

Supporting Information

Highly Hydrophilic Thin-Film Composite Forward Osmosis Membranes Functionalized with Surface-Tailored Nanoparticles

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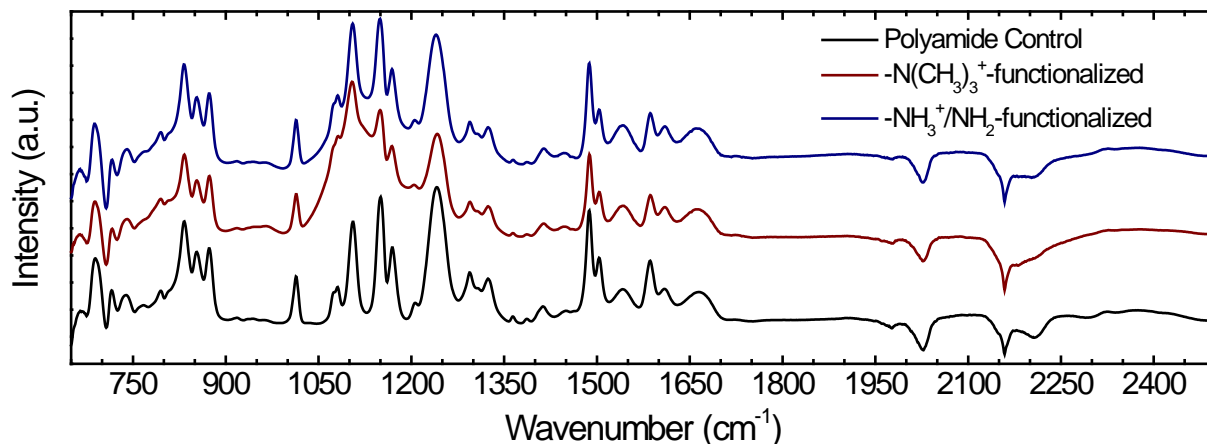


Figure S1. ATR-IR spectra show the appearance of a shoulder for the functionalized membranes around 1060-1100 cm⁻¹. An absorption peak around 1070-1080 cm⁻¹ is commonly attributed to stretching mode of Si-O-Si bonds, confirming the presence of silanized SiO₂ particles at the membrane surface.

