B－9 Difference in Rejection Behavior between Trihalomethane Precursors and Inorganic Salts by Ultra Low Pressure Nanofiltration

超低圧ナノろ過によるトリハロメタン前駆物質と無機塩の阻止率の違い

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1. INTRODUCTION

Nanofiltration (NF), generally operated at a transmembrane pressure of 0.5-2.0 MPa (Madaeni, 1999), is a process with membrane permeability in between reverse osmosis (RO) and ultrafiltration (UF) processes. It is one of the membrane processes, which can remove trihalomethane precursors (THMPs) with lower energy cost. Ultra low pressure nanofiltration is attractive for the treatment of fresh water, because fresh water has much lower osmotic pressure than seawater for which the desalination technology using reverse osmosis membranes has been developed.

In this study, we evaluated the rejection of trihalomethane precursors in nanofiltration, comparing it with that of inorganic salts, with very low pressure (below 0.5 MPa) nanofiltration pilot plant, which is located at the downstream of Tama river.

2. MATERIALS AND METHOD

2.1 Membranes and membrane module

Six types of nanofiltration membranes were used in this study. The nanofiltration membranes were supplied in flat sheet form and mounted in crossflow modules, which had 0.0044 square meter of effective membrane surface area. Table 1 shows the characteristics of the nanofiltration membranes.

Table 1 Characteristics of nanofiltration membranes used in this study.

Name	Manufacturer	Electric Charge	Skin layer-material	Nominal cut-off of NaCl
NTR-7250	Nitto Denko Corp.	Negative	Polyvinylalcohol / Polyamides	70%
NTR-7410	Nitto Denko Corp.	Negative	Polysulfonate	15%
NTR-729HF	Nitto Denko Corp.	Negative	Polyvinylalcohol / Polyamides	93%
SUL-G	Toray Industries	Negative	Aromatic polyamides	99%
UTC-60	Toray Industries	Negative	Aromatic polyamides	55%
UTC-20	Toray Industries	Positive	Aromatic polyamides	60%

2.2 Nanofiltration pilot plant

Figure 1 shows the schematic diagram of the nanofiltration pilot plant in Tamagawa water purification plant. The system was operated continuously with no chemical cleaning of the membranes.

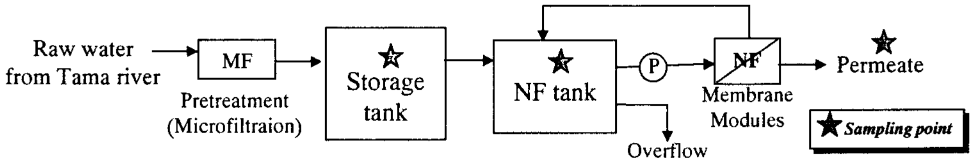

Figure 1 Schematic diagram of the nanofiltration pilot plant.

2.3 Nanofiltration experiments

Nanofiltration experiments were carried out by using the actual surface water from Tama river. Rejection was expressed as follow.

$$R = 1 - \frac{C_P}{C_B} \qquad (1)$$

where, R = rejection; C_P = concentration in the permeate; C_B = concentration in NF tank

3. RESULTS AND DISCUSSION

3.1 Characteristics of influent water quality and general performance of NF membranes

Table 2 shows the composition of pretreated water, feed water and NF permeates at applied pressure of 0.3 MPa.

Table 2 Compositions of pretreated water and feed water, and their rejection in nanofiltration.

	Pretreated water in storage tank	Feed water in NF tank	% Rejection					
			NTR-7250	NTR-7410	NTR-729HF	SUL-G	UTC-60	UTC-20
Temp. (°C)	15-23	37-45	-	-	-	-	-	-
pH	6.8-7.2	7.1-7.3	-	-	-	-	-	-
E260	0.031-0.041	0.052-0.067	91.6	66.3	79.5	99.0	94.6	96.3
THMPs (μg/l)	52.8-81.5	104.4-128.1	85.9	44.7	62.8	97.8	93.2	93.4
Chloroform (μg/l)	7.6-15.2	11.9-29.5	88.8	74.8	86.2	90.1	91.0	84.4
Br-THMs (μg/l)	37.6-67.2	83.3-98.7	85.1	36.7	56.7	99.8	93.8	95.7
Cl^- (mg/l)	10.3-27.5	22.4-30.8	5.7	9.7	21.2	98.4	23.4	50.1
NO_3^- (mg/l)	11.7-22.4	19.4-25.5	-8.6	6.0	4.8	95.4	-15.0	44.8
SO_4^{2-} (mg/l)	15.5-29.0	37.5-45.8	97.1	35.7	70.4	100	100	100
Na^+ (mg/l)	8.7-24.7	18.3-27.1	31.1	13.8	29.9	94.1	38.8	15.3
K^+ (mg/l)	2.0-5.5	4.1-6.3	36.7	18.9	38.1	94.8	41.6	15.3
Ca^{2+} (mg/l)	14.7-22.5	23.6-28.9	39.5	19.9	42.9	99.3	63.6	95.0
Mg^{2+} (mg/l)	2.7-4.9	4.9-5.7	35.2	16.6	37.6	99.4	70.1	96.1

From the results, the rejection of total trihalomethane precursors (THMPs) had high correlation to that of ultraviolet absorption at wavelength of 260 nm (E260) as shown in Table 2 and Figure 2. The rejection of THMPs is dependent on the molecular weight cut off size of the membranes. However, the rejection of organic matter would not necessarily gave dependency to the rejection of inorganic salts, because the main characteristic in rejection of the salts is electric charge repulsion between solutes and membrane surface. Among inorganic salts, divalent ions gave higher rejection than monovalent ions in the nanofiltration of surface water.

