Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Electronic Supplementary Material for

Antiscaling Efficacy of $CaCO_3$ and $CaSO_4$ on Polyethylene Glycol (PEG)-Modified Reverse Osmosis Membranes in the Presence of Humic Acid: Interplay of Membrane Surface Properties and Water Chemistry

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Summary: Five pages and three figures and references.

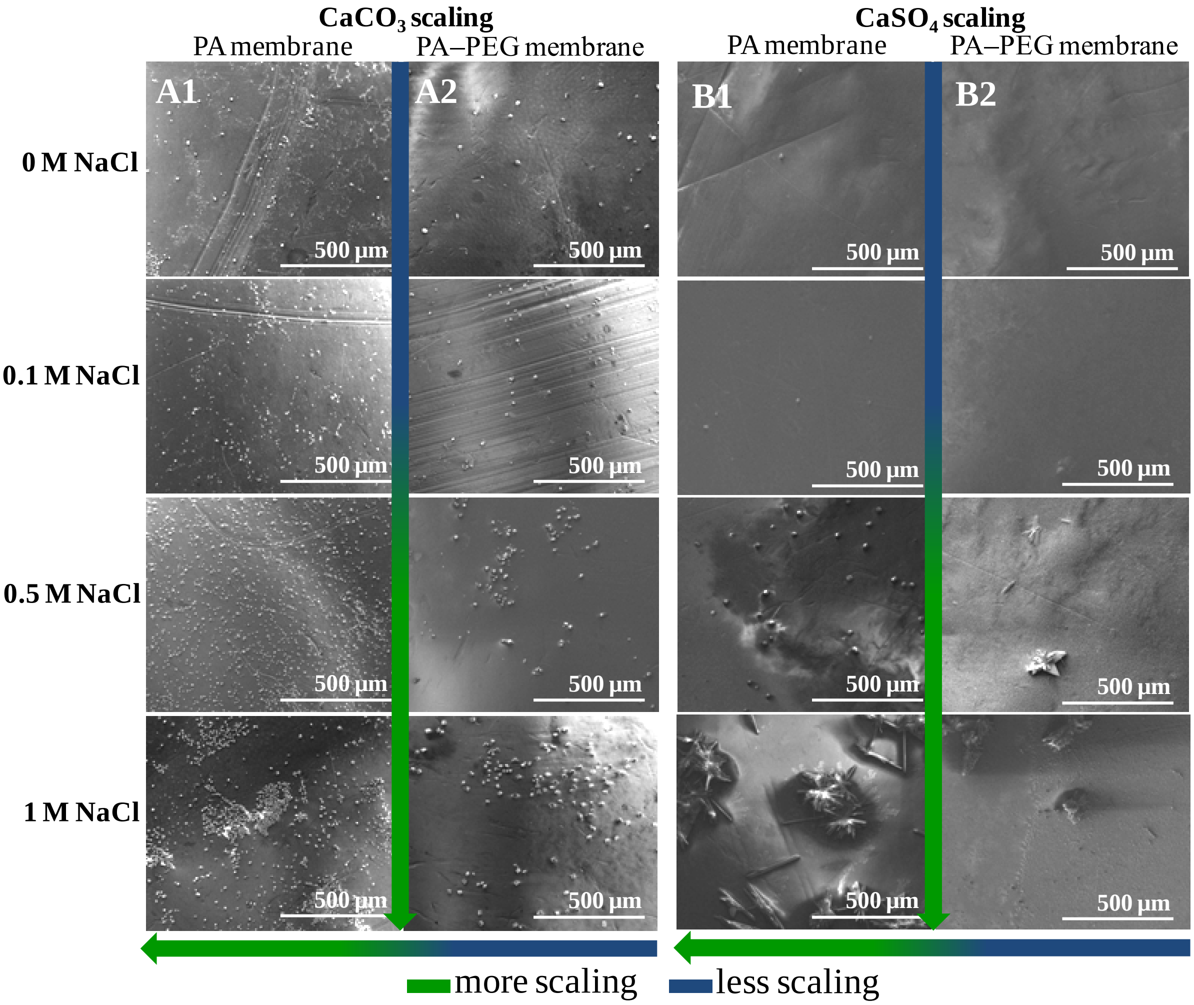

Figure S1. SEM micrographs of batch (A) $CaCO_3$ (SI, calcite = 2.16) and (B) $CaSO_4$ (SI, gypsum = 0.45) mineral colloidal formation experiments at increasing salinities for (1) PA and (2) PA–PEG membranes. The concentrations of reactant materials were adjusted to maintain the same calcite and gypsum SI values to better understand the effect of increasing salinity. The $CaCO_3$ and $CaSO_4$ scaling experiments on PA and PA–PEG were conducted for 2 h prior to gentle rinsing and drying for SEM analysis.

