前瞻全疏膜的製備、鑑定與應用

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Abstract

An omniphobic membrane was fabricated for membrane distillation (MD) by effectively depositing ZnO nanoparticles on a hydrophilic glass fiber (GF) membrane using a chemical bath deposition method to create hierarchical re-entrant structures, followed by surface fluorination and the addition of a polymer coating to lower the surface energy of the membrane. The omniphobic membrane revealed a higher wetting resistance to low surface tension feed solutions in direct membrane distillation (DCMD) experiments.

Preparation procedure1

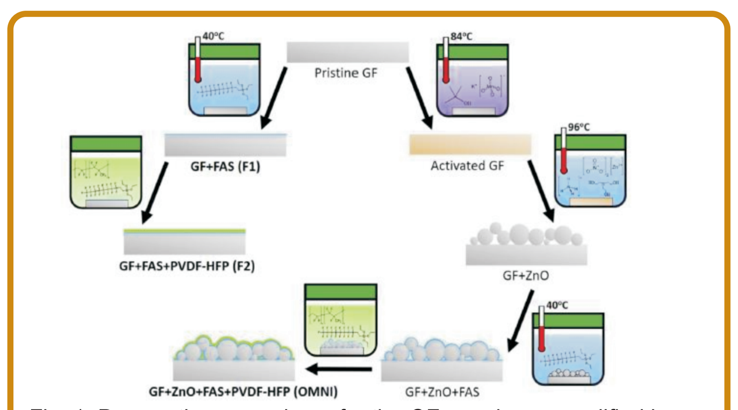

Fig. 1. Preparation procedures for the GF membrane modified by FAS17 (F1), the GF membrane modified by FAS17 and the polymer coating (F2), and the GF membrane with ZnO nanoparticles modified by FAS17 and the polymer coating (OMNI).

SEM

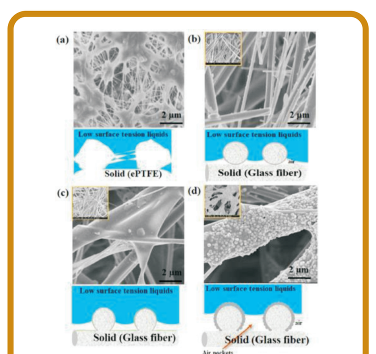

Fig. 2. SEM images of (a) the commercial ePTFE membrane, (b) the F1 membrane (c) the F2 membrane, and (d) the OMNI membrane

AFM

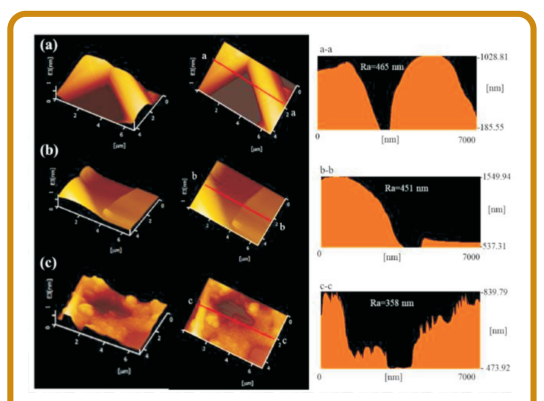

Fig. 3. 3D map and flat map along with a 2D profile in a given location of membranes of (a) the F1 membrane (b) the F2 membrane, and (c) the OMNI membrane

CA

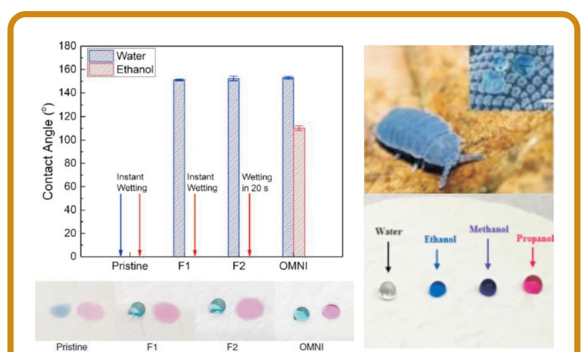

Fig. 4. Contact angles of a 2 μL liquid droplet of water and ethanol for(a) the F1 membrane (b) the F2 membrane, and (c) the OMNI membrane

