Supporting Information

Anti-biofouling effect of a thin film nanocomposite membrane with a functionalized-carbon-nanotube-blended polymeric support for the pressure-retarded osmosis process.

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Supporting Information for

Chemosphere

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Experimental

1. **Functionalization of CNTs**

First, 0.5 g of pristine MWCNTs was refluxed with an acid solution of sulfuric acid and nitric acid (volume ratio of 3:1) at 100 °C for 3 h to remove impurities. Second, after reflux was completed, the solution was diluted with DI to attain pH 5–6. Then, the solution was subjected to centrifugation at 1500 rpm to neutralize the solution by discarding highly acidic water and adding DI water until neutral pH was attained. The diluted solution was filtered using Isopore membrane filters (0.2 μm GTTP, Merck, Korea). The filtered solid was dried in a 35°C isothermal-isohumidity chamber. After drying, MWCNTs were again immersed in the same acid mixture (3:1) and sonicated at 70 °C for 9 h for the attachment of hydrophilic functional groups. After oxidation, the acid solution was cooled and diluted with DI water (pH 5–6). The functionalized CNTs were filtered and dried in the 35°C isothermal-isohumidity chamber. The final functionalized CNTs were smashed into small particles to mix with the polymer.

2. Membrane performance test

Water flux and reverse salt flux were measured in the FO mode (AL-FS)/PRO mode (AL-DS) and calculated by the following equations. J_w is the water flux through the membrane. V_{F0} is the initial volume of the feed solution. V_F is the final volume of the feed solution after operation. A_m is the effective membrane area. t is time. J_s is the reverse salt flux through the membrane. C_F is the final salt concentration of the feed solution after operation. The salt concentration of the feed solution was measured using an electrical conductivity meter (ES-71G, Horiba, Japan) for RSF calculation. The units of water flux and reverse salt flux are $Lm^{-2}h^{-1}$ (LMH) and $gm^{-2}h^{-1}$ (gMH), respectively.

$$J_w = \frac{V_{F0} - V_F}{A_m t}$$

$$J_s = \frac{C_F V_F}{A_m t}$$

3. Biofouling cleaning protocol

A biofouling cleaning protocol for thorough cleaning after each biofouling experiment was developed. Several cleaning steps were carried out to remove trace organic impurities and microorganisms: (1) circulating 0.5% of sodium hypochlorite (NaOCl) for 8 h, (2) washing with DI water for 30 min, (3) removing trace organic matter using sodium dodecyl sulfate (SDS) for 4 h, and (4) washing again with DI for 30 min.

4. Laser scanning confocal microscopy analysis of the biofouled membrane

The morphology of a biofouled membrane surface after the biofouling test was observed by confocal laser scanning microscopy (CLSM, TCS SP2, Leica, Germany). The biofouled membrane was collected and cut to pieces for staining using a BacLight live/dead bacterial viability kit (Molecular Probes, USA). Bacteria cells were stained with a dye mixture solution of 1 mL of DI water with 3 μL of SYTO9 and 3 μL of PI for 20 min in a dark room. The colored membranes were rinsed using a PBS solution. SYTO9 was excited at 488 nm, and PI was excited at 559 nm. Fluorescence images revealed green and red spots, corresponding to live bacteria and dead bacteria, respectively.

Figures

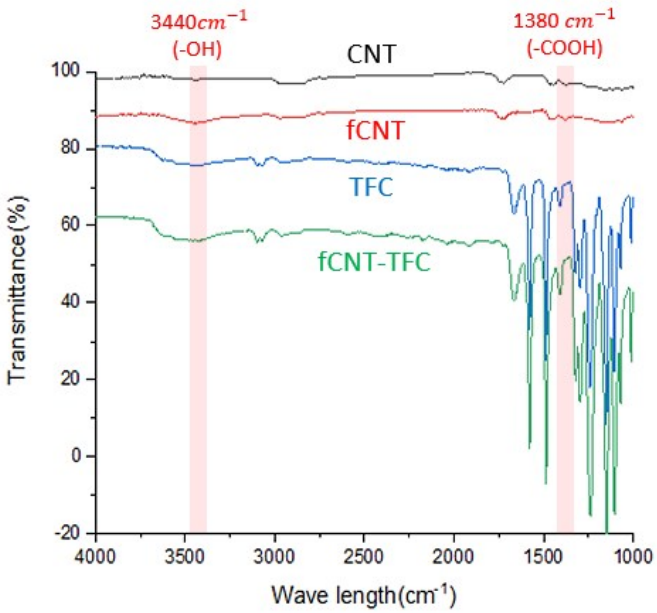

Fig. S1 FTIR spectra of bare CNTs, oxide-functionalized CNTs (fCNT), bare support layer (TFC), fCNT-blended support layer (fCNT-TFN)

