Electronic Supplementary Material (ESI) for Nanoscale Advances.

Rechargeable polyamide-based *N*‒halamine nanofibrous membranes for renewable, high-efficiency, and antibacterial respirators

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Supplementary Method 1

The titration of water used for rinsing the membranes for the last time: Firstly, 0.5 g of water were added into 15 mL of sodium thiosulfate ($Na_2S_2O_3$) solution (0.001 N) with gentle shaking for 0.5 h to ensure the complete consumption of redundant chlorine, then 0.001 N iodine standard solution was added into the solution dropwise to examine the amount of residual sodium thiosulfate. The volume of the iodine solution consumed for titrating $Na_2S_2O_3$ were 7.5 mL, indicating that all $Na_2S_2O_3$ reacted with iodine. Based on this result, we could draw a conclusion that there are no redundant hypochlorous moieties in membranes.

Supplementary Method 2

The derivation process for formula $N = {}^{n}/_{M_r}$: This formula was obtained based on the hypothesis that the quality of membranes was contributed by the masses of each macromolecules. Thus,

$$1 = \frac{M_r}{N_A}\tau$$

where M_r is the relative molecular mass of monomers, N_A is avogadro's number, τ refers to the degree of polymerization. Furthermore, the molar number of amide groups per grams of nanofibers (N) could be calculated by

$$N = \frac{n\tau}{N_A}$$

where n stands for the number of amide groups of each monomer. Thus, the formula $N = {}^{n}/_{M_r}$ could be easily obtained.

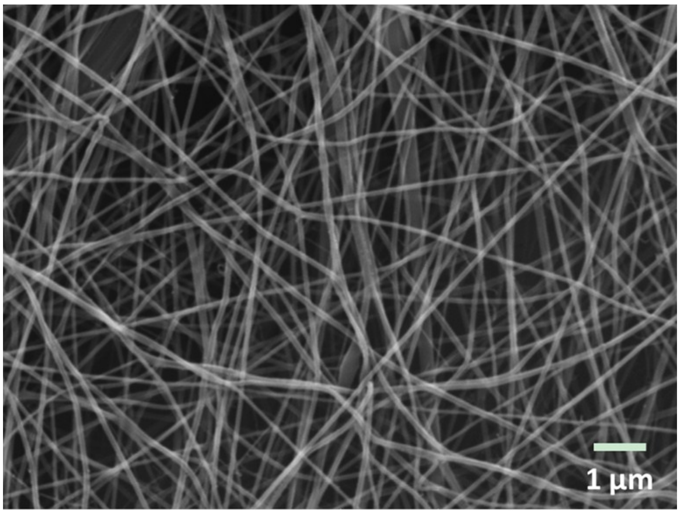

Fig. S1. Membranes after vibration, showing no bacteria attached.

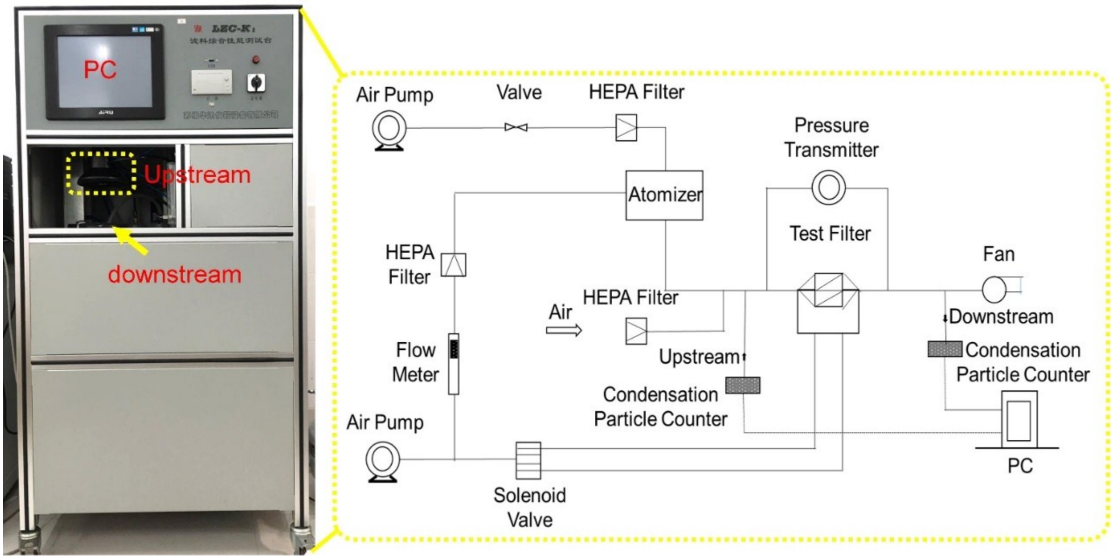

Fig. S2. Experimental setup for the evaluation of air filtration performance.

