Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Solar-Assisted Fast Cleanup of Heavy Oil Spill by a Photothermal Sponge

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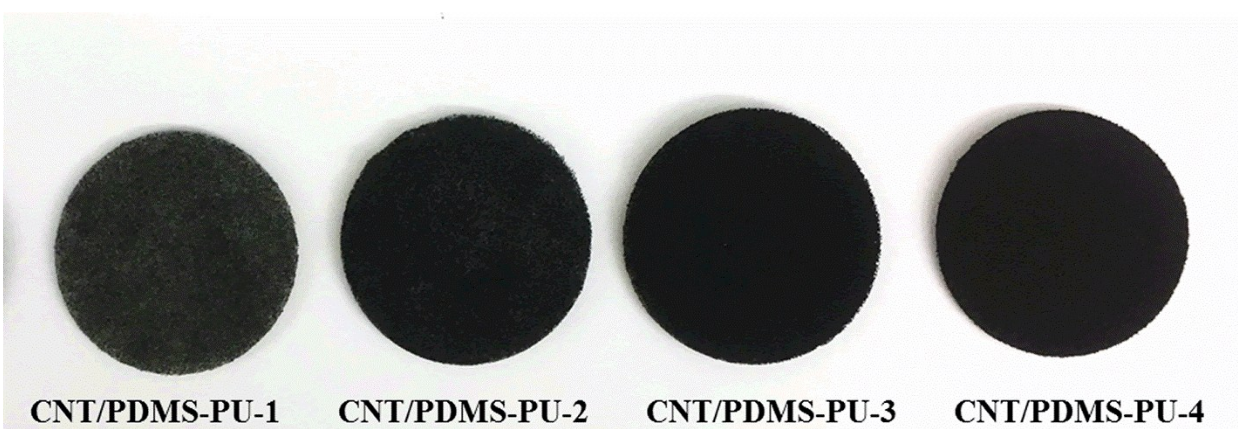

Figure S1. Photograph of the CNT modified sponges.

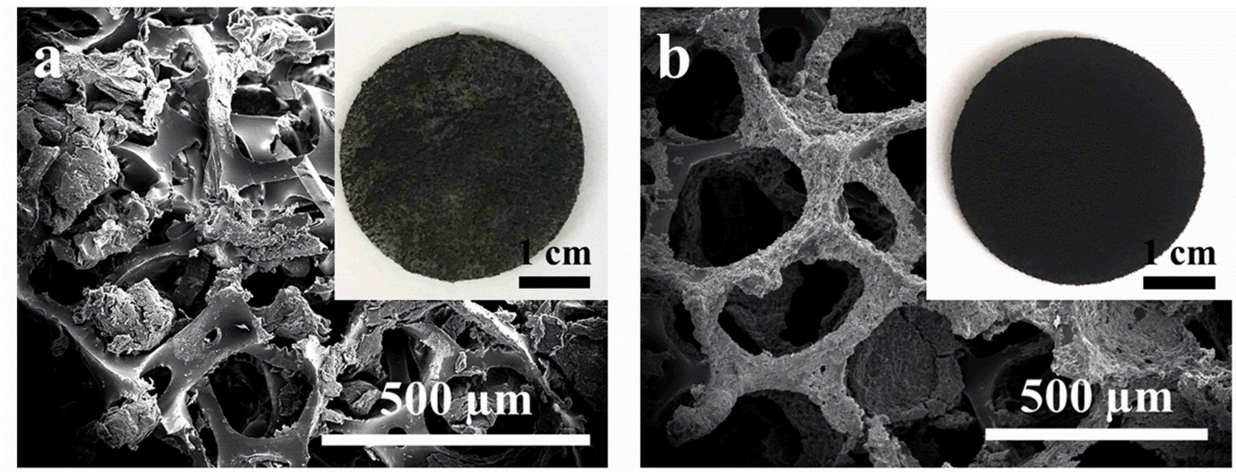

Figure S2. SEM images and photographs of CNT modified PU sponge without PDMS (a) and CNT/PDMS-PU-4 (b).

