Supplementary Information

Low-cost and scalable carbon bread used for an efficient solar steam generator with high performance of water desalination and purification

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Supporting Discussion

Thermal conductivity

The thermal conductivity of CB is measured by sandwiching it between two squared-shape quartz slabs (reference material, 30 × 30 × 8 mm^3).[1] The sandwich is placed between a heat source (ceramic heater, bottom) and a cooler (water-cooled copper plates, top). The interfaces were painted with heat-conducting silicone grease for fine contact and heat transfer. The cooler is maintained at a fixed temperature, while the current through the heat source is tuned to induce a range of temperature gradients across the sandwich. The thermal conductivity was measured and calculated through the known reference material by the Fourier equation. The linear correlation of heat flux and temperature gradient in Figure 3b and c suggest a negligible contribution of convection side losses in the measurements.

Heat loss

The test to calculate the heat loss is carried out using a CB-6 with a surface area of 2.00 cm^2.

The heat loss by absorber consists of three losses: (1) radiation, (2) convection, and (3) conduction. The details of the calculation are shown below.[2,3]

Radiation. It is assumed that the absorber has maximum emissivity of 0.97. For radiation loss to an ambient temperature of about 25 °C under 1 kW m^{-2}, the radiation loss was calculated by the Stefan-Boltzmann equation:

$$E_R = \varepsilon A \sigma \left(T^4 - T_\infty^4\right) \ldots\ldots (1),$$

where E_R denotes heat flux, ε is the emissivity, A is the surface area (2.00 cm^2), σ is the Stefan-Boltzmann constant (5.67×10^{-8} W m^{-2} K^{-4}), T is the temperature of the absorber (34 °C), and T_∞ is the ambient temperature in our experiment (25 °C). Therefore, based on Eq. S1, we can calculate that the radiation heat loss of the device accounts for ∼5.4% of all irradiation energy.

Convection. The convection loss was calculated by Newton's law of cooling.

$$Q = Ah(T - T_\infty)......(2),$$

where Q denotes the heat, h is the convection heat transfer coefficient, A is the surface area (2.00 cm^2). The convection heat transfer coefficient is about 5 W m^{-2} K^{-1}. Therefore, based on Eq. S2, we can calculate that the convection heat loss of the device accounts for ~4.5% of all irradiation energy.

Conduction. The conduction loss was calculated based on

$$Q = Cm\Delta T......(3),$$

where Q denotes the heat, C is the specific heat capacity of water (4.2 J g^{-1} $°C^{-1}$), m is the water weight (5 g), and ΔT (1.4 °C) is the elevated bulk water temperature within t seconds (3600 s). Therefore, based on Eq. S3, we can calculate that the conduction heat loss of the device accounts for ~4.1% of all of the energy.

Reusability test

The test was carried out under 1 sun. And each cycle lasted for 1 hour. The concentration of the NaCl solution is 3.5 wt%.

Supporting Figures and Tables

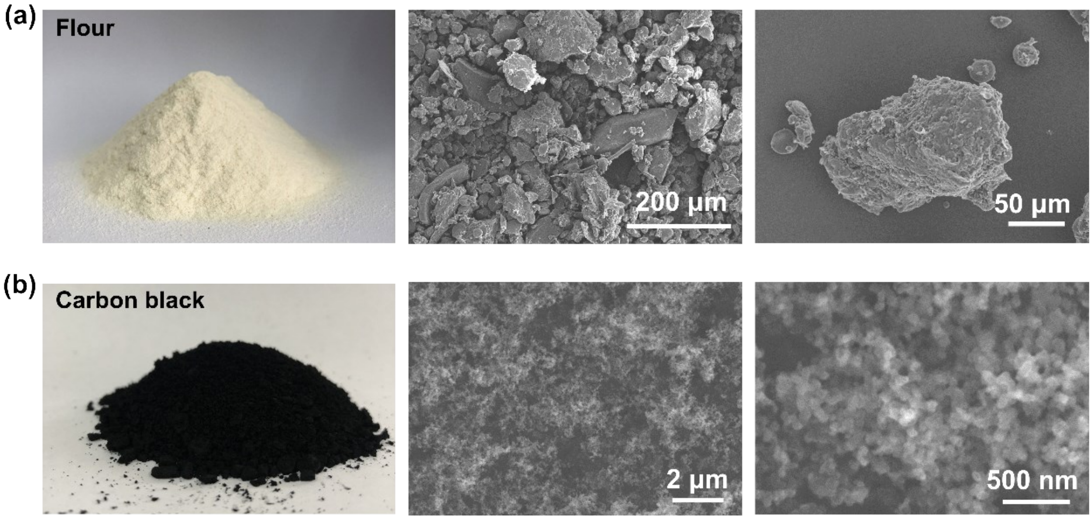

Figure S1 Optical and SEM images of (a) flour and (b) carbon black.

