Supporting Information

High-efficiency water collection on biomimetic surface with superwettable patterns

Hai Zhu\textsuperscript{ab}, Fuchao Yang\textsuperscript{a}, Jing Li\textsuperscript{b} and Zhiguang Guo\textsuperscript{ab}*  
\textsuperscript{a}Hubei Collaborative Innovation Centre for Advanced Organic Chemical Materials and Ministry of Education Key Laboratory for the Green Preparation and Application of Functional Materials, Hubei University, Wuhan 430062, People’s Republic of China.  
\textsuperscript{b}State Key Laboratory of Solid Lubrication, Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, Lanzhou 730000, People’s Republic of China.  
E-mail: zguo@licp.cas.cn; Fax: +86-931-8277088; Tel: +86-931-4968105

This ESI contains:

Experimental Section  
Supplementary Figures S1-10, Table S1-2  
Supplementary Movie S1-5
Experimental section

Materials: Copper mesh is commercially available. Sodium hydroxide (NaOH) is obtained from Tianjin Rionlon Pharmaceutical Science & Technology Development Co., Ltd. Ammonium persulfate ((NH₄)₂S₂O₈) is purchased from Sinopharm Chemical Reagent Co., Ltd. n-Octadecyl thiol (96%) is obtained from Acros organics. The humidifier is purchased from a local store in Lanzhou, China. All the measurements are conducted at room temperature.

The preparation of superhydrophilic, superhydrophobic copper meshes: The copper meshes were firstly cleaned in deionized water and acetone/ethanol to remove out the contaminations on the surfaces. Then, the clean samples were immersed in the mixtures of 1 M NaOH and 0.05 M (NH₄)₂S₂O₈ for 30 min. The superhydrophilic copper meshes were thus synthesized for the formation of Cu(OH)₂ on the surfaces, which can be explained by the following chemical oxidation process:\[^1\]

\[
Cu + 4NaOH + (NH₄)₂S₂O₈ = Cu(OH)₂ + 2Na₂SO₄ + 2NH₃ + 2H₂O. 
\]

To obtain the superhydrophobic wetting behavior, the above superhydrophilic surface was in direct immersion with 0.05 M ODT/ethanol for 5 s.

The fabrications of water-collecting copper meshes: All the superhydrophilic samples were designed as 2.5 × 5 cm² in size. And, the glass tube has an average inner and outer diameter of 1.7 cm, 3.1 cm (Fig. S1). The as-prepared superhydrophilic samples were fixed between the two fixtures with suitable positions. Water (10 mL) was firstly poured down the upper tube. Subsequently, n-hexane (15 mL) was added in turn, it was found that the oil was kept on the sample. When 0.05 M ODT/ethanol solution (20 mL) was followed to pour down, n-hexane originally above the sample flowed through. Quickly, the samples were removed out and followed to be cleaned with sufficient ethanol and deionized water. Consequently, superhydrophobic circles were embedded in the superhydrophilic samples (Fig. S2).

Water collection measurements: A homemade test system was constructed to verify the water collection performance of the samples.\[^2\] The as-prepared surfaces were fixed on a holder in the glass box with a sliding roof (length × width × height: 50 × 30 × 60, 70 cm). The samples were perpendicular to the horizontal plane, under which a water container was directly placed. The distance between the fog generator and the sample was 10 cm. A stimulated fog flow (about 10 cm s⁻¹) was generated by a commercial humidifier. The constant relative humidity of 80% and temperature of about 20°C are kept in the glass box. Water collected on the surfaces were drained into a container under gravity, meanwhile, it was weighted per 0.5 h during a period of 4 h.

Characterizations: The JEOL JSM-7100F field-emission scanning electron microscopes (FESEM, 20 kV) was applied to demonstrate the morphologies of the fabricated samples. Water contact angle measurements were tested by a JC2000D goniometer (Zhongchen digital equipment Co. Ltd Shanghai, China), the 5 μL droplet was dropped on such prepared surfaces and measured at five different positions to obtain the average values of contact angles. X-ray photoelectron spectroscopy (XPS, VG ESCALAB 250, Physical Electronics, USA) that operated through the Al Ka line as the excitation source was used.
to analyze the surface composition and surface element content of the samples. Fourier
transformer infrared spectra (FTIR) spectroscopy was recorded using Thermo Scientific
Nicolet iS10. All the measurements were conducted at room temperature.
**Fig S1.** Optical images of oil/water separation apparatus, the inner and outer diameter are about 1.7 cm, 3.1 cm, respectively.

**Fig S2.** Water-collecting surfaces fabricated through the modified oil/water separation process, whereby superhydrophilic areas were dyed in blue and superhydrophobic areas were dyed in cyan, all white dotted lines represent the axis of symmetry.
**Fig S3.** Fourier Transform Infrared Spectroscopy (FTIR) spectra of original copper mesh (line I), alkaline oxidized copper mesh (line II), oxidized copper mesh directly-immersed in ODT (line III), Cu mesh modified in the similar oil/water separation process (line IV). Cu can be examined at the wavenumber of and 2351 ~ 2364 cm$^{-1}$. The produced Cu(OH)$_2$ is confirmed to be existed at the wavenumber of 3552 ~ 3558 cm$^{-1}$ (line II-IV). -CH$_3$, -CH$_2$-, and -S-CH$_2$- at the respective wavenumber of 2920 ~ 2916 cm$^{-1}$, 2846 ~ 2857 cm$^{-1}$, 1460 ~ 1478 cm$^{-1}$ indicates the existence of ODT on the samples (line III and IV).

