Supporting Information

In situ dopamine-driven copper nanoparticle/thiol-modified superhydrophobic ceramic membranes for oil-water separation and membrane contamination control

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S1) Separating device diagram

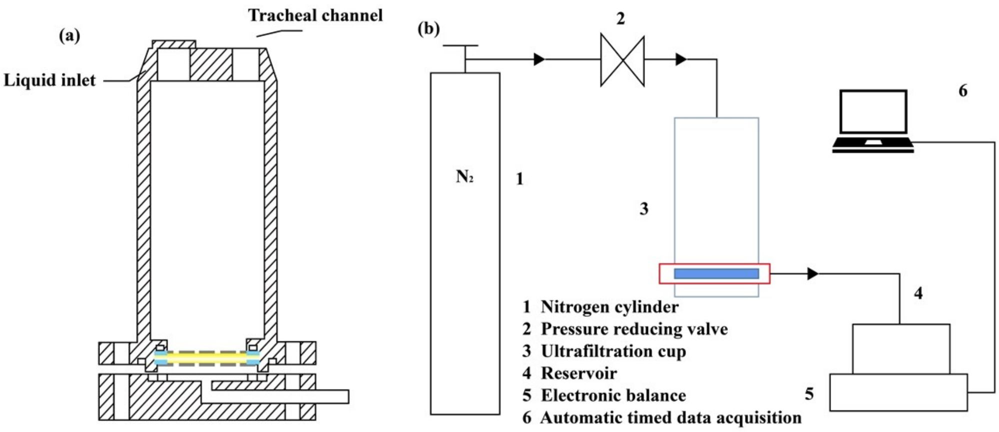

Figure S1. Experimental device (a) acrylic ultrafiltration cup, (b) Oil-water separation device diagram.

S2) Static three-dimensional morphology characterization of membrane surface

Figure S2 shows the static 3D morphology of the ceramic membrane surface. The average profile undulation of the CM surface of the unmodified ceramic membrane is -5 μm-5 μm in one direction, and the difference between the lowest point and the highest point is 47.9 μm, which shows that the surface of the ceramic membrane is relatively rough in structure. The average undulation of the PDA-CM surface in one direction after dopamine self-polymerization did not change much compared with that of the unmodified membrane, while the undulation of the Cu-PDA-CM surface with copper nanoparticles generated by the in-situ reduction of copper ions with dopamine increased significantly in one direction to about -7.5 μm-7.5 μm, and the roughness of the surface (Ra value) increased obviously. The surface roughness (Ra value) of HDT-Cu-PDA-CM with hydrophobic modification after final thiol grafting decreased to a certain extent in one direction.