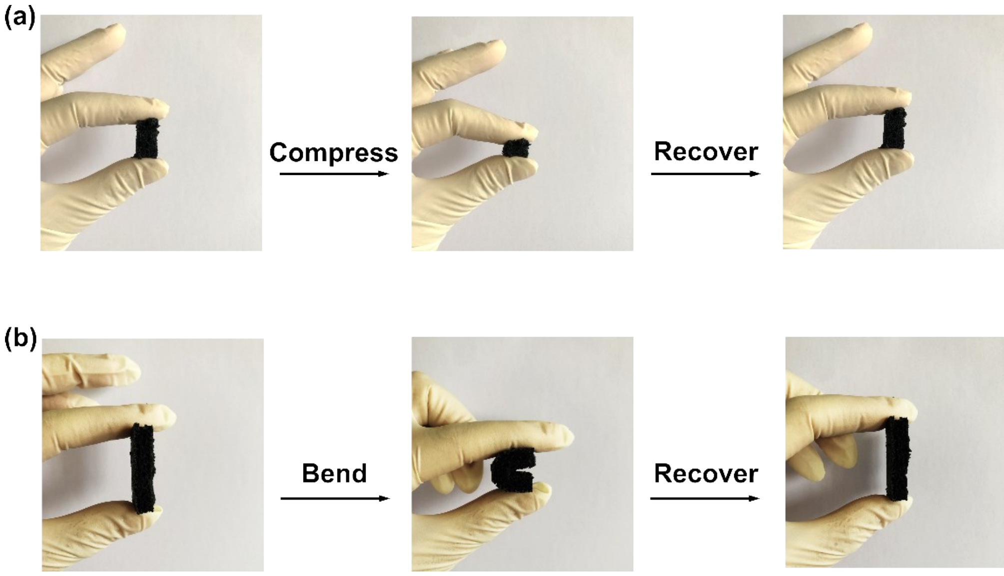

Figure S2 Photographs of carbon bread under (a) compression and (b) deformation condition without damage.

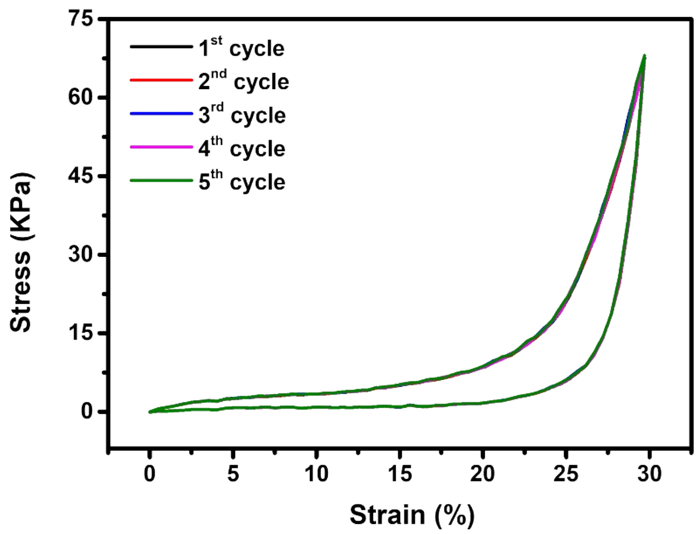

Figure S3 Stress-strain curves of five compress/release cycles with 0.5% strain s^{-1} rate.

