

Supporting Information for the manuscript entitled:

High Performance Reverse Osmosis CNT/Polyamide Nanocomposite Membrane by Controlled Interfacial Interactions

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Table S1. Membrane separation performance in current works in other CNT-polymer composite membranes and that of commercialized membrane.

Polymer matrix	CNT [wt%] ^a	Water flux [L ⁻¹ m ⁻¹ h ⁻¹ , LMH]	Rejection [%]	Feed solution	Feed pressure [Bar]	Unit water flux [LMH bar ⁻¹]	Ref. ^b
LFC-1 (commercialized)	-	39.50	96.50	NaCl 2000 ppm	15.5	2.54	Tested in this work
Polysulfone	MWNT 0.04 wt%	9.3	75	Na ₂ SO ₄	4.0	2.33	36
		9.3	17	NaCl	4.0	2.33	
Polyamide	MWNT 0.015 wt%	28	76	NaCl 4000 ppm	39.0	0.71	40
Polyamide (PEI/IPD)	MWNT 0.5 wt%	14.04	96.0	Brilliant blue 0.01 wt%	3.45	4.07	79
Polyester (TMC/TEOA)	MWNT 0.05 wt%	4.7	70	Na ₂ SO ₄ 5 mM	6.0	0.78	81
Brominated polyphenylene oxide	MWNT 5 wt%	487	94.18	Egg albumin 500 ppm	2.0	243.5	82
Polyamide (PIP/TMC)	MWNT 0.05 wt%	69.84	99.0	Na ₂ SO ₄ 2000 ppm	10.0	6.98	80
		25.2	44.1	NaCl 2000 ppm	10.0	2.52	
Polysulfone	MWNT 0.02 wt%	175	45	PEG 20,000 50 ppm	1.0	175	48
Polyamide (MPD/TMC)	Zwitterion-SWNT 20 wt%	48.45	98.6	NaCl 2000 ppm	36.54	1.33	43
Polyamide (MPD/TMC)	MWNT 0.1 wt%	28.05	90	NaCl 2000 ppm	16.0	1.75	78
Polyamide (MPD/TMC)	MWNT-COOH 0.17 wt%	44.34	95.72	NaCl 2000 ppm	15.5	2.86	This work

^awt% in polymer matrix, ^bReferences in main manuscript.

Table S2. Results of water flux and salt rejection values of polyamide membranes from different monomer and CNT4 concentration.

CNT\MPD [wt%] ^a	Water flux [$\text{L}^{-1} \text{m}^{-2} \text{h}^{-1}$, LMH] (Salt rejection [%])				
	1	2	3	4	5
0	26.86 ± 3.07 (97.11 ± 0.55)	36.60 ± 0.31 (97.57 ± 0.7)	34.34 ± 1.07 (97.49 ± 0.89)	32.60 ± 1.27 (96.80 ± 0.36)	28.31 ± 0.73 (95.50 ± 1.03)
0.0002	28.78 ± 2.2 (97.19 ± 0.30)	35.24 ± 1.58 (97.01 ± 1.01)	36.77 ± 1.2 (96.42 ± 0.64)	33.11 ± 1.98 (96.75 ± 0.57)	30.35 ± 0.67 (94.79 ± 0.64)
0.001	31.14 ± 1.34 (96.23 ± 0.56)	38.23 ± 1.49 (96.63 ± 0.52)	44.34 ± 2.37 (95.72 ± 0.38)	40.08 ± 0.15 (95.19 ± 0.34)	36.26 ± 0.81 (95.62 ± 0.67)
0.005	30.92 ± 1.2 (95.49 ± 0.75)	37.79 ± 2.52 (95.99 ± 1.13)	38.74 ± 0.83 (95.91 ± 0.38)	37.36 ± 1.39 (95.77 ± 0.32)	34.47 ± 2.32 (95.25 ± 0.81)

^awt% in aqueous solution using interfacial polymerization

Table S3. Surface compositions of polyamide-modified silicon wafer and PA membrane.

