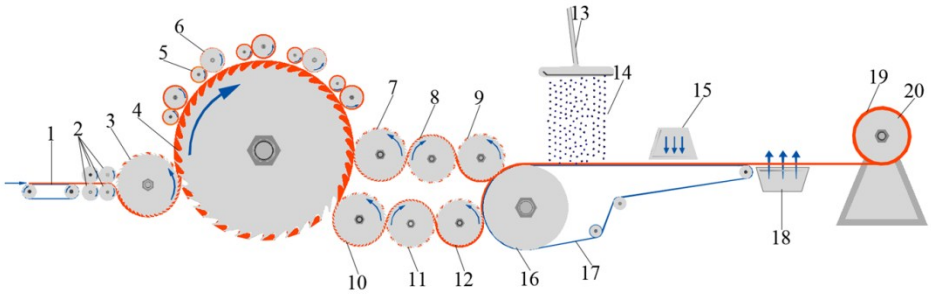
Supporting information for

Multifunctional polyethylene (PE)/ polypropylene (PP) bicomponent fiber filter with anchored nanocrystalline MnO_2 for effective air purification

Zijian Dai [a], Jiafei Su [b], Xiaoming Zhu [a], Kangli Xu [a], Jie, Zhu [a], Chen Huang [a], Qinfei Ke, [*, a, b]

a Key Laboratory of Textile Science & Technology (College of Textiles, Donghua University), Ministry of Education, Shanghai 201620, P. R. China. E-mail address: kqf@shnu.edu.cn

b Environmental Materials Research Center, Shanghai Normal University, Shanghai 200234, P. R. China



1-Feeding Plate; 2-Feeding Roller; 3-Licker-in; 4-Cylinder; 5-Striper; 6-Worker; 7/10-Doffer; 8/9/11/12-Transfer Roller; 13-Nozzle; 14-MnO_2 Nanoparticles; 15-Pre-heating Oven; 16-Take-off Roller; 17-Web Plate; 18-Oven; 19-Fiber Composite; 20-Winding Device

Fig. S1 Technological manufacturing process of MnO_2/PE/PP multifunctional filters.

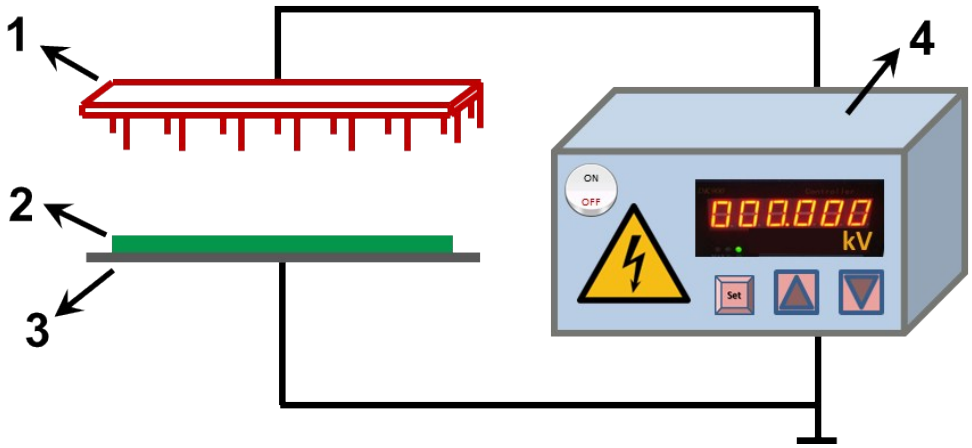


Fig. S2 Schematic diagram of needle-plane electrode system for corona charging process: 1. Metal needle, 2. Swatch, 3. Copper holder, 4. High voltage power supplier.

Synthesis of α-MnO_2, δ-MnO_2

To synthesize α-MnO_2 *via* co-precipitation method, 3.16 g of $KMnO_4$ and 4.53 g of $MnSO_4$ were added in 50 mL of deionized water and stirred at 90 °C, respectively. Afterward, the $KMnO_4$ and $MnSO_4$ solutions were added dropwise into 50 mL of deionized water, respectively. The as-prepared solution was then stirred and reacted at 90 °C for 2 h. Finally, the MnO_2 powders were washed, centrifuged and dried at 80 °C for 12 h. For δ-MnO_2, 3.16 g of $KMnO_4$ and 2.26 g of $MnSO_4$ were reacted at 80 °C for 2 h.