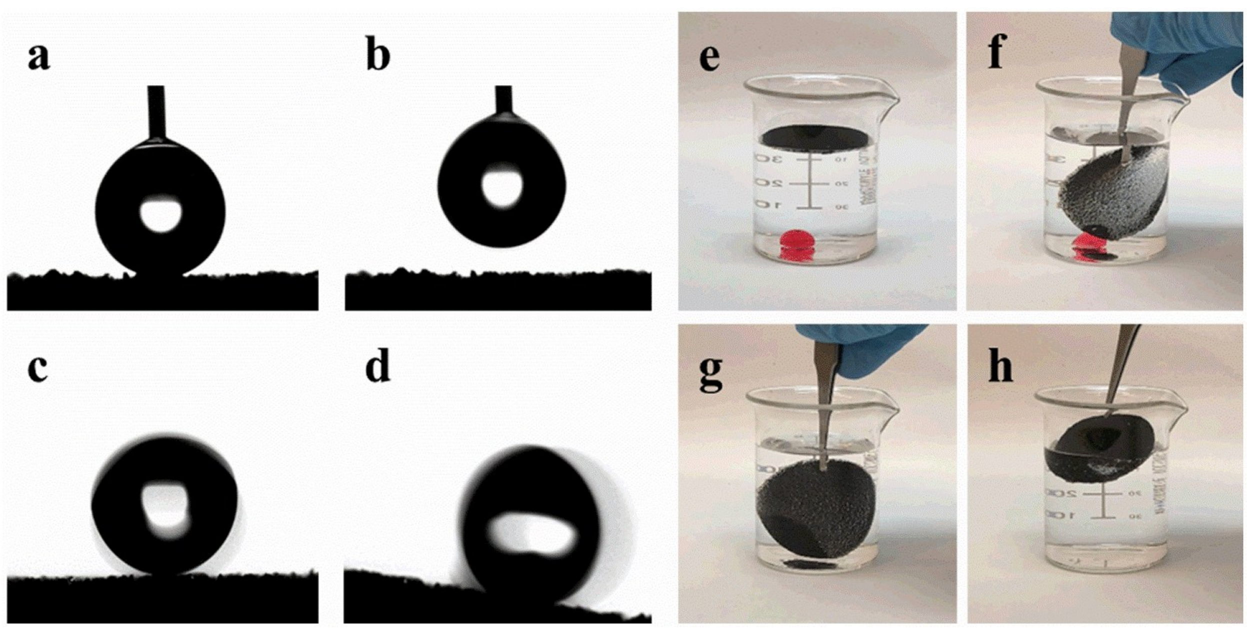

Figure S3 The water droplet contacts (a) and leaves (b) the surface of CNT/PDMS-PU-4 sponge. (c) A water droplet is standing on top of the surface of CNT/PDMS-PU-4 sponge, and (d) it is starting to roll off when the sponge surface is titled at an angle of 10°. (e-h) Absorption of silicon oil (dyed by Oil Red O) in water by CNT/PDMS-PU-4 sponge.

Oil absorption capacity estimation

To evaluate the oil absorption capacity of the CNT/PDMS-PU-4 sponge, CNT/PDMS-PU-4 sponge was put into different organic liquids and allowed to absorb the oils at room temperature for 5 min. The weight of the sponge was measured before and after the oil adsorption.

The K was estimated with the equation:

$$K = \frac{(m_a - m_0)}{m_0} \quad \text{(Equation S1)}$$

Where m_0 and m_a are the sponge weights before and after the absorption test, respectively.

