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A sulfonated polyphenylenesulfone (sPPSU) as the supporting substrate in thin film composite (TFC) membranes with enhanced performance for forward osmosis (FO)

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HIGHLIGHTS

- Sulfonated polyphenylenesulfone (sPPSU) used for forward osmosis (FO) membranes.
- Sponge-like structure and hydrophilic FO membranes formed by sPPSU support.
- 4.4-Fold increment on water flux using sPPSU for FO instead of non-sulfonated.
- Significant improvement on the water flux for seawater desalination application.

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ABSTRACT

The new sulfonated polyphenylenesulfone (sPPSU) materials synthesized via direct route with various content of sulfonated units, i.e., 2.5 and 5 mol% 3,3′-di-sodiumdisulfate-4,4′-dichlorodiphenyl sulfone (sDCDPS) monomer, have been effectively implemented as supporting layers of the thin film composite (TFC) membranes for forward osmosis (FO) applications. Not only does the hydrophilic nature of membrane substrates essentially facilitate the water transport across the membrane during the FO process, but also possibly provide anti-fouling characteristics as well as induce the formation of fully sponge-like structures. Compared to TFC-FO membranes made of hydrophobic non-sulfonated PPSU supporting layers, those made of hydrophilic sPPSU supporting layers comprising 2.5 mol% sDCDPS can achieve a 4.4-fold increment on water flux up to 54 LMH with 8.8 gMH salt reverse flux under the pressure retarded osmosis (PRO) mode using 2 M NaCl as draw solution. Surprisingly, the newly developed TFC-FO membranes show a much smaller difference in water flux between PRO and FO modes compared to previous works, indicating much lower ICP, particularly at low draw solution concentrations, i.e. 0.5–2 M NaCl. When tested for seawater desalination using 3.5 wt% NaCl as the feed and 2 M NaCl as the draw solution, the aforementioned membrane show a water flux up to 22 LMH under the PRO mode, which is the highest ever reported. Furthermore, the structural parameter indicating the internal concentration polarization (ICP) can be remarkably decreased with an increase in sulphonated material contents in membrane substrates.

1. Introduction

The forward osmosis (FO) process is an emerging technology for next-generation water purification and seawater desalination [1–3]. FO employs the osmotic pressure difference between the feed and the draw solution across a semi-permeable membrane as the driving force to induce clean water flow through the membrane into the draw solution. Compared to the traditional pressure driven process such as reverse osmosis (RO), the FO process exhibits several features that can potentially surpass the RO technology [1–3]: (1) lower energy consumption and equipment costs [1]; (2) higher water recovery [1]; (3) more reversible fouling behavior [4]; (4) more extensive applications, such as power generation [5–7], juice or food concentration [8,9], and protein and pharmaceutical enrichment [10,11].

To date, the major challenges on FO processes remain on (1) improving the productivity of current FO membranes to compete

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