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Aqueous Phase Co-Solvent-Assisted Preparation of High-Performance Polyamide Nanofiltration Membranes: Preparation, Performance and Mechanistic

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Abstract

Co-solvent-assisted interfacial polymerization is commonly used to enhance the characteristics of polyamide (PA) thin film composite (TFC) membranes. However, its application to PIP-TMC systems is less frequent, and there is limited understanding regarding the role of co-solvents. In this article, we selected N,N-dimethylacetamide (DMAc), 1-butanol, acetonitrile (ACN) and N-methyl pyrrolidone (NMP) with similar solubility parameters to modulate the PIP-TMC IP process. The introduction of co-solvents can enhance the mutual solubility between aqueous and organic phases, which promotes the PIP diffusion rate and contributes to the high-performance NF membranes characterized by smaller pore sizes. Notably, membranes prepared with DMAc demonstrated enhanced retention of divalent ions ($MgCl_2$: from 41% to 83.4%) and maintained high permeability (46.6L m-2 h-1 at 0.3 MPa), whereas excessive co-solvents could damage the performance. Additionally, Molecular dynamics (MD) simulations show that the co-solvent regulates PIP diffusion rate with its own diffusion rate by hydrogen bonding with the PIP molecules and moving together with PIP. Significant variations in the PIP diffusion rate resulted in a wrinkled morphology on the membrane surface. This study offers fresh insights into the selection of co-solvents for co-solvent-assisted TFC NF membrane preparation, presenting a straightforward, facile, and commercially viable approach for achieving high-performance NF membranes.

Keywords

Thin Film Nanofiltration Membrane, Co-Solvent-Assisted Preparation, Wrinkled Morphology, Hydrogen Bond, PIP Diffusion Rate