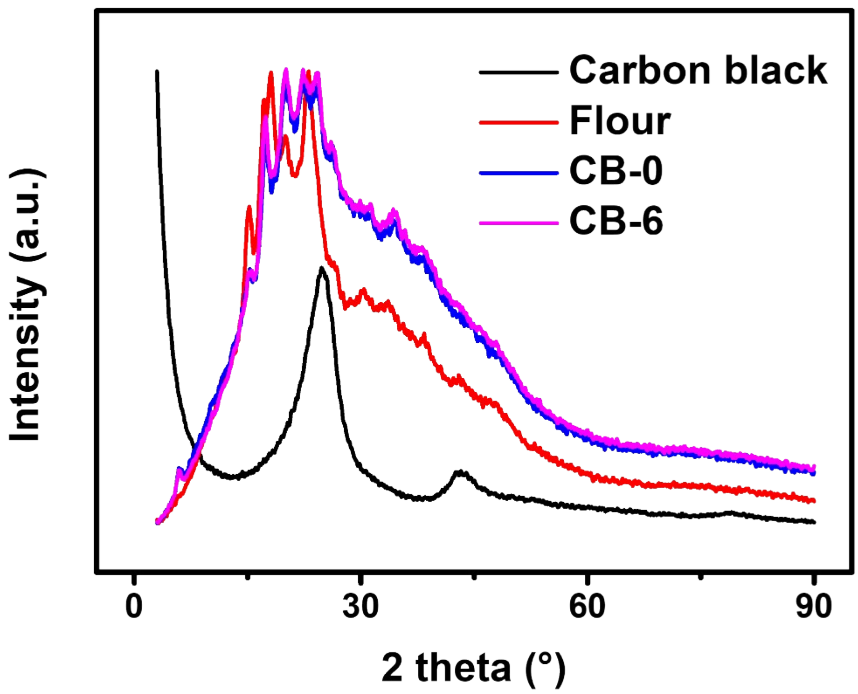

Figure S4 The XRD patterns of flour, carbon black, as-synthesized CB-0 and CB-6.

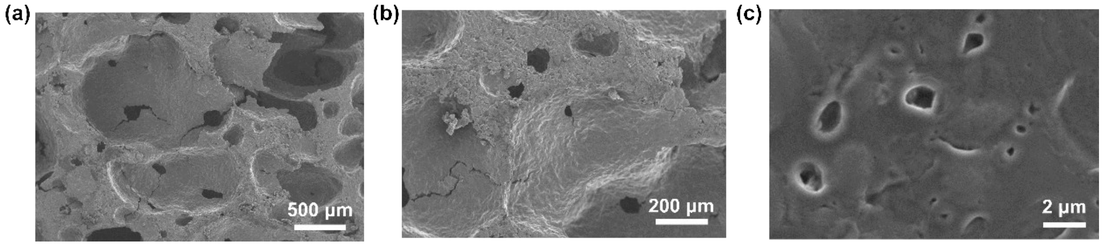

Figure S5 SEM images of CB-0.

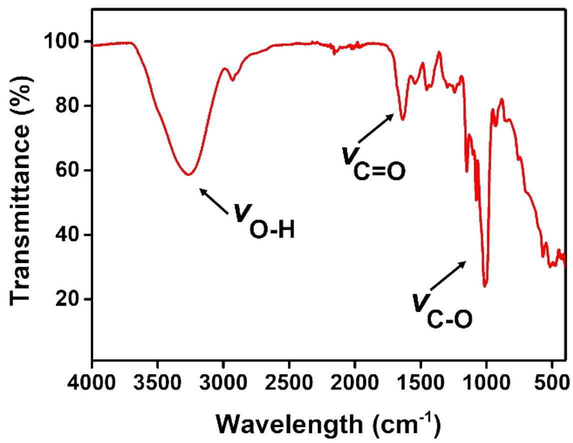

Figure S6 The IR spectrum of carbon bread. In the IR spectrum, the peaks at 1635 and 1010 cm^{-1} are assigned to the stretching vibrations of C=O and C-O, and the peak at 3270 cm^{-1} is mainly assigned to absorbed water.

