

MODIFIED PVA COMPOSITE MEMBRANES FOR NANOFILTRATION

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ABSTRACT

Nanofiltration (NF) composite membranes based on poly(vinyl alcohol) (PVA) and sodium alginate (SA) were prepared by coating PVA/SA (95/5 in wt %) mixture solutions on the microporous polysulfone (PS) supports, followed by the crosslinking with glutaraldehyde. The composite membranes prepared were characterized with a scanning electron microscopy (SEM), a fourier transform infrared spectroscopy (FTIR), an electrokinetic analyzer (EKA) and permeation tests.

INTRODUCTION

In spite of its good membrane performance, a polyamide (PA) composite membrane has limits in application because of its low chemical stability. Amide linkage of the PA membrane is very easy to be hydrolyzed in basic solutions, especially in NaOH solution (at pH 14). To solve such problems, the materials of the active layers of the membranes should be chemically stable, consisting of chemically stable backbone structure. In this point of view, PVA is one of the most optimum membrane materials that was comprised of chemically stable C-C backbone structure.¹⁻⁶ To develop PVA NF membranes with good performances by avoiding problems that encountered in the formation of PVA membranes,¹⁻⁴ composite type membranes consisting of very thin PVA/SA active layers with an optimum degree of crosslinking and microporous PS supports were prepared in this study. The membranes prepared were characterized with several analytical methods (SEM, FTIR, EKA). NF-properties of them were determined through permeation tests with various feed solutions (PEG 600, Na₂SO₄, MgCl, and NaCl)

EXPERIMENTAL

Composite membranes consisting of PVA/SA blend (95/5 in wt %) active layers and microporous PS supports were prepared by coating multiply the PS support with PVA/SA solutions having different concentrations, followed by drying at room temperature. The composition of the PVA/SA was 95/5 in wt % and the concentration of the solutions varied from 0.1 to 0.5 wt %. The

active layers formed on the support were crosslinked at room temperature by contacting them with an acetone solution containing 5 vol % of GA as crosslinking agent and trace amount of HCl as catalyst. The morphology, thickness and chemical properties of the active layers of the composite membranes were studied with a scanning electron microscopy (SEM) (model: JSM-80A, JEOL), a FTIR spectrophotometry (Bio-Rad, Digilab Division, model FTS-80, FTIR) and an electrokinetic analyzer (Model: EKA, Brookhaven). To test the performances of the membranes, a nanofiltration test set was used. The concentration of feed solutions was 1,000 ppm and upstream pressure was controlled by using back-pressure regulators (100, 200, 300, and 400 psi). All test was conducted at 25 °C.

RESULTS AND DISCUSSION

Characterization

(1) Morphology; Figure 1 presents the SEM photograph of the PVA/SA composite membrane prepared by coating the microporous PS support three times with a 0.5 wt % PVA/SA solution. The thickness of the active layer was about 0.25 μm and its surface was smooth.

(2) Zeta-Potential Measurement: Figure 2 shows the zeta-potentials as a function of the concentration of NaCl (electrolyte) of PVA/SA composite membrane and polyamide (PA) composite membrane prepared by the interfacial polymerization of piperazine with trimesoyl chloride on the PS support. The zeta-potential of the PVA/SA membrane was all negative in the range of concentration of NaCl solutions used and decreased with increasing concentration. Its decreasing zeta-potential with concentration can be explained by the more ions in the solution which may compensate the surface charge of the membrane.⁷ From the comparison between the values and behaviors of the zeta-potentials of both PVA/SA and PA membranes, it can be suggested that the PVA/SA composite membrane have also anionic character like the PA membrane. However, the lower zeta-potentials of the PVA/SA membrane indicate that it has less ionic character than the PA membrane.

Permeation Test

SA, anionic polymer, containing sodium carboxylate groups attached to the six-membered ring backbone structure was used to blend with PVA and expected to improve the NF performance of PVA membranes. Especially, the SA was expected to improve the solute rejection through the Donnan exclusion, because of its anionic character. The composition of the PVA/SA blend used was determined as 95/5 in wt %, since this composition was approved to be the best one with respect to the homogeneous blending and proper crosslinking reaction.⁶

Figure 3 shows the permeation properties of the membrane prepared by coating the PS

support three times with a 0.5 wt % PVA/SA blend solution, followed by crosslinking for two minutes. From these results, one can find that this membrane is a typical NF membrane; showing relatively good flux and high rejection of PEG 600 and Na₂SO₄ and very low rejection of NaCl and MgCl₂. The flux was not affected substantially by different feed solutions. However, the rejection depended. The flux increased almost linearly with increasing operating pressure and became about 0.5 m³/m²day at 200 psi which was about half of that of commercially available NF membranes such as NF-40.9

(1) Effect of thickness of active layer: To improve the performances of the PVA/SA composite membranes further, a new method to coat very thin active layer (about 0.01 μm) on the PS support was developed.⁸ Figure 4 exhibits the permeation properties of the PVA/SA composite membrane prepared by coating three times with a 0.1 wt % PVA/SA blend solution, followed by crosslinking for two minutes. The flux was highly improved with decreasing thickness of the active layer and about 1.35 m³/m²day at 200 psi when the feed solution was PEG600, which was very comparable with commercial NF membranes.