Atom	PA membrane [%]	Si wafer [%]
C	71.48	69.97
O	17.51	19.22
N	11.01	10.81

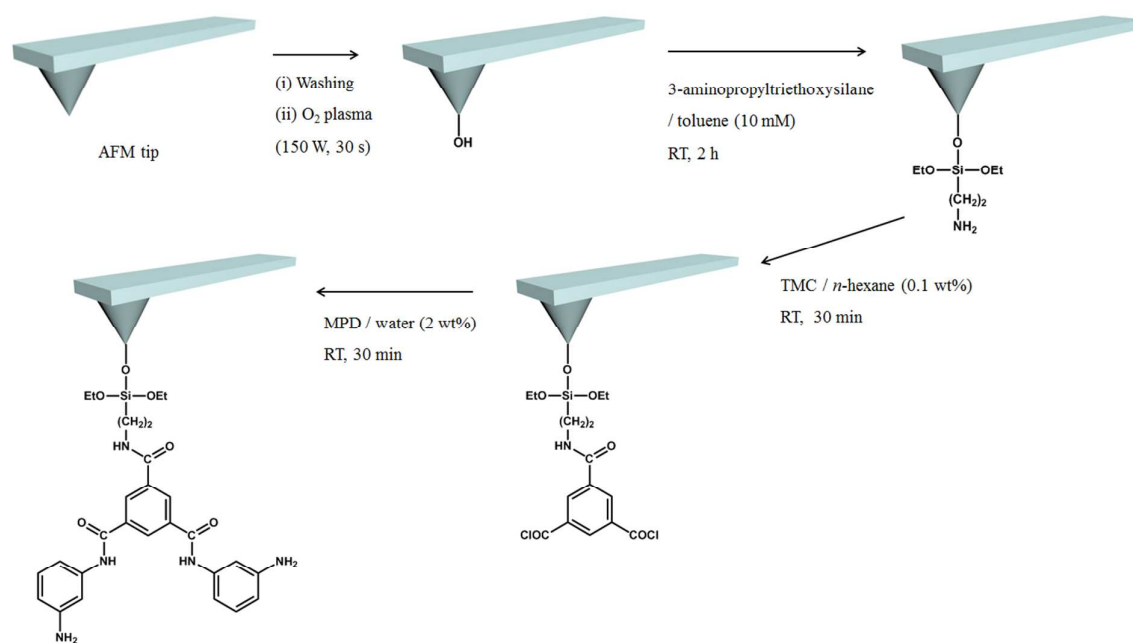


Figure S1. Functionalization procedure of AFM tip to polyamide repeating unit.

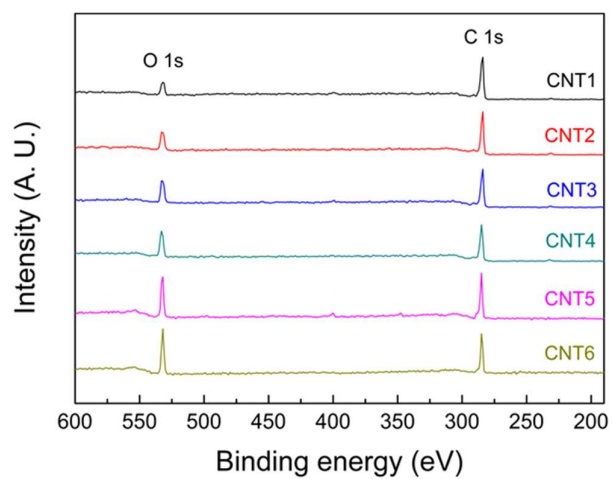


Figure S2. XPS spectra of CNTs in Table 1 of main manuscript.

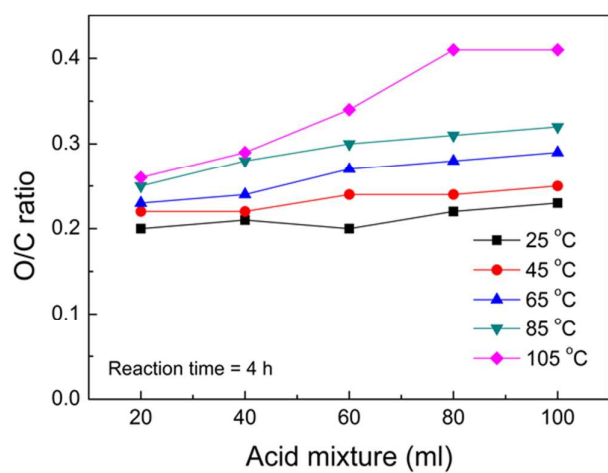


Figure S3. O/C ratios of CNTs modified in various conditions.