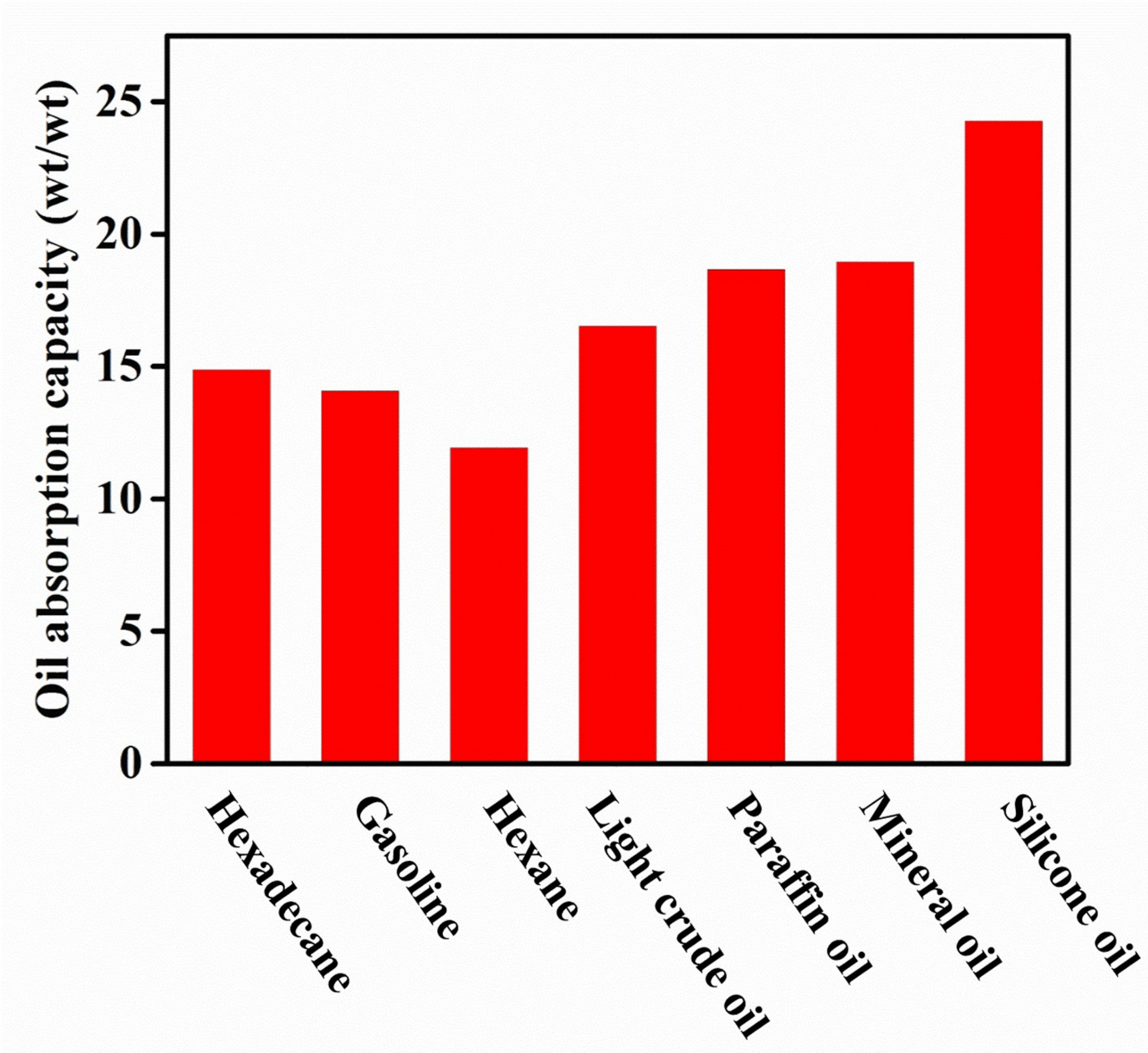

Figure S4. Absorption capacity of CNT/PDMS-PU-4 sponge for various organic liquids (hexadecane, gasoline, hexane, light crude oil, paraffin oil, mineral oil, and silicone oil) (wt/wt: the weight ratio between absorbed oils and CNT/PDMS-PU-4 sponge).

Sponge porosity estimation

The porosity (ϕ) of the sponge was estimated using the relationship:

$$\phi = 1 - \frac{\rho}{\rho_{PU}X + \rho_{CNT/PDMS}Y} \quad \text{(Equation S2)}$$

Where ρ, ρ_{PU} and $\rho_{CNT/PDMS}$ are the densities of the sponge, polyurethane and CNT/PDMS composite respectively and X and Y are the weight percentages of the polyurethane sponge and the CNT/PDMS mixture respectively. ρ=0.043 g/ml, ρ_{PU}=1.25 g/ml, and $\rho_{CNT/PDMS}$=1.53 g/ml.

