

Support information

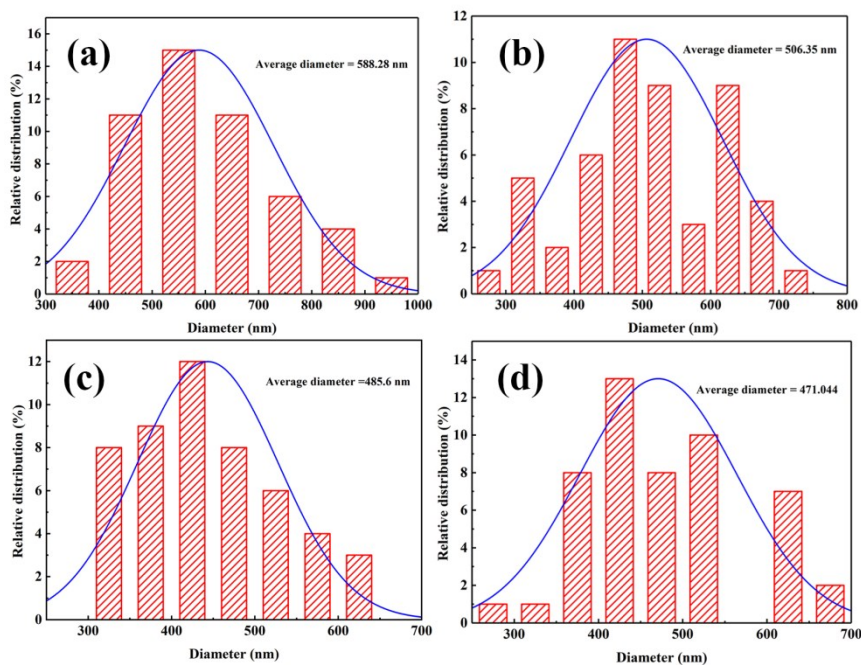


Figure S1. Histogram showing the fiber diameters distribution of the PAN-SiO₂ fibrous membranes after various alkali treatment time, (a) 0, (b) 0.5, (c) 1 and (d) 1.5 hrs, respectively

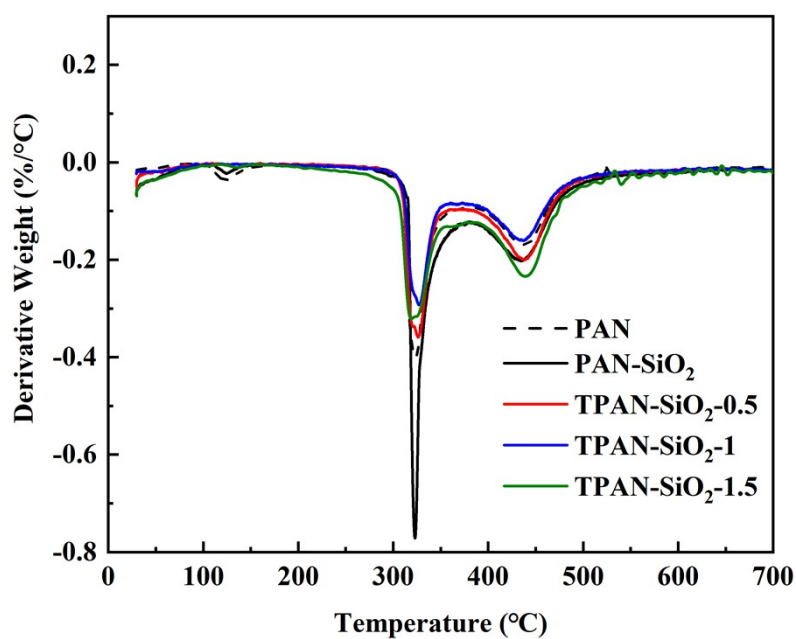


Figure S2. DTG of the corresponding fibrous membranes.

