Supplementary Information

Inverse opal structured Pt/TiO2-MnOy photothermocatalyst for enhanced toluene degradation activity

Zhili Chi, Zhiyong Liu, Wenbo Liu, Jiaqi Cai, Yiyang Zhang, Yangmei Dai, Jinlong Zhang, Ziwei Ye*, Baozhu Tian*

Shanghai Engineering Research Center for Multi-media Environmental Catalysis and Resource Utilization, Key Laboratory for Advanced Materials and Joint International Research Laboratory of Precision Chemistry and Molecular Engineering, Feringa Nobel Prize Scientist Joint Research Center, Key Laboratory of Specially Functional Polymeric Materials and Related Technology (Ministry of Education), School of Chemistry and Molecular Engineering, East China University of Science and Technology, 130 Meilong Road, Shanghai 200237, PR China

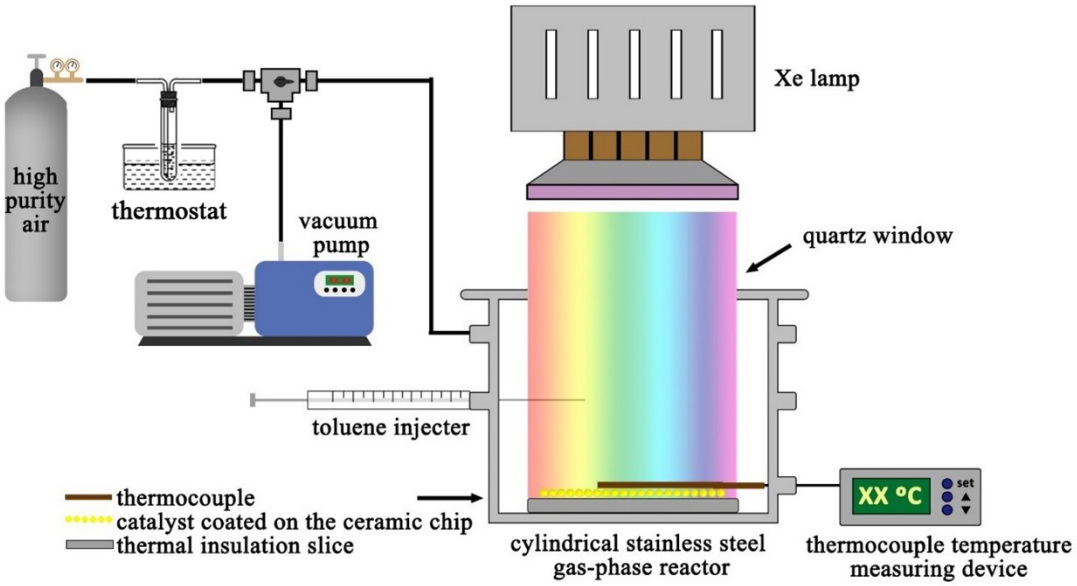

Fig. S1. Schematic diagram of the photothermocatalytic setup.

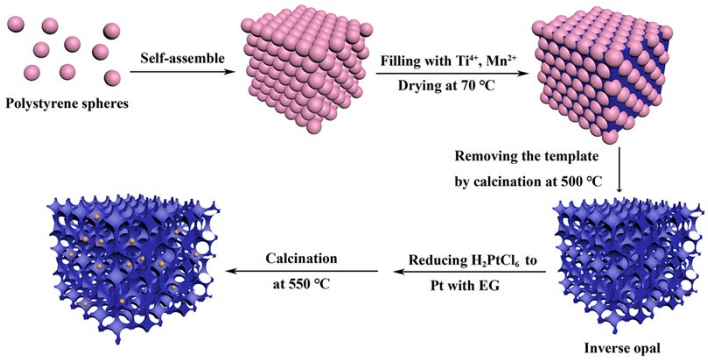

Fig. S2. Synthetic route for TM-x and Pt/TM-x.

