II－527 Rejection of anions by LPRO membranes under very low pressures as tertiary treatment for wastewater reclamation

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1. Introduction

RO is considered as a possible tertiary treatment process providing high quality of reclaimed wastewater, which can be utilized for cooling purpose and so on. Removal of nutrient salts especially phosphorus and nitrogen is becoming rather important to prevent regrowth of microorganisms in cooling pipelines. The development of new-generation LPRO (Low pressure reverse osmosis) as thin film composite (TFC) membranes has provided the possibility to selectively separate substances under lower operating pressures than those obtained with the traditional ones. Lower pressure operation is very attractive in reducing operation costs. However, little information is known for the operation of the LPRO membranes in treating dilute solution under very low pressure. In this research, the lowest operating pressure used was as low as 0.098 MPa (approximately 1 atm).

2. Experimental Methods

Three types of membranes used in this research are listed below:

Table 1 Characterization of three types of LPRO membranes

Membrane Type	Material	Rejection of NaCl *
NTR-7250	Polyvinyl alcohol	70%
NTR-729HF	Polyvinyl alcohol	93%
NTR-759HR	Aromatic polyamide	99.5%

*: Catalog value at 1.5 MPa, 0.15% NaCl

The membrane module used here is a flatsheet type C-10T (Nitto Denko Co.) and effective membrane surface area of the module is 60 cm^2. The composition of the feed solution is shown in Table 2. pH was adjusted to 7.2 by NaOH and temperature was in the range of 24-27 ^oC. The operating pressures used were in the range of 0.098- 0.49 MPa, which is considerably low pressure range for LPRO-membrane operation. Anion concentrations were measured by the indirect UV method of HPLC (Shimadzu LC-6A). This method utilized IC-Al column. Phatalic acid of 0.5 mM (pH = 4.6) was used as liquid phase.The detection wavelength of UV is 260 nm.

Table 2 Composition of the feed solution

Composition	Concentration
KH_2PO_4	10 mgP/l
$NaNO_2$	20 mgN/l
KNO_3	20 mgN/l
NaCl	30 mgCl/l
$MgSO_4 \cdot 7H_2O$	30 mgSO_4/l

3. Results and discussion

3.1) Flux characteristics of three types of LPRO membrane

From Fig. 1, the fluxes of three types of LPRO membrane were investigated under steady state after 120 minutes. It was found that the fluxes increase with transmembrane pressure. The membrane type NTR-7250 gave the highest flux of $1.1 * 10^{-5}$ m/s at the operating pressure of 0.49 MPa whereas the membrane types NTR-729HF and NTR-759HR produced the fluxes of $6.35 * 10^{-6}$ and $4 * 10^{-6}$ m/s, respectively under the same pressure. General transport equation to predict the flux of water across RO

membrane is Jv = A * (Δp - Δ¶). However, in this experiment, osmotic pressure, Δ¶, was considered negligible because of dilute solution.The water permeation coefficient, A, obtained under very low operating pressures here are $2.27*10^{-5}$, $1.51*10^{-5}$, $8.24*10^{-6}$ m/s-MPa for membrane types NTR-7250, NTR-729HF and NTR-759HR, respectively.

3.2) The performance of anion rejection

Figs. 2,3 and 4 illustrate the performance of the three types of LPRO membranes in rejecting anions such as HPO_4^{2-}-& $H_2PO_4^-$, SO_4^{2-}, Cl^-, NO_2^- and NO_3^- in the dilute solution as function of transmembrane pressure after the filtrate time of 120 minutes. The percentage of rejection increased with transmembrane pressure in the cases of Cl^-, NO_2^- and NO_3^- apparently for membrane types NTR-729HF and NTR-7250. However, the effect of transmembrane pressure to %rejection is considerably insignificant in operating with membrane type NTR-759HR, which is known as the most tight one among these three types of LPRO membranes. It has been recognized that multivalent ions can be rejected better than univalent ions in the case of RO membrane. From this result, it appears that HPO_4^{2-}-& $H_2PO_4^-$ and SO_4^{2-} could be removed easier than Cl^-, NO_2^- and NO_3^- (univalent ions) with all types of LPRO membranes under very low operating pressures. Moreover, the result of monovalent anions rejection in this research (in the case of Cl^-, NO_2^- and NO_3^-) also suggests that the solute permeate flux seems independent of the water flux and it can be considered relatively constant as the rejection of these monovalent anions in this research increased with higher transmembrane pressure.

