

Supplementary Information

1. Transmittance, reflectance and comparison between wet and dry

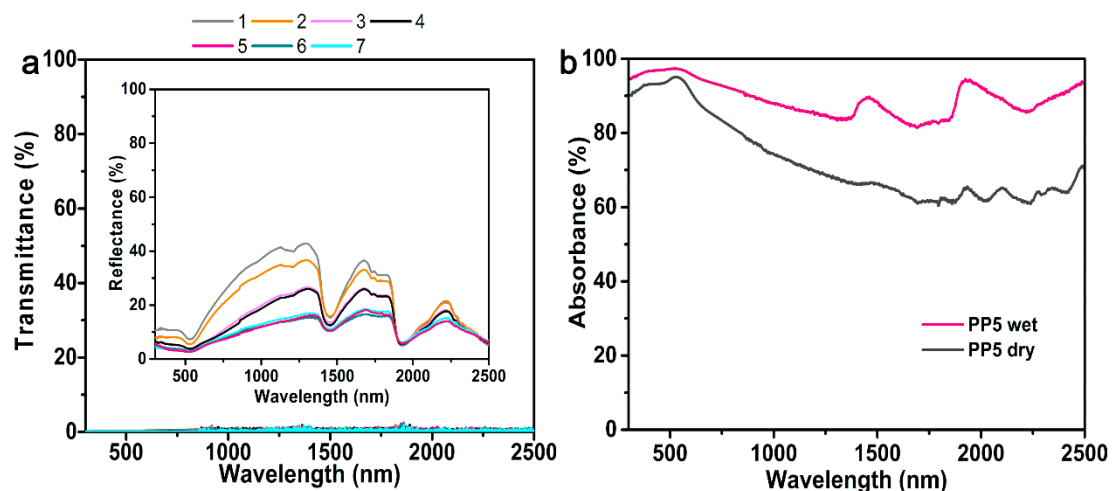


Fig. S1 (a) UV-Vis-IR reflectance and transmittance spectrum of PP1-PP7 in wet state. (b) Comparison of UV-Vis-IR absorbance spectrum between PP5 in wet and in dry state.

2. Calculation of solar energy absorbed by PP5

The solar energy absorbed by PP was calculated by multiply the value of AM1.5G and corresponding optical absorption value at the same wavelength first. Then make a spectrum according to these results calculated above, as the black line below shows. Finally, integrate the black line and the integration value was divided by that of AM1.5G (blue line below). The result shows that 92% of solar energy can be absorbed by PP. It is worth mentioning that the illumination filtered by our optical filter of AM1.5G is slightly more concentrated in visible range than actual spectrum of AM1.5G. Since the most intensive optical absorption of our PP is in visible range (>95%), the utilization efficiency of 10sun simulated by our devices might be slightly higher than the calculated value 92% of AM1.5G.