ACKNOWLEDGMENT

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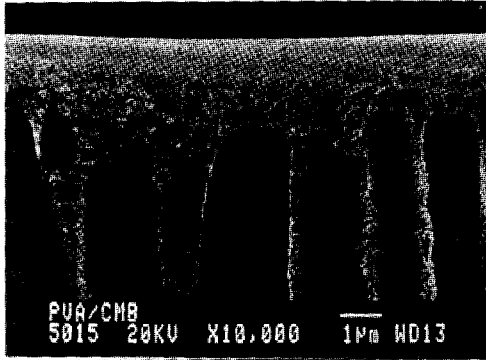


Fig. 1. SEM photograph of PVA /SA composite membrane

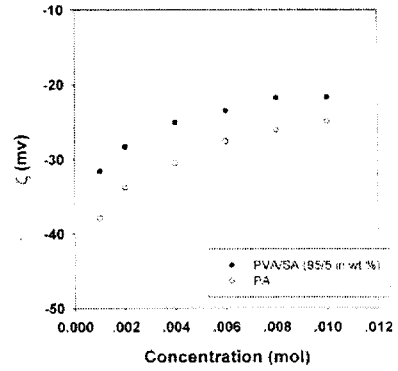


Fig. 2. Zeta-potential of PVA/SA and PA composite membranes

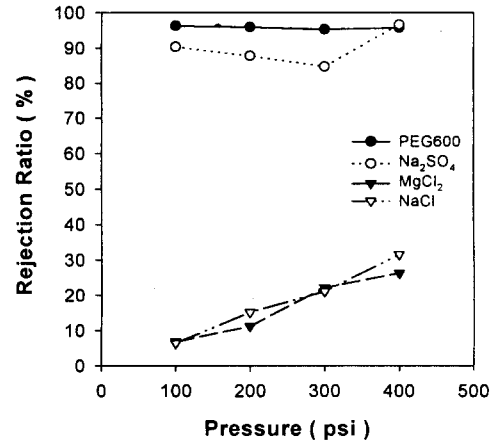
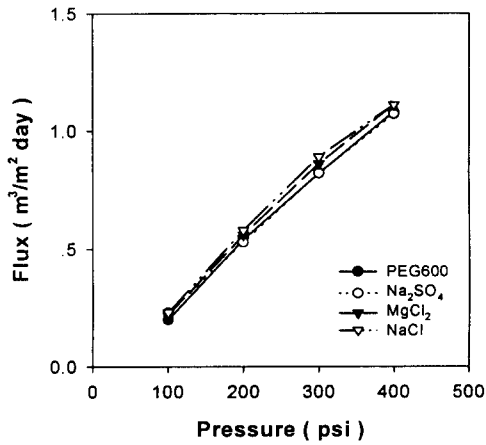


Fig. 3. Permeation properties of the PVA/SA composite membrane prepared by coating 0.5 wt PVA/SA blend solution followed by crosslinking for 2 minutes

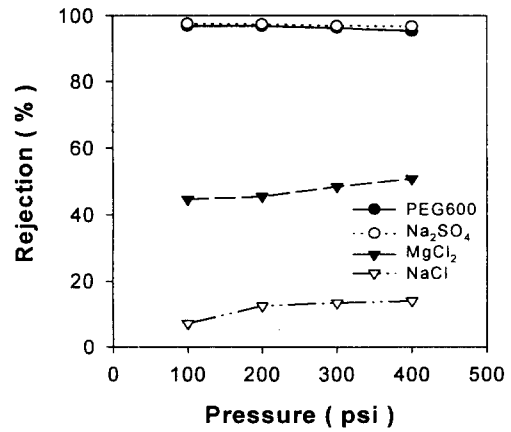
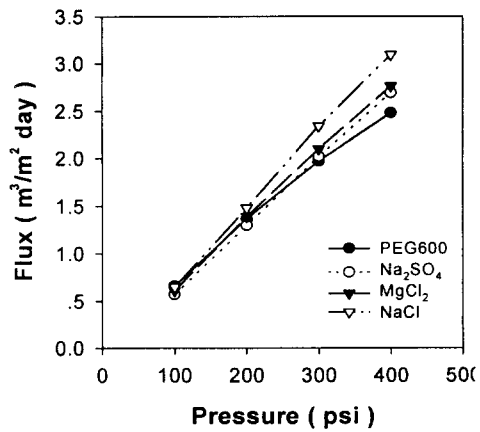


Fig. 4 Permeation properties of the PVA/SA composite membrane prepared by coating 0.1 wt PVA/SA blend solution followed by crosslinking for 2 minutes