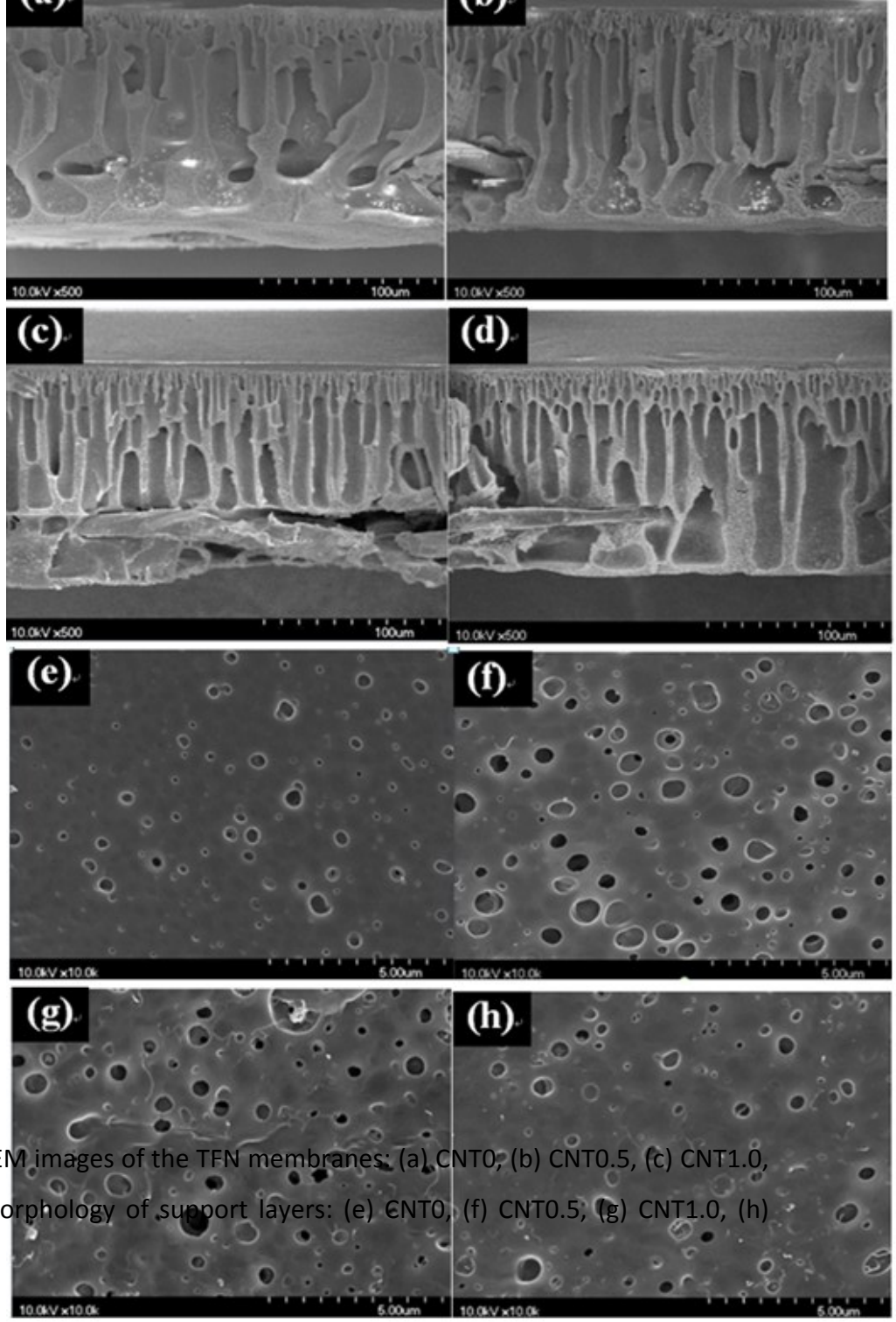

Fig. S2 Cross-sectional SEM images of the TFN membranes: (a) CNT0, (b) CNT0.5, (c) CNT1.0, (d) CNT2.0 as well as morphology of support layers: (e) CNT0, (f) CNT0.5, (g) CNT1.0, (h) CNT2.0