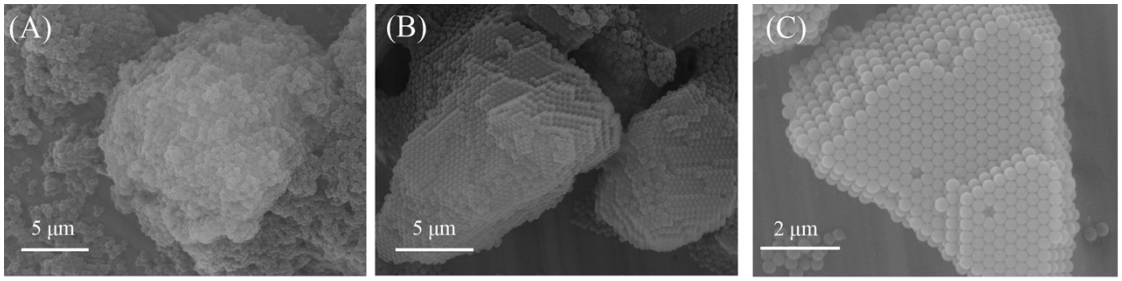

Fig. S3. (A-C) SEM images of the PS template.

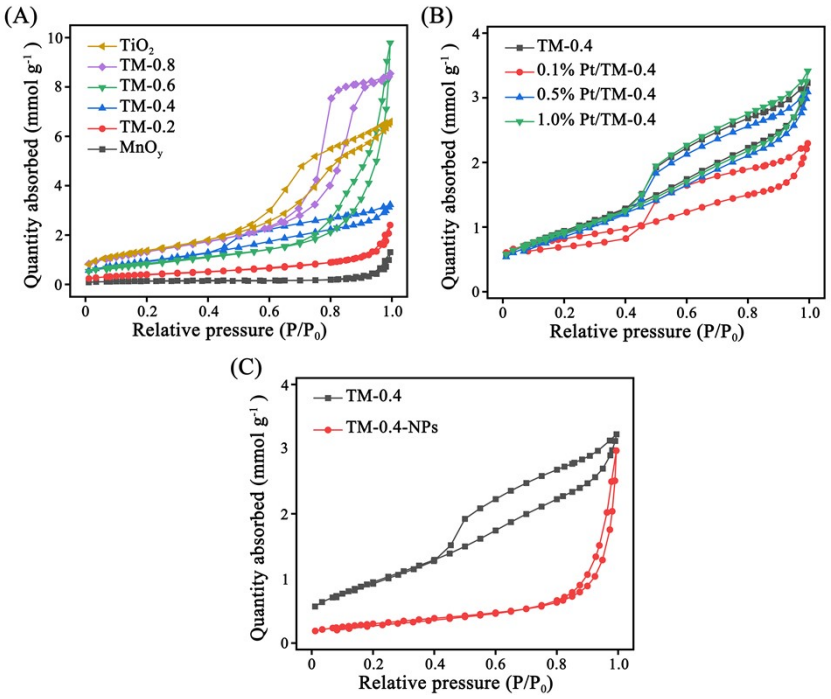

Fig. S4. (A) Nitrogen adsorption–desorption isotherms of TiO_2, TM-x, and MnO_y. (B) Nitrogen adsorption–desorption isotherms of TM-0.4 and Pt/TM-0.4 with different Pt loadings. (C) Nitrogen adsorption–desorption isotherms of TM-0.4 and TM-0.4-NPs.

