Materials
Horizons

ARTICLE

Supporting Information

Magnetically driven Janus conical vertical array for all-weather freshwater collection

*Xiangyi Zhang,[a] Mengyao Zhu,[a] Junhao Chen,[a] Zongwei Wang,[a] Sanchuan Li,[a] Huiyu Yang, *[b] Hongman Xu,[a] Guang He,[a] Ziwei Deng, *[c] Shaojin Gu,[a] Xin Liu[a] and Bin Shang *[a]*

[a] *State Key Laboratory of New Textile Materials and Advanced Processing Technologies, School of Materials Science and Engineering, Wuhan Textile University, Wuhan, 430200, P. R. China*

[b] *School of Chemistry and Materials Science, Hubei Engineering University, Xiaogan 432000, China*

[c] *Key Laboratory of Applied Surface and Colloid Chemistry, Ministry of Education, Shaanxi Key Laboratory for Advanced Energy Devices, Shaanxi Engineering Lab for Advanced Energy Technology, School of Materials Science and Engineering, Shaanxi Normal University, Xi'an 710119, P. R. China*

*Corresponding author, E-mail: binshang@wtu.edu.cn; hy-yang_wtu@hotmail.com; zwdeng@snnu.edu.cn

Calculation of equivalent evaporation enthalpies of water in mMF-JA.

The energy demand of water evaporation includes sensible heat and latent heat. Firstly, the latent heat of bulk water at different temperatures is calculated according to the following formulas:

$$h_{L,Water,T_w} = \int_{T_w}^{100℃} C_{p,l} dT + h_{L,100℃} + \int_{100℃}^{T_w} C_{p,g} dT \tag{1}$$

where h_L is the latent heat, $C_{p,l}$ is the heat capacity of the liquid water, and $C_{p,g}$ is the heat capacity of the gas water, T_w is the temperature of the surface. Here, $h_{L,100℃} = 2257$ J g $^{-1}$, $C_{p,l} = 4.2$ J K $^{-1}$ g $^{-1}$, $C_{p,g} = (3.470 + 1.45 \times 10^{-3} \times T + 0.121 \times 10^5 \times T^{-2}) \cdot R \cdot M^{-1}$, $R = 8.314$ J K^{-1} mol^{-1} , $M = 18.02$ g mol^{-1} , T is the temperature in Kelvin scale.

Based on the experimental results in formula, the latent heat of water in the evaporator can be estimated by the formula:

$$h_{L,evaporator} = h_{L,\, water,T_w} \times \frac{v_{water,dark}}{v_{evaporator,dark}} \tag{2}$$

The sensible heat can be calculated by the formula:

$$h_S = \int_{T_{i,w}}^{T_w} C_{p,l} dT \tag{3}$$

where $T_{i,w}$ is the initial temperature of the surface.

Therefore, the total energy demand for water evaporation in the evaporator can be written as:

$$h_{LV} = h_{L,evaporator} + h_S \tag{4}$$

Table 1. Summary of the water vaporization enthalpy calculation.

	Bulk water	mMF-F	mMF-JA
Evaporation rate (dark env.) (kg m^{-2} h^{-1})	0.0591	0.0912	0.1082
Vaporization enthalpy (J g^{-1})	2423.8	1570.7	1323.9

Calculation of heat loss in photothermal conversion process

The energy consumption of the system mainly originates from: (1) conduction heat loss from mMF-JA to water, (2) radiation and (3) convection heat losses from mMF-JA to environment.

(1) Conduction heat loss η_{cond}

The conduction heat energy loss from mMF-JA to water is calculated as follows:

$$P_{cond} = \frac{Cm\Delta T}{At} = \frac{4.2 \times 3.96 \times 1.3}{0.0009 \times 1200} = 20.02 W\ m^{-2} \quad (5)$$

$$\eta_{cond} = \frac{P_{cond}}{P_{in}} = \frac{20.02}{1000} = 2.00\% \quad (6)$$

Where C is the specific heat capacity of pure water (4.2 kJ·kg^{-1}·℃$^{-1}$), m denates the weight of water (~ 3.96 g) in the test system, and ΔT is increased temperature of the bulk water within 20 min, t is the irradiation time (1200 s), A is the projected area (0.0009 m^2).