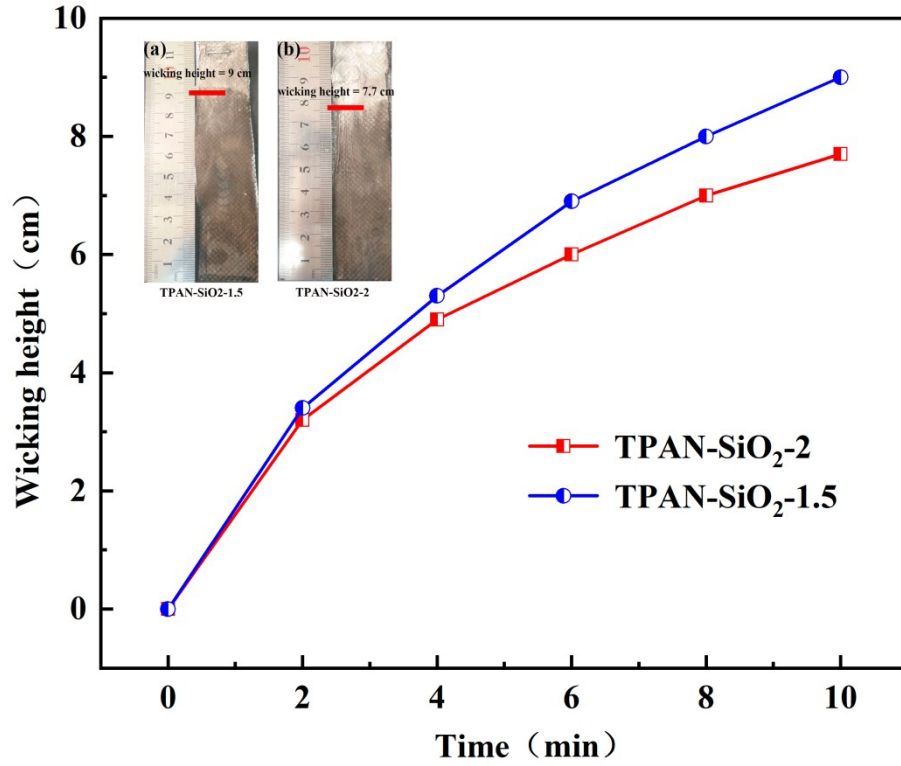
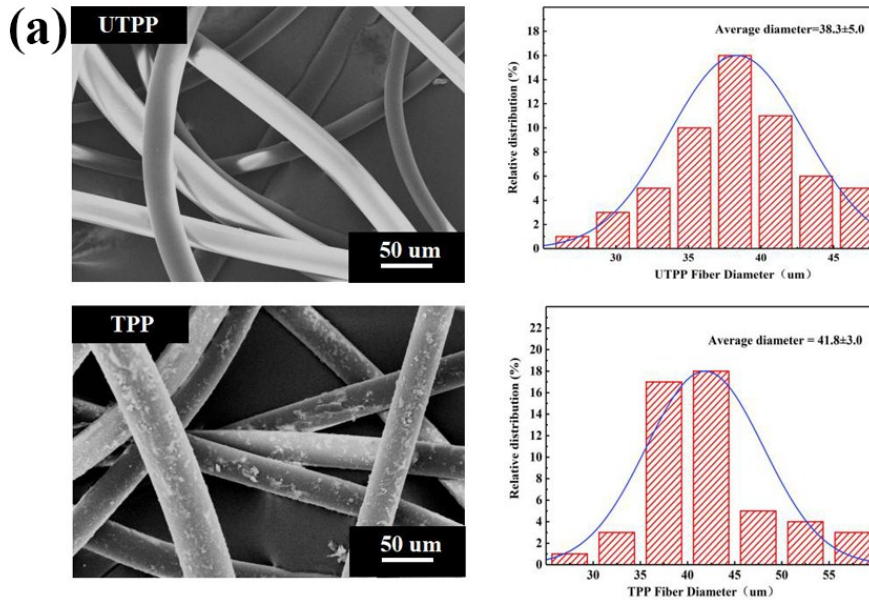


Figure S3. Wicking height with 1.5h and 2h treatment time, respectively.