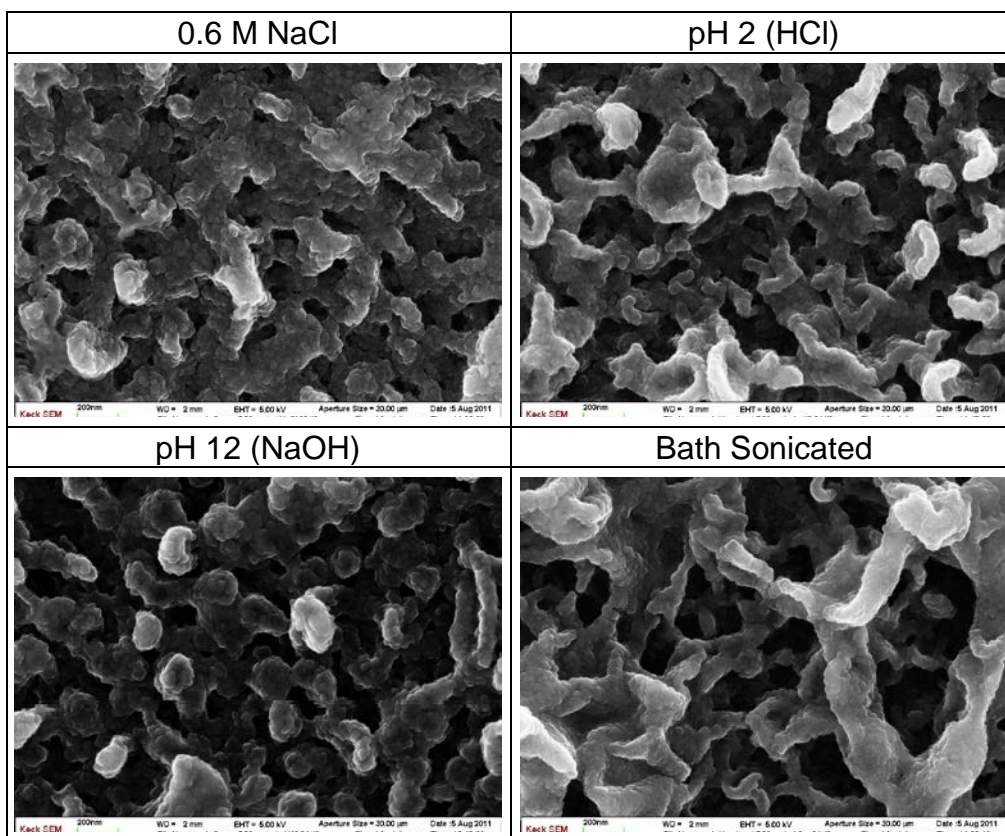
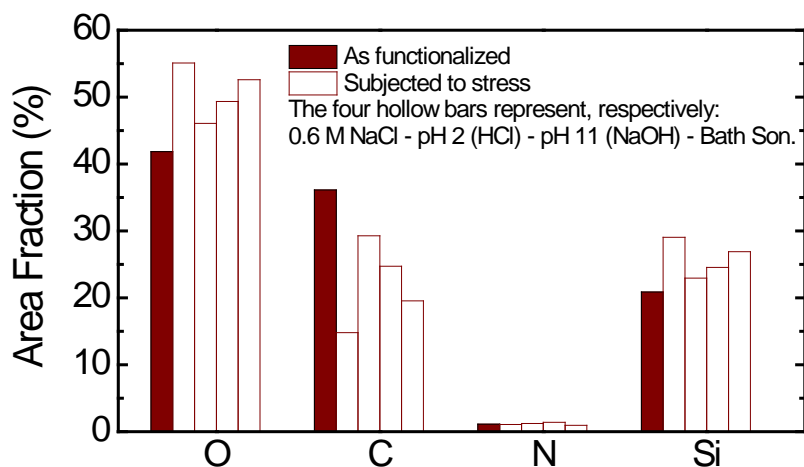


Figure S2. XPS and SEM analyses performed after the membranes functionalized with nanoparticles coated with $\text{-N(CH}_3)_3^+$ -terminated ligands were subjected to stress. Results are within experimental error with those obtained on membranes as functionalized, suggesting the irreversibility of the functionalization.

