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Thin-film composite hollow fiber membrane with inorganic salt additives for high mechanical strength and high power density for pressure-retarded osmosis

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Abstract

Using high salinity draw solutions in pressure retarded osmosis (PRO) demands novel membranes with a higher withstanding pressure and a higher power density to take full advantage of the increased osmotic gradient for greater osmotic energy production. This study highlights novel strategies to design an inner-selective thin-film composite (TFC) PRO hollow fiber membrane with a high operating pressure and a high power density by adding an inorganic salt, $CaCl_2$, to the dope solution and fine-tuning the spinning conditions. An optimal $CaCl_2$ dosage can not only effectively increase the dope viscosity but also reduce the mean pore size and narrow the pore size distribution of the polyethersulfone (PES) hollow fiber substrates. A high flowrate ratio of dope solution to bore fluid greatly enhances the mechanical strength of the PES substrates. The combination of these two strategies results in a more permeable, better-supported and less defective polyamide selective layer after interfacial polymerization. The best newly developed TFC hollow fiber has a power density of 38 W/m^2 at 30 bar by using 1.2 M NaCl and deionized water as the feed pair. To our best knowledge, these are the highest power density and operation pressure ever achieved by PRO hollow fiber membranes in the literature. The improved performance will advance the PRO technology closer to commercialization and make osmotic energy more competitive with other renewable energies.