Supporting information

A Salt-resistant and Self-floating Janus Evaporator by Electrospinning for Stable Solar Desalination

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1 Experimental Processes

1.1 Materials

Candles were purchased from local supermarkets. N, N-dimethylformamide (DMF) was purchased from Tianjin Damao Chemical Reagent Factory and polyvinylpyrrolidone (PVP) was purchased from Sinopharm Chemical Reagent Co. Polyacrylonitrile (PAN)) and polystyrene (PS) sodium chloride (NaCl) were purchased from Shanghai Aladdin Biotechnology Co. Cetyltrimethoxysilane was purchased from Shanghai McLean Biochemical Technology Co. Rhodamine B (RhB), Methylene Blue (MB) were purchased from Xi'an Chemical Reagent Factory (Shaanxi, China). The reagents used in this study were all analytical grade reagents without further purification. All stock solutions were prepared with distilled water.

1.2 Preparation of PAN/SA-PS/C NPs (PSPC)

Vacuum drying oven 40 ℃ constant temperature drying 12 h PAN will be put into DMF (N, N-dimethylformamide) to form a 10% solution, add 1% of sodium alginate and 1% of PVP (polyvinylpyrrolidone) to increase the activity of the magnetic blender into the stirring for 24 h to the solution is uniform, static defoaming to a clarified and transparent solution, set up the parameters of the electrostatic spinning voltage 14-17 kV, flow rate of 0.5 ml/hour. The needle and receiver height of 17 cm. Set the electrospinning parameter voltage at 14-17 kV, flow rate at 0.5 ml/hour, the height of needle and receiver at 17 cm, electrospinning for 6 h. The lower hydrophobic layer solution consisted of 30% PS and 50:1 C NPs, and the solution was spun directly onto

the hydrophilic layer, set the electrospinning parameter voltage at 10-11 kV, flow rate at 1 ml/hour, the height of needle and receiver at 17 cm, spinning for 3 h. In addition to PCPS, we also designed two sets of comparison samples, one is PAN-PS/ C NPs (PPC) without SA and the other is PS /C NPs (PS) with single layer. All samples need to be soaked in calcium ion solution before use.

1.3 Supporting results and discussion

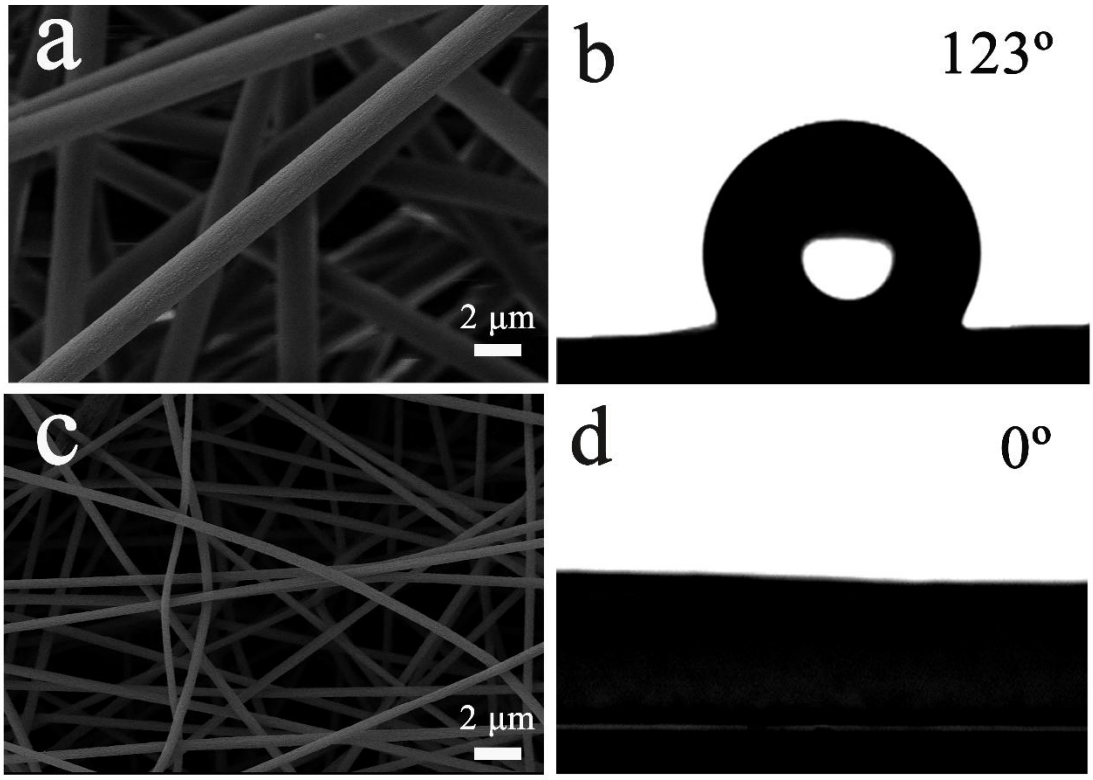

Fig.S1 (a)SEM images of PS, (b)water contact angel of PS; (c)SEM images of PAN, (d)water contact angel of PAN;

The electrospun nanofiber absorber floats on the water surface and absorbs solar energy to heat the surface water to produce steam instead of heating the overall water

to improve the evaporation efficiency[1]. The PS/C NPs layer stays above the water surface due to its hydrophobicity while the PAN layer is immersed in the water due to its hydrophilicity to achieve efficient water supply. In the solar desalination process, the upper PS/C NPs layer collects solar energy, converts the light energy into heat energy, and generates steam from the interface region of PS/C NPs and PAN.

