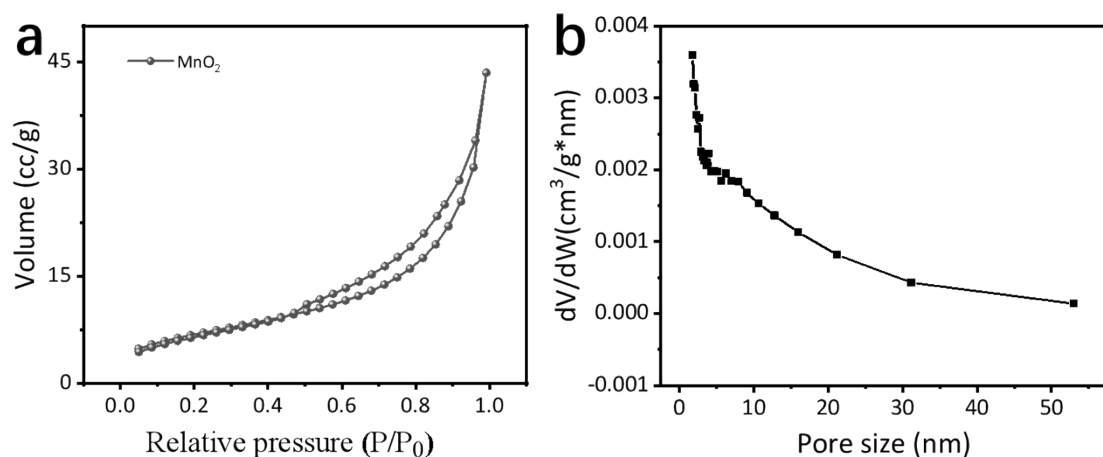


Figure S1. Nitrogen adsorption—desorption isotherms and corresponding pore size distribution curves of MnO₂.

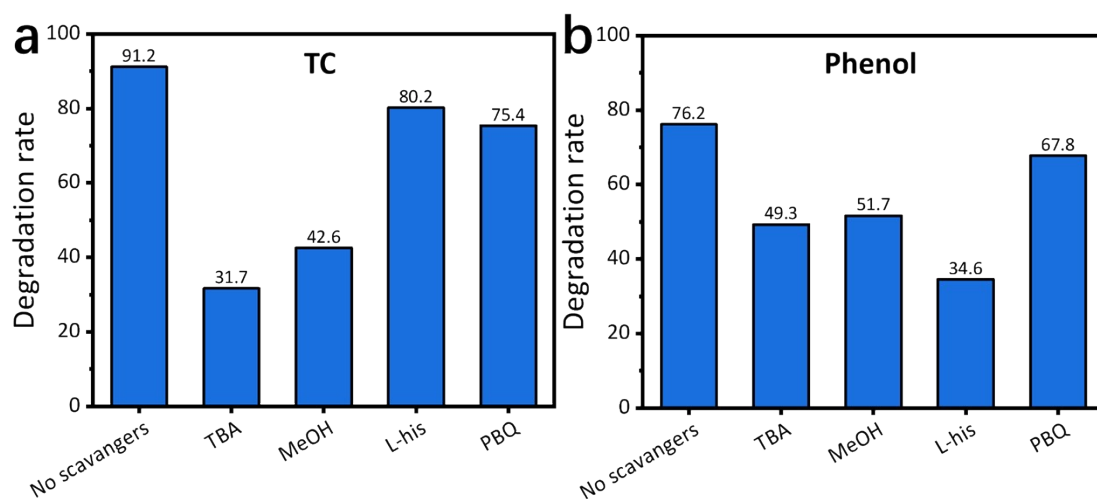


Figure S2. Radical-trapping experiment results for TC and phenol degradation.

Table S1. Mass ratio of Mn with the sample

Cycle Time	1	2	3
Manganese content	98.4	97.9	97.7

Table S2 comparison table summarizing several recent MnO₂-based strategies for
PMS activation toward phenol or tetracycline degradation

Catalyst (structure/support)	Pollutant	PMS dosage	Catalyst loading	Performance (time/kinetics)	Notes/pH (if stated)	Refs.
α -MnO ₂ (powder)	Phenol	1.5 mM	0.2 g·L ⁻¹	99.3% removal	pH effect weak	[1]
MnO ₂ @g-C ₃ N ₄ (Z-type heterojunction)	Tetracycline	0.6 mM	0.6 g·L ⁻¹	96.97% removal in 180 min	Natural water matrices tested; PMS- assisted photocataly- sis	[2]
CuO-OMS-2 (MnO ₂ OMS-2 framework, CuO supported)	Phenol	1.0 g·L ⁻¹	0.5 g·L ⁻¹	93.6% removal in 30 min	Under varied pH (3~9)	[3]
CeO ₂ @MnO ₂	Tetracycline	0.8 g·L ⁻¹	1 g·L ⁻¹	95.18% removal in 180 min	Under varied pH (3~9)	[4]
γ -Fe ₂ O ₃ @MnO ₂ (SiO ₂ template)	Phenol	0.6 g·L ⁻¹	0.35 g·L ⁻¹	97.6% in 80 min	Room temperature , dark	[5]
hollow SiO ₂ /MnO ₂ (HSM)	Phenol	0.5 g·L ⁻¹	0.4 g·L ⁻¹	~80% removal in 140 min	Room temperature	This work
hollow SiO ₂ /MnO ₂ (HSM)	Tetracycline	0.5 g·L ⁻¹	0.4 g·L ⁻¹	91.2% removal in 140 min	Under varied pH (3~11)	This work

Reference

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- [3] S. Tian, J. Liu, L. Sun, X.J. Yuan, C. Sans. Activation of peroxymonosulfate by CuO-OMS-2 for efficient phenol mineralization: performance, contributions of ROS, and catalytic mechanisms, *Environmental Science and Pollution Research*, 31 (2024) 66938-66952.
- [4] J.H. Zhang, J.W. Sun, X.F. Zhu, J.Q. Liu, L.L. Chang, G.F. Li, et al. CeO₂@MnO₂ with

strong Ce-Mn interaction activating PDS to promote in situ degradation of adsorbed tetracycline, *Journal of Rare Earths* 43 (2025) 490-499.

[5] J.K. Wang, T.P. Xie, G.K. Han, Q.X. Zhu, Y.J. Wang, Y. Peng, et al. SiO₂ mediated templating synthesis of γ -Fe₂O₃/MnO₂ as peroxymonosulfate activator for enhanced phenol degradation dominated by singlet oxygen, *Applied Surface Science*, 560 (2021) 149984.