Filtration process. The neutral sodium chloride (NaCl) monodisperse aerosol particles produced from atomizing air pump passed through the test samples with a valid test area of 100 cm^2. The NaCl aerosol particles, featured with a mass-average particular size of 0.3-0.5 µm and a standard deviation less than 1.86, were detected in the upstream and downstream of the tested sample with the quantity of ε_1 and ε_2, respectively under the ambient temperature of (25 ± 2°C) and RH of (45 ± 5%). The resulted filtration efficiency could be calculated via $\eta = 1 - \varepsilon_1/\varepsilon_2$. The pressure drop was resulted from the D-value of upstream and downstream measured by flow gauges. The nonwoven substrate was attached while testing the air filtration properties.

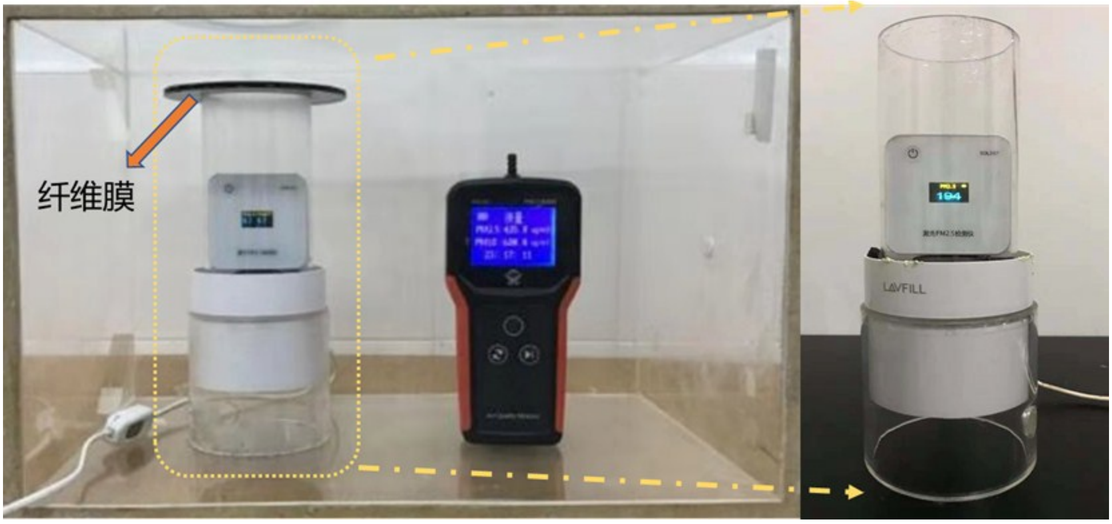

Fig. S3. Self-designed test platform for recycling filtration performance.

The test of recycling filtration performance toward $PM_{2.5}$. The recycling filtration performance was performed in a closed cabin that contains a small air purification machine with the airflow of 14 L min^{-1} and two professional $PM_{2.5}$ concentration detection instrument bough from Shandong Nuofang electronic technology Co., LTD. To test the clean air delivery rate, the charged PA membrane was placed in the air inlet and sealed with the double sides adhesive tape to guarantee the air passing into the air purification machine through filter materials completely. Simulated particles were generated by burning a cigarette in the closed cabin, resulting in white smoke with particles ranging from 0.3 μm to 10 μm. The initial concentration of $PM_{2.5}$ (500 μg m^{-3}) was reached by controlling the burning time or diluting the smoke with clean air to achieve a severe pollution level. Upon the $PM_{2.5}$ concentration reached to 500 μg m^{-3}, the air purification machine was turned on to make the polluted air pass through membranes and remove particles. When the $PM_{2.5}$ concentration in the cabin was decreased to 35μg m^{-3}, the time was noted as the clean air delivery rate. The long term recycling operational performance was evaluated by test 15 cycles of $PM_{2.5}$ concentration decrease from 500 μg m^{-3} to 35 μg m^{-3}. In addition, the $PM_{2.5}$ removal efficiency could also be obtained by comparing noting of the two $PM_{2.5}$ concentration detection instrument.

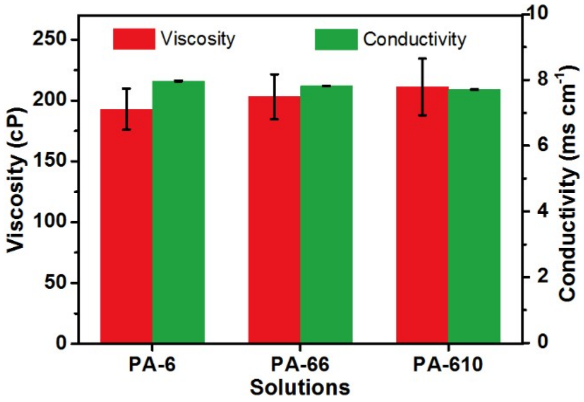

Fig. S4. Viscosity and conductivity of PA-6, PA-66, PA-610 solutions.