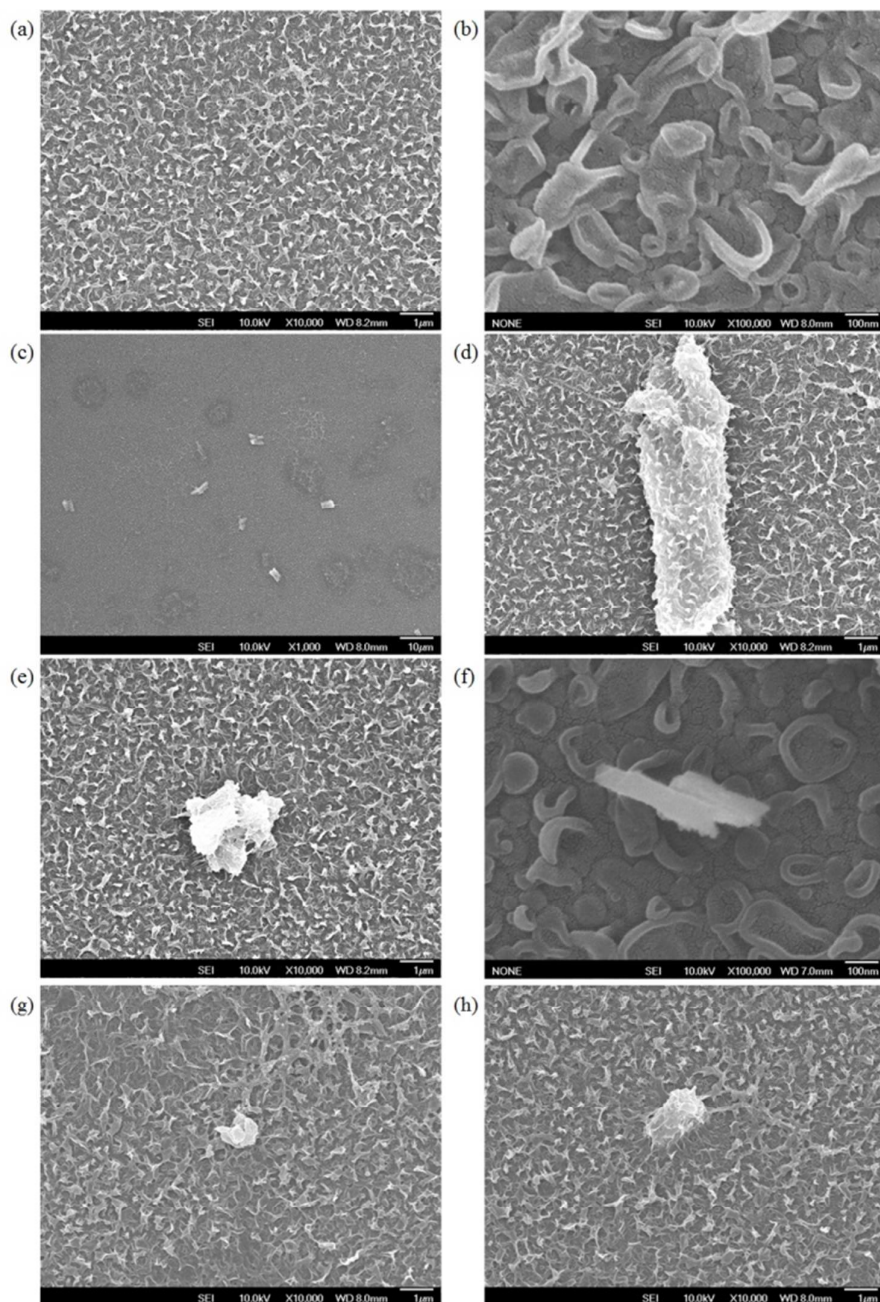


Figure S4. SEM images of top surfaces of the (a) PA membrane (prepared by 2 wt% of MPD in aqueous solution) (x 10,000), (b) PA membrane (x 100,000), (c) PA-CNT1 membrane (x 1,000), (d) PA-CNT1 membrane (x 10,000), (e) PA-CNT2 membrane (x 10,000), (f) PA-CNT4 membrane (x 100,000), (g) and (h) PA-CNT6 membrane (x10,000) (All the PA-CNT membranes were prepared by 2 wt% of MPD and 0.002 wt% of CNT in aqueous solution).

