Electronic Supplementary Material (ESI) for Environmental Science: Nano.

Supporting Information

Multifunctional and asymmetrically superwettable Janus membrane for all-day freshwater harvesting

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Experimental Section

Materials

Polyvinyl alcohol (PVA, Mw= ~67 000), pyrrole (99.0 %) and (heptadecafluoro-*1,1,2,2*-tetradecyl) trimethoxysilane (96%, 17-FAS) were purchased from Aladdin Biochemical Technology Co. Ltd. Polyacrylic acid solution (PAA, Mw= ~3 000, 30 wt%), sodium hydroxide (NaOH, 96.0%) and ammonium persulphate ($(NH_4)_2S_2O_8$, AR) were purchased from Shanghai Macklin Biochemical Co. Ltd. Ethanol (C_2H_5OH, AR) and Hexyl hydride (C_6H_{14}, AR) were purchased from Nanjing Chemical Reagent Co. Ltd. Copper mesh (200#) was purchased from Zhongzhen Copper Technology Co. Ltd. The deionized (DI) water produced from Millipore were used in all experiments.

Preparation of the copper hydroxide mesh

The copper mesh with 3×3 cm^2 was ultrasonically cleaned in DI water and ethanol for five minutes, respectively. After that, the copper mesh was etched in 200 mL solution containing 10 g of NaOH and 4.45 g of $(NH_4)_2S_2O_8$ for 10 min. Next, the etched copper mesh was washed with DI water for 5 min and then dried at 60°C.

Preparation of the superhydrophobic copper mesh with photothermal layer.

The etched CM was then polymerized in 50 mL solution containing 0.1 g of pyrrole and 0.18 g of $(NH_4)_2S_2O_8$ for 1 h and dried at 60°C for another 1 h. Then, the polymerized copper mesh was immersed in 1wt% of 17-FAS/n-hexane solution to fabricate a superhydrophobic copper mesh with photothermal characteristics, denoted as SPCM.

Fabrication of the SPCM with PVA/PAA interlayer

0.23 g of PVA and 1.24 g of 30wt% PAA solution were dissolved in 18.53 g DI water to prepare a 3 wt% PVA/PAA solution. Then, ~0.5 g of the solution was sprayed coated on one side of the SPCM and the weighing paper removed the excess solution. In this process, the mass of PVA/PAA deposited onto the SPCM is weighed by a ten thousandth place balance and the basis weight was calculated to be 0.38 g m^{-2}. After that, the PVA/PAA coated SPCM was thermally crosslinked at 100 ℃ for 1 h, denoted as CSPCM.

Fabrication of the multifunctional and asymmetrically superwettable Janus membrane.

Firstly, 0.91 g of PVA and 4.96 g of 30% PAA solution were dissolved in 14.13 g of DI water to obtain a 12 wt% of PVA/PAA solution. Secondly, the as-prepared solution was loaded into a 10 mL syringe, and the coating layer of CSPCM was placed on the rotary drum as the receiver. A high positive voltage of 25 kV and a negative voltage of 5 kV were applied to the needle tip and the collector, respectively. The distance between the needle and the collector was 20 cm. The injection speed was kept at 0.05 mm min^{-1}. The spinning process was carried out in an enclosed environment with a humidity of about 45% and a temperature of 25 °C. At last, the PVA/PAA nanofiber layer deposited onto the CSPCM was crosslinked at 100°C for 1.5 h and the basis weight was calculated to be 2.82 g m^{-2}. The obtained sample was denoted as ECSPCM.