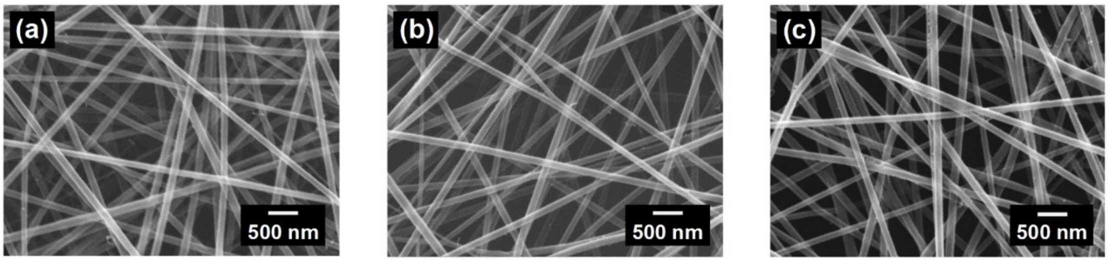

Fig. S5. Morphologies of (a) PA-6, (b) PA-66, and (c) PA-610 nanofibrous membranes after chlorination.

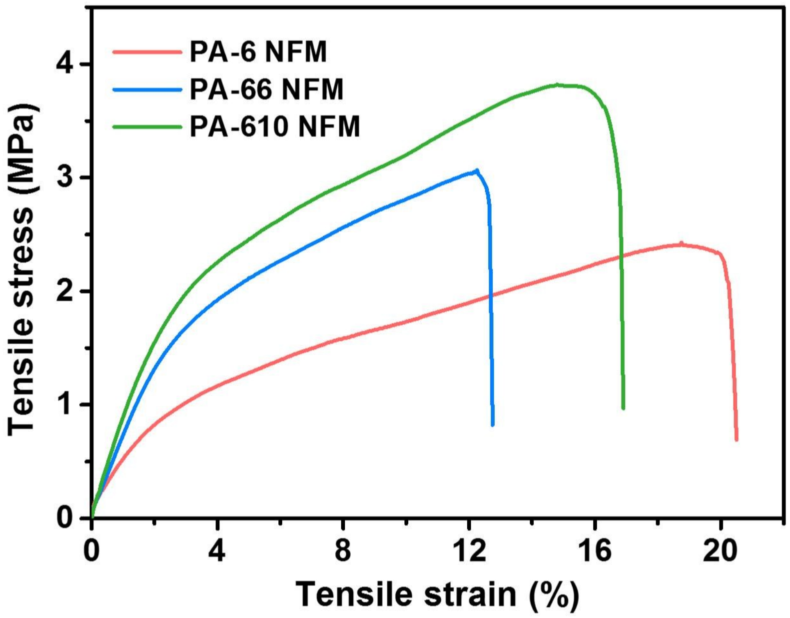

Fig. S6. The mechanical property of PA-6, PA-66, and PA-610 nanofibrous membranes.

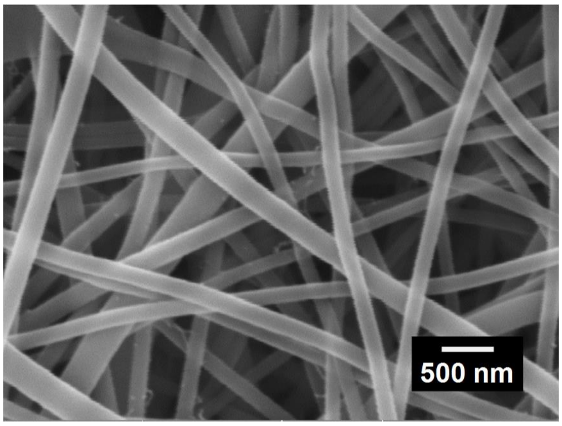

Fig. S7. Morphology of PA-6 nanofibrous membranes after 5 repeated quenching/chlorination cycles.