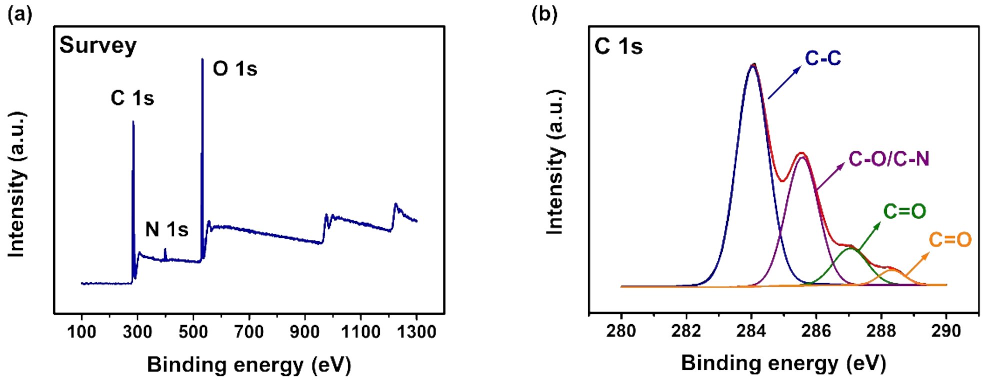

Figure S7 (a) Survey spectrum and (b) high resolution C 1s spectrum. In the high-resolution XPS spectrum of C 1s from CBs, the peaks at 284.0, 285.6, 287.1, 288.4 eV were attributed to C-C, C-O/C-N, C=O, and O-C=O, respectively.

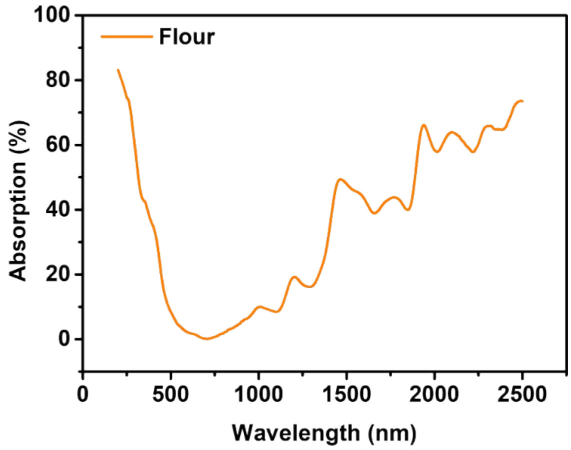

Figure S8 The absorption of flour over 200-2500 nm.

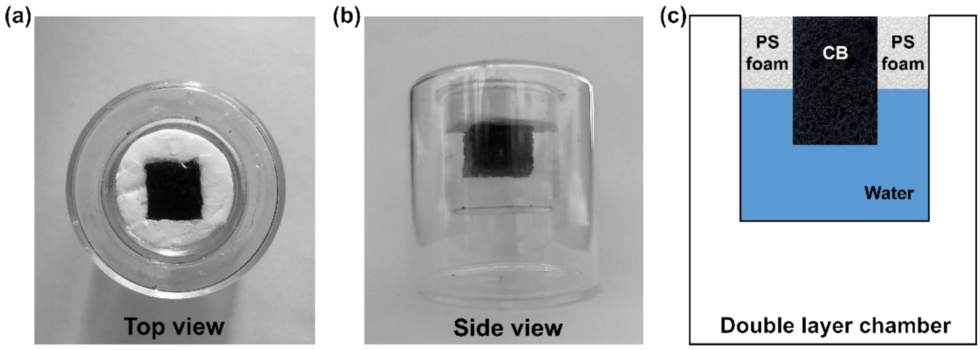

Figure S9 The (a) top, (b) side view and (c) schematic of the double layer test chamber.

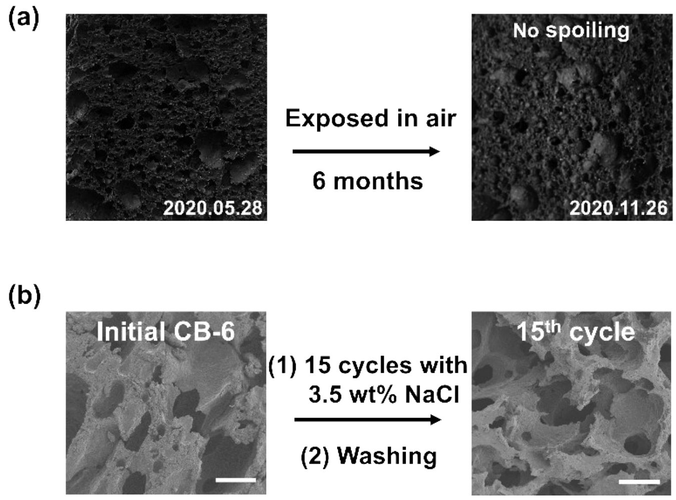

Figure S10 Optical images of the carbon bread before and after exposed in air for 3 months.