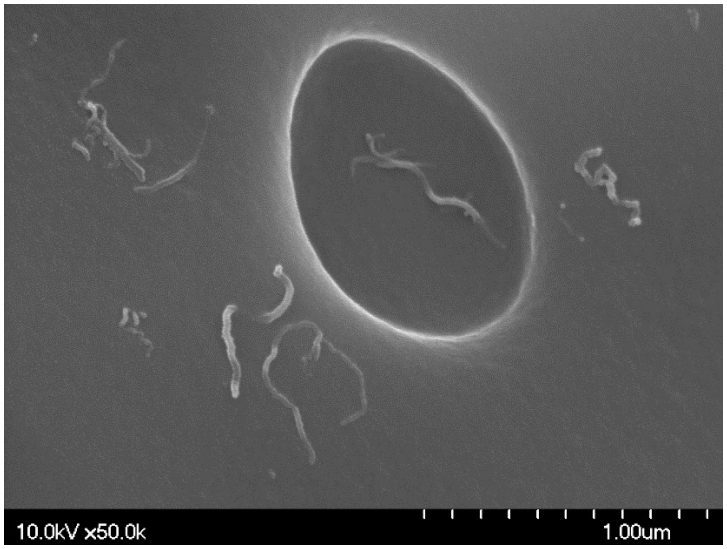

Fig. S3 Deposition of fCNTs on the bottom surface of the fCNT-TFC0.5 support layer

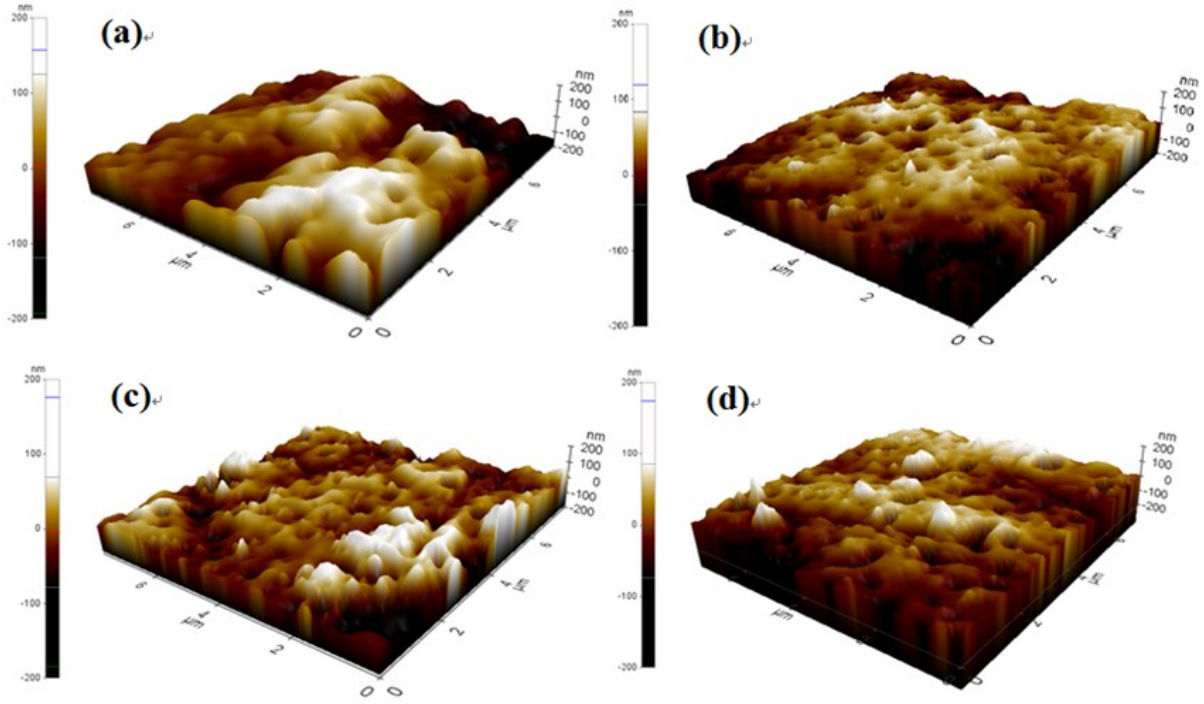

Fig. S4 AFM images showing the support layer roughness of the fabricated TFN membranes: (a) CNT0, (b) CNT0.5, (c) CNT1, (d) CNT2

Table

Table S1 List of abbreviation

	Abbreviation	Definition
1	TFN	Thin film nanocomposite
2	TFC	Thin film composite
3	PRO	Pressure-retarded osmosis
4	FO	Forward osmosis
5	SEM	Scanning electron microscopy
6	AFM	Atomic force microscopy
7	FTIR	Fourier transform infrared
8	CLSM	Confocal laser scanning microscopy
9	RSF	Reverse salt flux