Characterization

The surface morphologies of the as-prepared copper meshes were characterized by

scanning electron microscopy (FESEM, JEOL JSM-7800F). The crystal structure of the relevant copper mesh was analyzed with X-ray diffraction (XRD, BURKER D8, Cu Ka). The pore size of the copper mesh and electrospinning layer was characterized by a capillary flow porometer (CFP-1100AI, Porous Materials Inc.). The water wettability was measured by water contact angle measurements using a Krüss DSA30 shape analysis system. The optical properties of the samples were measured by UV-vis absorption spectra (Shimadzu, UV-3600i Plus). The ion concentration of simulation seawater and the collected water was measured by an inductively coupled plasma (ICP) spectrometer (PerkinElmer, AVIO500). The surface characteristic of the crosslinked PPy and PVA/PAA was characterized by the Fourier-transformed infrared (FTIR, (Bruker HYPERION, Germany). The water transportation behavior of relevant samples was recorded by a digital camera (Panasonic, GX9) and an industrial camera (Gaopin, GP-680V).

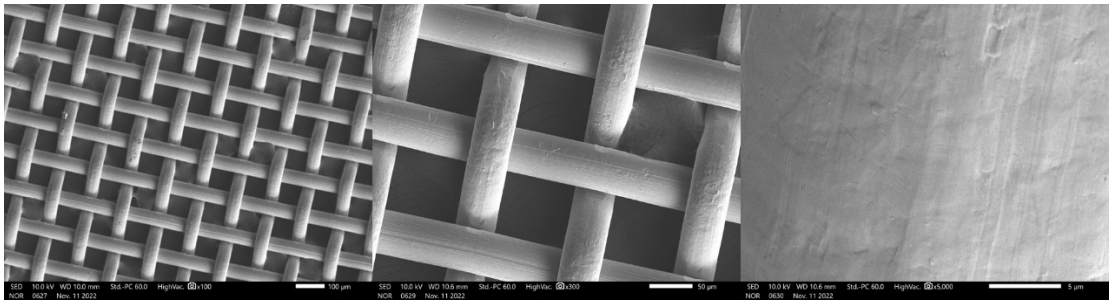

Fig. S1 FE-SEM images of the Cu mesh at different magnifications.

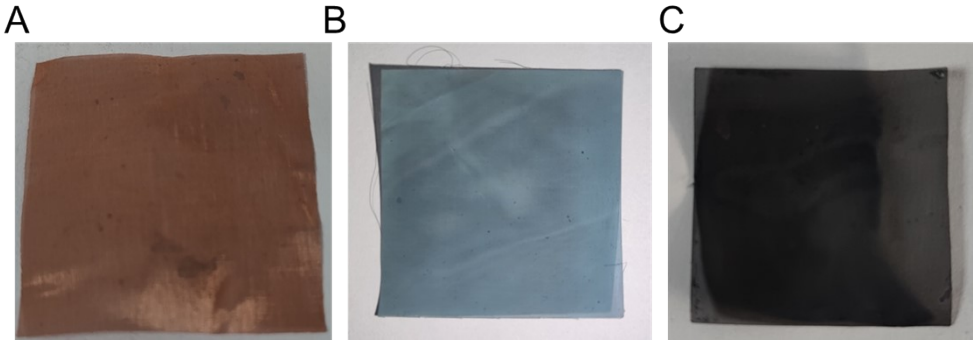

Fig. S2 Photographs of (A) the virgin Cu mesh, (B) the etched Cu mesh and (C) the SPCM.

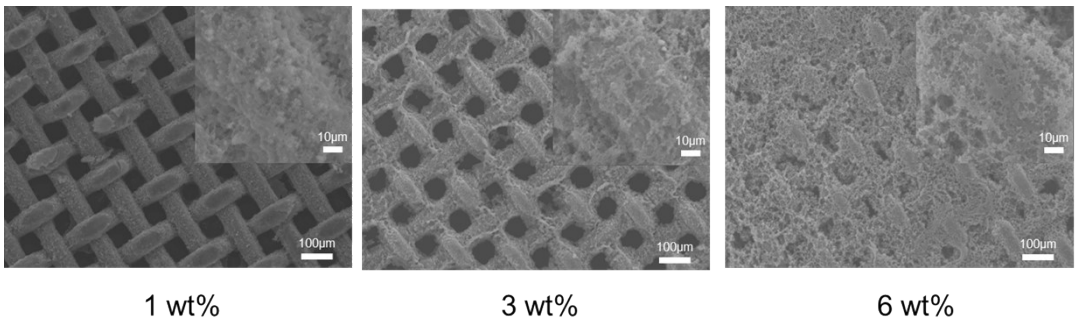

Fig. S3 FE-SEM images of the SPCM mesh after coating with various concentrations of PVA/PAA solution.