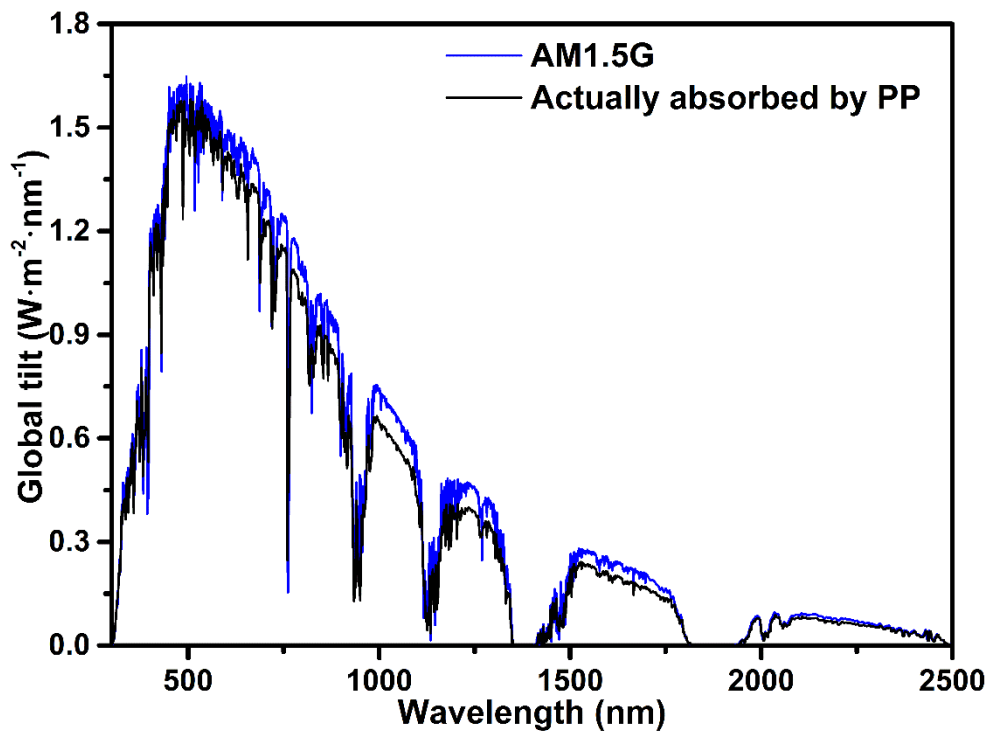


Fig.S2 The spectrum of AM1.5G (blue line) and the solar energy absorbed by PP (black line).