The PSPC were placed on the surface of deionized water. A xenon lamp with an intensity of 1.0 k W m^{-2} was utilized to simulate solar irradiation of the PSPC. During the experiment, the evaporation efficiency was calculated by recording the mass change of deionized water in the beaker using an electronic analytical balance.

According to the energy conversion principle, water evaporation rates can be expressed using the equations[2].

$$\dot{m}h_{LV}=\alpha q_{solar}\text{-}Q_{rad}\text{-}Q_{conv}\text{-}Q_{cond} \tag{1}$$

$$\eta=\alpha\text{-}\frac{Q_{rad}}{q_{solar}}\text{-}\frac{Q_{conv}}{q_{solar}}\text{-}\frac{Q_{cond}}{q_{solar}} \tag{2}$$

where α was the absorption of the PSPC, Q_{rad} denotes the radiation heat loss, Q_{conv} denotes the convection heat loss, and Q_{cond} denotes the conduction heat loss.

According to the energy conversion principle, water evaporation rates can be expressed using the equations[3].

$$\dot{m}h_{LV}=\alpha q_{solar}\text{-}Q_{rad}\text{-}Q_{conv}\text{-}Q_{cond} \tag{3}$$

$$\eta = \alpha - \frac{Q_{rad}}{q_{solar}}\text{-}\frac{Q_{conv}}{q_{solar}}\text{-}\frac{Q_{cond}}{q_{solar}} \tag{4}$$

where α was the absorption of the PSPC, Q_{rad} denotes the radiation heat loss, Q_{conv} denotes the convection heat loss, and Q_{cond} denotes the conduction heat loss.

which is μ NaCl (SA) and μ`NaCl (bulk brine).

$$RTlnC_{NaCl(SA)} = RTlnC'_{NaCl(bulk\ brine)} \quad (5)$$

$$a_{Na^+} +\cdot a_{Cl^-} = a'_{Na} +\cdot a'_{Cl^-} \quad (6)$$

where μ NaCl (SA) and μ`NaCl (bulk brine) are the chemical potential in the water supply layer and brine solution. Assuming consistent ionic activity coefficients of salt ions inside and outside the SA hydrogel.

$$(\varphi + C_w)C_w = (C_b)^2 \quad (7)$$

$$\frac{C_w}{C_b} = \sqrt{\left(\frac{\varphi}{2C_b}\right)^2 + 1} - \frac{\varphi}{2C_b} \quad (8)$$

where C_w and C_b are the salt concentrations in the water supply layer and brine solution. φ is the concentration difference in the water supply layer between Na^+ and Cl^-.

As shown above, Eq. (9 and 10) meets the following boundary conditions[4].

$$\lim_{\frac{\varphi}{2C_b}\to 0} \frac{C_w}{C_b} = 1, \text{ that is the } \varphi = 0, C_w = C_b \quad (9)$$

$$\lim_{\frac{\varphi}{2C_b}\to \infty} \frac{C_w}{C_b} = 0, \text{ that is the } \varphi \gg C_b, C_w = 0 \quad (10)$$

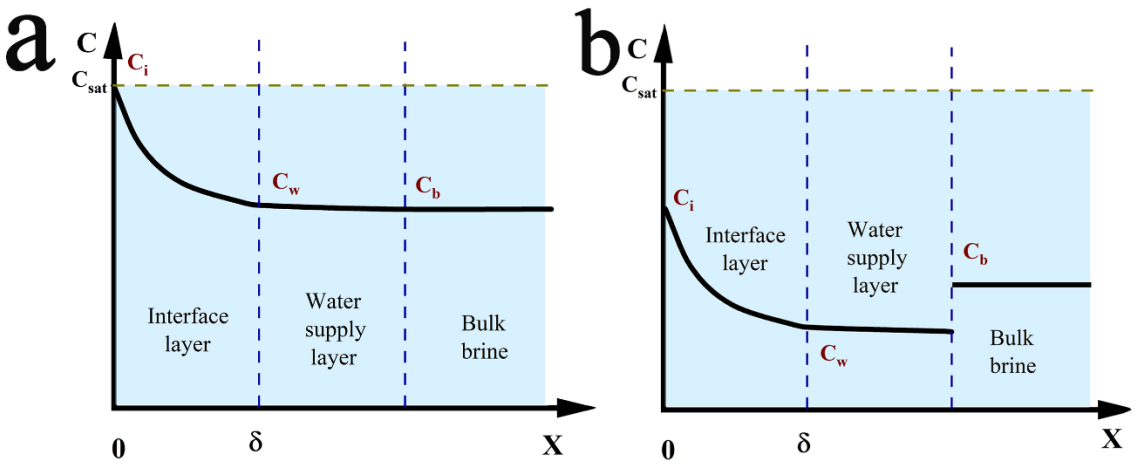

Fig S2 Mechanism analysis of salt accumulation at the photothermal interface.

For further explanation, we modeled the boundary-layer mass-transfer differential

equation to understand the mechanism. As a function of the quantity of salt ions diffusing into the evaporator, the concentration of salt ions on the surface may be quantified in Eq. (S1)[2]

$$C_i = C_w \times \exp\left(\frac{J_w}{K}\right) \quad \text{(S1)}$$

where C_i and C_w refer to the concentrations of salt ions on the surface and diffusing into the water supply layer, respectively. J_w refers to the water evaporation rate, and K is the diffusion rate of the salt ions in the water supply layer.

References

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