Adsorption and Catalytic Activity Test

A polytetrafluoroethylene layer stainless steel reactor (0.5 L) was used, at the bottom of which was placed a quartz Petri dish with MnO_2/PE/PP swatch inside. After putting the dish into the reactor, 300 ppm of HCHO was injected into the reactor. After stabilizing the concentration of HCHO to 150 ppm, the cover of the dish was removed to start the adsorption and catalytic reaction of HCHO. HCHO, CO_2, CO and water vapor were recorded online during test at 30 °C. The yield of CO_2 (ΔCO_2) and the concentration variation of HCHO were calculated to analyze the HCHO removal ratio.

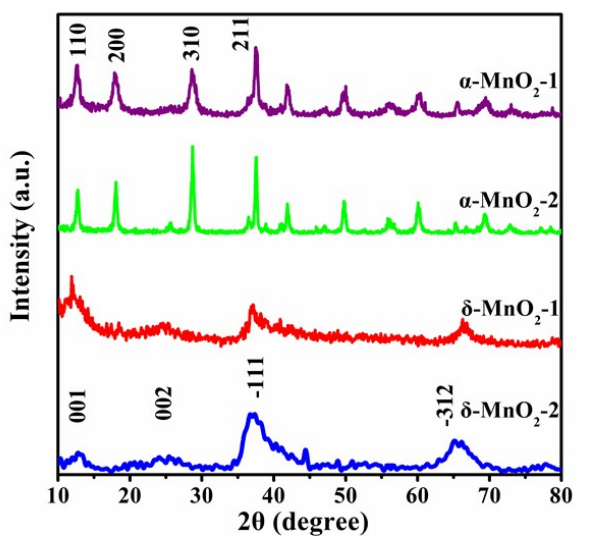


Fig. S3 XRD patterns of α-MnO_2-1, α-MnO_2-2, δ-MnO_2-1, and δ-MnO_2-2.

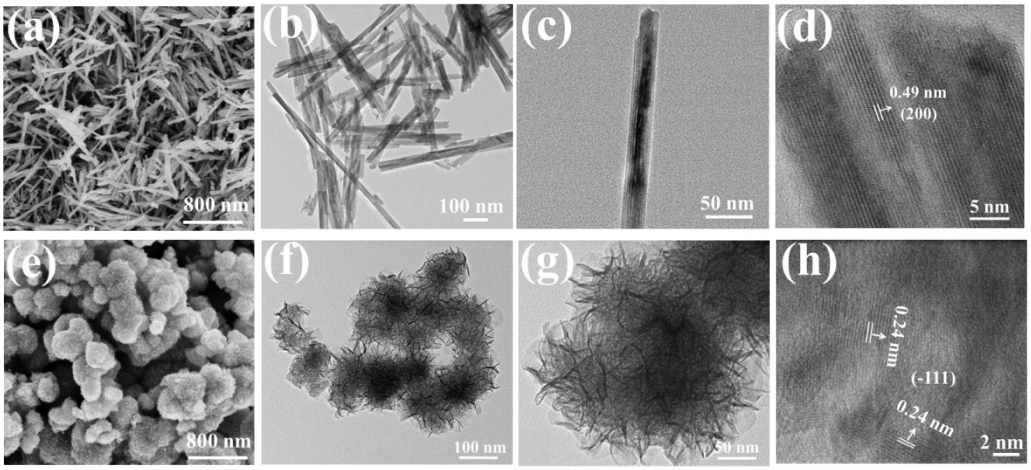


Fig. S4 FE-SEM, TEM and HR-TEM images of different manganese dioxide samples: (a-d) α-MnO_2-1, (e-h) δ-MnO_2-1.

Detailed operating process of O_2-TPD

The as-prepared samples were first transferred to U-type quartz tube and pretreated by 20% O_2/He mixed gas. The samples were heated from room temperature to 300 ^oC at a rate of 10 ^oC/min and were soaked for 30 min. After that, the samples were cooled down to 50 ^oC at flowing stream of 20% O_2/He (30 mL/min), and then pure He gas was introduced to flow through the sample for 30 min. Finally, the temperature was elevated from 50 ^oC to 900 ^oC at He stream (30 mL/min).