3. SEM of PP2,4,6 and EDS mapping.

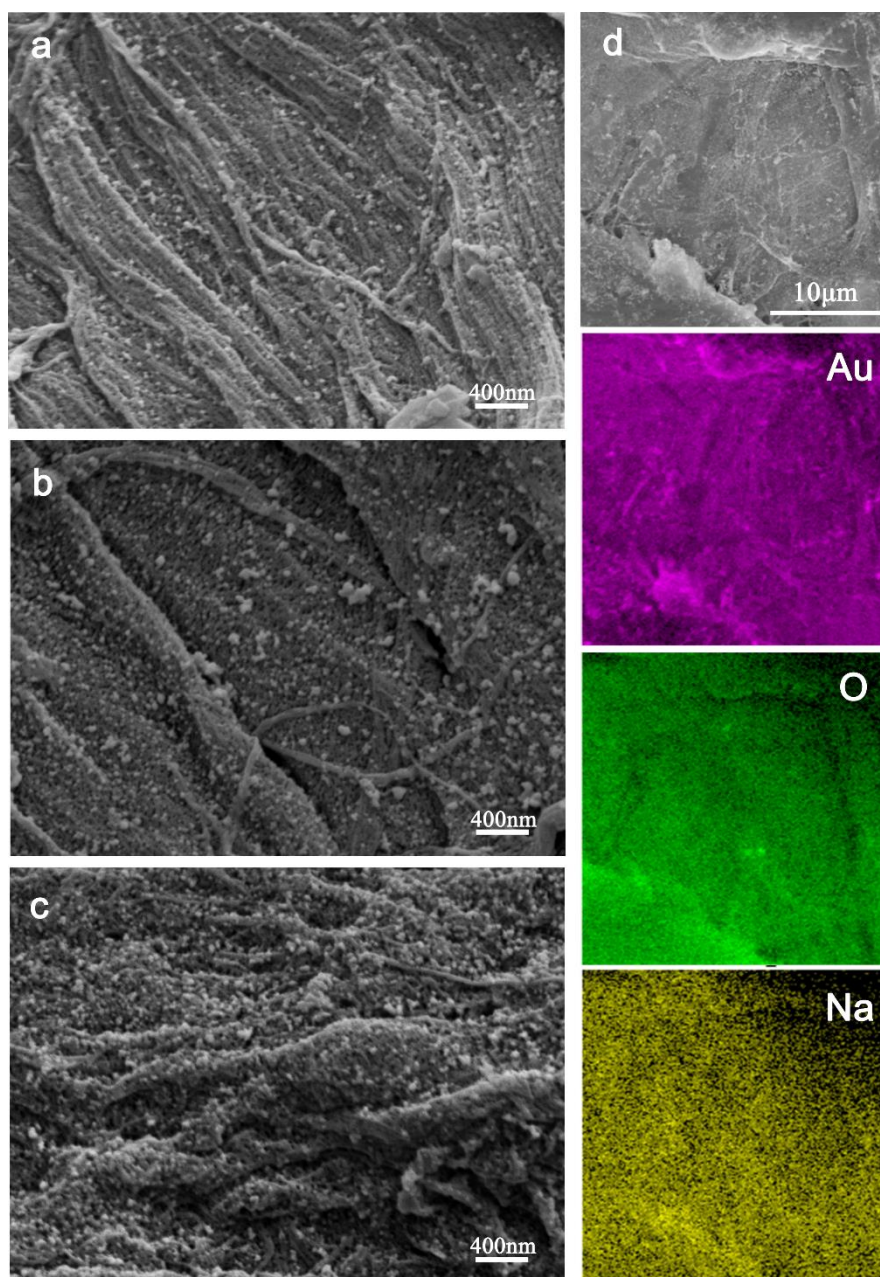


Fig. S3 SEM images of PP2(a), PP4(b), PP6(c). These images were taken by JSM-7800F. As we can see, the morphology changes such as particle load and the particle size distribution over different PTR times is consistent with the rules mentioned in the main text. (d) EDS elemental mapping image of PP 5 and the SEM image of such area. With carbon spraying on the PP before the sample begins to scan.

4. Preparation method and characterization of PPa

(1) **Preparation of PPa:** We also use PTR method to prepare PPa, the concentration and the amount of chloroauric acid solution were the same as PP5 which mentioned in main text, but dipped 200 μL of 0.5g/mL sodium citrate solution (adjusting pH to 6.60). PPa was prepared after 5 PTR times.

(2) **Particles loading test:** Ten sheets of empty 30mm-diameters filter paper were fully dried and weighing at once. Then prepared GNPs on filter paper by PTR method and washed several times. Finally, as-prepared PP dried fully and weighing at once. The results shows below:

$$\Delta m (\text{PP5}) = 8.7\text{mg}$$

$$\Delta m (\text{PPa}) = 8.8\text{mg}$$

We can further calculate the particle loading that 1.23g/m² of PP5 and 1.24g/m² of PPa.

(3) Characterizations of PPa:

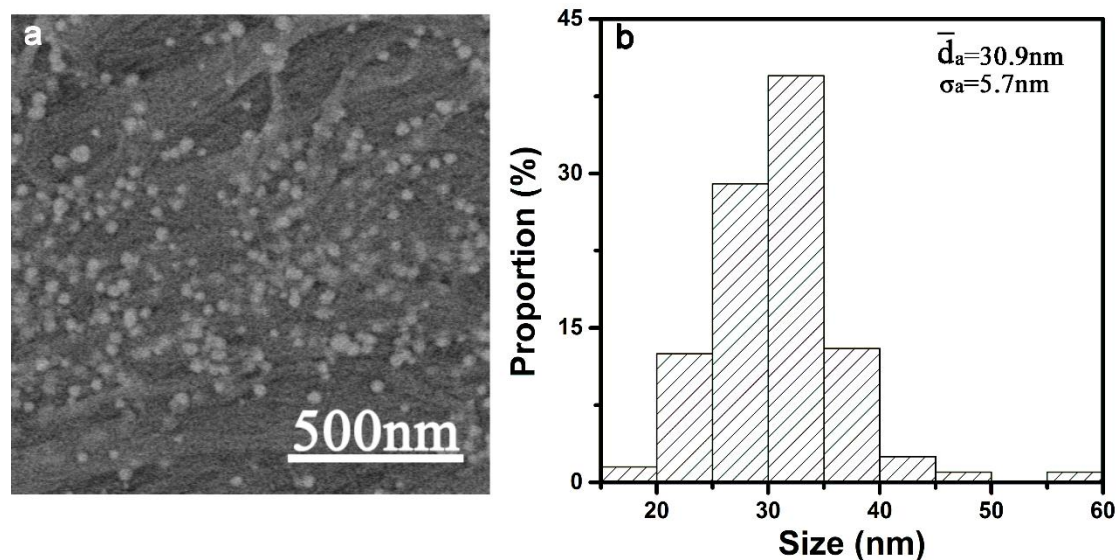


Fig. S4 (a) SEM image of PPa (b) Size distribution of PPa, obtained by randomly counting 200 particles in different areas. The mean particle diameters (\bar{d}) and standard deviations (σ) were shown in this figure.