(2) Radiation heat loss η_{rad}

The radiation flux is based on Stefan-Boltzmann law, which is calculated as follows:

$$P_{rad} = \varepsilon\sigma\left(T_2^4 - T_1^4\right) = 0.874 \times 5.67 \times 10^{-8} \times (322.75^4 - 320.05^4)$$

$$= 17.84\ Wm^{-2} \tag{7}$$

$$\eta_{rad} = \frac{P_{rad}}{P_{in}} = \frac{17.84}{1000} = 1.78\% \tag{8}$$

Where ε (0.874) is the emissivity, σ is the Stefan-Boltzmann constant 5.67 ×10^{-8} W (m^2 K^4)$^{-1}$, T_2 (322.75 K) is the temperature at the surface of mMF-JA, and T_1 (320.05 K) is the temperature of the adjacent environment of mMF-JA after 1200 s irradiation.

(3) Convection heat loss η_{conv}

The convection heat loss is calculated based on Newton's law of cooling:

$$P_{conv} = h\left(T_2 - T_1\right) = 5 \times (322.75 - 320.05) = 13.5\ W\ m^{-2} \tag{9}$$

$$\eta_{conv} = \frac{P_{conv}}{P_{in}} = \frac{13.5}{1000} = 1.35\% \tag{10}$$

Where h is the heat tranfer coefficient id approximately 5 W·m^{-2}·K^{-1} according to the previously reports. T_2 (322.75 K) is the temperature at the surface of mMF-JA, and T_1 (320.05 K) is the temperature of the adjacent environment of mMF-JA.

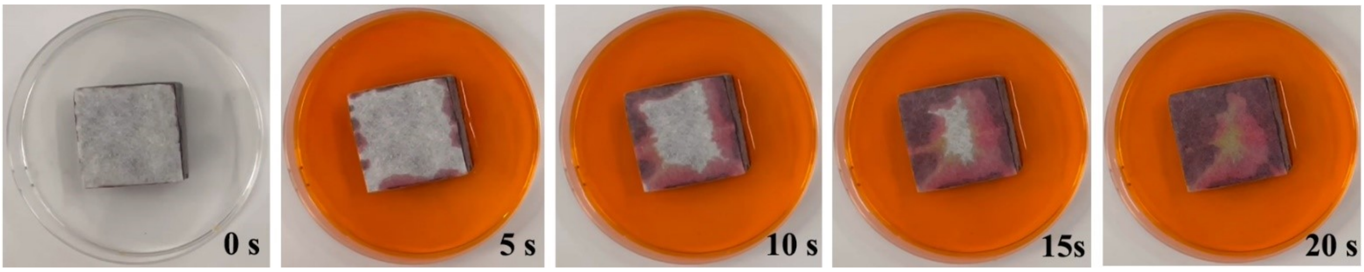

Fig. S1. Water transport behavior of mMF.

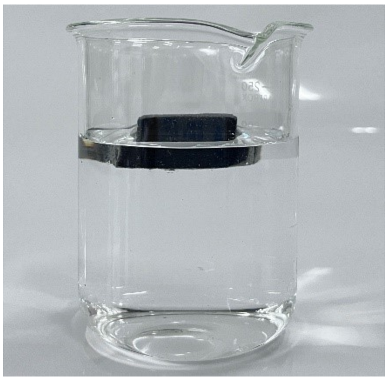

Fig. S2. Photograph of the mMF floating on water.

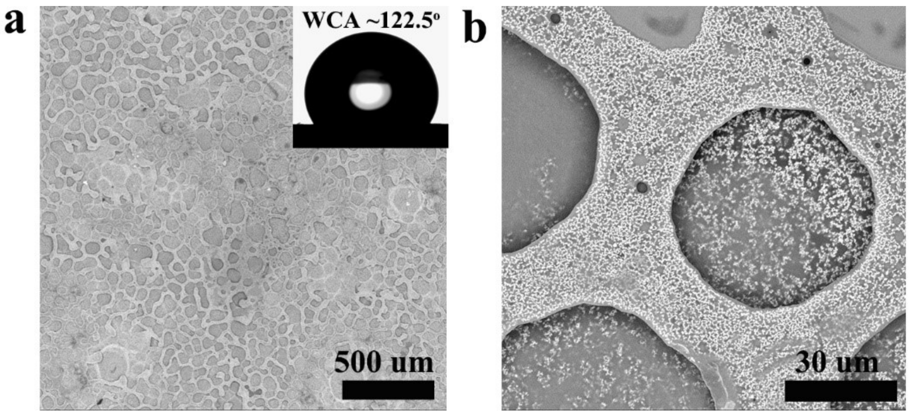

Fig. S3. SEM images of the fabricated mMF-F. Inset is the corresponding water contact angle.

