

SUPPLEMENTARY MATERIALS

Cellulose-based triboelectric nanogenerator prepared by multi-fluid electrospinning for respiratory protection and self-powered sensing

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This includes:

Extended Materials and Methods.

Figures S1-S5.

Extended Materials and Methods

SEM analysis

The surface morphologies of the CEC/PVDF and CNC/Zein nanofibers were observed by SEM (JSM-7500 F, JEOL, Tokyo, Japan) with an accelerating voltage of 12.5 kV. The fiber samples were coated with platinum to increase electrical conductivity before SEM operation.

Output performance analysis

The size of the cellulose-based TENG used for testing was 3.5×6 cm. A thin copper wire was connected to the aluminum electrode and a stepper motor was used as a contact and separation device to provide power. The speed of the stepper motor was adjustable, and the distance between the two dielectrics was set as 2 cm. The other end of the copper wire was connected to the electrochemical workstation (CHI600E, Shanghai Chenhua Instrument Co., Ltd., Shanghai, China) to test the open-circuit voltage and short-circuit current of the cellulose-based TENG.

PM filtration efficiency

We used a filter material tester (LZC-H, Hangzhou Bai Ming Instrument Co., Ltd. Hangzhou, China) to characterize the filtration efficiency and resistance of the nanofiber membrane. The effective area of the membrane was a square with a diameter of $10 \times 10 \text{ cm}^2$. The test used a NaCl solid aerosol with a particle size ranging from 0.3 to $10 \text{ }\mu\text{m}$, and the air flow rate was set as 85 L/min . The nanofibrous membrane was filtered by calculating the difference in the number of particles on the upper and lower surfaces of the membrane during the filtration process. The ambient temperature and humidity were unchanged during the test, and the lasting time of the test was 1 min. The η can be calculated from Equation (1):

$$\eta = \frac{1 - \mu_1}{\mu_2} \times 100\% \quad (1)$$

where μ_1 is the number of NaCl particles on the upper surface of the sample and μ_2 is the number of NaCl particles on the lower surface of the sample.

To measure the contribution of the two parameters of the performance of nanofibrous membrane, it can be balanced by introducing a quality factor (QF). The calculation formula of the relationship between filtration efficiency and pressure drop was determined by Equation (2):

$$QF = -\frac{\ln(1-\eta)}{\Delta P} \quad (2)$$

where η (%) is the filtration efficiency and ΔP (Pa) is the pressure drop.

Formaldehyde filtration

We used an indoor air quality analyzer (des-F, Wuxi Deersi Environmental Testing

and Governance Co., Ltd. Wuxi, China) to detect the formaldehyde adsorption and filtration efficiency of the CNC/zein nanofibrous membrane. The prepared formaldehyde solution was put into sealed glassware. One end of the glassware was put in nitrogen for the mixed gas, and a small fan above the glassware was used to stir the gas. The other end of the glassware led to the sampling bottle of the atmospheric sampler with the detection liquid. The CNC/zein membrane was placed in the middle of the channel, the sampling speed was set as 1 L/min, and the collection time was 5 min. The concentration of formaldehyde before (*a*) and after (*b*) the CNC/zein nanofiber membrane was placed in the channel was detected. The adsorption filtration efficiency (*k*) of formaldehyde can be calculated from Equation (3):

$$k = \frac{a - b}{b} \times 100\% \quad (3)$$

where *a* (mg/m³) is the formaldehyde concentration without the CNC/zein membrane and *b* (mg/m³) is the formaldehyde concentration after use of the CNC/zein membrane.

FTIR analysis

The FTIR spectra of the samples were obtained by a Fourier transform infrared spectrometer (FTIR, NICOLET 6700, Thermo Fisher Co., Ltd., Agawam, MA, USA). This analysis was used to explain the changes in molecular structure and internal functional groups during the conversion of polymer materials into nanocomposite. The wavenumber range was 4,000~500 cm⁻¹ and the resolution was 4 cm⁻¹.

Hydrophobic analysis

The water contact angle was measured by contact angle measuring system (OCA 40, Dataphysics Co., Ltd. Stuttgart, Germany) with droplets of 5 μL.