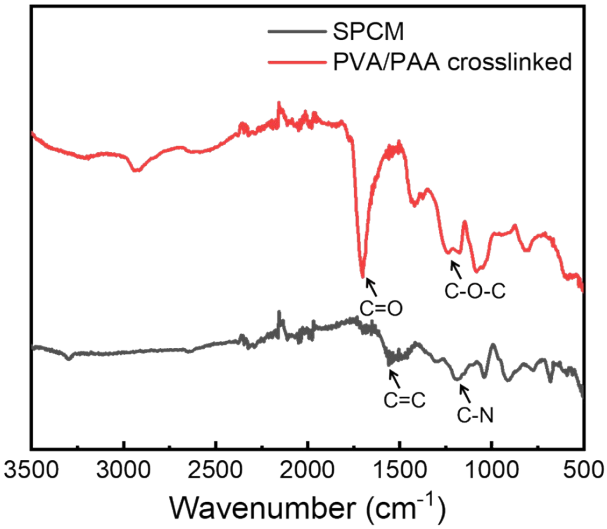

Fig. S4 FT-IR spectra of the crosslinked PVA/PAA and the polymerized PPy.

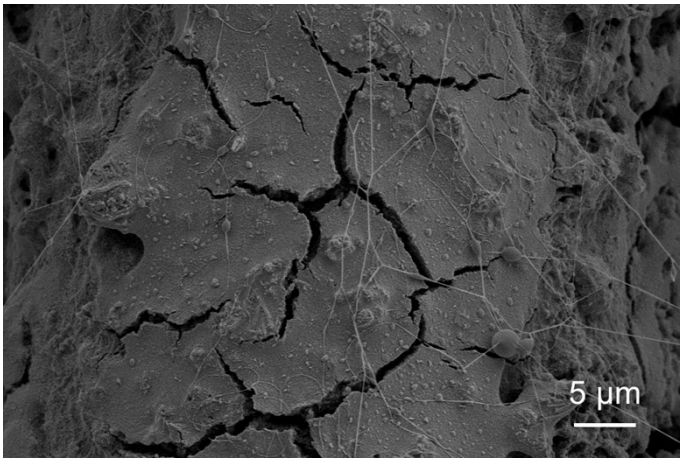

Fig. S5 FE-SEM images of the PVA/PAA nanofibers welded with the PVA/PAA coating layer.

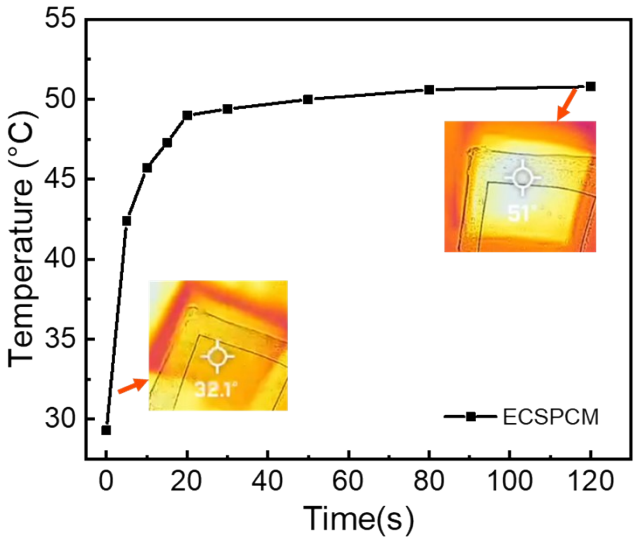

Fig. S6 Temperature−time relationship of the SPCM without contacting water under one simulated solar irradiation.