XPS

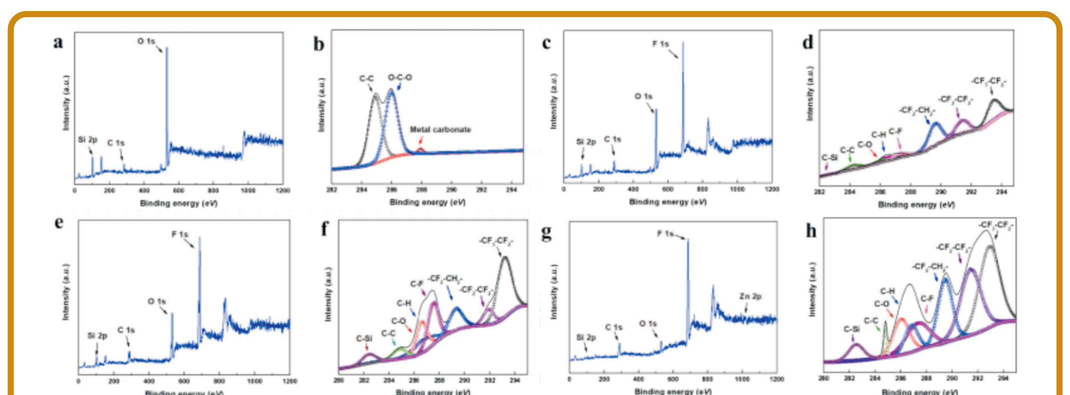

Fig. 5.(a, c, e, g) XPS survey scans and (b, d, f, h) carbon spectra of the (a, b) pristine GF membrane, (c, d) F1 membrane, (e, f) F2 membrane, and (g, h) the OMNI membrane

DCMD

Results & discussion

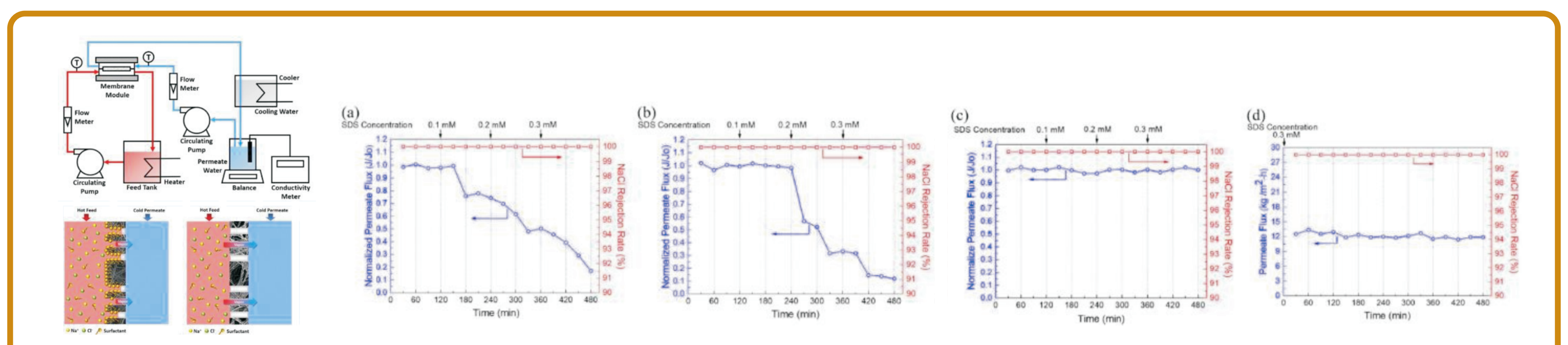

Fig. 6. Water flux and salt rejection for (a) the F1 membrane), (b) the F2,and (c) the OMNI membrane. The initial permeate fluxes (J0) of the F1, F2, and OMNI membranes were 12.5 ± 0.2, 12.4 ± 0.2 and 11.4 ± 0.9 kg/m2-h, respectively. (d) 8-h DCMD experiment for the OMNI membrane with 0.3 mM SDS (60 °C 1 M NaCl) solution as initial feed.