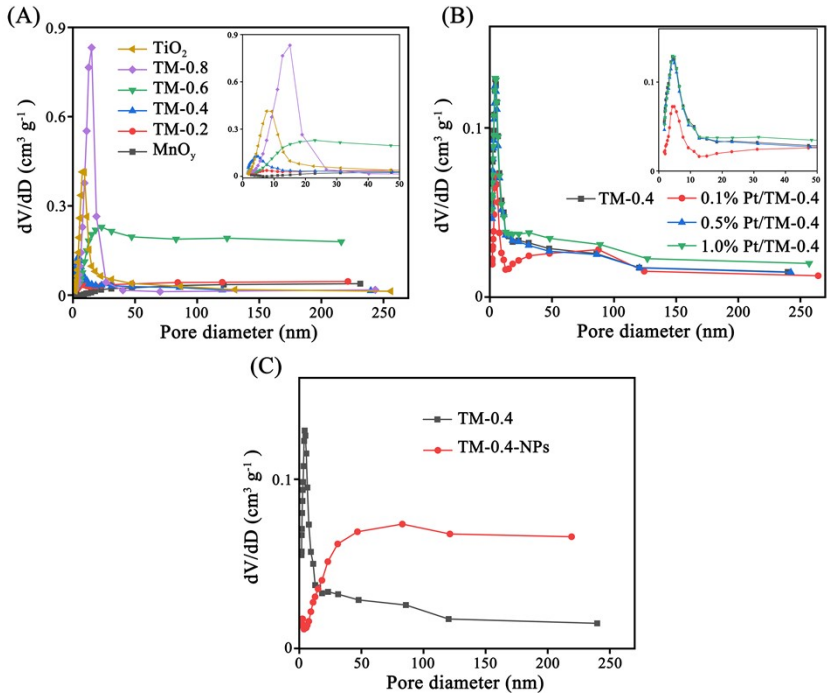

Fig. S5 (A) Pore size distribution curves of TiO_2, TM-x, and MnO_y. (B) Pore size distribution curves of TM-0.4 and Pt/TM-0.4 with different Pt loadings. (C) Pore size distribution curves of TM-0.4 and TM-0.4-NPs.

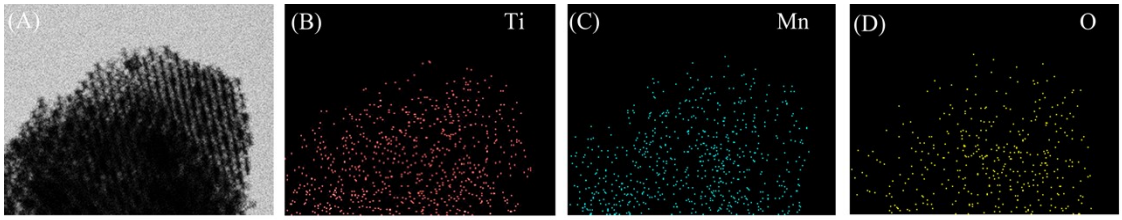

Fig. S6. (A-D) EDX element mapping diagrams of TM-0.4.

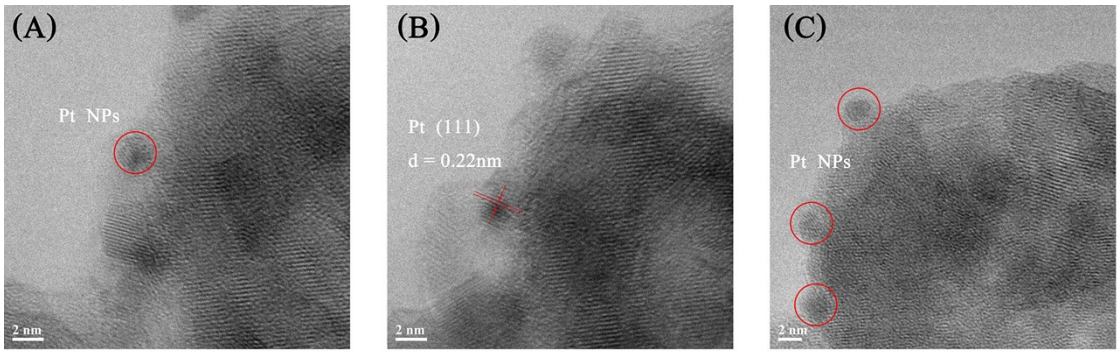

Fig. S7. (A-C) HR-TEM images of (A) 0.1% Pt/TM-0.4, (B) 0.5% Pt/TM-0.4, and (C)1.0% Pt/TM-0.4.