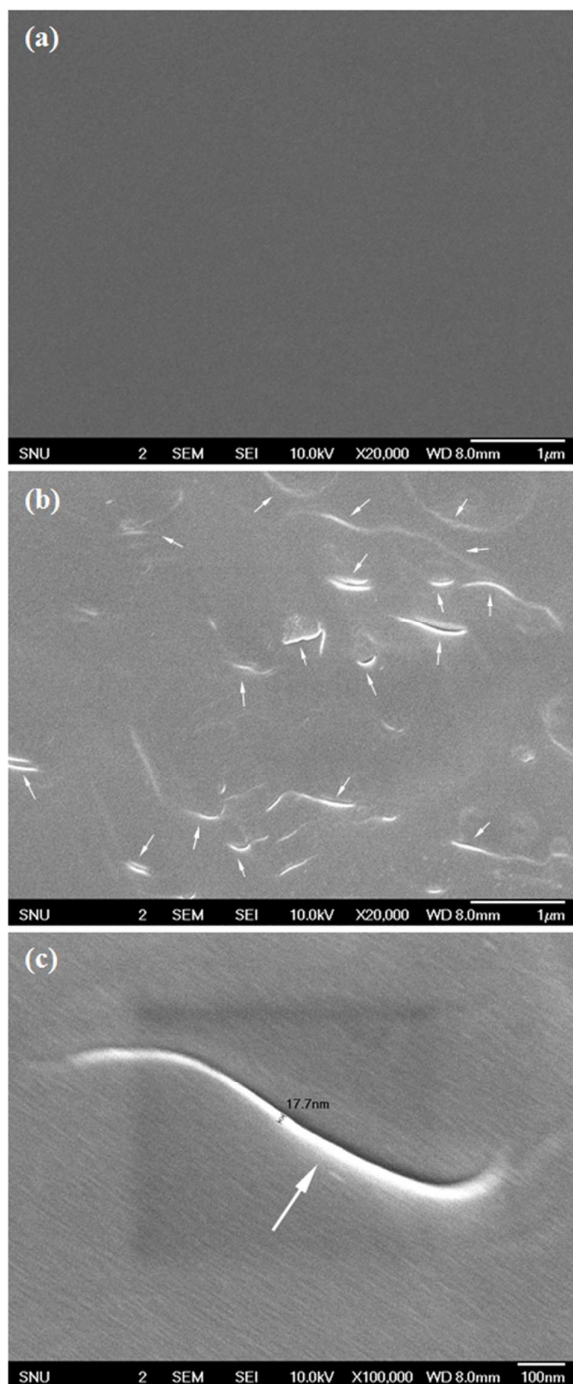


Figure S5. SEM images of bottom side of the (a) PA membrane (prepared by 2 wt% of MPD in aqueous solution) (x 20,000), (b) and (c) PA-CNT4 membrane (x 20,000 and x 100,000) (All the PA-CNT membranes were prepared by 2 wt% of MPD and 0.002 wt% of CNT in aqueous solution).

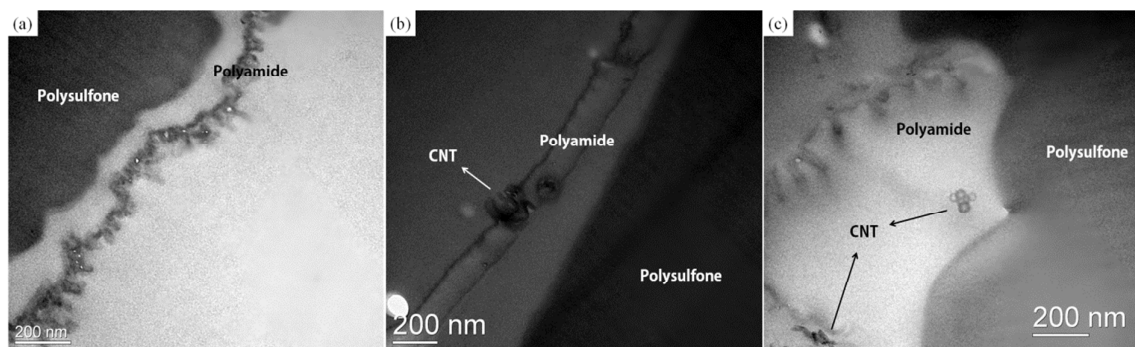


Figure S6. TEM images of cross-section of (a) PA, (b) PA-CNT1, and (c) PA-CNT4 membranes.