5. Surface temperature and mass change-time curve when evaporating in bilayer system

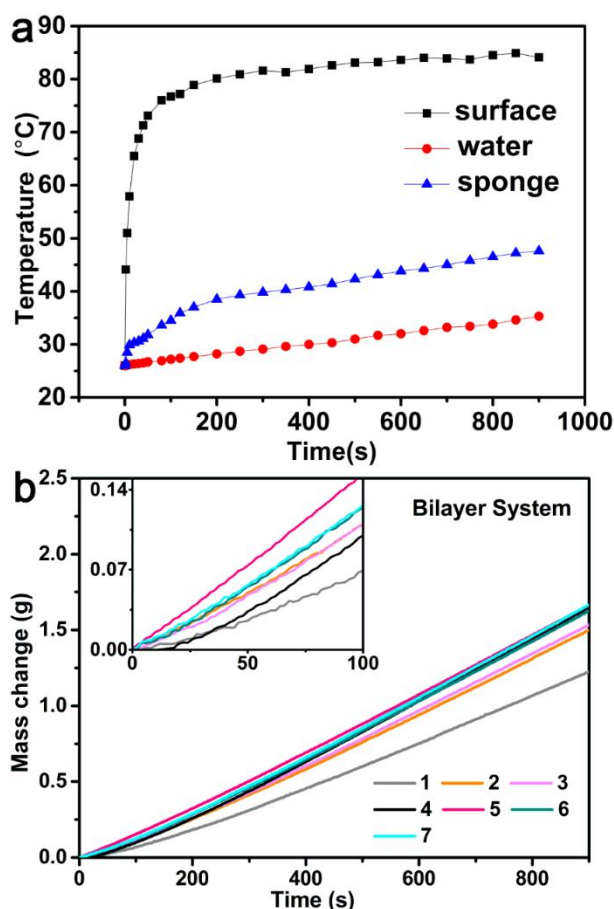


Fig. S5 (a) The temperature change of bilayer system (using PP5) during 900s evaporation process. (b) The mass change over time curve of bilayer system using PP1-7 and tripolycyanamide sponge (measured heat conductivity $0.0269 \text{ W m}^{-1} \text{ K}^{-1}$, and $0.5508 \text{ W m}^{-1} \text{ K}^{-1}$ when it is wet) under 10 kw m^{-2} . The stable evaporation rate of PP1-7 are $7.67, 9.16, 9.32, 10.13, 10.13, 10.08, 10.07 \text{ kg m}^{-2} \text{ h}^{-1}$ respectively. The figure of the evaporation process during 0-100s shows that the evaporation rate of bilayer system is relatively slow at the beginning of the evaporation process and rises gradually.

