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## **Supporting information**

## Hybrid Engineering Materials with high water-collecting efficiency inspired by Namib Desert beetles

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## This ESI contains:

Experimental Section Supplementary Figures S1-S13, Table S1-S2 Supplementary Movie S1-3

## **Experimental section**

*Materials:* Copper powders are purchased from Kelong Chemical (Chengdu, Sichuan Province, China). Epoxy resin (E51) and curing agent are obtained from Beijing oriental Yuhong Waterproof Technology Co., Ltd. Copper sheets  $(3.3 \times 0.7 \text{ cm})$  are purchased from Sinopharm Chemical Reagent Co., Ltd. n-Octadecyl thiol (96%) is obtained from Acros organics. TiO<sub>2</sub> powders (Degussa p25, ca. 80% anatase, 20% rutile; BET area, ca. 50 m<sup>2</sup> g<sup>-1</sup>) and other chemicals were of analytical grade and used as received.

*Preparation of hybrid superhdrophilic-superhydrophobic surface:* The fabrication processes of superwettable hybrid surfaces are shown in Fig. S1. Firstly, resin epoxy and curing agent (weight ratio, 3:1) was prepared and artificially brush-coated on the clean copper. Then, Cu and TiO<sub>2</sub> (p25) particles were mixed with a series of molar ratio (0:1, 1:1, 2:1, 3:1, 4:1, 5:1, 6:1, 9:1, 12:1, 1:0), and ethanol solution were added in the mixed particles and centrifuged for 15 min to obtain the uniformly dispersed solution. This was followed by dip-coating the mixed particles on ER/copper sheets. The samples were then settled in room temperature (RT) for 12 h. After the surfaces were dried, the samples were immersed in 0.01 M n-octadecylme/n-hexane solution for 45 min to earn low energy surfaces.

*Water collection measurements:* In order to verify the water collection performance of the samples, a homemade test system was constructed. The as-prepared samples  $(3.3 \times 0.7 \text{ cm})$  were fixed on a holder in the glass box with a sliding roof (length  $\times$  width  $\times$  height:  $50 \times 30 \times 60$ , 70 cm), and their surfaces were perpendicular to the horizontal plane. A water container was placed directly under this sample, and the distance between the fog generator and the sample was kept at 10 cm. A stimulated fog flow (about 10 cm s<sup>-1</sup>) was generated by a commercial humidifier with a constant relative humidity of 80% in the glass box. And, the temperature is about 20°C. Water collected by the samples was drained by gravity into a container, which was weighted per 0.5 h during a period of 5 h.

Sandpaper abrasion and self-cleaning test: The as-prepared sample was faced to the sandpaper with a 200 g weight upon, and then an outer force was applied to move the sample in one direction for 15 cm. The WCAs and RAs were tested after every abrasion. What is more, in order to show the self-cleaning property, the as-prepared surface was fixed on a culture dish with a title angle and muddy water was then poured on the sample.

*Characterization:* To demonstrate the morphologies of the samples, the field-emission scanning electron microscopes (JEOL JSM-7100F) was obtained, and an X-ray energy dispersive spectrometer (EDS) attached to the scanning electron microscopes (JEOL JSM-5600LV) was utilized to analyze the chemical composition of the as-prepared surfaces. Water contact angle measurements were carried out using a JC2000D goniometer (Zhongchen digital equipment Co. Ltd Shanghai, China). A 5  $\mu$ L droplet was dropped on such samples and measured at five different positions on the samples to acquire the average values of contact angle. To analyze the surface composition and surface element content of the samples, X-ray photoelectron spectroscopy (XPS, VG ESCALAB 250, Physical Electronics, USA) was operated through the Al K $\alpha$  line as the excitation source.



Fig. S1 Schematic illustration of the preparation procedure of the superhydrophilic-superhydrophobic hybrid materials.

WCA Samples	unmodified	modified
TiO2 dominant surface	0°	0°
Cu dominant surface	122.3°	143.7°

Fig. S2 WCAs of the  $TiO_2$  dominate surface and Cu dominate surface before and after thiol treatment.



Fig. S3 Rolling-off angle of 8.2° on the Cu dominant surface after thiol modification.



**Fig. S4** XPS spectra of the  $TiO_2$  dominate surface before (a) and after (b) thiol treatment. XPS spectra of Cu dominate surface before (c) and after (d) thiol treatment.