Conclusions

The DCMD experiments demonstrated that the OMNI membrane possessed the excellent wetting resistance and durability to the low surface tension feed solution. The above results suggest that the OMNI membrane is promising and feasible for desalinating low surface tension wastewaters. Overall, this facile CBD process can effectively engineer membrane nanostructures and provides a scalable route for preparing these novel omniphobic membranes.

Abstract

Omniphobic alumina hollow fiber membranes were developed for direct contact membrane distillation (DCMD) with a low surface tension feed in this study. In the DCMD experiments with the sequential addition of SDS from 0.2 to 2.0 mM, the HF membranes with ZnO nanostructures exhibited superior wetting resistances with low surface tension feeds. The results not only suggested that the deposition of nanostructures enhanced the wetting resistance of the alumina hollow fiber membranes to low surface tension liquids but also showed the promise of utilizing these membranes for the desalination of low surface tension wastewaters.

Preparation procedure1

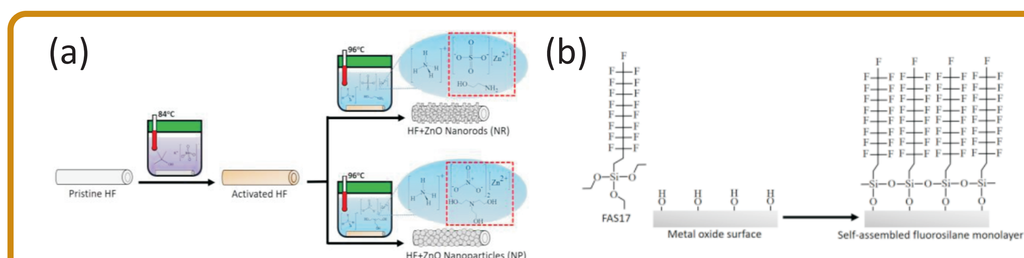

Fig. 1. (a) Preparation procedures for the ZnO nanostructure depositions.(b) Schematic illustration of the self-assembled fluorosilane monolayer.

SEM

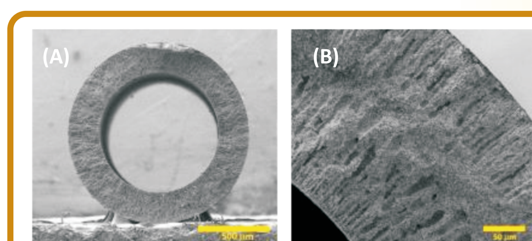

Fig. 2. SEM images of (A) the cross section and (B) the membrane wall of the HF membrane

SEM

AFM

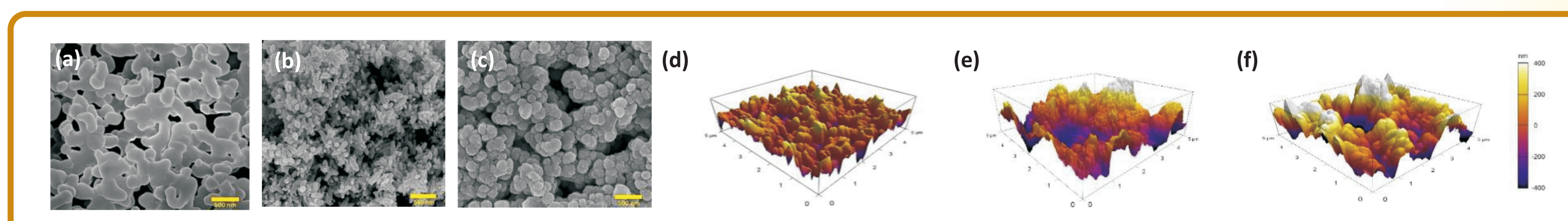

Fig. 3. SEM images (a-c) and 3D AFM images (d-f) of (a,d) the outer surface of the HF membrane,(b,e) the outer surface of the HF membrane deposited by ZnO nanorods, and (c,f) the outer surface of the HF membrane deposited by ZnO nanoparticles. The scale bars for SEM images are 500 nm.