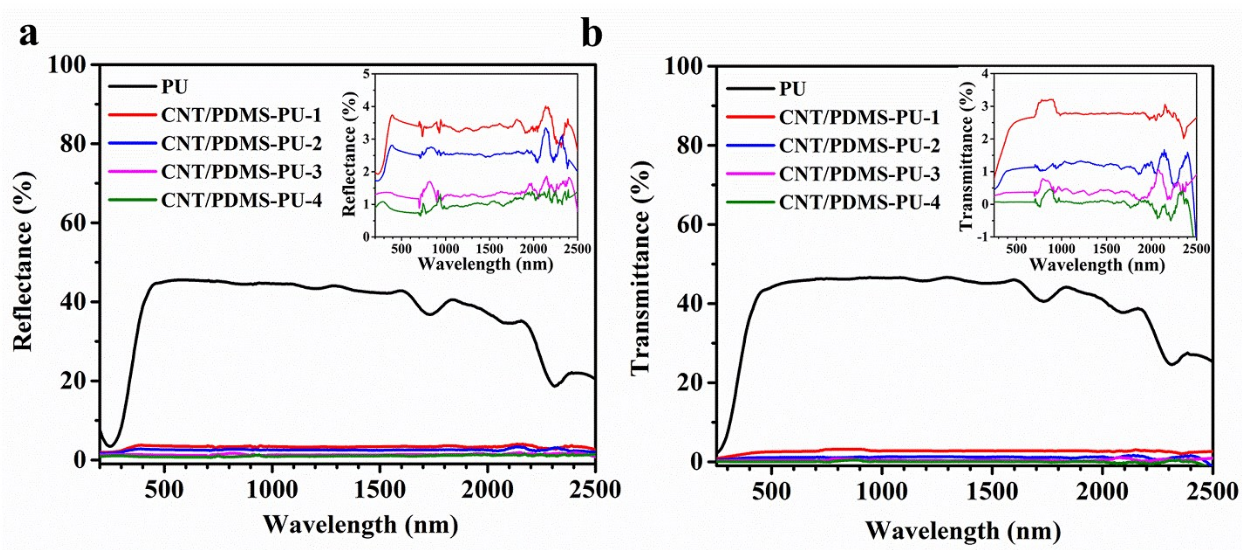

Figure S5. (a) Diffuse reflection and (b) transmission spectra of the unmodified and CNT modified sponges. Inset in (a) and (b) show the detailed comparison of the modified sponges.

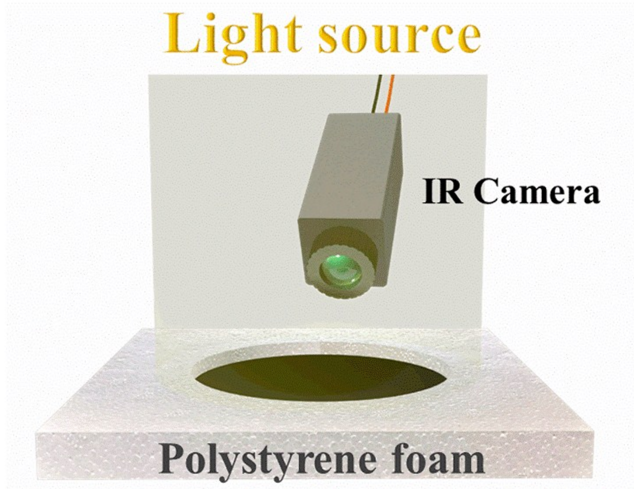

Figure S6. Schematic illustration for the determination of the surface temperature of the sponges.

Thermal conductivity estimation

To estimate the thermal conductivity of CNT/PDMS-PU-4 and original PU sponge, samples with the thickness of 3 mm were placed into the holes with matching size in a thermally insulating polystyrene foam. The top surfaces of these samples were exposed to the simulated solar light, and the temperatures of the top surface and the bottom surface of the sponges were recorded by the IR camera (Figure S6).