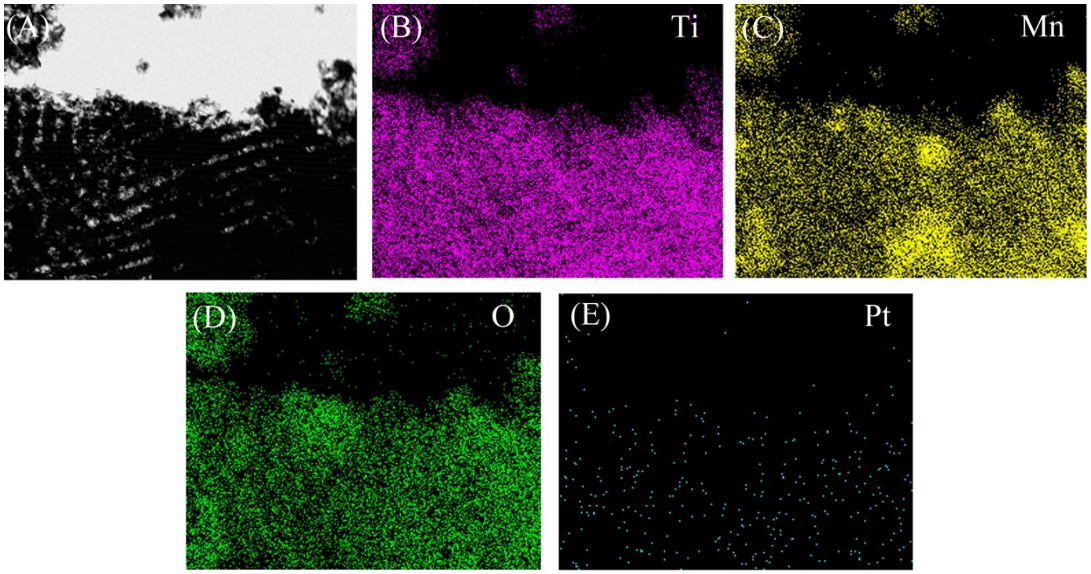

Fig. S8. (A) HR-TEM and (B–E) EDX element mapping images of 0.5%Pt/TM-0.4.

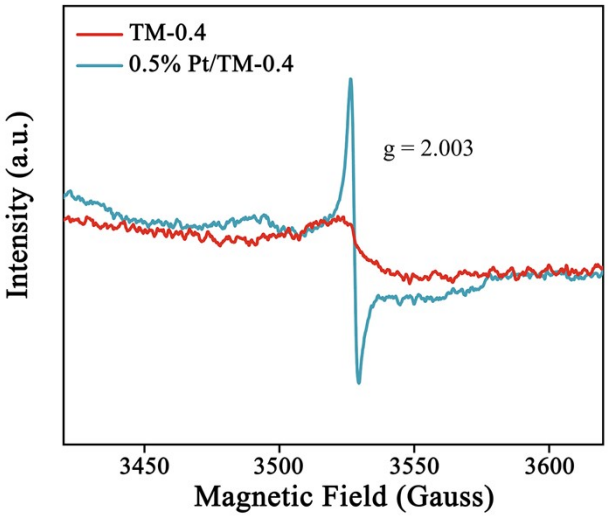

Fig. S9. EPR spectra of TM-0.4 and 0.5% Pt/TM-0.4.

