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Nanofiltration Composite Membranes Based on Poly(vinyl alcohol)

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1. Introduction

It has been proved by the study on nanofiltration with PVA dense membranes in our laboratory that the PVA is good material for the formation of chemically stable nanofiltration (NF) membranes. However, the PVA NF composite membranes prepared so far have rarely shown flux and rejection high enough for the commercialization. The reasons for them would be the relatively thick thickness and improper crosslinking degree of the PVA active layers of the composite membranes. In this study, PVA composite membranes with improved nanofiltration properties have been prepared and characterized in terms of the morphology and permeation properties.

2. Experimental

PVA composite membranes were prepared by coating PVA solutions on the microporous polysulfone support (UOP UF membrane). The coating layers were crosslinked using glutaraldehyde as crosslinking agent. The morphologies and the chemical structures of the membranes were characterized with SEM and FTIR (Bio-Rad, Digilab Division, model FTS-80, FTIR), respectively. The membranes were tested with different feed solutions (1000 ppm solutions of PEG 600, PEG 400, PEG 200, Na₂SO₄, MgCl₂, and NaCl) at various operating pressures (100 - 400 psi) to observe their permselective performances. All tests were conducted at room temperature. The fluxes of the membranes were measured by weighing the

permeate penetrated through the membranes per unit time (g/min) and solute rejections were obtained from the data from high performance liquid chromatography (HPLC) using the following equation:

$$\text{Rejection (\%)} = \frac{(A_f - A_p)}{A_f} \times 100$$

where A_f is the HPLC peak area of feed solution and A_p is the HPLC peak area of permeate.

3. Results and Discussion

FTIR : The chemical structures of the crosslinked active layers of the composite membranes were characterized with FTIR. The FTIR spectrum of the crosslinked PVA layer showed characteristic peaks of acetal linkage as a strong C-O-C stretching at 1110 cm^{-1} . That acetal linkage was formed from the crosslinking reaction between the hydroxyl groups of PVA and glutaraldehyde.

SEM : The morphology and thickness of the active layers of the composite membranes were observed with scanning electron microscope (SEM). PVA composite membranes showed relatively smooth surface compared to the polyamide composite membranes and the thickness of the active layer was less than $0.1 \mu\text{m}$.

Permeation Test: PVA composite membranes were tested with different feed solutions. To see the effect of the molecular size of the solute on the permeation through the PVA composite membranes, PEG 600, 400, and 200 were used as the solute of the feed solution. In case of the PEG 600, the flux at 200 psi was about $1.3 \text{ m}^3/\text{m}^2\text{day}$ and rejection was about 96 %.

From the test with various inorganic salt solutions such as Na_2SO_4 , MgCl_2 , and NaCl , the effect of the ionic character was studied. For the PVA composite membranes, the order of rejection was appeared as follows : $\text{Na}_2\text{SO}_4 > \text{MgCl}_2 > \text{NaCl}$, indicating that the surface of the PVA membrane is anionic. The PVA composite membranes showed high Na_2SO_4 rejection of over 97 %, but low NaCl rejection of less than 15 % at 200 psi operating pressure.

From these high rejections of PEG 600 and Na_2SO_4 and low rejection of NaCl , it is found that PVA composite membranes are typical anionic nanofiltration membranes.

4. References

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