CA

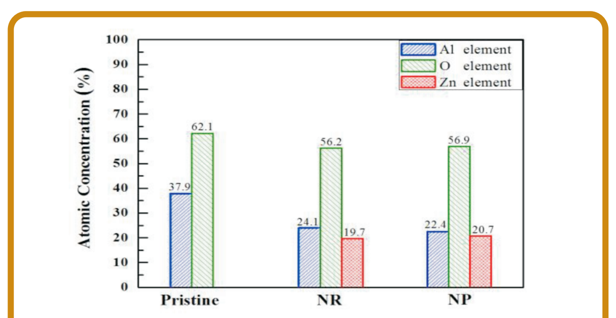

Fig. 4. Surface compositions (before surface fluorination) of the pristine HF membrane (Pristine), the HF membrane deposited by nanorods (NR), and the HF membrane deposited by nanoparticles (NP).

EDX

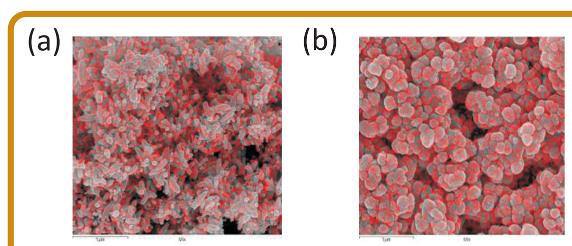

Fig. 5. Zinc elemental mappings of (a) the outer surface of the HF membrane deposited by ZnO nanorods and (b) the outer surface of the HF membrane deposited by ZnO nanoparticles.

DCMD

Results & discussion

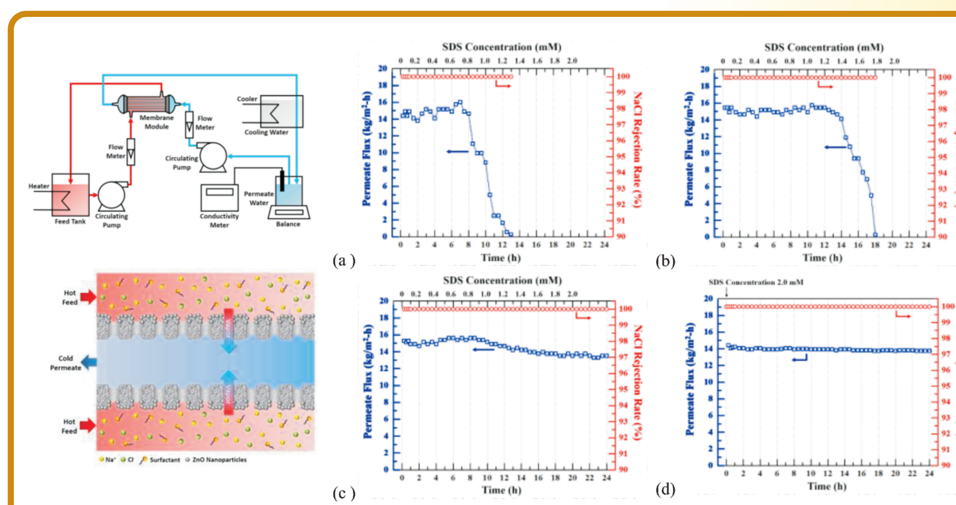

Fig. 6. Permeate flux and NaCl rejection rate for (a) the pristine HF membranes (Pristine), (b) the HF membranes deposited by ZnO nanorods (NR), and (c) the HF membranes deposited by ZnO nanoparticles (NP). All of the membranes were modified by FAS17. (d) Twenty-four-hour DCMD test for the HF membranes deposited by ZnO nanoparticles (NP) with a 2.0 mM SDS (70°C, 1 M NaCl feed) solution as the initial feed. The membranes were modified by FAS17.

Conclusions

The DCMD experiments demonstrated that the omniphobic alumina hollow fiber membrane possessed the excellent wetting resistance and durability to the low surface tension feed solution. Therefore, the omniphobic alumina hollow fiber membranes not only possessed extraordinary wetting resistance for desalinating low surface tension wastewaters, but also exhibited promise for industrial applications because of the easiness of scaling-up.