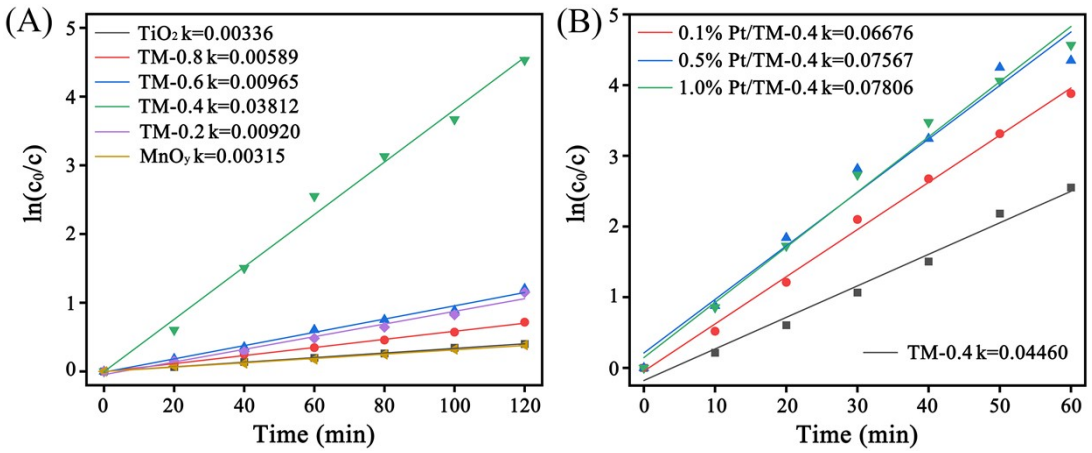

Fig. S10. (A) Kinetic curves of TiO_2, TM-x, and MnO_y. (B) Kinetic curves of TM-0.4 and Pt/TM-0.4 with different Pt loadings.

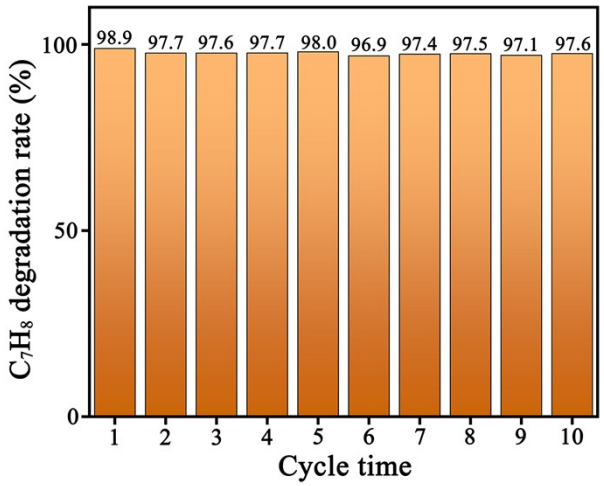

Fig. S11. Cycling degradation tests for TM-0.4.

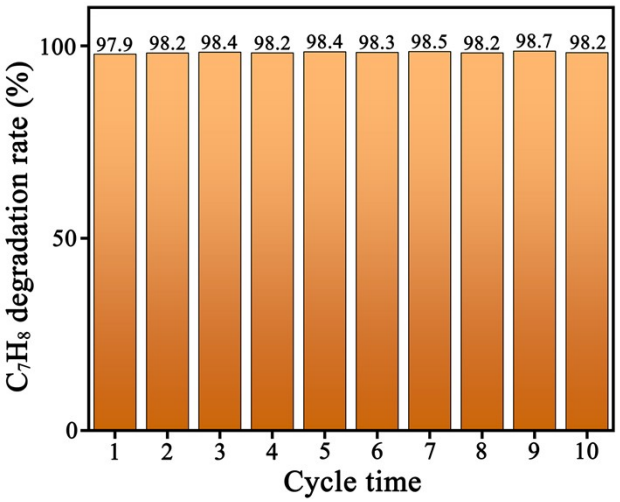

Fig. S12. Cycling degradation tests for 0.5% Pt/TM-0.4.

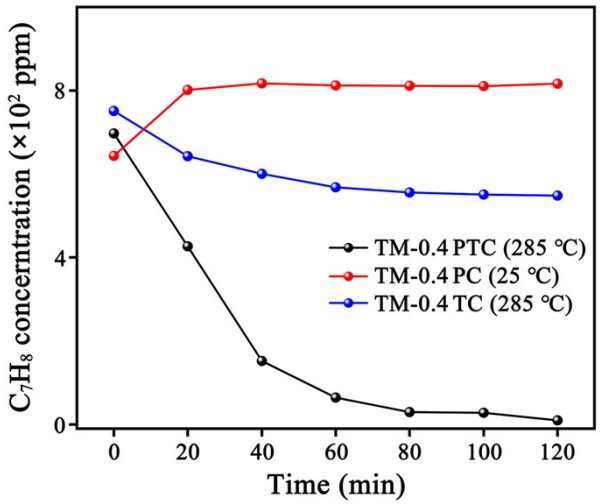

Fig. S13. Concentration change of toluene under the PTC, TC and PC conditions for TM-0.4.