**Fig S4.** RAs of about 8.4° and 5.3° on the directly-immersed-modified Cu mesh (a), Cu mesh modified in oil/water separation (b), respectively.

**Fig S5.** Optical image of water droplets on the surface with an average WCA of 152.4°.
Fig S6. (a-c) SEM image of directly ODT-immersed Cu mesh, (b), (c) represents the enlarge view of area 1, 2 in (a), respectively. (d) A water droplet on the surface with an average WCA of 159.5°.

Fig S7. X-ray photoelectron spectra (XPS) spectrum of directly-immersed-modified Cu mesh (a), modified Cu mesh in oil/water separation (b), respectively. Cu2p3 and S2p appear at the respective peak of 932 eV, 162 eV in both of the XPS spectrum.
<table>
<thead>
<tr>
<th>Surface</th>
<th>Horizontal Scale bar (1 cm)</th>
<th>Vertical Scale bar (1 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface II</td>
<td><img src="image1.png" alt="Images" /></td>
<td><img src="image2.png" alt="Images" /></td>
</tr>
<tr>
<td>Surface III</td>
<td><img src="image3.png" alt="Images" /></td>
<td><img src="image4.png" alt="Images" /></td>
</tr>
<tr>
<td>Surface VII</td>
<td><img src="image5.png" alt="Images" /></td>
<td><img src="image6.png" alt="Images" /></td>
</tr>
</tbody>
</table>

**Fig S8.** Water collection processes of Surface II, III, VII. The samples were placed on a horizontal...
and vertical plane to test the water collection processes. On the superhydrophobic sample (Surface II), tiny water droplets occupied on the surface and rolling down quickly. It took a relative long time for the water film to form on the superhydrophilic surface (Surface III), and a puddle was observed to take shape on the lower portion of this sample (showed by the red dashed rectangle in Surface III). It was found that amounts of tiny water droplets was quickly captured on the superhydrophobic circle and grew larger and larger (Surface VII), and they would fell down to the superhydrophilic area and change into water film layer. At the lower superhydrophilic portion, the puddle was formed (showed by the red dashed rectangle in Surface VII). There is an obvious boundary between superhydrophobic and superhydrophilic area, where water drops fully occupied on the superhydrophobic pattern and water film was formed on the superhydrophilic area.

**Table S1** Water collection measurements on the as-prepared samples

<table>
<thead>
<tr>
<th>Samples</th>
<th>Contrast</th>
<th>Surface I</th>
<th>Surface II</th>
<th>Surface III</th>
<th>Surface IV</th>
<th>Surface V</th>
<th>Surface VI</th>
<th>Surface VII</th>
</tr>
</thead>
<tbody>
<tr>
<td>k (Slope)</td>
<td>1453.9</td>
<td>10068.7</td>
<td>15297.4</td>
<td>10925.7</td>
<td>12672.4</td>
<td>12818.3</td>
<td>13553.1</td>
<td>17915.1</td>
</tr>
<tr>
<td>R (mg h⁻¹ cm⁻²)</td>
<td>689.2</td>
<td>1107.5</td>
<td>757.7</td>
<td>909.2</td>
<td>957.3</td>
<td>1029.0</td>
<td>1316.9</td>
<td></td>
</tr>
</tbody>
</table>

**Fig S9.** Weight of water on the water container for 4 h of the contrast sample (a) and Surface VII with different inclined angle (b).

**Fig S10.** Water collection rates on the Surface VII at different inclined angles.
Table S2 Water collection of Surface VII with different inclined angles

<table>
<thead>
<tr>
<th>Inclined angle</th>
<th>Contrast</th>
<th>15°</th>
<th>45°</th>
<th>90°</th>
</tr>
</thead>
<tbody>
<tr>
<td>k (Slope)</td>
<td>1453.9</td>
<td>3251.2</td>
<td>10271.3</td>
<td>17915.1</td>
</tr>
<tr>
<td>R (mg h⁻¹ cm⁻²)</td>
<td>143.7</td>
<td>705.4</td>
<td>1316.9</td>
<td></td>
</tr>
</tbody>
</table>

Video S1, The fabrication processes of water-collection materials.

Video S2, Wetting characterizations of superhydrophilic surface with an upper or lower superhydrophobic circular pattern.

Video S3, Wetting characterizations of superhydrophilic surface with a middle superhydrophobic circular pattern.

Video S4, Wetting characterizations of superhydrophilic surface with two superhydrophobic circular patterns.

Video S5, Wetting characterization of superhydrophobic surface.

Reference