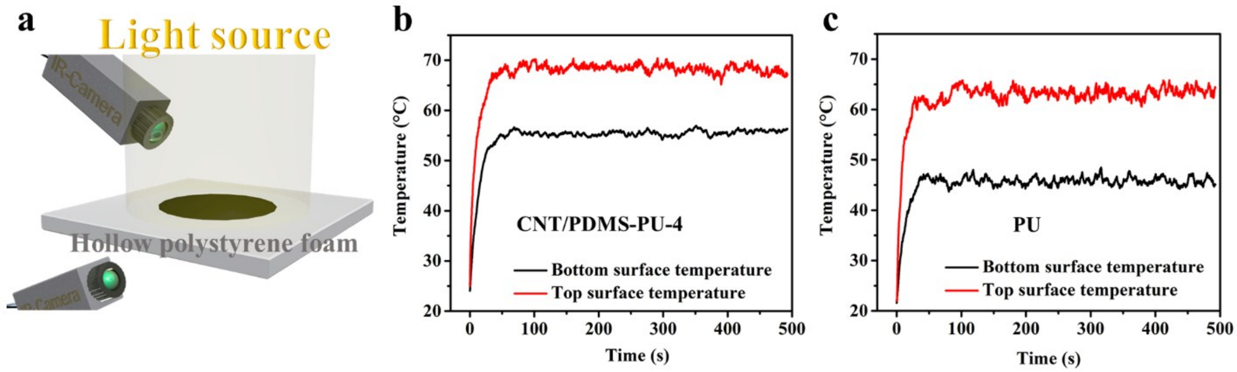

Figure S7. (a) Schematic illustration for the determination of the thermal conductivity of the sponges. Time course of the temperature of the top surface (black curves) and bottom surface (red curves) of the CNT/PDMS-PU-4 sponge (b) and the original PU sponge (c).

Before the measurement, the top surface of the PU sponge was cast with a thin layer of CNT/PDMS composites to prevent the simulated light from transmitting through the semi-transparent PU sponge (transmission~ 39%) and improve light absorption. As shown in Figure S6, under one sun irradiation, both samples reached their steady state temperatures quickly and the difference between the top and bottom surface temperature were 12 °C for the CNT/PDMS-PU-4 and 18 °C for the original PU sponge. The smaller temperature difference of CNT/PDMS-PU-4 sponge indicates its enhanced thermal conductivity.

By using the Fourier equation (Equation S3),[1] the thermal conductivity can be estimated as,

$$Q = k\frac{\Delta T}{\Delta X} \quad \text{(Equation S3)}$$

Where Q is the heat flux (1000 W/m^2- $P_{radiation}$), $P_{radiation}$ is radiation power of primary energy compensation source, k is the thermal conductivity, ΔT is temperature difference between the top and bottom surfaces, ΔX is the thickness of the samples and ΔT/ΔX is the temperature gradient across the sample.

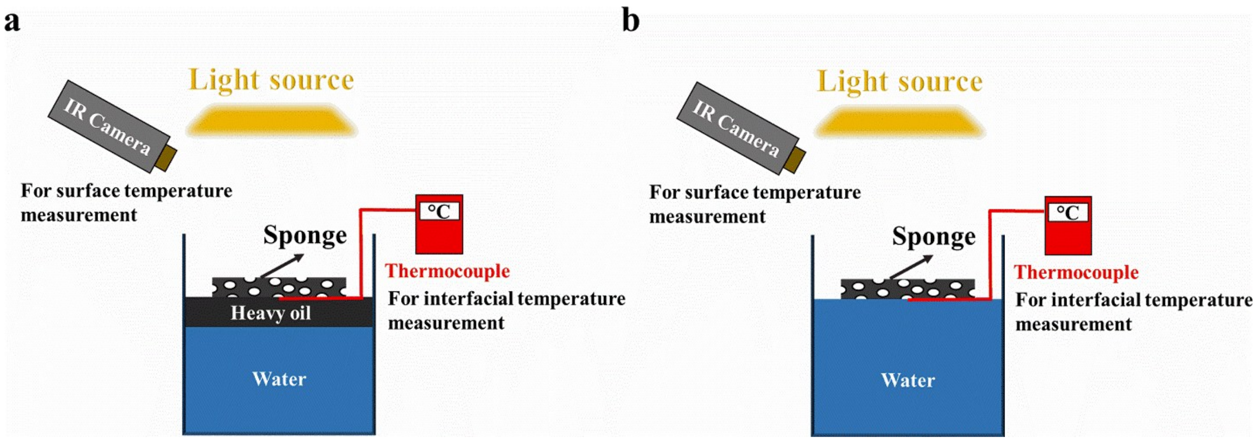

Figure S8. Schematic illustration of the measurement of the surface temperature of the sponges by IR camera and the sponge-liquid interfacial temperature by thermocouple when the sponges float on the surface of heavy oil (a) and water (b), respectively.