From the data obtained in this research, the membrane type NTR-759HR gave the highest performance of all types of anion removal as about 100 % for HPO_4^{2-}-& $H_2PO_4^-$ and SO_4^{2-}, 89-98% for Cl^-, 83-97% for NO_3^- and 83- 93% for NO_2^- ,respectively. The membrane type NTR-729HF yielded the second good performance of anions removal as about 100% for HPO_4^{2-}-& $H_2PO_4^-$ and SO_4^{2-}, 43-82% for Cl^-, 11-60.5% for NO_3^- and 11-66.5% for NO_2^- ,respectively. In the case of membrane type NTR-7250 with the highest flux of permeate resulted the removal as 96-100% for HPO_4^{2-}-& $H_2PO_4^-$, 96-100% for SO_4^{2-}, 15.5-58% for Cl^-, 0-22% for NO_3^- and 0-37% for NO_2^- , respectively

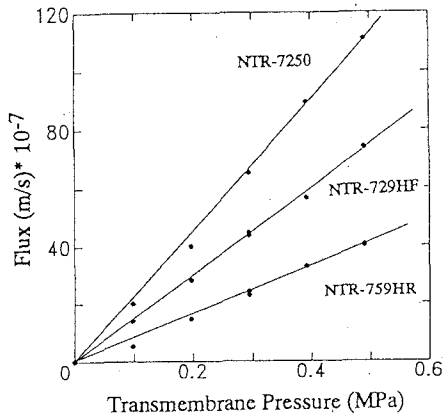

Fig. 1 Fluxes of three types of LPRO-membrane

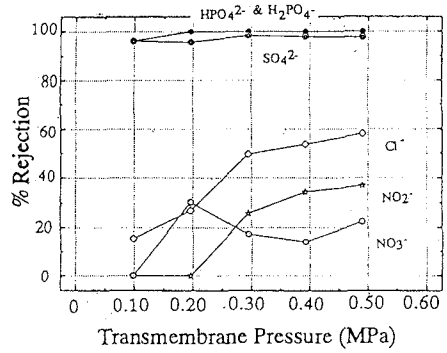

Fig. 2 The performance of anion rejection of the membrane type NTR-7250

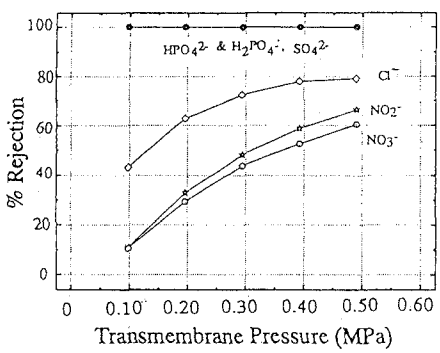

Fig. 3 The performance of anion rejection of the membrane type NTR-729HF

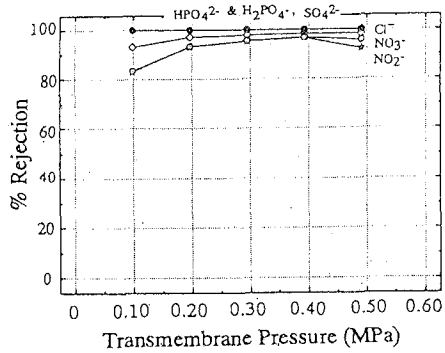

Fig. 4 The performance of anion rejection of the membrane type NTR-759HR