

(Short Paper)

Fouling Evaluation of Anion-exchange Membranes in Electrodialysis Systems

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Abstract

The fouling behavior of Neosepta AMX and ASM was investigated in batch and flow electro dialysis systems, using humic acid (HA) and sodium dodecylbenzene-sulfonate (DBS) as foulants by measuring the voltage drop between probe electrodes. DBS fouled AEMs; however, in the case of HA, the voltage drop of the batch system increased while that of the flow system did not change. This is because the increase in the voltage drop in the batch system was caused not by fouling of HA, but by the increase in the solution resistance. From these results, the fouling test using the flow system indicated clearly that HA does not significantly foul AMX and ASM.

Key Words : Anion-exchange membrane, Organic fouling, Electrodialysis, Flow system, Batch system

1. Introduction

In many application fields of electro dialysis (ED) desalination processes¹⁾, membrane fouling is one of the most significant considerations. Fouling causes an increase in membrane electrical resistance, followed by an increase in energy consumption and shortening of membrane life.

It has been reported that fouling takes place mainly on the surface of anion exchange membranes (AEMs) during ED²⁾. Hence, many researchers have focused on the fouling of AEMs by organic foulants²⁾. This is because AEMs have positive charges and most organic foulants present in natural water and effluents, such as surfactants, proteins and organic acids, are negatively charged. Moon et al. tested the fouling properties of Neosepta AMX in a batch type ED system using humic acid (HA), bovine serum albumin (BSA), and sodium dodecylbenzene-sulfonate (DBS) as foulants³⁾. In the case of DBS, membrane resistance increased within 100 min. On the other hand, in the case of HA and BSA, a gradual increase in resistance occurred at more than 500 min, leading to the conclusion that the increase in resistance occurred due not to membrane fouling but to a decrease in ionic conductivity on the diluted side. However, fouling behavior must be checked using an ED system where the effect of the decrease in ionic conductivity on resistance can be negligible.

The aim of this study is to perform a fouling test using batch and flow type ED systems using two AEMs to make clear the relationship between the fouling behavior and the chemical structure of AEMs and foulants.

2. Experimental

Commercially available AEMs [Neosepta AMX and ASM: ASTOM Corp] were used as a sample membrane. AMX and ASM are the standard grade membrane and a specific grade membrane with high water content¹⁾, respectively. The fundamental properties of the AEMs were listed in Table 1.

A sample membrane was fixed between the four chambers of a batch and flow type ED cells (Fig. 1) equipped with a silver electrode and a silver chloride electrode. In the batch cell, the concentrated chamber was filled with 0.1 dm³ of 0.1 mol/dm³ NaCl aqueous solution and the dilution chamber with 1.0 dm³ of a mixed solution of 0.1 mol/dm³ NaCl and 500 ppm of DBS (Aldrich, USA) or HA (Aldrich, USA) as an aromatic foulant. In the flow cell, the dilution chamber was connected to a feed tank containing the same solution as the dilution chamber. The solution of the tank and the dilution chamber was circulated using a liquid feeding pump. The electrode chamber was filled with 0.1 dm³ of 0.5 mol/dm³ NaCl aqueous solution. The solution in all chambers was stirred at a rotation speed of 1,000 rpm and ED was conducted at a current density of 10 mA/cm². The effective area of the cell is 4.0 cm². During the constant current operation of the ED period, the voltage drop between the

Table 1 Fundamental properties on commercially available AEMs

IEC: ion-exchange capacity, W: water content, Rm: membrane resistance, d: membrane thickness, t: transport number

	IEC [meq/g]	W [-]	Rm [Ω cm ²]	d [μ m]	t [-]
AMX	1.4	0.24	2.3	140	0.98
ASM	2.0	0.38	1.4	170	0.98