Please do not adjust margins

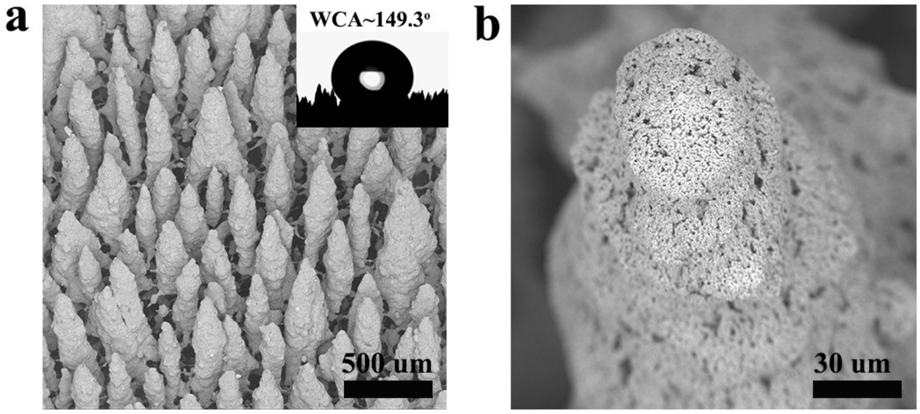

Fig. S4. SEM images of the fabricated mMF-OA. Inset is the corresponding water contact angle.

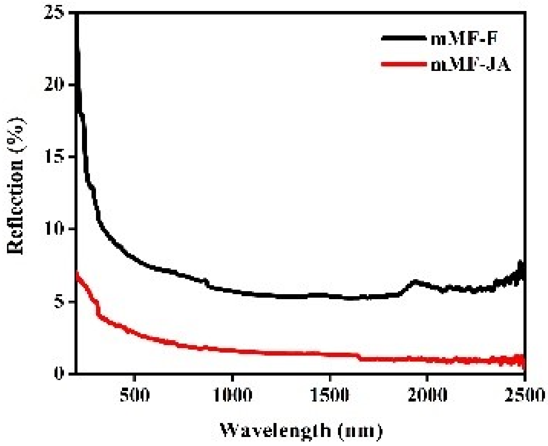

Fig. S5. Reflectance spectra of mMF-F and mMF-JA.

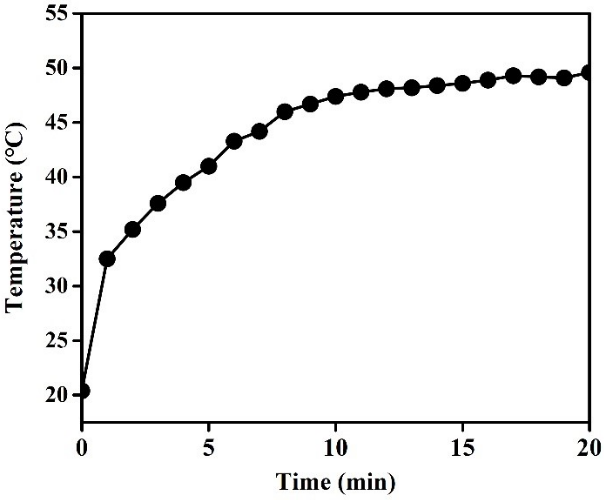

Fig. S6. The change of surface temperature of mMF-JA with irradiation time.

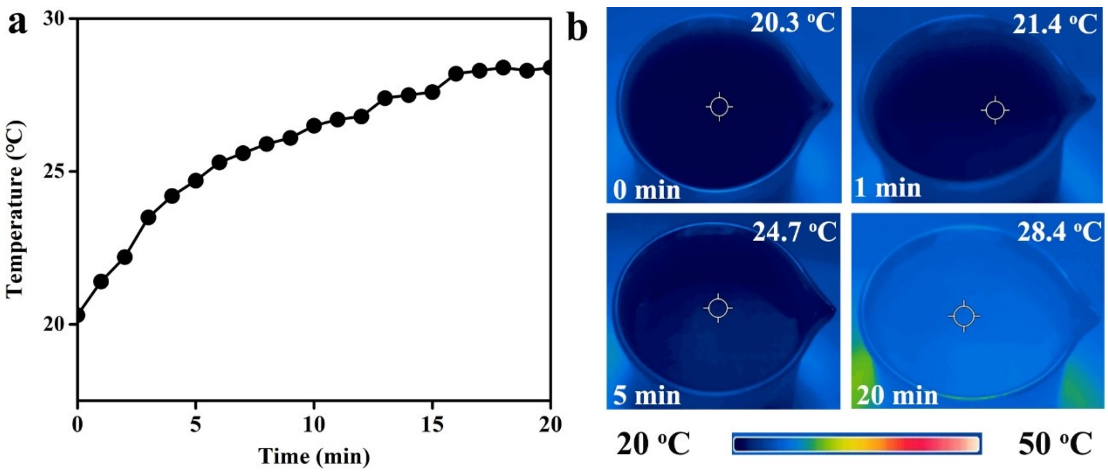

Fig. S7. (a) The change of surface temperature of pure water with irradiation time. (b) Infrared images of the surface temperature of pure water.