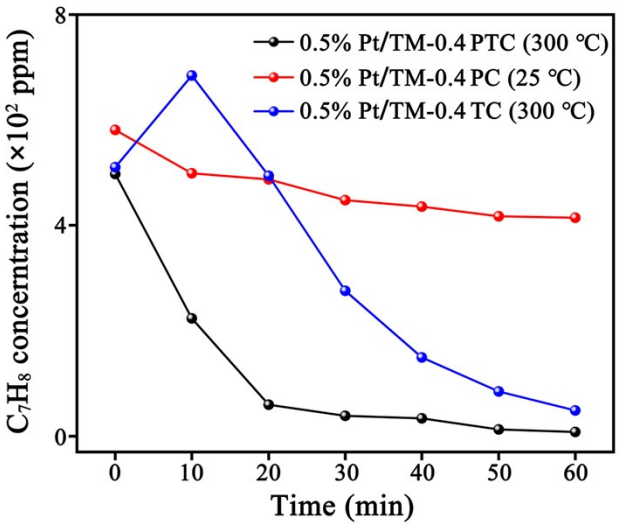

Fig. S14. Concentration change of toluene under the PTC, TC and PC condition for 0.5% Pt/TM-0.4.

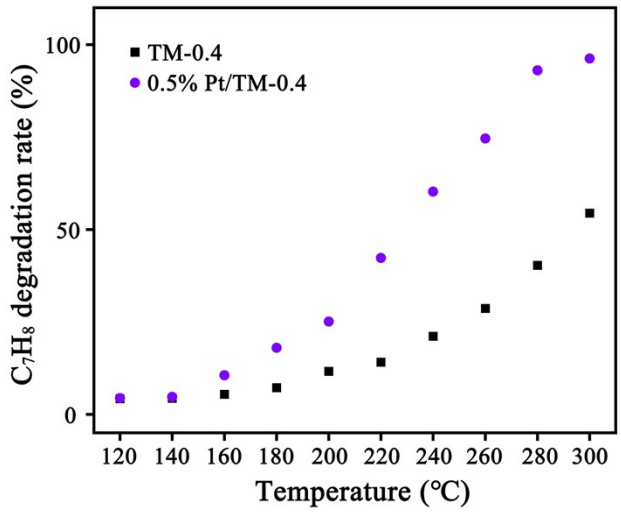

Fig. S15. TC degradation rates of toluene for TM-0.4 and 0.5% Pt/TM-0.4 at different temperatures.

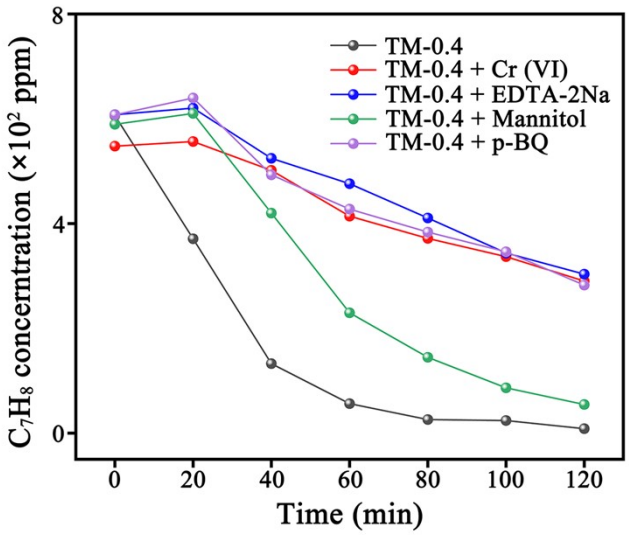

Fig. S16. Concentration change of toluene under Xe lamp illumination for TM-0.4 mixed with $K_2Cr_2O_7$, EDTA-2Na, mannitol and p-BQ.