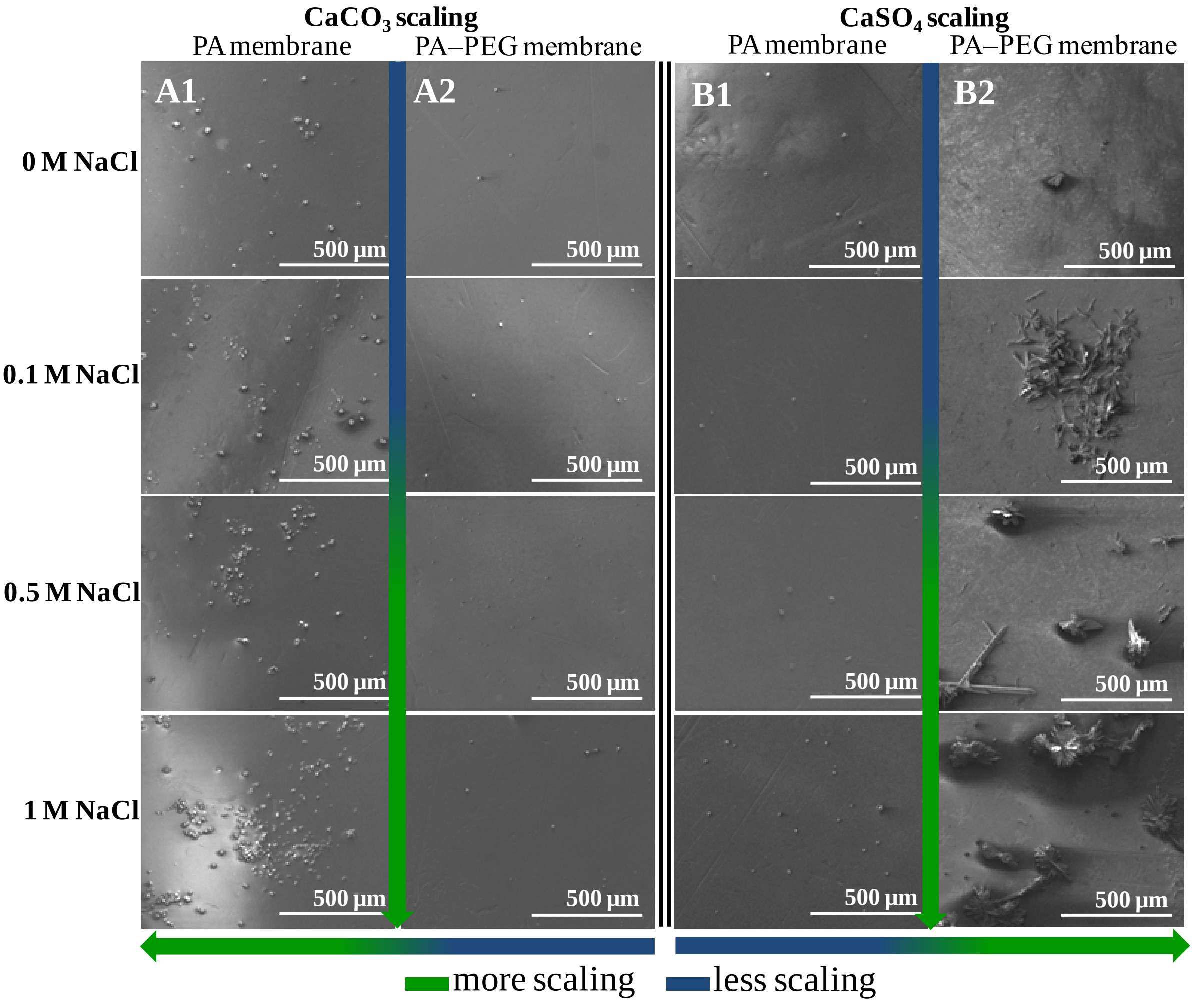

Figure S2. SEM micrographs of batch (A) $CaCO_3$ (SI, calcite = 2.16) and (B) $CaSO_4$ (SI, gypsum = 0.45) mineral colloidal formation experiments at increasing salinities for (1) PA and (2) PA–PEG membranes in the presence of 10 mg/L humic acid (HA). The $NaHCO_3$ + $CaCl_2$ and Na_2SO_4 + $CaCl_2$ reactant solutions were prepared in 10 mg/L HA at the corresponding salinity before mixing to initiate the colloidal formation experiment. The concentrations of reactant materials were adjusted to maintain the same calcite and gypsum SI values to better understand the effect of increasing salinity. The $CaCO_3$ and $CaSO_4$ scaling experiments on PA and PA–PEG were conducted for 2 h prior to gentle rinsing and drying for SEM analysis.