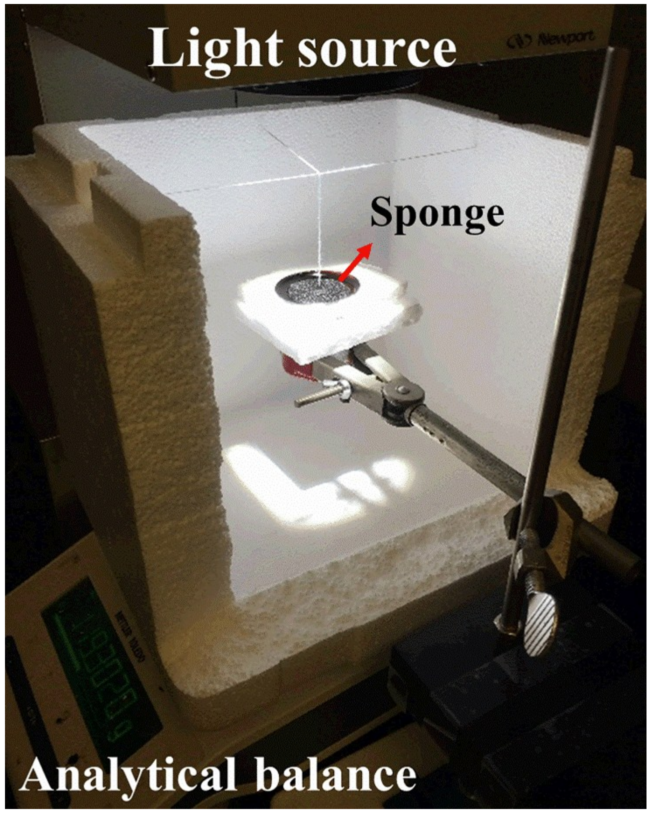

Figure S9. Photograph of the lab made solar-assisted heavy oil absorption set up.

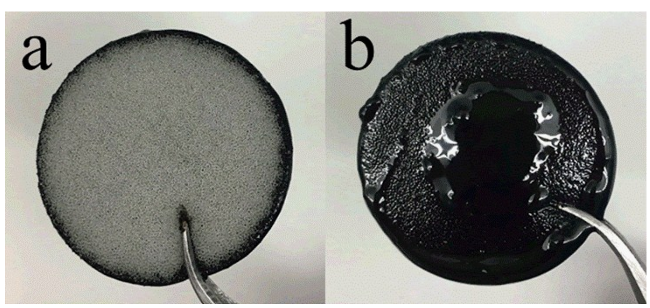

Figure S10. Photographs of the top surface (a) and bottom surface (b) of the pristine PU sponge after solar-assisted oil absorption.