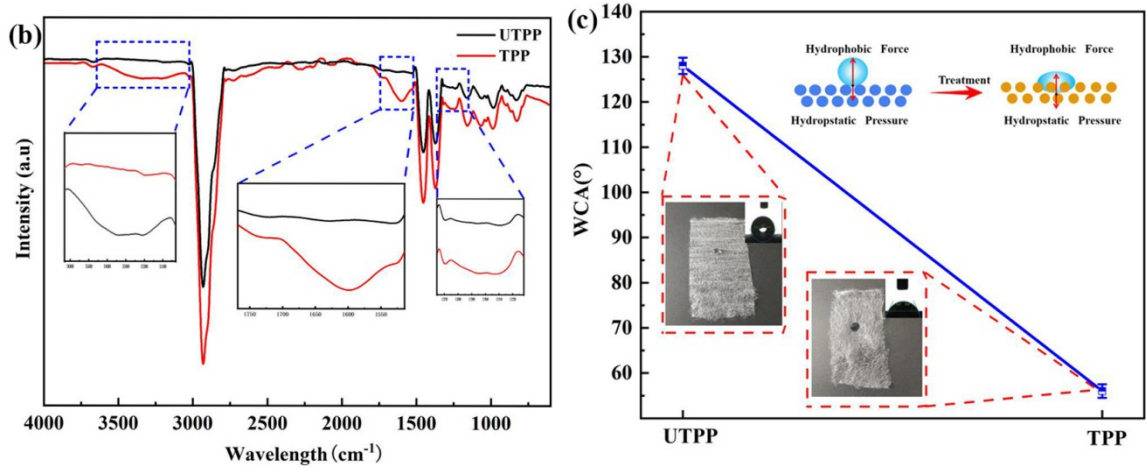


Figure S4. (a) SEM images and distribution of fiber diameters of UTPP and TPP. (b) FTIR spectra of the UTPP and TPP. (c) WCA of the UTPP and TPP

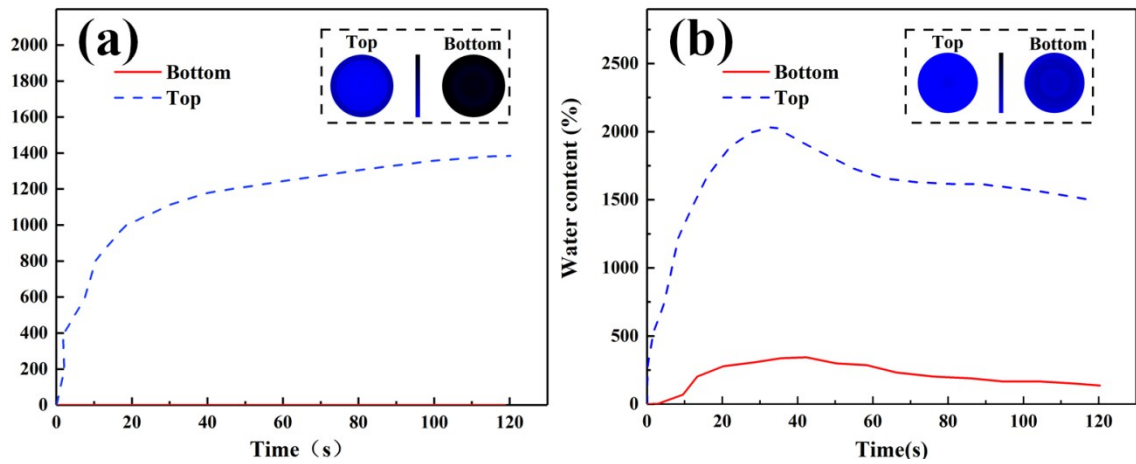


Figure S5. MMT results of the TPAN-SiO₂/TPP (a) and TPAN-SiO₂/Cotton mesh/TPP (b) in the reverse direction, respectively.