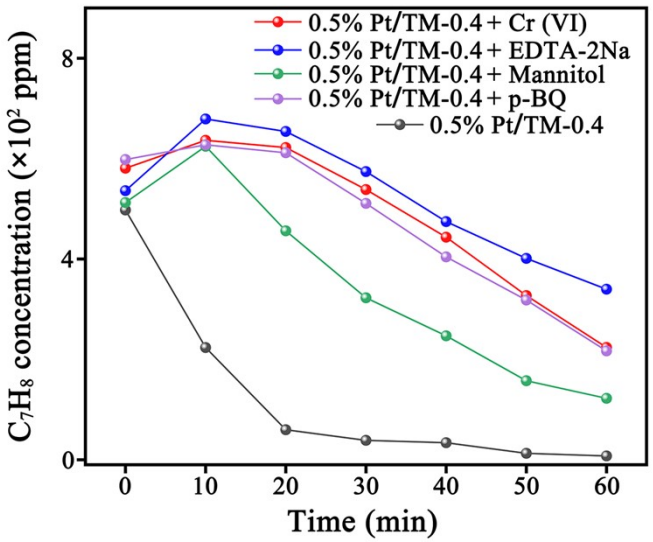

Fig. S17. Concentration change of toluene under Xe lamp illumination for 0.5% Pt/TM-0.4 mixed with $K_2Cr_2O_7$, EDTA-2Na, mannitol and p-BQ.

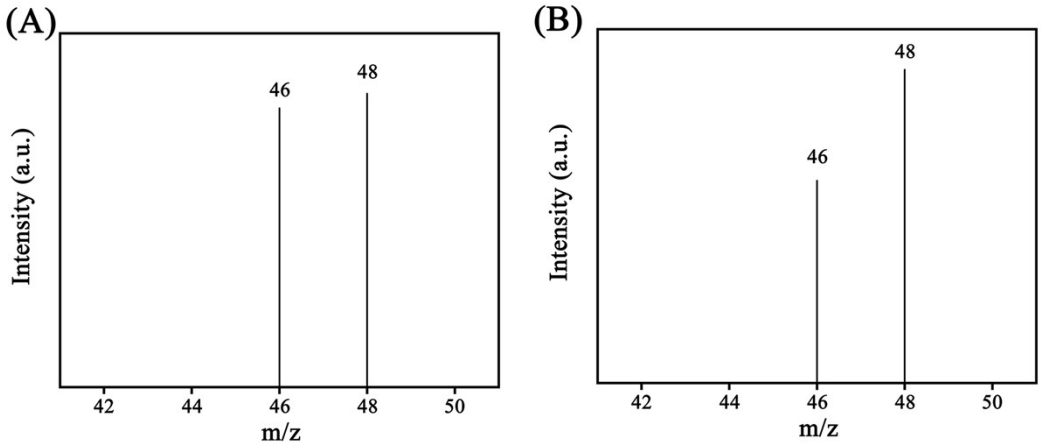

Fig. S18. GC-MS spectra of the gas mixture extracted at 60 min in the presence of (A) TM-0.4 and (B) 0.5% Pt/TM-0.4.

Table S1. BET surface areas of the different samples

Sample	BET surface area (m^2/g)
TiO_2	110.7120
TM-0.8	108.3551
TM-0.6	79.1883
TM-0.4	69.6200
TM-0.2	32.8527
MnO_y	10.7281
TM-0.4-NPs	24.0182
0.1% Pt/TM-0.4	69.9248
0.5% Pt/TM-0.4	69.3475
1.0% Pt/TM-0.4	67.1345

Table S2. Surface temperature of different samples after light irradiation for 5 min.

Sample	Surface temperature (°C)
TiO_2	186
TM-0.8	260
TM-0.6	280
TM-0.4	285
TM-0.2	299
MnO_y	252
0.1% Pt/TM-0.4	291
0.5% Pt/TM-0.4	300
1.0% Pt/TM-0.4	311

Table S3. Comparison of photothermocatalytic activity for toluene degradation reported in the previous literatures [1–11].

