Electronic Supplementary Information

Electroconductive nanofibrous membranes with nanosheet-based microsphere-threaded heterostructures enable oily wastewater remediation

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Supplementary Materials

Fig. S1. Electrospun SiO$_2$ nanofibrous membrane with a width of 1.2 m. Inset showing the flexibility of SiO$_2$ nanofibrous membrane.

Fig. S2. SEM images of the SiO$_2$/PANI/BiOBr nanofibrous membranes with (a) 1, (b) 3, and (c) 9 SILAR cycles.

Fig. S3. SEM images of the SiO$_2$/BiOBr nanofibrous membranes with 6 SILAR cycles, and inset is the high magnification SEM image of nanofibers.
Fig. S4. High-resolution (a) Br 3d and (b) O 1s XPS spectra of SiO$_2$/PANI/BiOBr nanofibrous membrane (top) and BiOBr powder (bottom).

Fig. S5. An oil droplet displaying a very quick spreading on the SiO$_2$/PANI/BiOBr nanofibrous membrane in the air.

Fig. S6 The advancing contact angle ($\theta_{\text{adv}}$), receding contact angle ($\theta_{\text{rec}}$), and contact angle hysteresis ($\theta_{\text{hys}}$) of the fouled and cleaned SiO$_2$/PANI/BiOBr membranes.
Fig. S7. PL spectra of different samples.

Fig. S8. Schematic of the separation and transfer of photo-generated charge carriers in the SiO$_2$/PANI/BiOBr membrane under visible light irradiation.

Because $\pi^*$-orbital energy of PANI is more negative than the conduction band (CB) energy of BiOBr and valence band (VB) energy of BiOBr is more positive than the $\pi$-orbital energy of PANI, the interface between the PANI and BiOBr resulted in an oriented electron flow from $\pi^*$-orbital of PANI to the CB of BiOBr and a hole flow from VB of BiOBr to the $\pi$-orbital of PANI.
**Fig. S9.** The photosynthesis mechanism of chloroplast.

**Fig. S10.** Optical microscopy images and photographs of the surfactant-free/stabilized emulsions before and after separation.

**Fig. S11.** The photographs of feed solution with (a) oil droplets plus NaCl and (b) oil droplets plus Sudan III in aqueous solution and the corresponding filtrates. n-Hexane was taken as model oil.
Fig. S12. Surfactant-stabilized soybean oil-in-water emulsion (SSE) before and after separation by different membranes.

Fig. S13. (a) Cycle separation performance test of the SiO$_2$/PANI/BiOBr nanofibrous membrane. (b) The FRRs of SiO$_2$/PANI/BiOBr nanofibrous membrane for various surfactant-stabilized oil-in-water emulsions.

Fig. S14 (a) SEM and (b) HRTEM images of SiO$_2$/PANI/BiOBr membrane after photocatalytic process.
Table S1. Permeation fluxes of SiO$_2$/PANI/BiOBr membrane for separating surfactant stabilized oil-in-water emulsions in comparison with the separation membranes in literature.

<table>
<thead>
<tr>
<th>Membrane</th>
<th>Pressure applied (kPa)</th>
<th>Permeation flux (L m$^{-2}$ h$^{-1}$)</th>
<th>Normalized flux (L m$^{-2}$ h$^{-1}$ bar$^{-1}$)</th>
<th>Ref.</th>
</tr>
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<tr>
<td>SiO$_2$@PEI-PAN-SEP</td>
<td>10</td>
<td>~1500-2000</td>
<td><del>15000</del>20000</td>
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<tr>
<td>Modified PAA-g-PVDF</td>
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<td>1230-1360</td>
<td>1230-1360</td>
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<td>26700-64700</td>
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<td>45500-100400</td>
<td>This work</td>
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</tbody>
</table>

Supplementary Methods

Calculation method of the adhesion work

The adhesion works of the oil and water on the surface of the relevant membrane were calculated by the Young Dupré’s Equation: $W_{ad} = \gamma_{lg}(1 + \cos \theta_{lv})$, where the $W_{ad}$ is the adhesion work, the $\gamma_{lg}$ is the surface tension of liquid/air interface, and the $\theta_{lv}$ is the relevant liquid contact angle in air. For the SiO$_2$/PANI and SiO$_2$/PANI/BiOBr nanofibrous membrane, both the WCA and OCA are 0° in air. And the surface tension in air for water and dichloroethane are 72.8 mN m$^{-1}$ and 23.2 mN m$^{-1}$, respectively. Consequently, for water, the $W_{ad} = 72.8 \times (1 + \cos 0°) = 145.6$ mN m$^{-1}$. For dichloromethane, the $W_{ad} = 23.2 \times (1 + \cos 0°) = 46.4$ mN m$^{-1}$. 
References