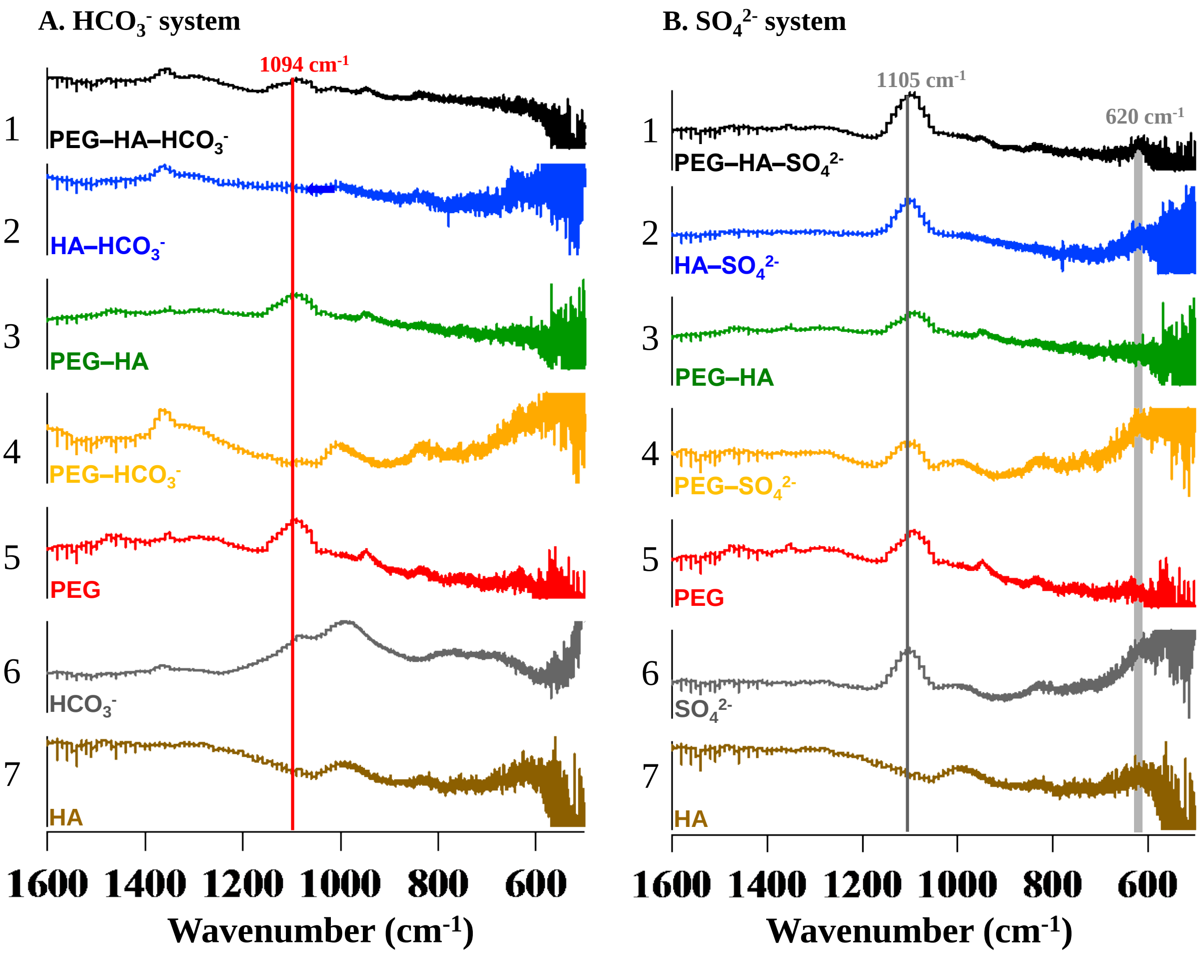

Figure S3. ATR-FTIR data for (A) the carbonate (HCO_3^-) and (B) sulfate (SO_4^{2-}) system with representation from individual species, binary, and ternary mixtures. Solutions were prepared containing mixtures of 0.1 M Na_2SO_4, 0.1 M $NaHCO_3$, 0.1 M PEG, and/or 10 mg/L HA. The peak at 1094 cm^{-1} in the PEG spectra corresponds to stretching vibrations of the C–O–C bond[1,2] of the PEG structure and shifting of this peak indicates binding or favorable interactions of PEG with other species in the system.[3] For system (A) investigating the PEG, HA, and HCO_3^- system, there are contributions from PEG, HA, and HCO_3^- in the ternary mixture indicating weak or negligible bonding between each of three components in the system. In system (B), the peaks at 1105 cm^{-1} and 620 cm^{-1} correspond to the SO_4^{2-} anion (B6).[4-7] In comparing B1 and B3 spectra, the enhanced sulfate peaks at 1105 and 620 cm^{-1} in B1 compared to B3 suggest binding with sulfate species. Because the sulfate binding on PEG–HA will decrease surface charge further, this may result in more Ca^{2+} attractions in the PEG–HA system. As such, SO_4^{2-}-complexed HA may form a layer on the PEG membrane surface to promote $CaSO_4$ formation.

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