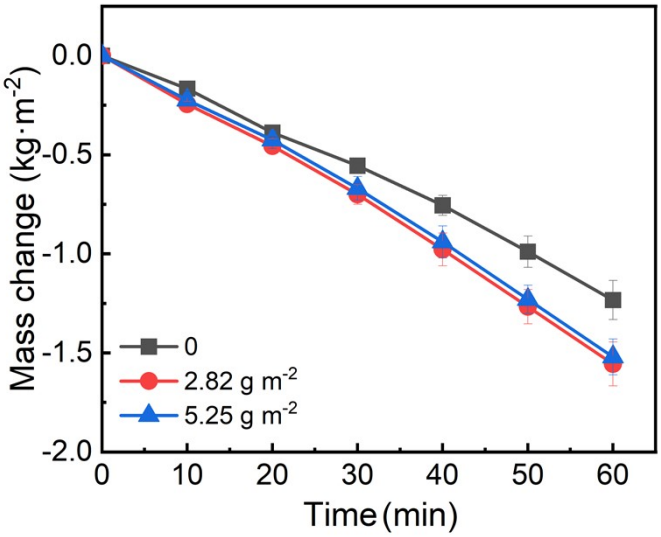

Fig. S7. Variation in water harvesting using ECSPCM membrane with varying basis weight of PVA/PAA nanofiber controlled by electrospinning time.

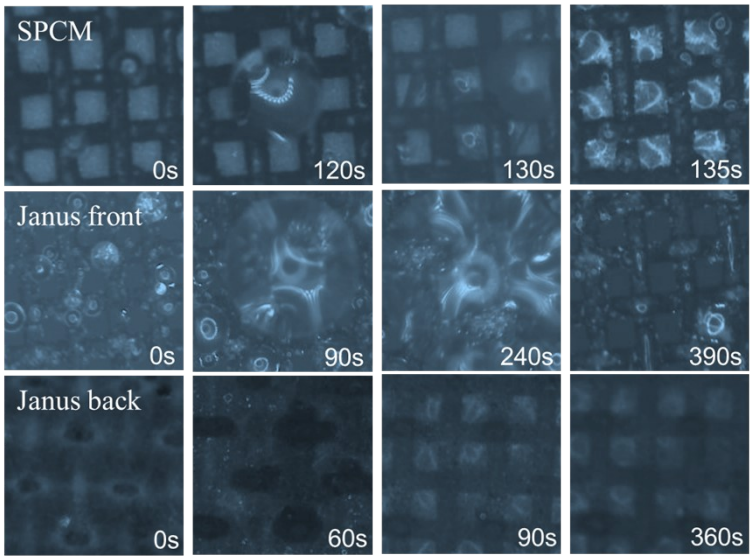

Fig. S8 Dynamic photographs of water droplets captured by the differently wettable interface.

Table S1 Comparison of the sloar evaporation and fog harvesting performances with the literature.

Materials	Solar evaporation ($kg\ m^{-2}\ h^{-1}$)	Fog harvesting ($kg\ m^{-2}\ h^{-1}$)	Ref
CuO tree system	1.42	—	[1]
Pine wood & polydopamine	1.38	—	[2]
PAN@PPy NFs	1.63	—	[3]
MBE	1.59	—	[4]
Multilayer PPy nanosheets.	1.38	—	[5]
PVDF-HFP selective absorber	1.02	—	[6]
CF-3	1.47	—	[7]
Willow catkin biochar	1.65	—	[8]
carbonized lotus seedpod	1.30	—	[9]
Hydrophilic slippery rough surface	—	5.03	[10]
Fluorinated-PAN nanofibers	—	3.35	[11]
Cactus-like fog collector	—	5.50	[12]
Cu-x-PFDT-PS-y	—	1.59	[13]
Antibacterial needle-array (ABN)	—	10.66	[14]
Janus surface	—	2.00	[15]
CM@PDMS-PS	—	9.07	[16]
HHNCM	—	11.11	[17]
MHA/OTS-$SiAu_2$	—	10.51	[18]
ECSPCM	1.56	11.36	This work

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