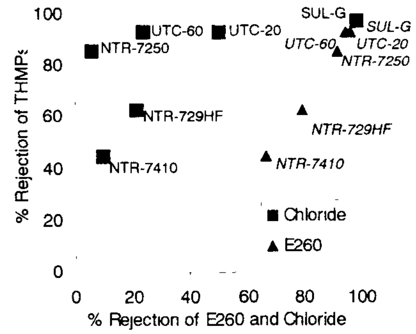

Figure 2 Dependence in rejection.

3.2 Dependence in rejection

Fugure 2 shows the dependence in rejection between trihalomethane precursors (THMPs) and ultraviolet absorption at wavelength of 260 nm (E260), and the independence in rejection between THMPs and inorganic salt such as chloride.

As the results, precursors of trihalomethane obtained higher rejection than monovalent ions, sodium and chloride. Precursors of trihalomethane consists of larger molecule which are highly rejected. Membranes, which obtained lower rejection of chloride, would not necessarily give lower rejection of THMPs.

3.3 Effect of operational pressure

Figure 3 shows the effect of operational pressure on volume flux. The osmotic pressure of the feed water used in this study was approximately 0.05 MPa, judging from Figure 3, because volume flux is generally in proportional to the applied pressure subtracted by the osmotic pressure difference between feed and permeate solution.

Figure 4 shows the rejection change of organic matter (E260), relating to precursors of trihalomethane formation, with applied pressure. The rejection decreased with decrease in applied pressure. Not only the rejection of the THMPs but also the rejection of inorganic salts decreased with the decrease in applied pressure as shown in Figure 5. The rejection of monovalent ions, sodium and chloride, were relatively low while the rejection of the organic matter which was represented by the light absorption of 260 nm (E260) was comparatively high.

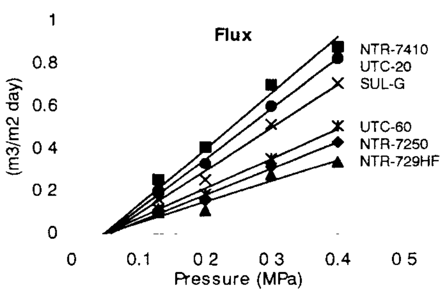

Figure 3 Volume flux of the nanofiltration of surface water.

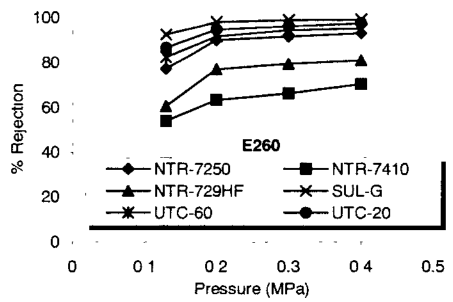

Figure 4 Rejection change of natural organic matter in very low pressure operation.

4. CONCLUSION

The rejection characteristics of the nanofiltration membranes were investigated in a pilot plant treating surface river water. Rejection slightly decreased with decrease in applied pressure. The speed of rejection decrease was high in lower pressure range of operation, especially in the case of rejection of organic matter.

Precursors of trihalomethane, consisting of larger molecule, gave higher rejection than monovalent ions, sodium and chloride. Membranes, which gave lower rejection of chloride, would not necessarily give lower rejection of trihlomethane precursors. Among of inorganic salts, divalent ions gave higher rejection than monovalent ions in the nanofiltration of surface water.

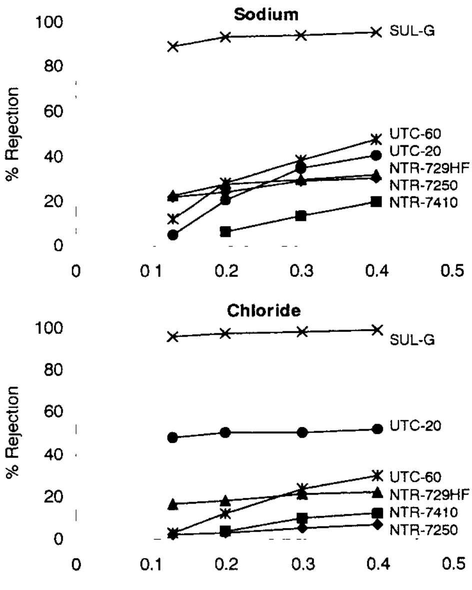

Figure 5 Rejection change of inorganic salts in very low pressure operation.

5. REFERENCES

MADAENI S.S. (1999) The application of membrane technology for water disinfection. *Wat. Res.* **33**(2), 301-308.