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Influence of colloidal fouling on pressure retarded osmosis

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HIGHLIGHTS

- Colloidal fouling behavior in pressure retarded osmosis (PRO) was systematically investigated.
- Colloidal fouling is dominantly influenced by the cake layer formation and the deposition of foulant within the support layer.
- Severe flux decline was observed with smaller colloidal particles.
- The feed solution pH has potential to mitigate the colloidal fouling.

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ABSTRACT

In this study, colloidal fouling behavior in pressure retarded osmosis (PRO) was systematically investigated in terms of the effects of draw solution concentration, applied hydraulic pressure at the draw side, feed solution pH, and particle size. Commercially-available cellulose triacetate (CTA) membranes were fouled with feed solution containing silica colloidal particles. Two different silica particles with mean diameter of 27 and 152 nm were used as model foulants. Our findings demonstrated that the colloidal fouling in PRO was dominantly affected by the cake layer buildup at the membrane surface. Fouling was further exacerbated by diffused salts from the draw side because retained salts within the cake layer elevated the salt concentration on the membrane surface, and consequently reduced the driving force of PRO. Substantial flux decline with the smaller particles was attributed to the high cake layer resistance due to the formation of the void-less cake layer. In addition, our approaches to mitigate the colloidal fouling revealed that the hydraulic cleaning by increasing the cross-flow rates was not effective to eliminate the compact cake layer. However, adjusting the feed solution pH showed the high potential to relieve the colloidal fouling resulting from the more stabilization of particles at low solution pH.

1. Introduction

Heavy dependence on fossil fuels which deteriorates the climate change places an increasing demand for alternative energy resources. To secure the sustainable energy supply and simultaneously reduce the carbon emissions, researches to explore the substitutes of current power source have been actively conducted. As a result, now over 20% of the global energy supply is shared by the renewable energies such as solar, biomass, geothermal, wind, and wave energies [1]. Recently, a technology using salinity gradient energy (SGE) is considered as a prospective alternative of traditional energy-production technologies. As harnessing the free energy released from mixing of two solutions having different salinities, SGE has benefits of less environmental footprint and less periodicity to weather variations. Extractable energy between a cubic meter of fresh river water and seawater was approximately 0.61 kWh in a thermodynamic point of view [2]. Furthermore, considering the freshwater and seawater, the potential of SGE is assessed to be a total of ~2.6 TW, equivalent to the global energy demands [3].

Pressure retarded osmosis (PRO) as one of the SGE processes, has recently drawn strong attention, whose impetus is the chemical potential difference between a diluted feed solution and a concentrated draw solution. Such salinity gradient induces the water permeation from the feed to the draw side, and then the hydraulic pressure lower than osmotic pressure difference is applied at the draw side to retard the permeate water flux. The pressurized volumetric water flow runs a hydro-turbine to convert the mechanical energy to the electric energy. Due to the remarkable advances in membrane technologies, PRO has

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