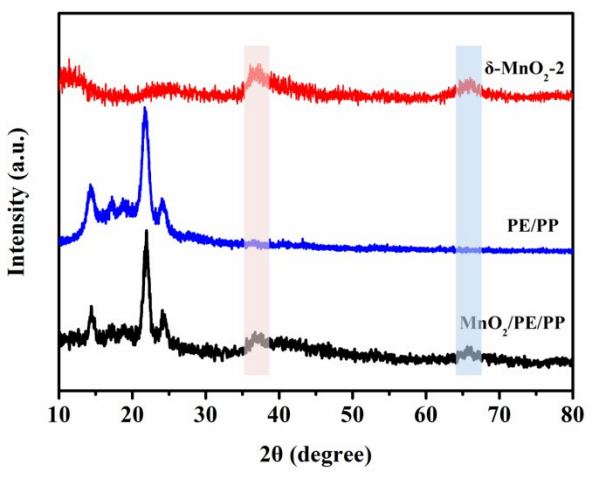


Fig. S5 XRD patterns of δ-MnO_2-2 (treated at 135 °C for 30 min), PE/PP bicomponent fiber and MnO_2/PE/PP fiber mat.

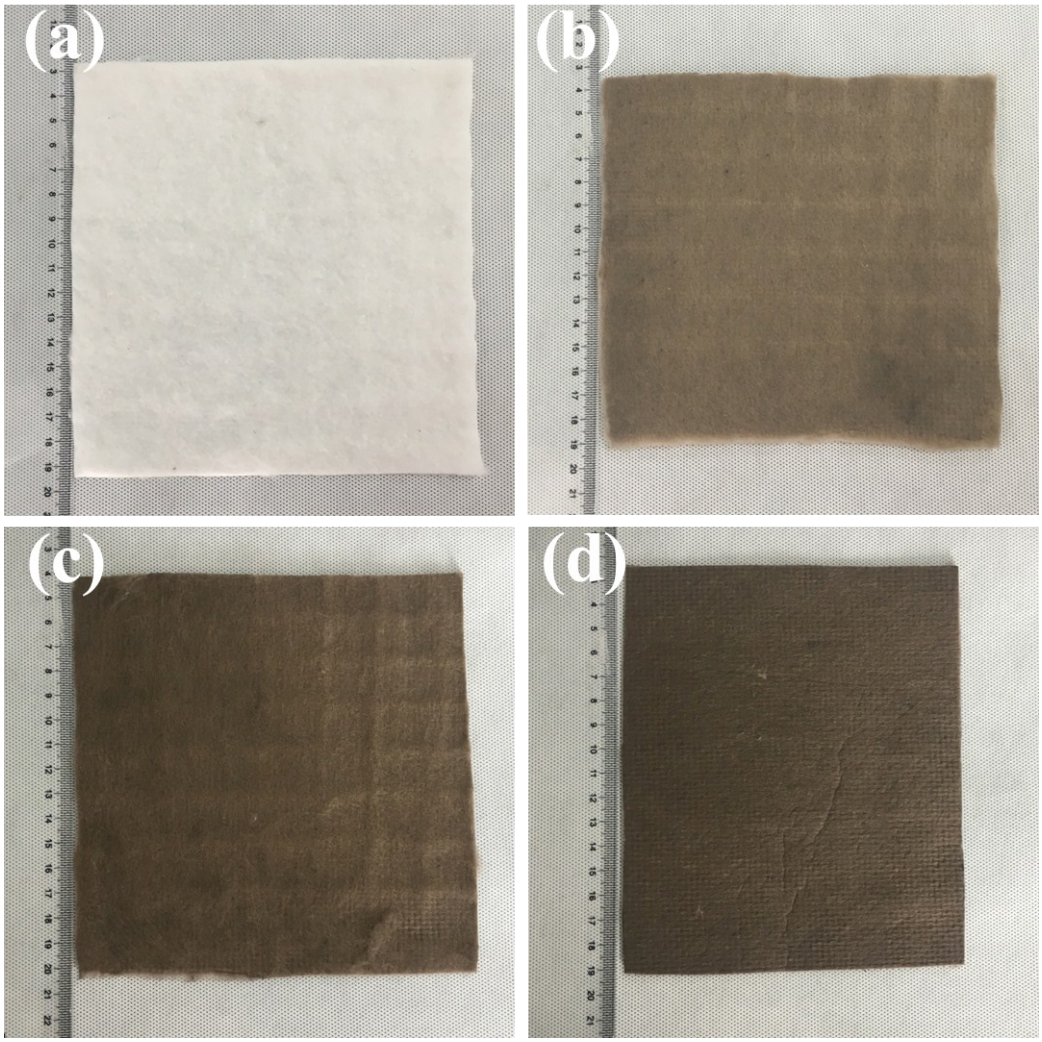


Fig. S6 Optical images of MnO_2/PE/PP nonwovens with (a) 0%, (b) 5%, (c) 8% and (d) 11% of δ-MnO_2-2.

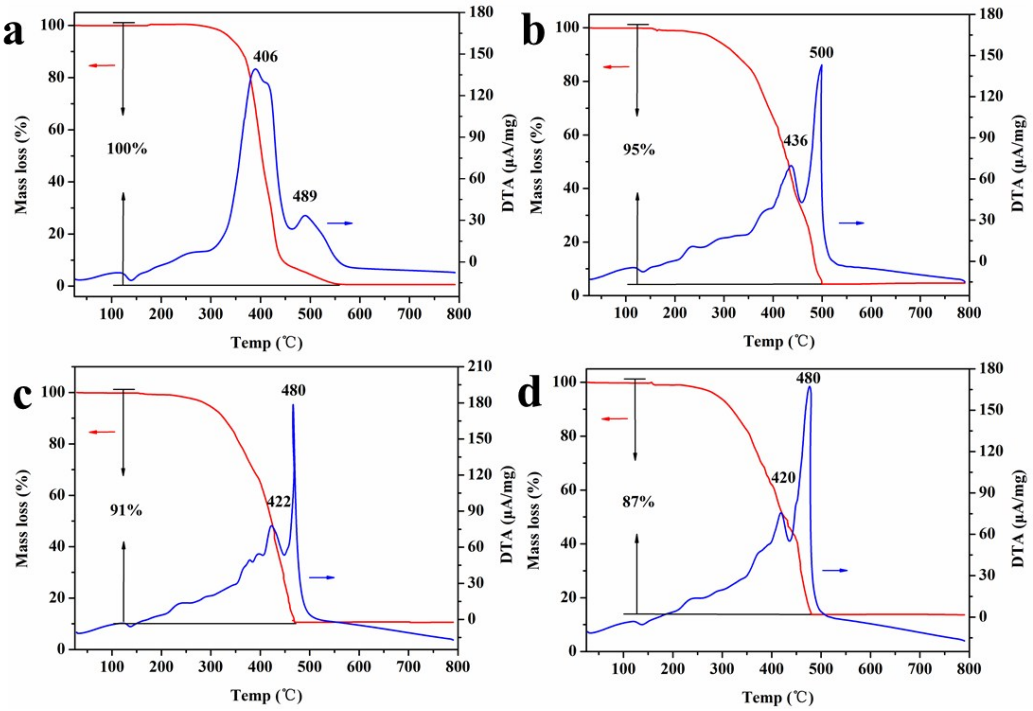


Fig. S7 TG-DTA results for MnO_2/PE/PP swatches with different supply air pressure: (a) 0 Pa, (b) 0.1 Pa, (c) 0.2 Pa, and (d) 0.3 Pa.

Table S1 Filtration performance of selected materials for air filtration

Filters	Basic weight ($g \cdot m^{-2}$)	Filtration efficiency (%) [a]	Pressure drop (Pa)	QF (Pa^{-1}) [b]	Ref
Spunbond PP/PE	120	88.61%±1.96%	22.56±2.24 Pa	0.096±0.0065	1
Meltblown PP/PET	35	67.47	13.12	0.086	2
Sundbond PET/PA6	170	69.00	100	0.012	3
Sundbond PA6/PE	106	60.70	27.44	0.034	4
Meltblown nano PP	40	99.98	280	0.030	5
Electrospun PA-6	0.9	99.99	95	0.11	6
Electrospun PSU/PU	6.79	99.94	184.6	0.040	7
Through-air bonded MnO_2/PE/PP	180	71.73	6.02	0.222	This work

[a] The filtration efficiency was measured using aerosols with an average diameter of 0.3 μm. The face velocity was around of 5.33 $cm \cdot s^{-1}$.