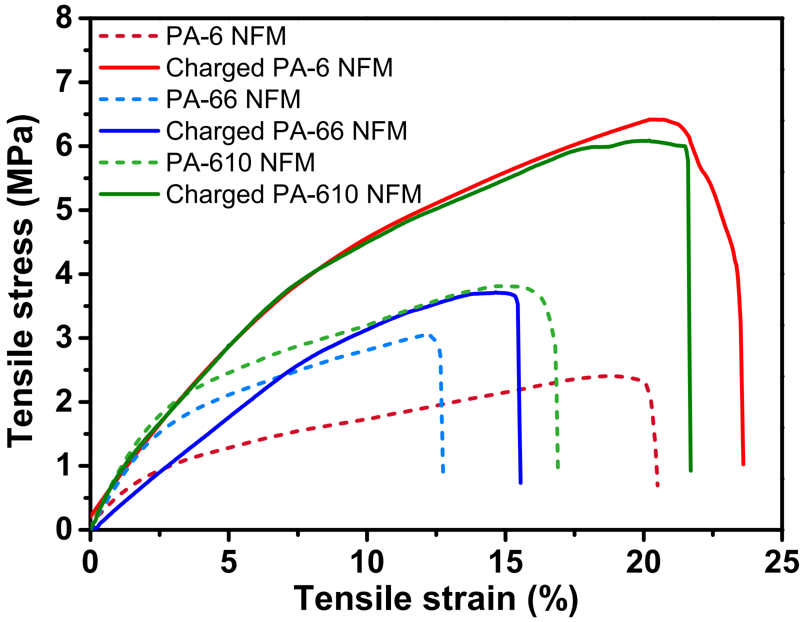

Fig. S8. The mechanical property of PA NFM before and after chlorination.

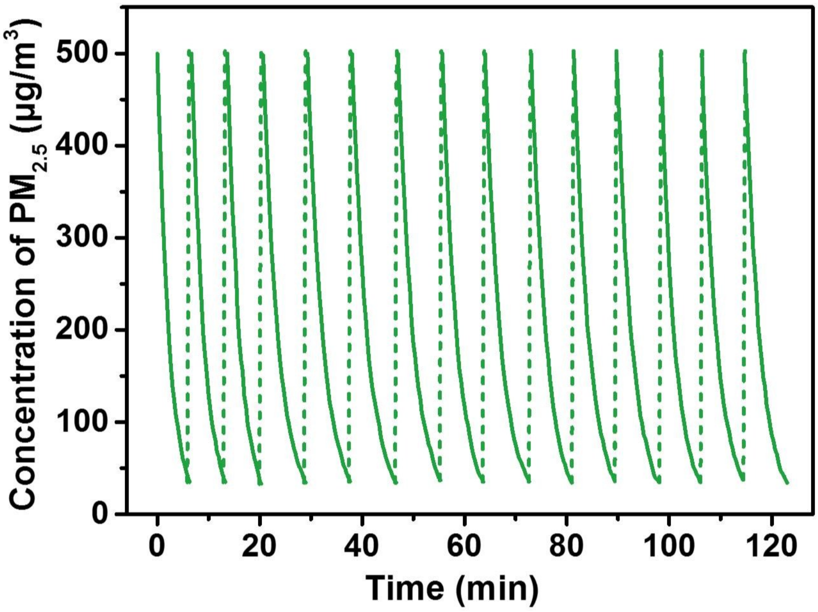

Fig. S9. Clean air delivery rate of charged PA-6 nanofibrous membranes during recycle test.

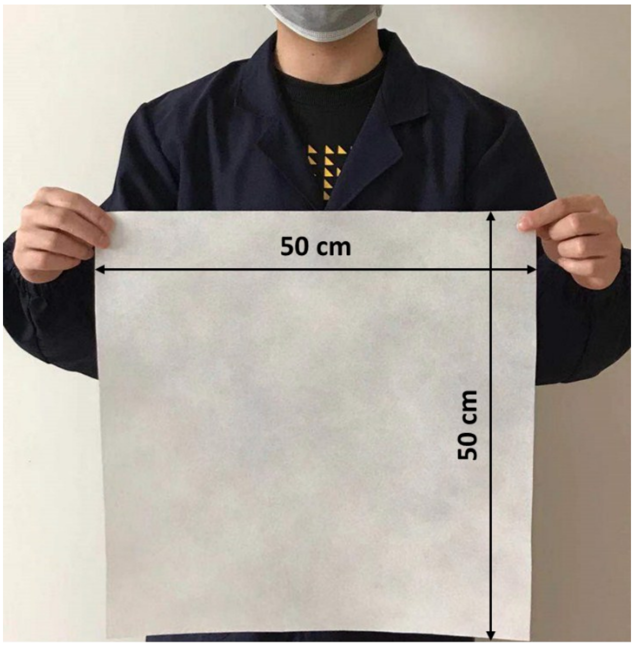

Fig. S10. The scale production of antibacterial PA-6 nanofibrous membranes.

Tab. S1 The structural parameters of PA-6 nanofibrous membranes before and after chlorination.

	Pristine PA-6 NFM	**Charged PA-6 NFM**
Area (cm^2)	36±0.024	30.16±0.031
Fiber diameter (nm)	193±16	205±13
Pore size (µm)	0.36±0.02	0.3±0.032
Thickness (µm)	18.5±2.15	19.2±1.54
Porosity (%)	92.9±0.14	92.1±0.29