6. Installation and mass change-time curve of evaporating using peristaltic pump

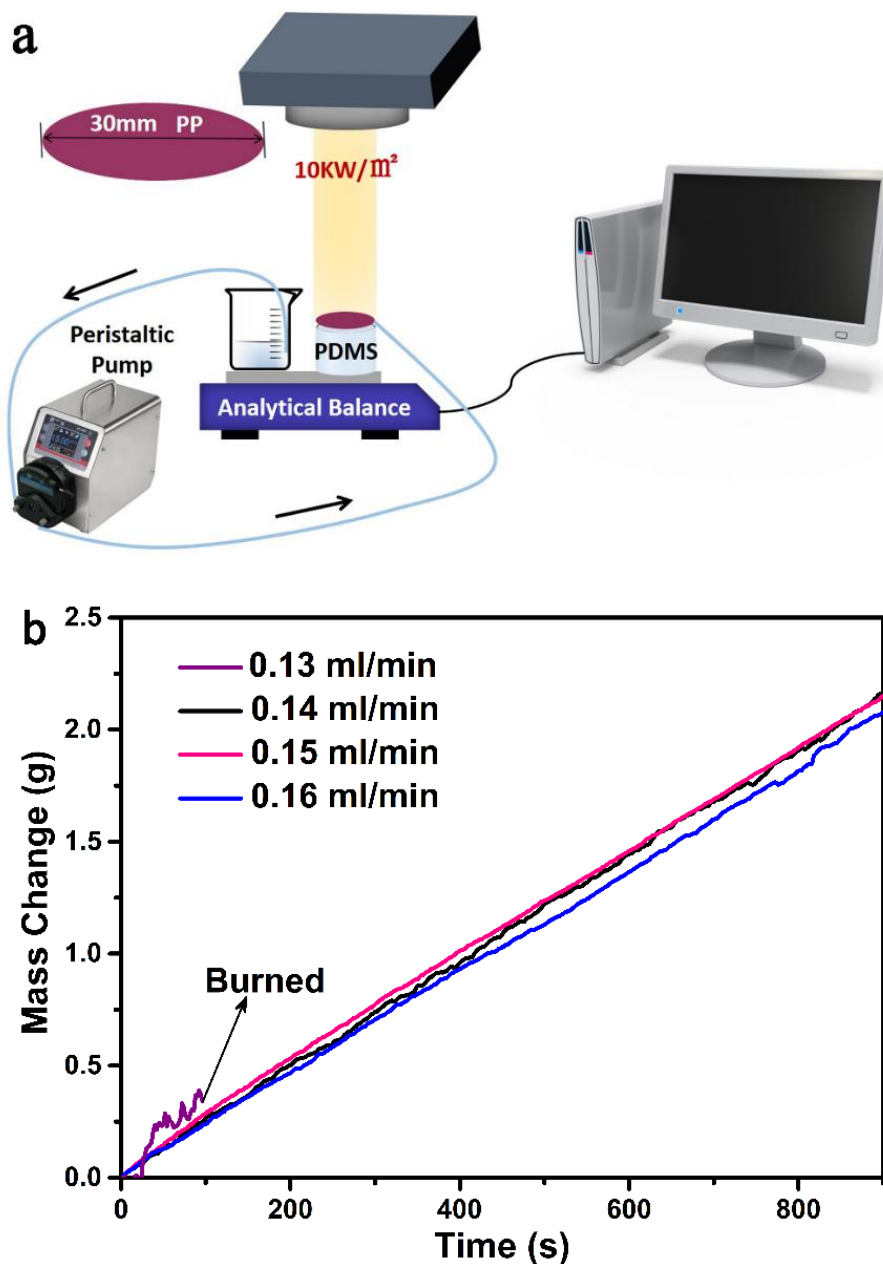


Fig.S6 (a) The Schematic graph of the solar evaporation experiment using peristaltic pump to realize the measurable water supplementation. (b) The mass change over time curves of different water flow velocity. As we can see, under the optimal water flow velocity 0.15ml/min, the evaporation rate keeps stable and fast ($11.97\text{ kg m}^{-2}\text{ h}^{-1}$). Below or above this water flow velocity, the evaporation rate reduced and becomes instable. The sample burned when the water flow velocity fell to 0.13 ml/min.