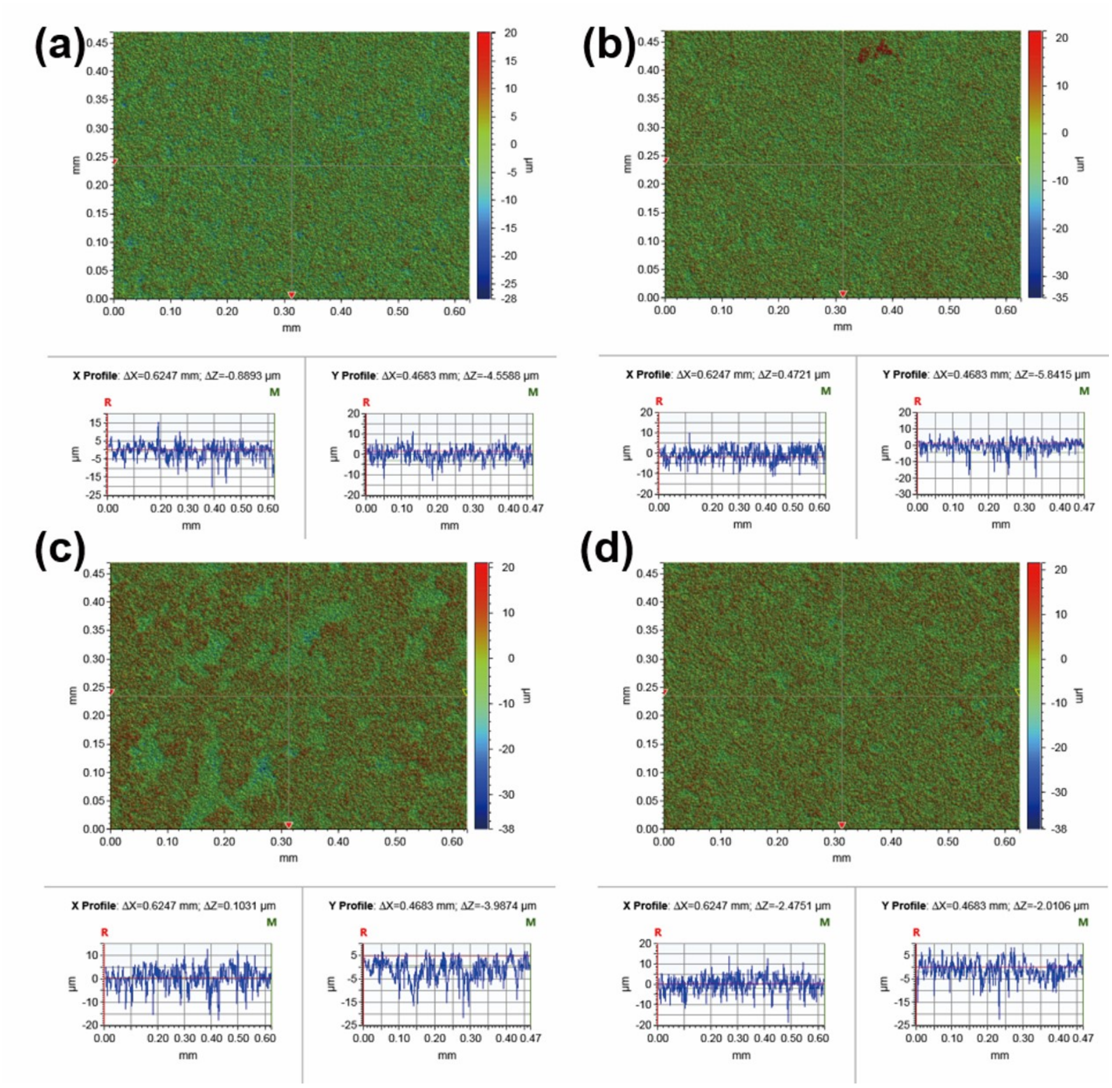

Figure S2. Static three-dimensional morphology characterization of ceramic membrane surface (a)CM, (b)PDA-CM, (c)Cu-PDA-CM, (d)HDT-Cu-PDA-CM.

S3) Kinetic fitting of membrane contamination

Four classical membrane contamination models (complete clogging model, intermediate clogging model, standard clogging model, and cake layer contamination model) were used to linearly fit the membrane contamination occurring in the separation of n-octane water-in-oil emulsion with the unmodified membrane CM and the modified membrane HDT-Cu-PDA-CM, and it is generally believed that the first three types of contamination belong to the reversible contamination, whereas the standard clogging occurring inside the membrane pores belongs to the irreversible contamination.

The results of the membrane contamination modeling of the unmodified membrane CM during the separation of water-in-oil emulsion are shown in Figure S2, from which it can be seen that the correlation coefficients of the (b) intermediate clogging model and the (d) standard clogging model have reached more than 0.9, of which the R2 value of the standard clogging model is as high as 0.9996, which indicates that the behavior of this contamination type is the most common in the separation of the CM with unmodified membrane, causing serious irreversible contaminations. more, resulting in serious irreversible contamination. As can be seen from Figure S2, the intermediate blockage and standard blockage are also better fitted in the separation of water-in-oil emulsion by modified membrane HDT-Cu-PDA-CM, with the correlation coefficients of intermediate blockage model of 0.9906 and standard blockage model of 0.9945; while the correlation coefficients of complete blockage model and cake layer blockage model of 0.7724 and 0.8824 are 0.9996 and 0.9945, respectively. 0.7724 and 0.8899, indicating that more intermediate clogging and standard clogging behaviors occurred during the separation of emulsion by modified membrane HDT-Cu-PDA-CM. By comparing Figure S2 with Figure S2, where the R2 value of the fitted correlation coefficient for the complete clogging model decreased from 0.8207 to 0.7724, and the R2 value of the fitted correlation coefficient for the standard clogging model decreased from 0.9996 to 0.9945, which indicates that the behaviors of these two types of contamination occurring during the separation of emulsion by the modified ceramic membrane are reduced; whereas, the R2 value for the model fit of the intermediate clogging model increased from 0.9026 to