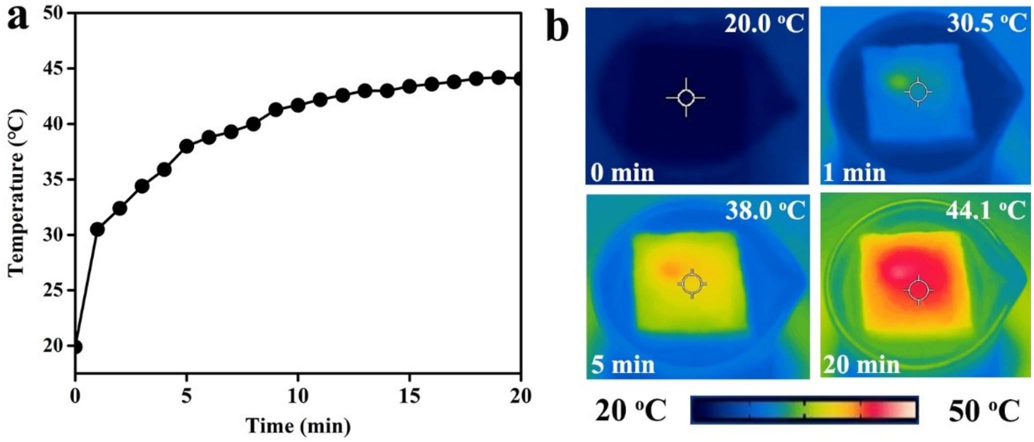

Fig. S8. (a) The change of surface temperature of mMF-F with irradiation time. (b) Infrared images of the surface temperature of mMF-F.

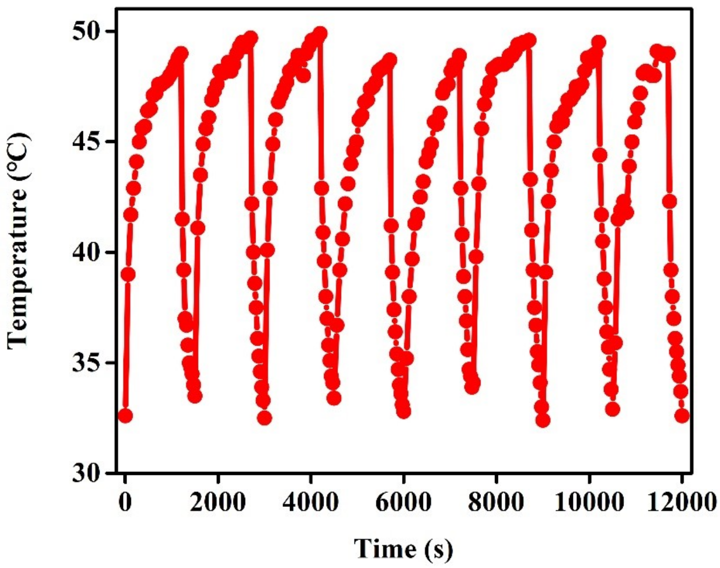

Fig. S9. Cyclic stability of photothermal performance of the fabricated mMF-JA.

