Effect of surface interactions on oil adhesion and wetting resistance of poly(acrylic acid)-grafted PVDF membranes in membrane distillation

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Abstract:

Oil adhesion to hydrophobic membranes can cause serious wetting and performance decline in membrane distillation (MD). A common approach to tackle this issue is to coat/graft a hydrophilic material onto the hydrophobic membrane surface. We previously showed the superior MD performance of a novel poly(acrylic acid) (PAA)-grafted PVDF membrane against adhesion and wetting by a model unemulsified oil dispersion (1000ppm dodecane in 0.1M NaCl solution), in which however the oil-resistance mechanism was not sufficiently elucidated in the framework of hydrophobicity and hydrophilicity [1]. Despite the fact that the more hydrophilic side of the PVDF-PAA membrane was still relatively hydrophobic (contact angle of 110°), wetting did not occur. Therefore, this work aims to comprehensively investigate the underlying mechanism by which PAA prevents the oil adhesion and wetting in MD.

Here, PAA was grafted onto a commercial PVDF membrane using a new UV-assisted ATRP method [1]. Streaming-potential analysis and underwater oil contact-angle (CA_{UWO}) (with Milli-Q water and 0.1M NaCl, respectively) were employed to analyze the surface potential and oil-wetting properties of PVDF and PVDF-PAA, respectively. An increase in the negative charge of PVDF-PAA (c.a. -30 mV) was observed compared to pristine PVDF (c.a. -15 mV) at the pH of MD experiments ($\sim$5.5). In CA_{UWO} tests, the pristine membrane was instantly wetted by the dodecane droplet in both tested media. However, PVDF-PAA showed a unique wetting behavior, i.e., instant wetting by oil under Milli-Q water, while no wetting under the 0.1M NaCl solution. The oil-adhesion resistance of the PVDF-PAA membrane can be attributed to the increased double-layer repulsion (due to a higher negative surface potential), and/or the effect of salt on the interfacial energy of the interacting surfaces. These effects will be investigated in more detail in the next steps of this research to better understand oil-adhesion resistance of PAA-modified membranes.

Keywords: Membrane distillation, Surface interactions, Oily waters, Atom-transfer radical polymerization

References:

1. Mahdi Shahrooz, Maedeh Nadimi, Rong Wang, Mikel C. Duke, and Xing Yang, "Surface modification by UV-assisted oxygen-tolerant atom-transfer radical polymerization (ATRP) for oil-resistant membrane distillation,", *13th Conference of the Aseanian Membrane Society (AMS13)*, 4-6 Jul 2022, Nanyang Technological University, Singapore