7. Evaporation performance and photos of PP5 treated by ultrasonic, acid and alkali.

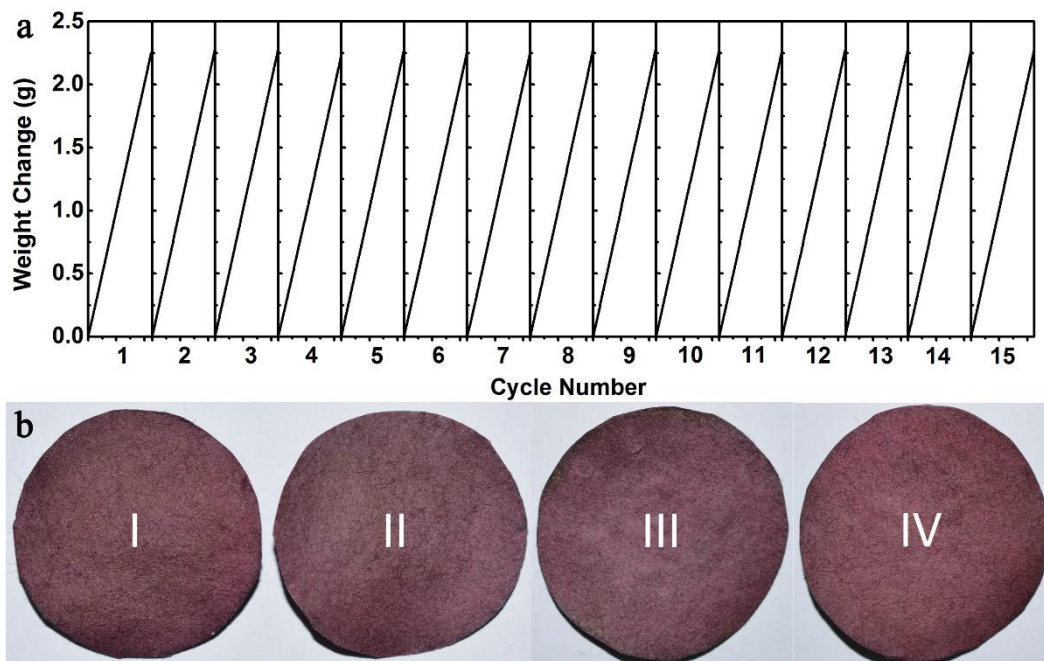


Fig.S7 (a)The evaporation cycle performance of PP and the bionic system; each cycle sustained for 900 s. b) The macro morphology change of PP after ultrasonic treatment for 1 h (II), alkali treatment (III) and acid treatment (IV) for 5 h, and sample (I) is the PP with no special treatment. PP5 were used in all the stability tests. As we can see, no obvious macro morphology change on PPs after the treatment above.

8. Surface temperature illuminated by natural sunlight of dry PP5

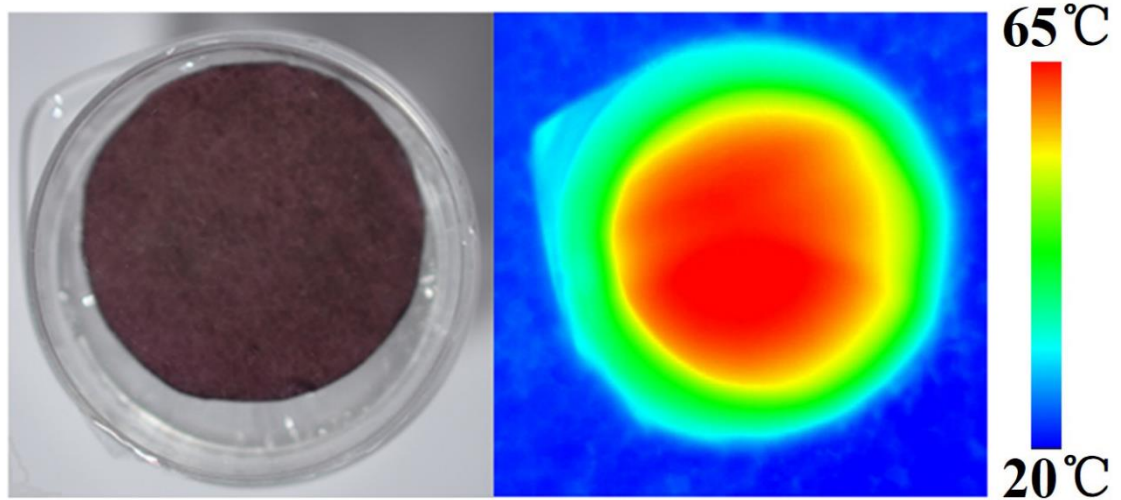


Fig.S8 IR camera image of PP5 in dry state illuminated by natural sunlight (solar intensity was about 0.80 kW m^{-2}). The highest temperature was 65°C during the measurement process.