Please do not adjust margins

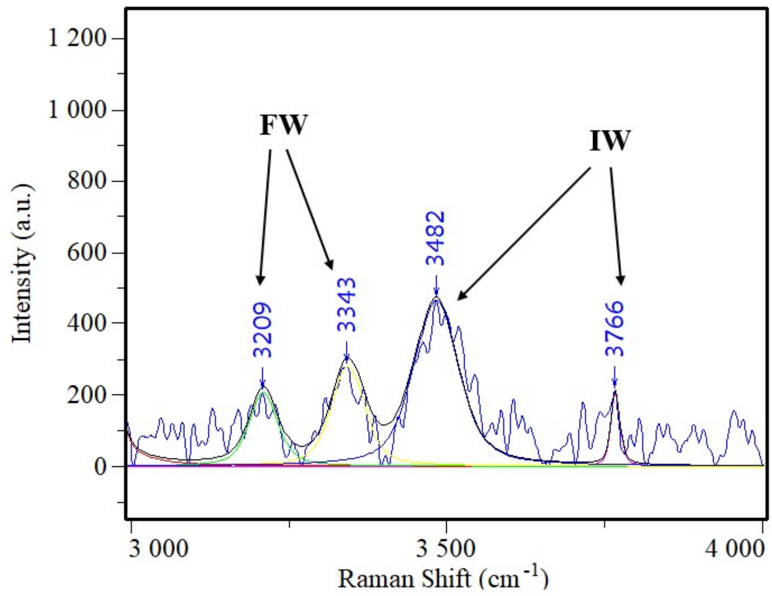

Fig. S10. Raman spectrum showing the fitting peaks of IW and FW in mMf-JA

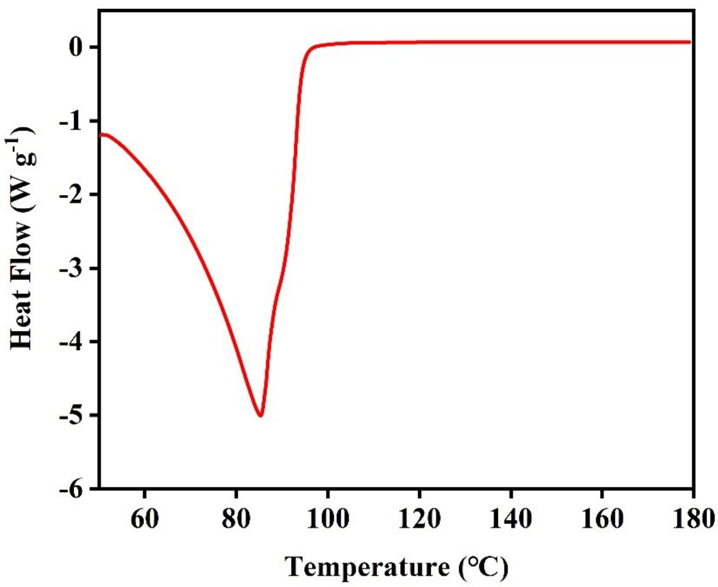

Fig. S11. DSC curve of the water in mMF-JA

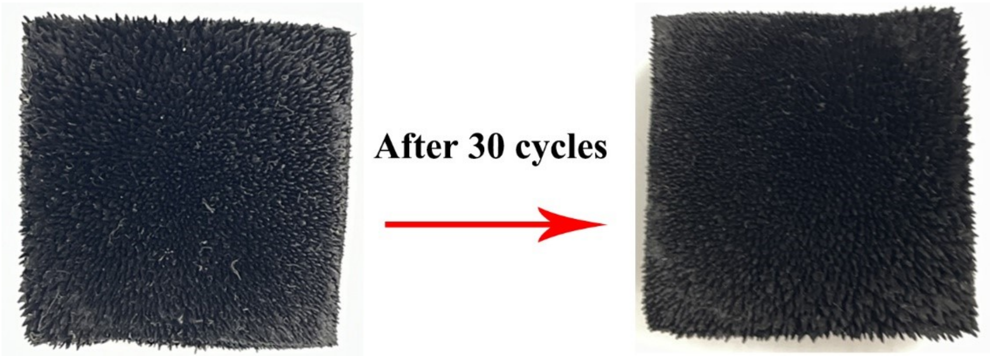

Fig. S12. Photographs of the fabricated mMF-JA before and after long-term application.

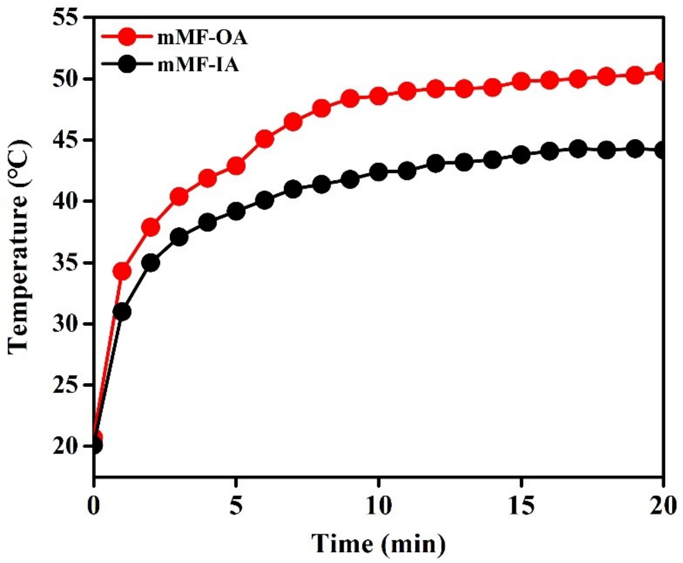

Fig. S13. The change of surface temperature of mMF-OA and mMF-IA with irradiation time.

Please do not adjust margins