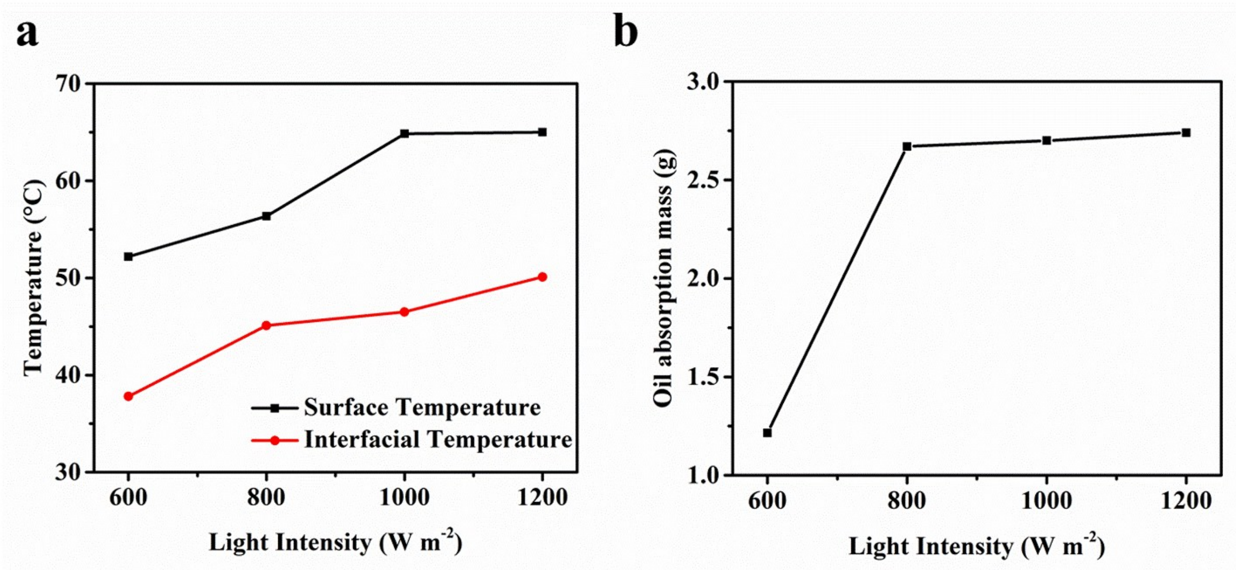

Figure S11 (a) The surface temperature and oil-sponge interfacial temperature of CNT/PDMS-PU-4 sponge as a function of light intensity (600, 800, 1000, 1200 W m^{-2}). (b) Weight of the oil absorbed into CNT/PDMS-PU-4 sponge as a function of light intensity (600, 800, 1000, 1200 W m^{-2}) after 20 min exposure under light.

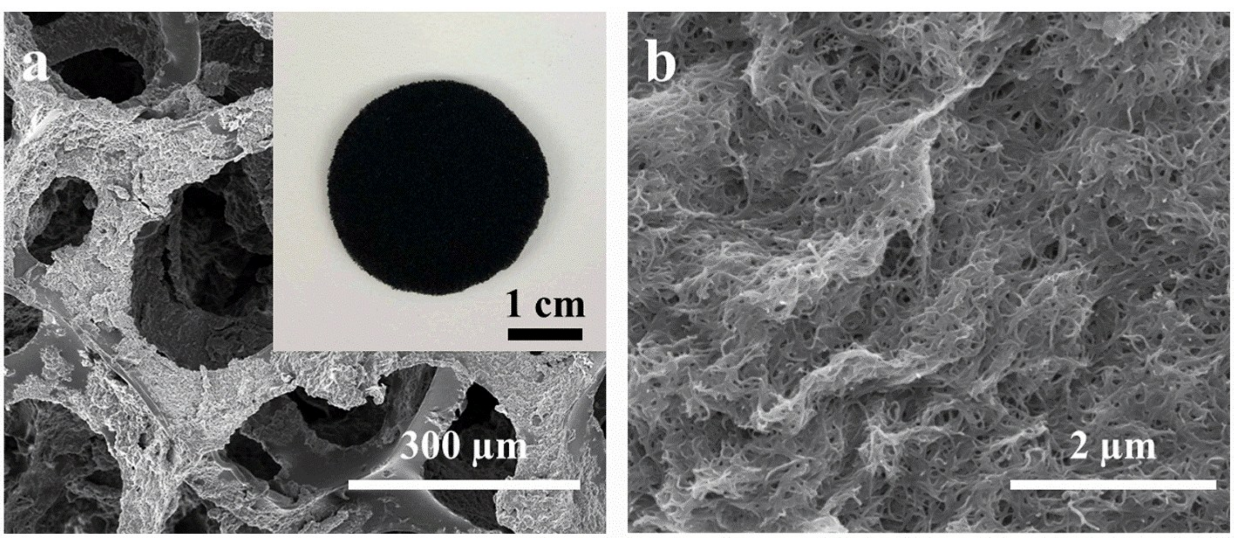

Figure S12 (a, b) SEM images and (inset) photographs of CNT/PDMS-PU-4 sponge after 5 cycles of oil absorption and extrusion processes and following by rinsing in hexane.

REFERENCES

(1) H. Ghasemi, G. Ni, A. M. Marconnet, J. Loomis, S. Yerci, N. Miljkovic and G. Chen, *Nat. Commun.*, 2014, **5**, 4449.