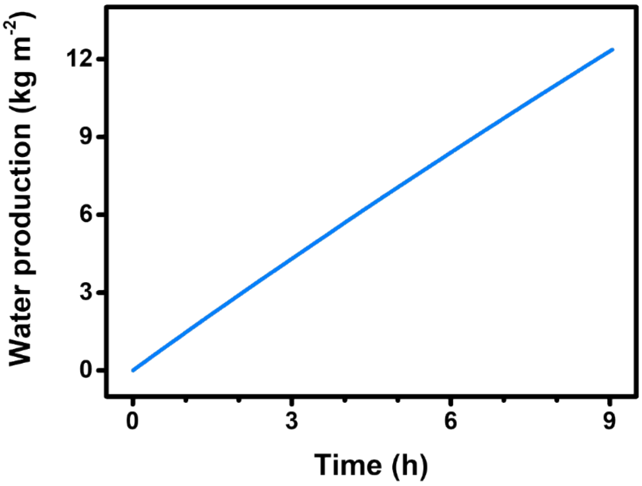

Figure S11 Water production under 1 sun over 9 hours.

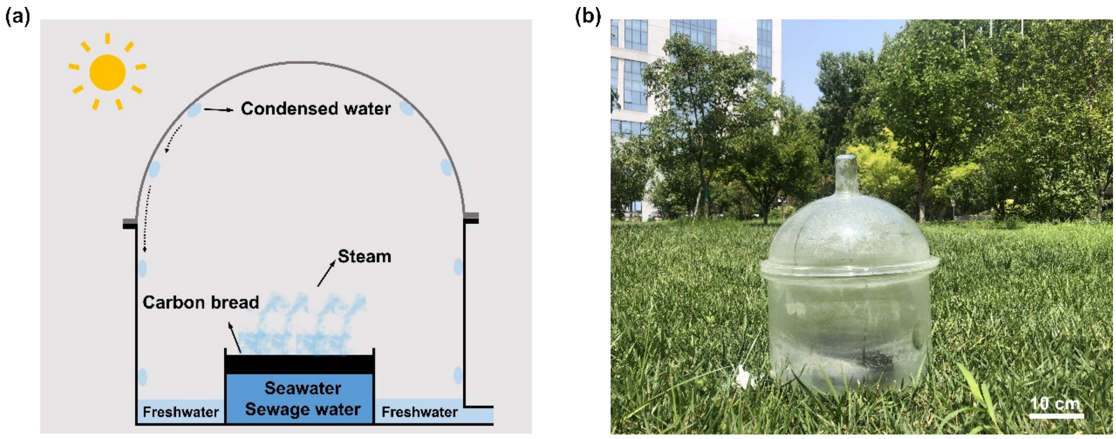

Figure S12 (a) The schematic of the solar evaporator based on carbon bread. (b) The steam was condensed into liquid when it arrived at the cold condenser. The condensed water automatically flowed along the container glass surfaces into the condensing receptacle under gravity.

Table S1 The consumptions of flour, carbon black and yeast of a series of carbon bread.

	Flour (g)	Carbon black (g)	Yeast (g)
CB-0	30	0	0.5
CB-1	30	0.001	0.5
CB-2	30	0.005	0.5
CB-3	30	0.015	0.5
CB-4	30	0.025	0.5
CB-5	30	0.050	0.5
CB-6	30	0.075	0.5
CB-7	30	0.100	0.5
CB-8	30	0.200	0.5

Reference

1. H. Ghasemi, G. Ni, A. M. Marconnet, J. Loomis, S. Yerci, N. Miljkovic and G. Chen, *Nat. Commun.*, 2014, **5**, 4449.
2. X. Li, W. Xu, M. Tang, L. Zhou, B. Zhu, S. Zhu and J. Zhu, *Proc. Natl. Acad. Sci. U. S. A.*, 2016, **113**, 13953-13958.
3. Y. Yang, R. Zhao, T. Zhang, K. Zhao, P. Xiao, Y. Ma, P. M. Ajayan, G. Shi and Y. Chen, *ACS Nano*, 2018, **12**, 829-835.