9. Conductivity over concentration of sodium chloride solution

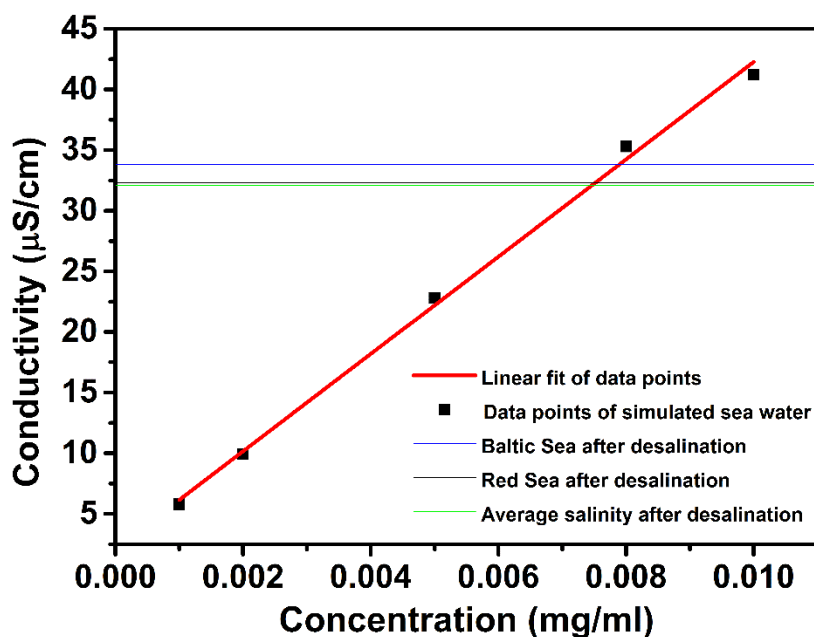


Fig.S9 The conductivity(G) changes over sodium chloride solution with different concentration(C). The sodium chloride solution with concentration 0.01wt%, 0.008wt%, 0.005wt%, 0.002wt%, and 0.001wt% was prepared, and the conductivity tests results are 41.2, 35.3, 22.8, 9.93, 5.79 $\mu\text{S}/\text{cm}$ respectively. Such 5 points were linear fitted ($G=4012.687C+2.138$) and show good linear correlation ($R^2=0.99607$). Thus, we further test the conductivity of freshwater of different simulated sea water collected by bionic system under natural sunlight. The conductivity was 32.3 $\mu\text{S}/\text{cm}$ (Red Sea), 32.1 $\mu\text{S}/\text{cm}$ (Average salinity of world oceans) and 33.8 $\mu\text{S}/\text{cm}$ (Baltic Sea), respectively. So, the concentrations of sodium chloride of these freshwater samples can be calculated by formula of linear fitting—0.00751 mg/ml (Red Sea), 0.00749 mg/ml (Average salinity of world ocean), 0.00789 mg/ml (Baltic Sea). These sodium chloride concentrations were further converted to sodium concentrations to compared with the simulated sea water samples and the standard of desalinated fresh water specified by the World Health Organization (WHO).