Catalysts	Toluene concentration /ppm	Toluene Conversion rate	light	Ref.
TM-0.4 (50 mg)	1150	97.1% 60 min	300W Xe lamp	This work
0.5% Pt/TM-0.4 (50 mg)	1150	97.4% 30 min	300W Xe lamp	This work
Mn-TiO_2 (100 mg)	278	56.4% 160 min	300W Osram lamp	1
Nanodiamond-decorated ZnO (100 mg)	50	100% 120 min	50W Xe lamp with Band-Pass UV-365 filter	2
TiO_2 coupling 2.0 wt% Pt with 1.0 wt% MoS_2 (50 mg)	50	91.5% 25min	300W Xe lamp	3
0.7% Fe-TiO_2 (1200 mg)	370	96.5% 120 min	300W Xe-arc lamp	4
$TiBi_{1.9\%}Zn_{1\%}O_2$ (100 mg)	280	93% 200 min	300W Xe lamp	5
Pt/$SrTiO_3$ (200mg)	700	100% 60 min	300W Xe lamp	6
Pt/$SrTiO_3$ (200 mg)	700	100% 120 min	150 °C	6
SiO_2@Pt@ZrO_2 (0.3 wt% Pt) (200 mg)	800	100% 60 min	300W Xe lamp	7
SiO_2@Pt@ZrO_2 (0.3 wt% Pt) (200 mg)	800	80% 60 min	150 °C	7
Co_3O_4/TiO_2 (Co/Ti ratio, 0.30) (100 mg)	800 (benzene)	95% 40 min	500W Xe lamp	8
1% Pt-rGO-TiO_2 (100 mg)	200	95% 90 min (toluene) 72% 90 min (CO_2)	150 °C	9
Co_3O_4/TiO_2 treated with H_2 (Co/Ti ratio, 0.30) (100 mg)	200	90%	170 °C 300W Xe lamp	10
Ag/Ag_3PO_4/CeO_2	600 (benzene)	10% 180 min	135 °C	11
	600 (benzene)	90.18% 180 min	300W Xe lamp	
TiO_2 (500 mg)	76.5 (benzene)	100% 60 min	UV lamp	12
		16.3% 60 min	240 °C	
0.1 wt% Pt/TiO_2 (500 mg)	76.5(benzene)	100% 30 min	UV lamp	12
		~90% 60 min	240 °C	

Reference

1 V. Binas, V. Stefanopoulos, G. Kiriakidis and P. Papagiannakopoulos, *J. Materiomics*, 2019, **5**, 56-65.

2 J. Liu, P. Wang, W. Qu, H. Li, L. Shi and D. Zhang, *Appl. Catal., B*, 2019, **257**, 11788.

3 J. Qu, D. Chen, N. Li, Q. Xu, H. Li, J. He and J. Lu, *Appl. Catal., B*, 2019, **256**, 117877.

4 S. Sun, J. Ding, J. Bao, C. Gao, Z. Qi, X. Yang, B. He and C. Li, *Appl. Surf. Sci.*, 2012, **258**, 5031-5037.

5 J. Li, S. Cai, Z. Xu, X. Chen, J. Chen, H. Jia and J. Chen, *J. Hazard. Mater.*, 2017, **325**, 261-270.

6 X. Yang, S. Liu, J. Li, J. Chen and Z. Rui, *Chemosphere*, 2020, **249**, 126096.

7 C. Jiang, H. Wang, S. Lin, F. Ma, Y. Wang and H. Ji, *Ind. Eng. Chem. Res.*, 2019, **58**, 16450-16458.

8 Z. Shi, L. Lan, Y. Li, Y. Yang, Q. Zhang, J. Wu, G. Zhang and X. Zhao, *ACS Sustain. Chem. Eng.*, 2018, **6**, 16503-16514.

9 J. Li, S. Cai, E. Yu, B. Weng, X. Chen, J. Chen, H. Jia and Y. Xu, *Appl. Catal., B*, 2018, **233**, 260-271.

10 Y. Yang, S. Zhao, F. Bi, J. Chen, Y. Li, L. Cui, J. Xu and X. Zhang, *Cell Rep. Phys. Sci.*, 2022, 3, 101011.

11 B. Borjigin, L. Ding, H. Li and X. Wang, *Chem. Eng. J.*, 2020, **402**, 126070.

12 Y. Li, J. Huang, T. Peng, J. Xu and X. Zhao, *ChemCatChem*, 2010, **2**, 1082-1087.