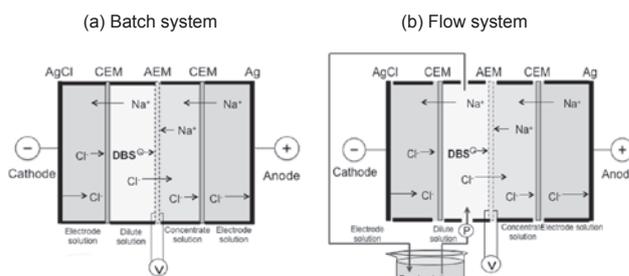


Fig. 1 Experimental setup for fouling experiments

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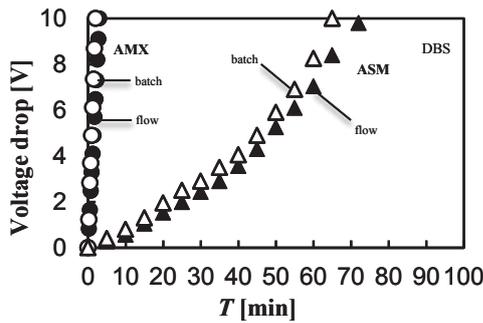


Fig. 2 Voltage drop between the probe electrodes as a function of measuring time, T , using two ED systems. Fouulant: DBS. Sample membrane: circles, AMX; triangles, ASM ED systems: open symbols, batch type; closed symbols, flow type

platinum wire electrodes fixed near the membrane surfaces was measured.

3. Results and Discussion

Fig. 2 shows the voltage drop between the probe electrodes of the two ED systems as a function of measuring time. In the constant current operation, the increase in the voltage drop means an increase in membrane resistance, implying that organic fouling occurs during the ED period. The slope of the voltage-time curve of ASM was gentler than that of AMX, indicating that ASM has better anti-fouling properties than AMX. This is the same result as reported by Tanaka et al¹⁾. The slope of the batch type system in both AEMs was larger than that of the flow type one. The reason is as follows: the permeation coefficient of Cl^- ions through AEMs is much higher than that of DBS, and the volume of the desalination chamber of the flow type system is 4 times larger than that of the batch type one. Hence, the relative concentration of DBS to Cl^- ions in the batch type system became larger than that in the flow one during ED period. Therefore, the AEMs in the batch system fouled much more than those in the flow one.

Fig. 3 (a) shows the voltage drop in the batch system using HA as a foulant. The voltage drop of both AMX and ASM did not change within 250 min and increased at more than 250 min because the salt concentration in the desalination chamber decreased less than 0.02 M at more than 250 min. This result is almost the same as that reported by Moon et al³⁾. However, the voltage drop in the flow system did not change at more than 350 min as shown in **Fig. 3 (b)**. The membrane resistance of ASM before and after the ED test showed almost the same values while that of AMX increased dramatically after the ED test as shown in **Table 2**. These data indicate clearly that the increase in the voltage drop in the batch system was caused not by the fouling of HA, but by the increase of solution resistance in the dilution chamber. From these results, the flow ED system is found to be useful for a long term fouling test because the influence of the decrease in Cl^- concentration on fouling behavior is smaller than that of the batch ED system.

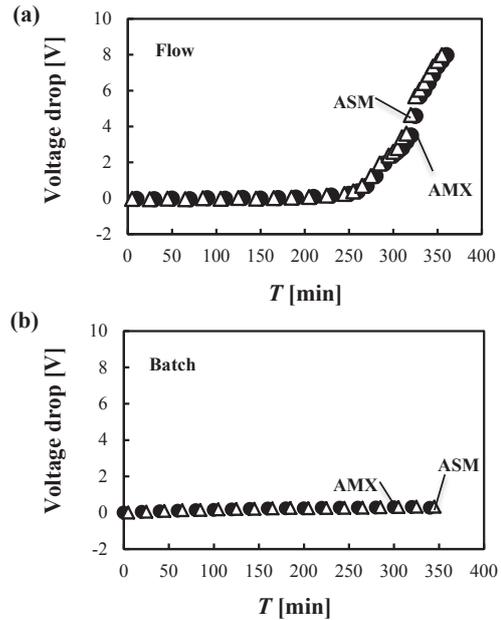


Fig. 3 Voltage drop between the probe electrodes as a function of measuring time, T , using two ED systems. Foulant: HA. Sample membrane: circles, AMX; triangles, ASM ED systems: (a) batch type; (b) flow type

Table 2 Membrane resistance, R_m , of the AEMs before and after the ED test

Foulant	Sample	ΔR_m [Ωcm^2]	
		Batch	Flow
HA	AMX	0.3	0.3
	ASM	0.3	0.3
DBS	AMX	10.1	9.8
	ASM	2.4	2.1

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