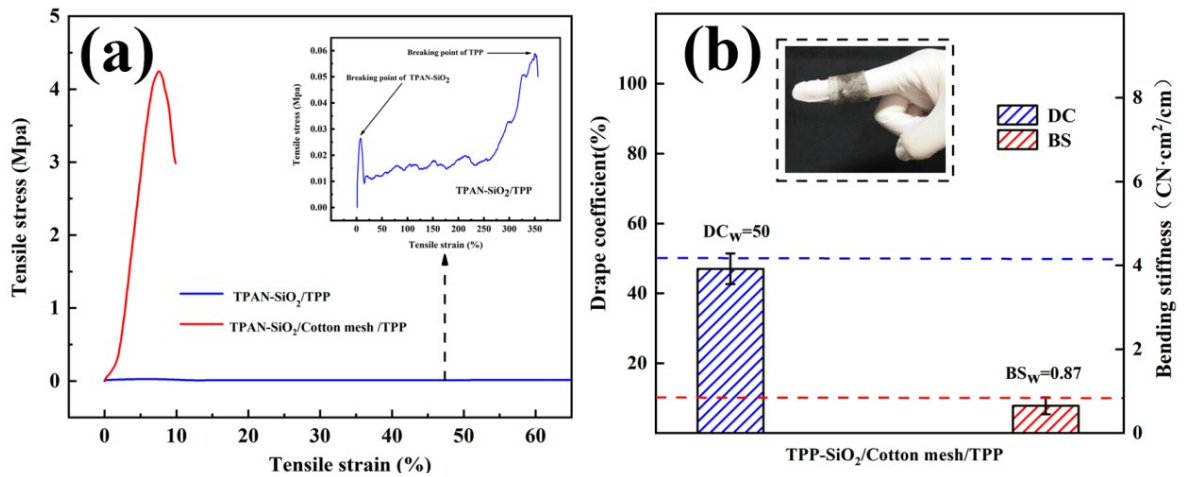


Figure S6. Tensile strength test (a) and Flexibility test (b) of the TPAN-SiO₂/Cotton mesh/TPP

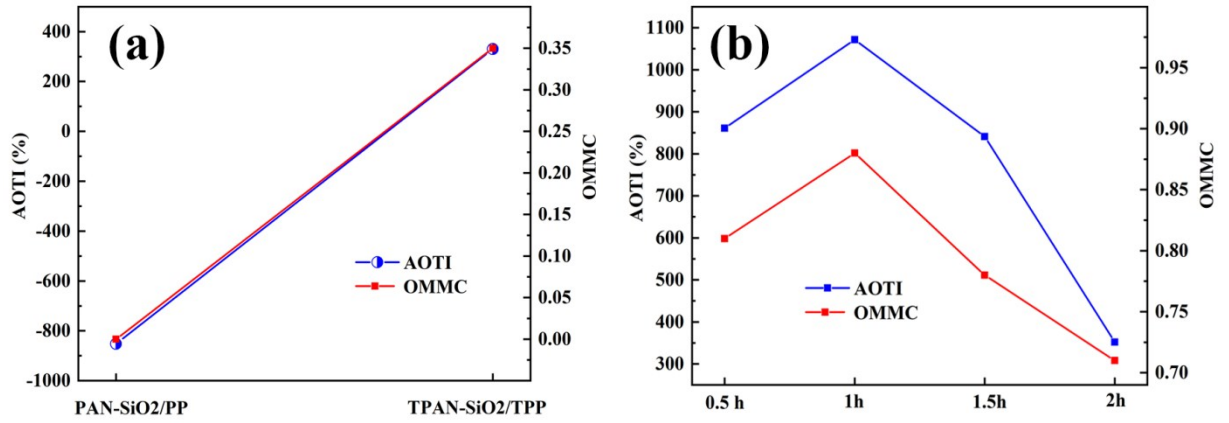


Figure S7. The accumulative one-way transport index and overall moisture management performance of bilayered fibrous mats (a) and multilayered superfine fibrous mat with various melt-electrospinning time (b).