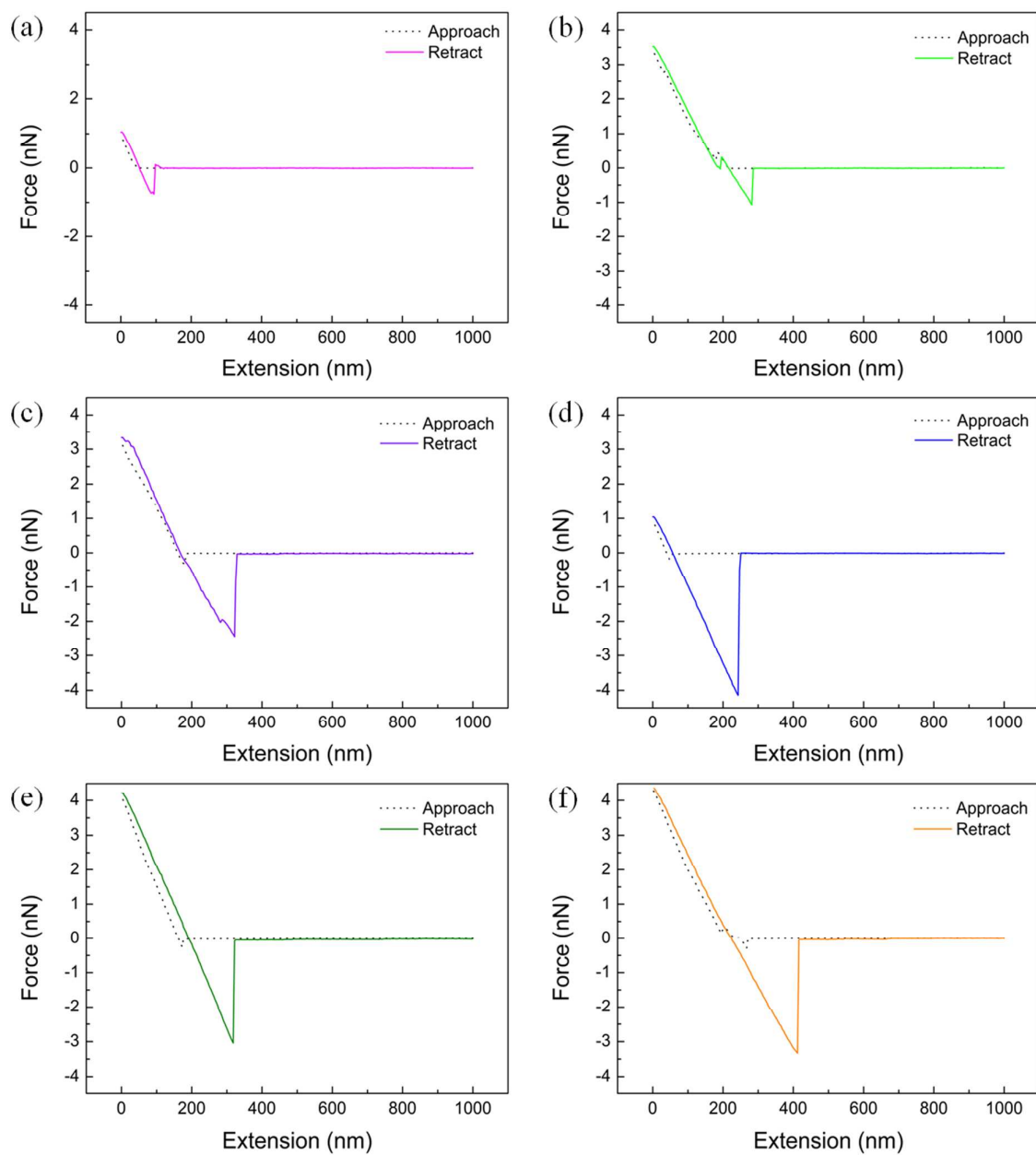


Figure S7. Typical force-extension curves recorded with a polyamide-modified tip against various types of CNT; (a) CNT1, (b) CNT2, (c) CNT3, (d) CNT4, (e) CNT5 and (f) CNT6.