Extended Data and Figures

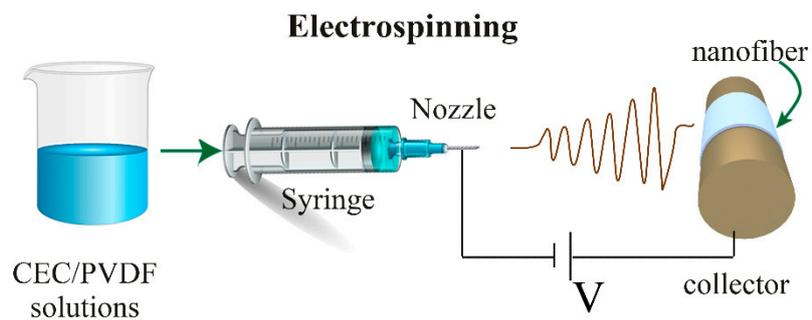


Figure S1. Schematic of electrospinning process to prepare CEC/PVDF nanofibers

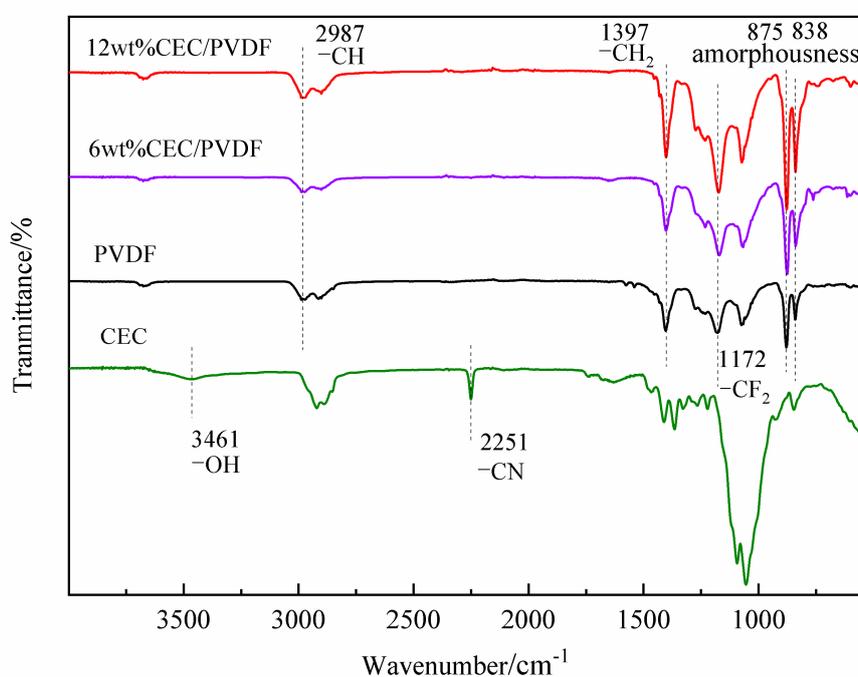


Figure S2. FTIR spectra of CEC, PVDF, and CEC/PVDF nanofibers.

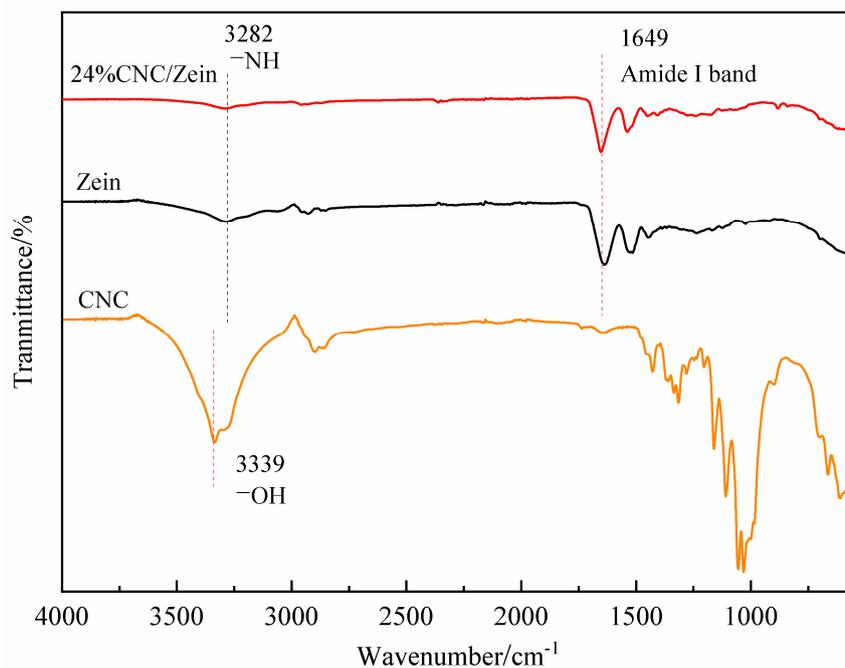


Figure S3. FTIR spectra of CNC, zein, and CNC/zein nanofibers.