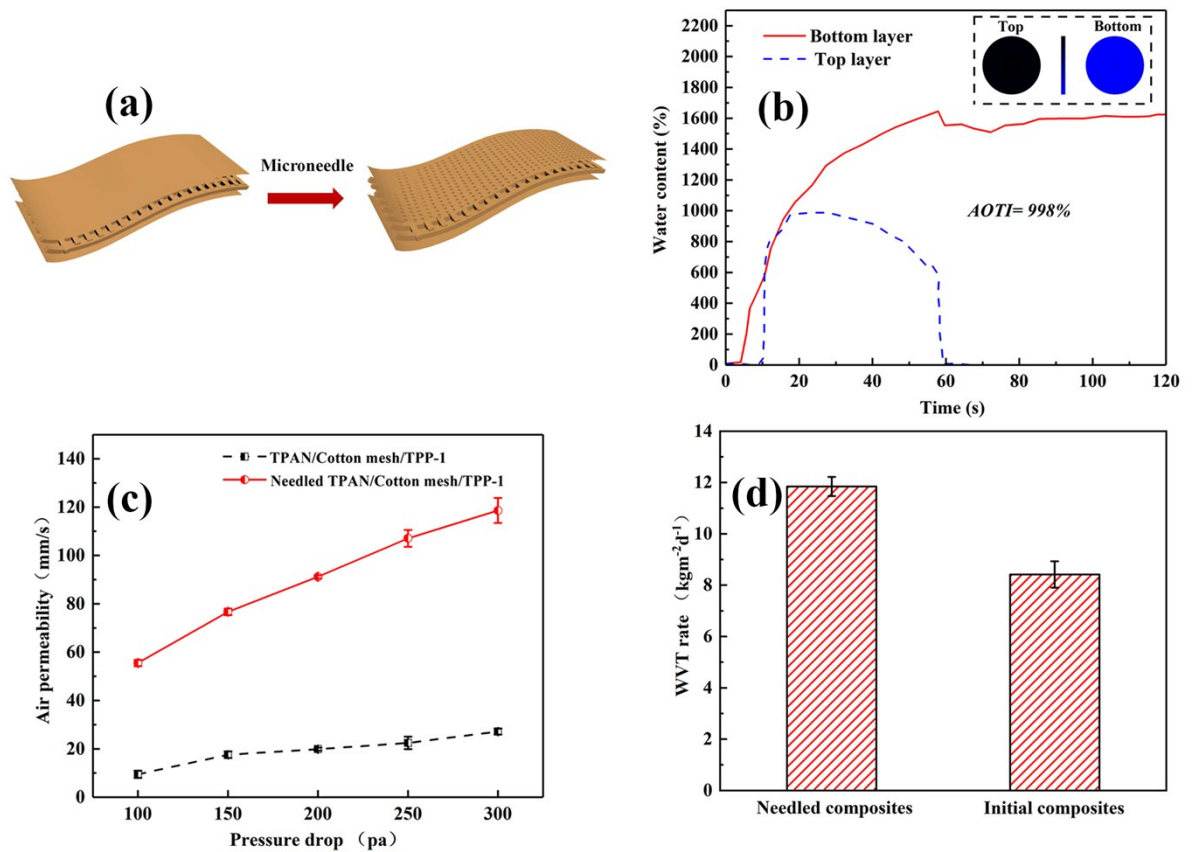


Figure S8. The Needled TPAN-SiO₂/Cotton mesh/TPP for testing. Schematic of the fabrication process of needled TPAN-SiO₂/Cotton mesh/TPP (a). The MMT resultant (b), air permeability test (c), and water vapor transport rate of TPAN-SiO₂/Cotton mesh/TPP.

Supplementary Discussion

Preparation and Characterization of Needled Multilayered Fibrous Mat

The outer layer of multilayered fibrous mat do not possess the excellent permeability due to the relative long solution-electrospinning time forming a compact nanofibre membranes with small pore size. The small pore size of outer layer limit the air gas flow in the membranes, which would cause the sense of non-sultry heat when the people stay in the motion status. In order to improve the performance of permeability, the method of needled treatment was utilized on the surface of composites. The holes with a diameter of 0.04 mm spaced 0.2 mm apart with commonly used microneedle punching were created on the material to form rectangular array finally ³⁵. The property of directional water transport and related permeability were measured systematically. The resultant of MMT exhibited that the AOTI value still remained 998% after needling. Meanwhile, the air permeability can be increased from 27.17 mm/s to 118 mm/s, and water vapor transport (WVT) rate can achieve 11.6 kg d⁻¹m⁻² showing the outstanding permeability performance.