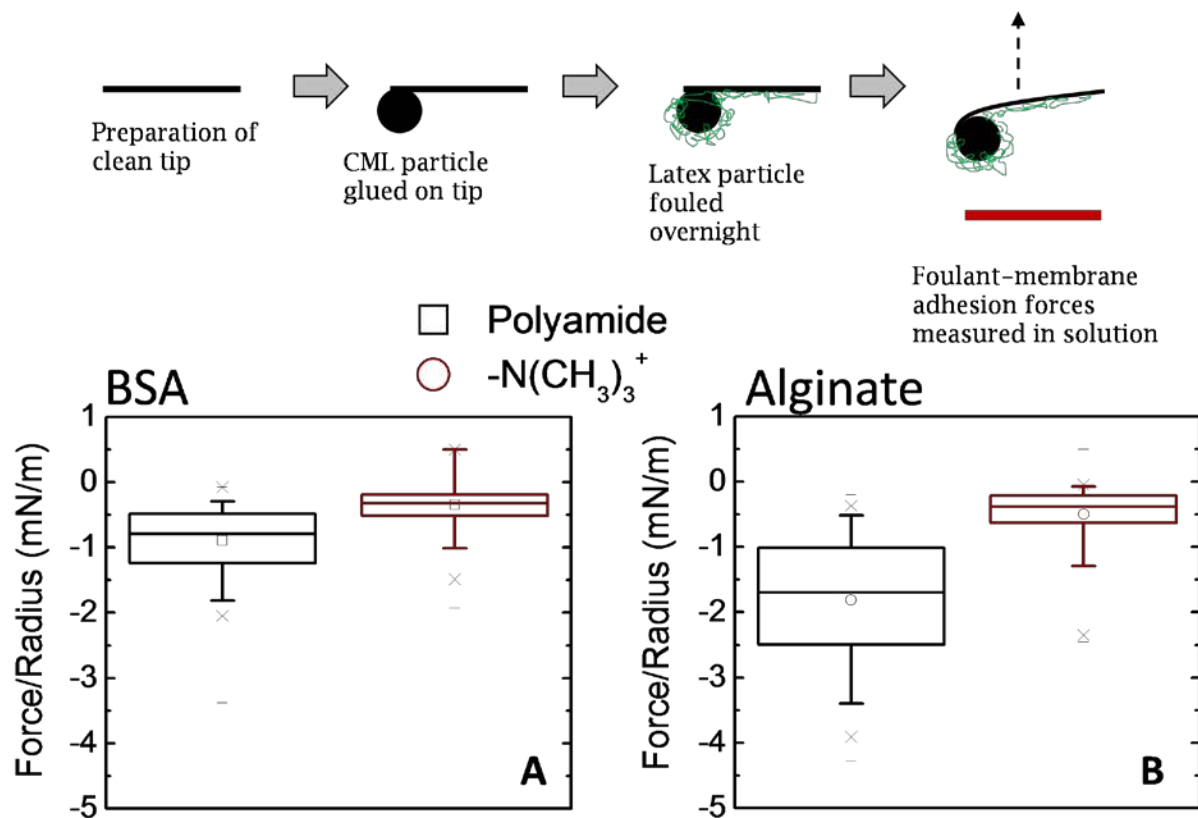


Figure S3. Statistics of foulant-membrane interaction forces measured by AFM (presented as F/R , with R being the radius of the particle probe). Data for control polyamide and for membranes functionalized with $-\text{N}(\text{CH}_3)_3^+$ -functionalized nanoparticles are shown in black and red, respectively. Plot 7A shows data for BSA-fouled tip, while plot 7B presents results obtained using an alginate-fouled tip. The average, median, standard deviation, 1st, 5th, 95th, and 99th percentile are shown for 125 separate retracting curves. The test solution for the measurements is synthetic wastewater effluent as described in the experimental section. Measurements were carried out at room temperature (23 °C).

Table S4. Summary of the forward osmosis performance test parameters, including feed solution concentration, c_F , draw solution concentration, c_D , water flux, J_w , reverse NaCl flux, J_s , and resulting transport parameters A , B , and S . All tests were conducted at 25 °C and at a cross-flow of 21.4 cm/s (without spacers).

Run #	NaCl draw concentration, c_D (M)	Feed concentration, c_F (M)	Water flux, J_w ($L\ m^{-2}h^{-1}$)	Reverse NaCl flux, J_s (moles $m^{-2}h^{-1}$)	Pure water permeability, A ($L\ m^{-2}h^{-1}bar^{-1}$)	NaCl permeability, B ($L\ m^{-2}h^{-1}$)	Structural parameter, S (μm)
1	~1	~0	16.85	0.302	2.28	2.12	600
2	~1	~0	17.42	0.339	2.30	2.28	562
3	~1	~0	17.17	0.152	1.91	0.88	551
4	~1	~0	15.85	0.231	4.35	3.74	607
5	~1	~0	17.14	0.147	3.55	0.99	503
6	~1	~0	17.14	0.125	1.81	0.70	286
7	~0.5	~0	10.47	0.167	1.15	0.99	469
8	~0.5	~0	11.19	0.103	0.95	0.44	331
9	~0.5	~0	11.24	0.153	3.81	3.15	916
Averages					2.46 ± 1.19	1.70 ± 1.18	536 ± 182