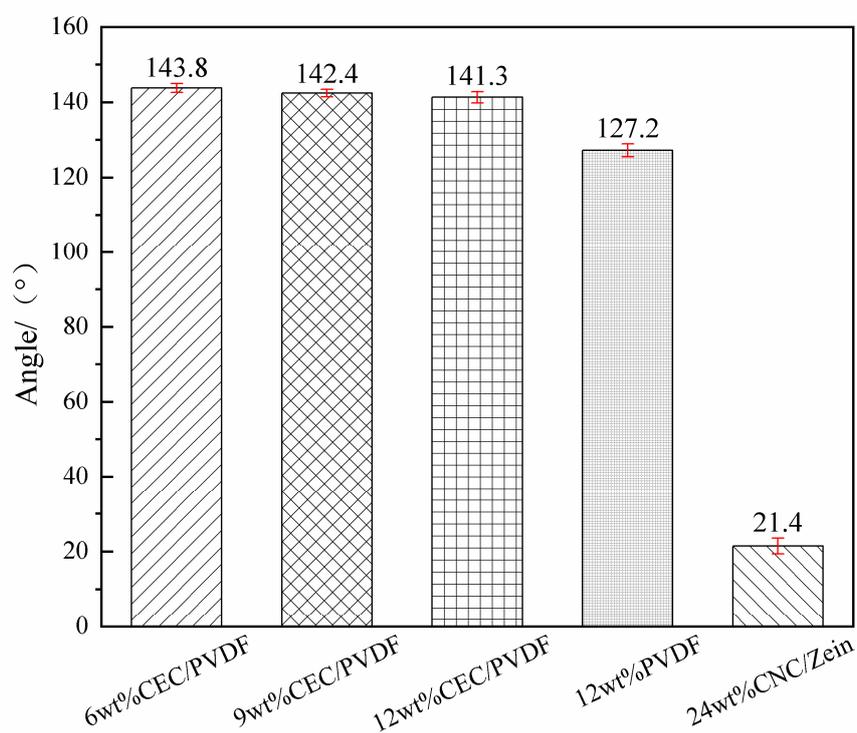


Figure S4. Water contact angle of CEC/PVDF, PVDF, and CNC/zein nanofibrous membranes.

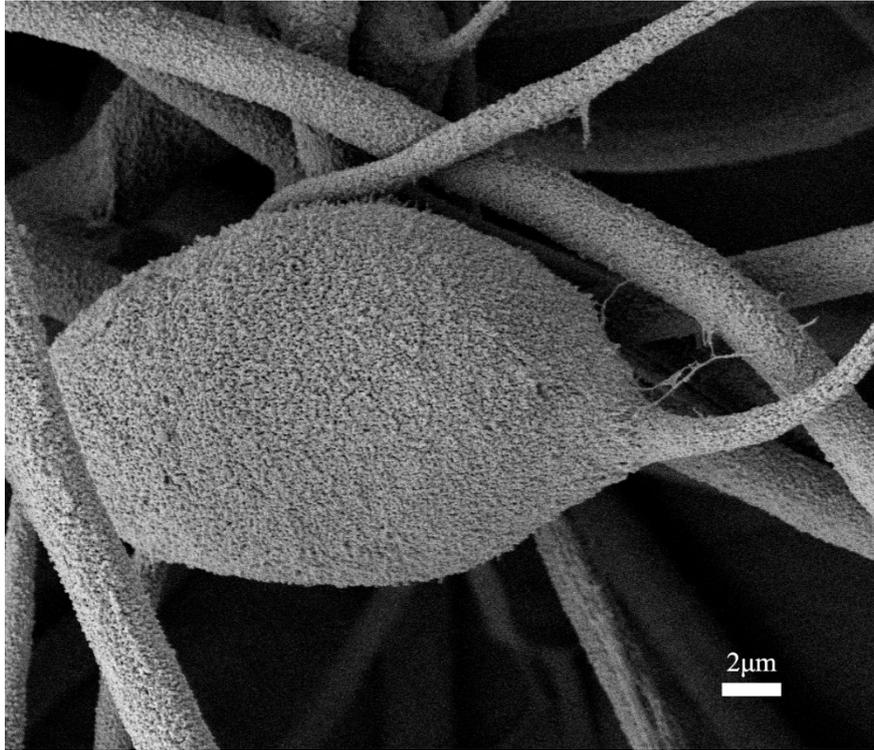


Figure S5. SEM image of 9 +12 wt% CEC/PVDF fibrous membrane.