**Table S1**Atomic concentration rates, water contact angles, rolling-off anglesmeasurements on the prepared samples

Precursor	0:1	1:1	2:1	3:1	4:1	5:1	6:1	9:1	12:1	1:0
(Cu:TiO <sub>2</sub> )										
ACR <sup>a</sup>	0:1	1:4.6	1:3.5	1:2.9	1:1.8	1:1.5	1:1.1	1:0.93	1:0.77	1:0
WCA <sup>b</sup>	0	39.3°	57.6°	85.1°	128.5°	140.4°	151.7°	155.1°	157.3°	143.7°
$RA^{c}$					$\mathbf{N}\mathbf{A}^{d}$	$NA^d$	6.1°	4.5°	2.3°	8.2°

<sup>*a*</sup>As determined by XPS data. <sup>*b,c*</sup>The average values of WCA and RA. <sup>*d*</sup>Water droplets on the surfaces with high adhesion force.



Fig S5. Rolling-off angles of 6.1° and 2.3° on the samples with the precursor molar ratio (Cu :



**Fig S6.** SEM images of Cu dominant sample before (a-b) and after (c-d) thiols modification, (b), (d) are the enlarged views of (a), (c), respectively. Scale bar:  $30 \mu m$  (a),  $3 \mu m$  (b, c),  $1 \mu m$  (d).



Fig S7. SEM images of TiO<sub>2</sub> dominant sample before (a-b) and after (c-d) thiols modification, (b), (d) are the enlarged views of (a), (c), respectively. Scale bar: 30  $\mu$ m (a), 3  $\mu$ m (b, c), 300 nm (d).

Skyn Mag	Presursor 1:1	Presursor 3:1	Presursor 6:1	Presursor 12:1
× 500 Scale bar: 30 µm				
× 5000 Scale bar: 3 µm				
× 5000 (modified) Scale bar: 3 μm				
× 15000 (modified) Scale bar: 1 µm				

Fig S8. SEM images of the samples with different molar ratios.



**Fig S9**. WCA of nearly  $0^{\circ}$  on the unmodified sample with the precursor molar ratio (Cu : TiO<sub>2</sub>) of 9 : 1.



**Fig S10.** Water collection processes on the samples with the precursor molar ratio (Cu : TiO<sub>2</sub>) of 0 : 1(I), 1 : 1(II), 9 : 1(III), 0 : 1(IV). The samples were placed on a horizontal and vertical plane to test the water collection processes. For the superhydrophilic TiO<sub>2</sub> dominate surface, it took a long time for the very thin water film layer to form on the sample and directly wetted the surface (I). A large water drop was firstly formed on the sample of precursor molar of 1 : 1, then resulting in a layer of water film (II). On the sample with precursor molar of 9 : 1, some tiny water droplets were firstly captured on the surface, then the droplets grew larger and larger, they coalesced with each other to become much larger droplets. Finally, the droplets are transported and collected under gravity (III). As for the Cu dominate sample, tiny water droplets fully occupy on the surface quickly, and water was collected in a shorter time (IV).



Fig S11. Weight of water on the water container for 5 h on the water-collecting tests of the contrast sample.



Fig S12. Water collection rates on the superhydrophobic copper mesh, copper sheet, fabric, and  $Cu-TiO_2$  composite material, respectively.



**Fig S13.** Stability of WCA and WCR on the sample for 10 times repeats of water collection processes, whereby the WCA was respectively about 155.1°, 154.5°, and .152.9° on the sample for 1st, 5st, 10st water collection cycle.

Table S2 Water collection rates on the as-prepared samples

Presursor	0:0	0:1	1:1	3:1	6:1	9:1	12:1	20:1	1:0
(Cu:TiO <sub>2</sub> )									
k (Slope)	1453.9	1549.0	1880.3	2422.8	3546.1	4479.7	3651.4	3261.1	3011.9
WCR (mg		80.3	184.6	419.5	905.7	1309.9	951.3	782.3	674.4
h <sup>-1</sup> cm <sup>-2</sup> )									

**Videos 1-2**, the unstable water contact angles on the samples with the precursor molar ratio (Cu :  $TiO_2$ ) of 1 : 1 (1) and 3 : 1 (2).

Video 3, self-cleaning test on the sample with the precursor molar ratio (Cu :  $TiO_2$ ) of 9 : 1.