Title:

Early detection of surfactant-induced wetting in direct contact membrane distillation using impedance for hydrophobic PVDF phase inversion membrane

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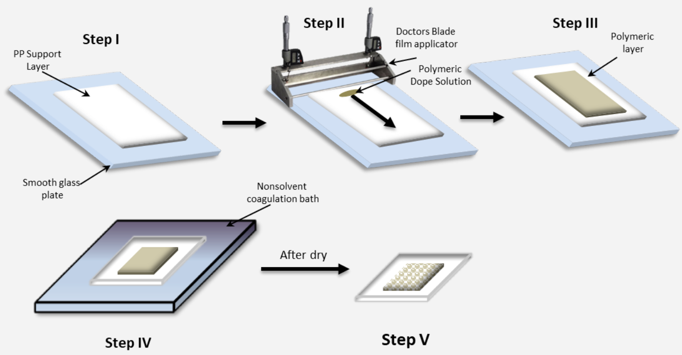
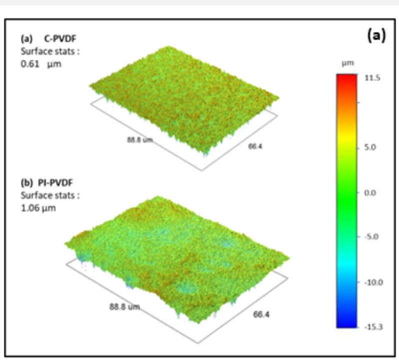
Abstract:

The challenges of wetting, fouling, and scaling on hydrophobic membranes are significant limitations in membrane distillation (MD) technology. Recently, there has been a growing focus on developing novel membrane fabrication methods to address these issues, which are primarily caused by low surface tension chemicals such as surfactants and dissolved organic matter present in feed water. In this study, we fabricated a highly hydrophobic membrane using the phase inversion technique with polyvinylidene fluoride (PVDF) polymer under an alcohol coagulation bath (ethanol). We monitored the wetting, fouling, and scaling of the membrane using electrochemical impedance spectroscopy (EIS) combined with direct contact membrane distillation (DCMD). The surface tension of synthetic brine water was reduced by adding a surfactant, and model algal organic matter was dissolved to study organic fouling. The PVDF membrane produced an asymmetric interconnected pore structure with high hydrophobicity (water contact angle of 146°). The membrane had a narrow pore size distribution (~0.43 µm), a raised liquid entry pressure (~1.3 bar), porosity (~75%), high surface roughness (1.06 µm), and low surface energy (~28 mN/m), making it suitable for DCMD under various feed compositions. We used EIS to assess different stages of pore wetting and their progression. Additionally, the conductivity on the permeate side was correlated with the impedance measured during EIS, demonstrating our advanced ability to distinguish intrusion and different stages of wetting.





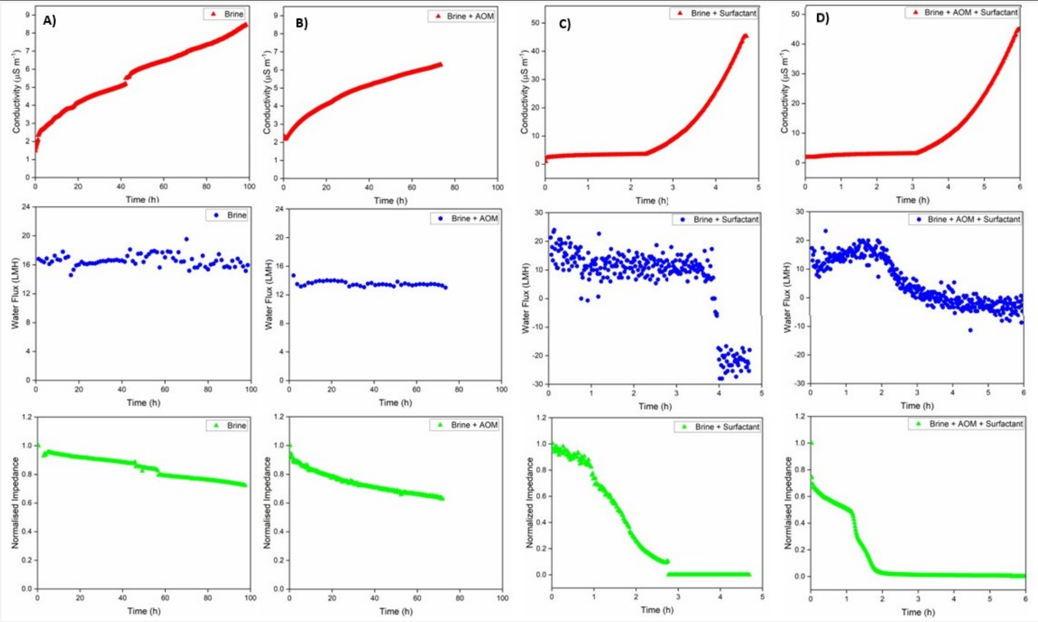


Figure 1. (a) Roughness Images (optical profiles) of (a) commercial PVDF (C-PVDF) (b) PI-PVDF, (b) wetting and fouling study of PI-PVDF membrane (feed type: brine with algal organic matter & surfactant)

Table 1. Characteristics of the commercial PVDF and lab-made phase inversion membrane

Membrane type	Mean pore size (µm)	Largest pore size (µm)	LEP (bar)	Porosity (%)	Water CA (°)	Surface energy (mN/m)	Surface roughness (µm)
C-PVDF	0.44 ± 0.07	0.56 ±0.09	0.56 ± 0.2	59.3 ± 0.3	110.1 ± 1.9	29.5 ± 1.8	0.61
15% PVDF	0.43 ± 0.08	0.52 ± 0.07	1.40 ± 0.7	75 ± 0.9	146.5 ± 1.1	28.4 ± 2.3	1.06