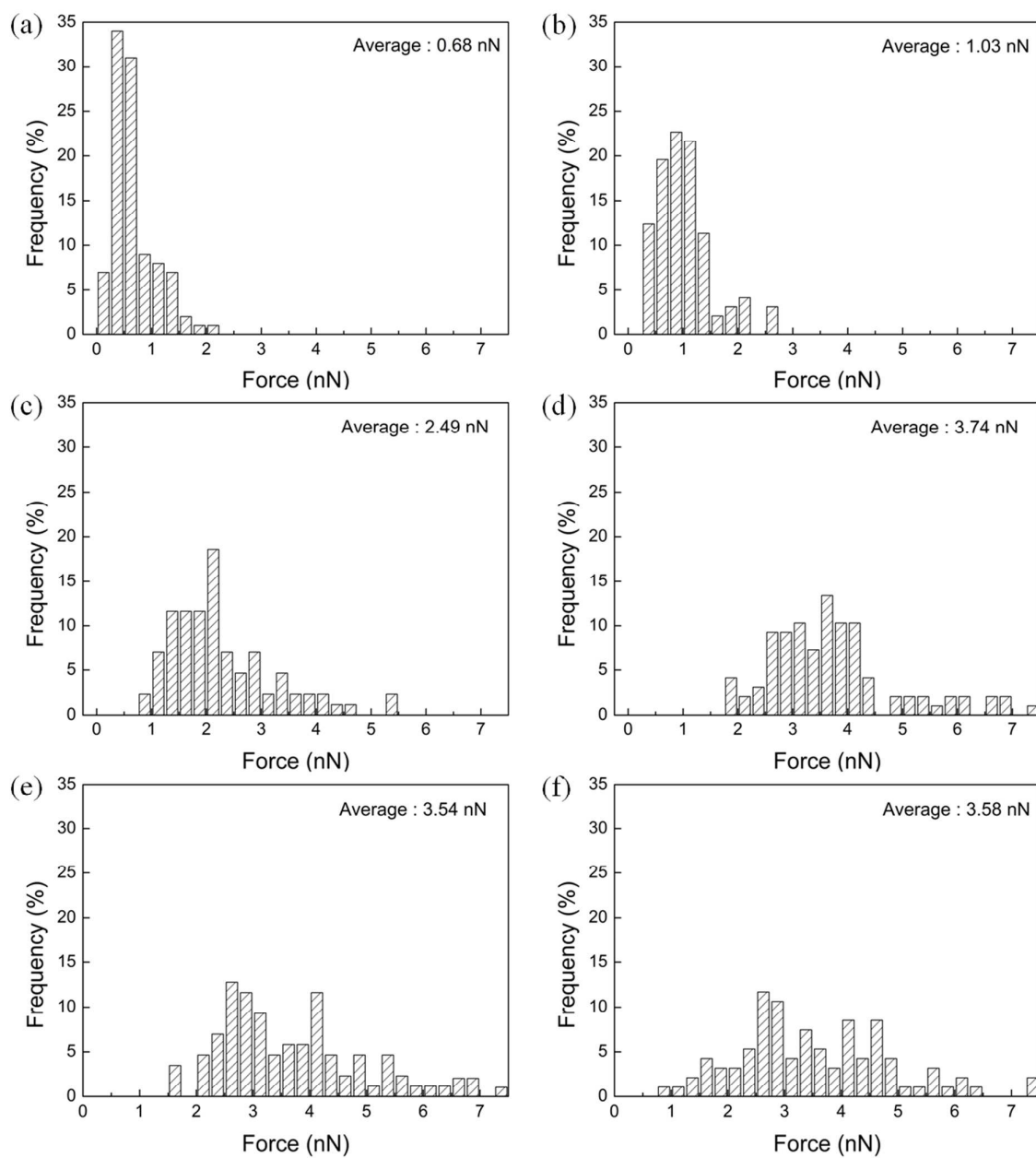


Figure S8. Interaction force histograms which were used to determine the mean interaction forces; (a) CNT1, (b) CNT2, (c) CNT3, (d) CNT4, (e) CNT5 and (f) CNT6.