[b] The quality factor (QF) was calculated by the following formula: $QF = -\ln(1-\eta)/\Delta p$, where η and Δp represent filtration efficiency and pressure drop, respectively.

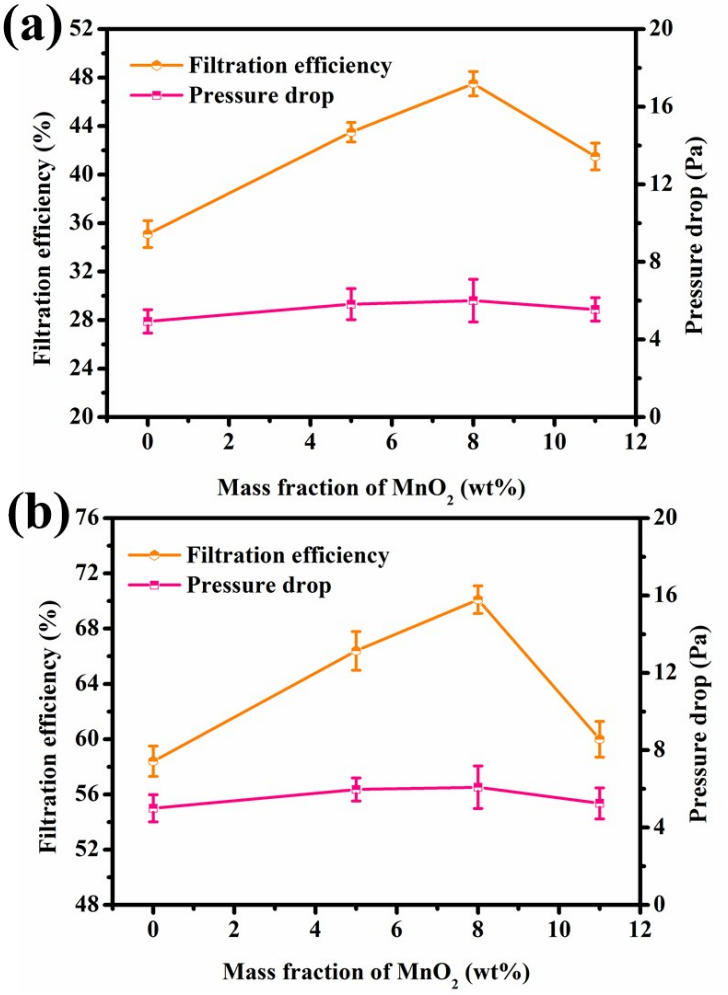


Fig. S8 Representative filtration efficiency and pressure drop of MnO_2/PE/PP nonwovens with 0%, 5%, 8% and 11% of δ-MnO_2-2 after 35 days decay. (a) before corona and (b) after corona charge.

Notes and references

1. J. X. Liu, X. Zhang, H. F. Zhang, L. Zheng, C. Huang, H. B. Wu, R. W. Wang and X. Y. Jin, *Rsc Advances*, 2017, **7**, 43879-43887.
2. Y. Liu, B. W. Cheng, N. Wang, W. M. Kang, W. L. Zhang, K. Q. Xing and W. J. Yang, *Journal of Applied Polymer Science*, 2012, **124**, 296-301.
3. H. Zhang, X. M. Qian, Q. Zhen and Z. H. Yang, *Journal of Industrial Textiles*, 2015, **45**, 48-65.
4. B. Y. Yeom and B. Pourdeyhimi, *Journal of Materials Science*, 2011, **46**, 5761-5767.
5. M. A. Hassan, B. Y. Yeom, A. Wilkie, B. Pourdeyhimi and S. A. Khan, *Journal of Membrane Science*, 2013, **427**, 336-344.
6. S. C. Zhang, H. Liu, F. L. Zuo, X. Yin, J. Y. Yu and B. Ding, *Small*, 2017, **13**.
7. X. Chen, Y. Xu, M. M. Liang, Q. F. Ke, Y. Y. Fang, H. Xu, X. Y. Jin and C. Huang, *Journal of Hazardous Materials*, 2018, **347**, 325-333.