10. Salt distribution by using side-to-center water supplement mode

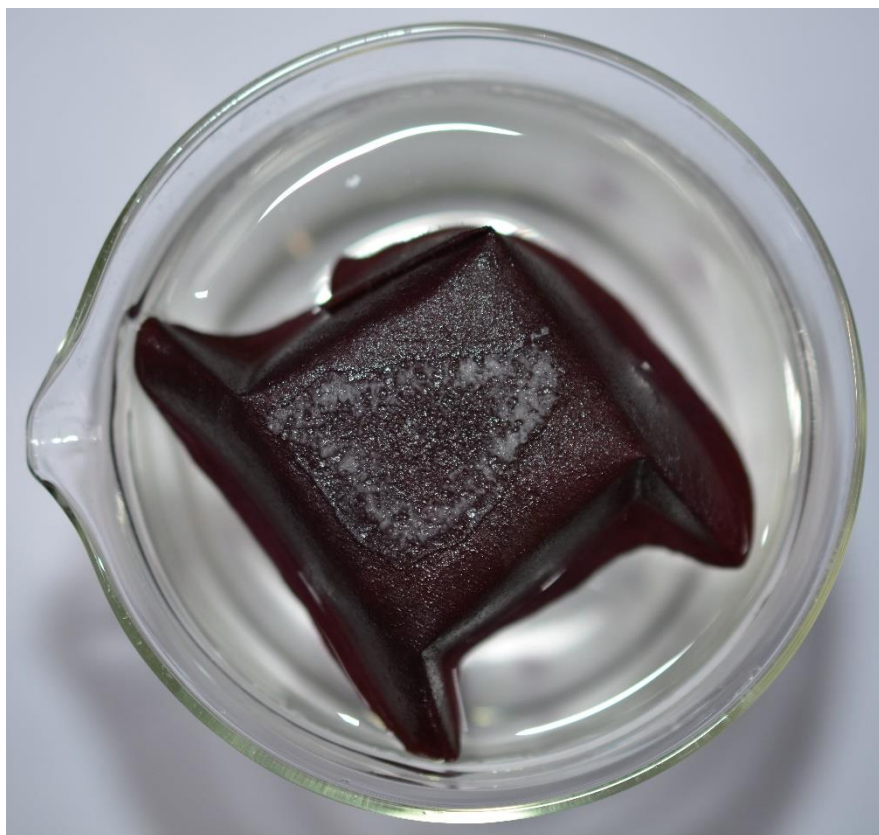


Fig.S10 The photo of PP after 5h sunlight illumination using side-to-center water supplement mode. Unlike the ringlike distribution along the side of PP by using center-to-side water supplement mode (described in the main text), the salt mainly distributed on center and occupied a large area of PP. Such salt distribution will reduce the solar absorption of PP because of the enhanced reflectance, so need a washing process after several hours evaporation in the practical use and thus add the cost of this device.

11. Calculation of evaporation efficiency under natural sunlight

The evaporation efficiency under natural sunlight was calculated by the formula:

$$\eta = \frac{M * h_{LV}}{E}$$

M is the output mass of freshwater per unit area.

h_{LV} is sensible heat + enthalpy of phase change. We use corresponding data of pure water (sensible heat $4.2 \text{ J g}^{-1} \text{ K}^{-1}$ from 30°C to 100°C ; enthalpy of phase change: 2256 J g^{-1}) to calculate approximately.

E is solar energy illuminating on per unit area. This value was calculated by doing integration of the “Solar intensity-Time” curve. The solar intensity values were recorded by total solar radiation meter every one minute, so the unit of the integration is $\text{kW m}^{-2} \text{ min}$ (8:00-18:00).

The results of calculation shows in the table below:

M (kg m^2)	E ($\text{kW m}^{-2} \text{ min}$)	η	Time
5.84	339.35	73%	April 3, 2017
4.77	267.01	76%	April 16, 2017
5.78	344.51	71%	April 17, 2017
5.34	293.99	77%	April 18, 2017
5.93	348.34	72%	April 19, 2017
5.50	295.41	79%	July 13, 2017
5.85	337.53	73%	July 13, 2017

12. Cost analysis of PP.

We evaluated the cost of the film according to the precursor we used to be about \$247/m² and can be as low as \$52/m² by using cheaper raw materials.

Names of raw materials	The price of materials we used	The lowest price we find
Tetrachloroauric acid hydrate	\$ 51.75/g	\$ 26.61/g
Sodium citrate	\$ 38.44/500g	\$ 1.18/500g
Filter paper	\$ 2.1/m ²	\$ 2.1/m ²

Compared with the materials in peer work which gave the valuation, the cost of our PP is on medium level. For example, the structure Al NPs/AAM proposed by Zhou et.al (**Ref.27**) cost about \$4800/m² (although the Al and PVD cost only \$0.3/m², but the price of AAM reached \$50 for a 4-inch piece), which is far more expensive than PP. However, the material OAS proposed by Ni et.al (**Ref.36**) cost only \$6/m² according to the valuation by author, which is much cheaper than PP. It is worth mentioning that although the cost of PP is relatively high at present, the stability of PP make it recyclable for many times and possess a long service life, which is helpful to reduce the cost of unit freshwater production.