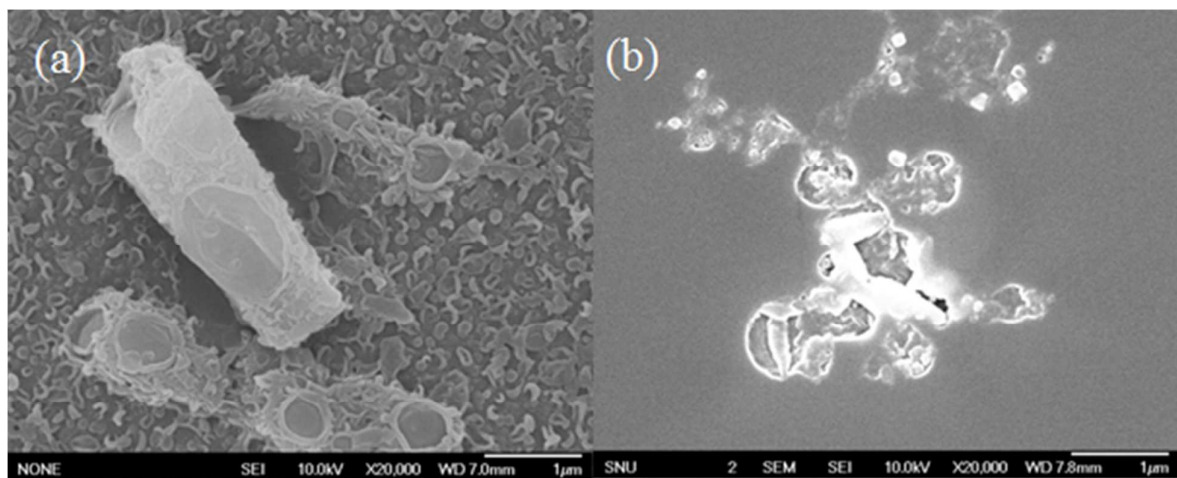


Figure S9. SEM images of PA-CNT4 membrane with 0.025 wt% of CNT; (a) surface and (b) bottom side.

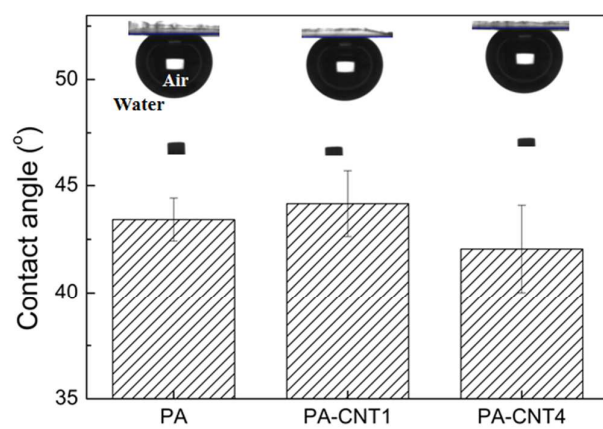


Figure S10. Contact angles of PA, PA-CNT1, and PA-CNT4 membranes measured by captive bubble method.

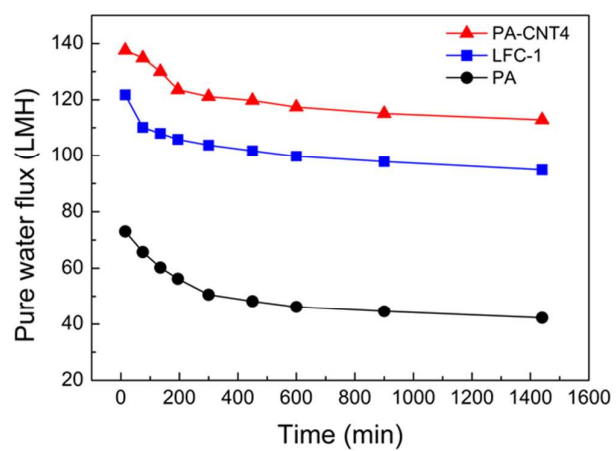


Figure S11. Pure water flux of PA and PA-CNT4 membranes with time (operated under the 40 bar of feed pressure).

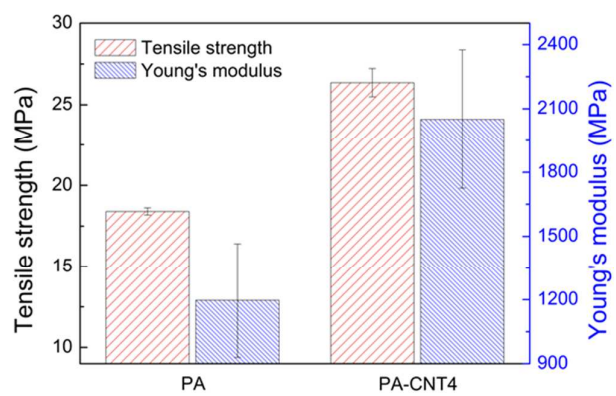


Figure S12. Mechanical properties of PA and PA-CNT4 membrane tested by UTM.