0.9906, and the R2 value of the model fit for cake layer contamination increased from 0.6697 to 0.8899, indicating an increase in the behavior of these two types of contamination occurring during the separation of emulsions after the modification; the results indicate that the hydrophobic modification of the surface of the ceramic membranes resulted in an increase in the reversible contamination behavior and a decrease in the irreversible contamination behavior of the ceramic membranes during the separation.

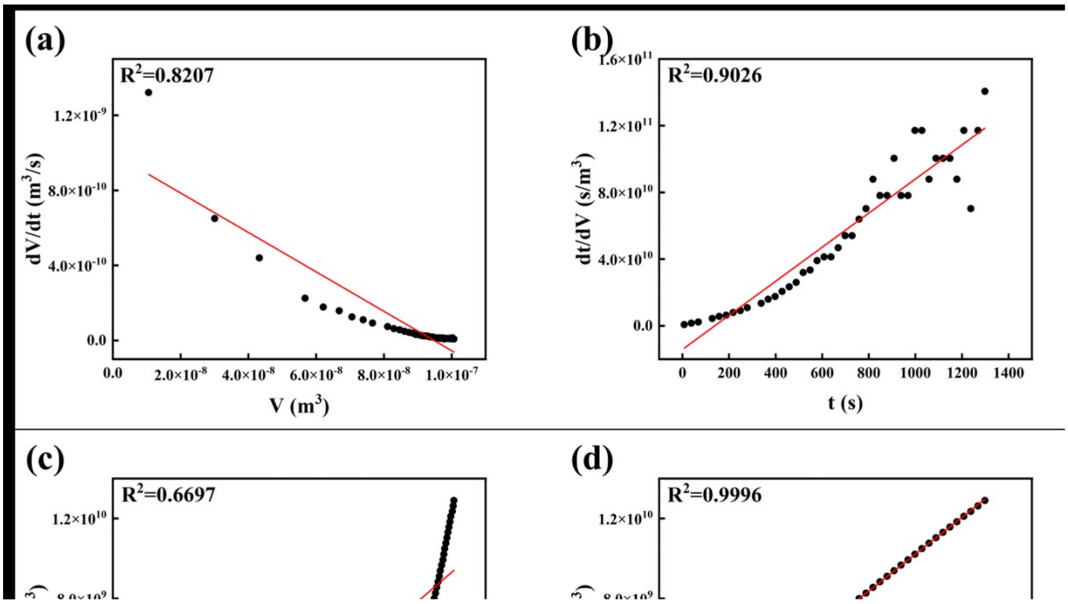

Figure S3. Fitting of membrane fouling model of n-octane water-in-oil emulsion filtered by unmodified membrane CM (a) Completely blocked model, (b) Intermediate blockage model, (c) Filter cake layer pollution model, (d) Standard blockage model.

Figure S4. Modified membrane HDT-Cu-PDA-CM filtration n-octane water-in-oil emulsion membrane fouling model fitting (a) Completely blocked model, (b) Intermediate blockage model, (c) Filter cake layer pollution model, (d) Standard blockage model.

Table S1. Composition of chemical elements on the surface of ceramic membrane before and after modification

specimen	atomic composition (%)					
	C	O	Al	N	Cu	S
CM	40.94	30.22	12.34	4.64	-	-
PDA-CM	60.85	26.04	-	7.11	0.33	1.00

Cu-PDA-CM	69.98	22.34	-	5.85	1.11	1.70
HDT-Cu-PDA-CM	88.65	4.94	-	1.56	1.65	3.21