

일반강연 II-1

실리카를 포함한 용액의 전기투석에서 음이온 교환막 특성분석연구

이홍주, 문승현
광주과학기술원 환경공학과
e-mail: shmoon@kjist.ac.kr

A study on characterization of anion exchange membranes in electro dialysis of silica-containing solution

Hong-Joo Lee, Seung-Hyeon Moon
Dept. of Env. Sci. & Eng.
Kwangju Institute of Science and Technology (K-JIST)

1. Introduction

Colloidal particles exist in natural waters and many effluent streams in forms of clay minerals, colloidal silica, iron oxides, aluminium oxide, manganese oxides, organic colloids and suspended matter, and calcium carbonate precipitates.[1] Fouling by colloids, which has been concerned in the pressure-driven membrane processes, is caused by accumulation of colloidal particles on the membrane surface and/or a cake layer formation.[2] The cake layer formation provides an additional hydraulic resistance to water flow through membranes, reducing flux. Fouling of ion exchange membranes depends on the electrochemical and physical properties of colloids and the interaction between colloids and the membrane surface.

Electrodialysis (ED) is an ion exchange membrane separation process which uses an electrical potential difference as a driving force. In spite of the perspectives of ED, fouling of ion exchange membranes is one of the most important limitations in the design and operation of electro dialysis process. Foulants in electro dialysis move toward ion exchange membranes under the electric field and then deposit on the surface of membranes by electrical interaction between the membrane surface and the foulants, increasing the electric resistance of membranes.[3] Silica sol with negative charges move toward an anion

exchange membrane and the electric field and electrostatic attraction to membrane cause to deposit on the membrane. The deposit of colloids on the membrane surface in electro dialysis depends on the charge properties of colloidal particles and membrane.[4] Therefore, the extent and the nature of fouling tendencies in electro dialysis can be indicated by the membrane and foulant properties

In this study the fouling tendencies were examined by physical and electrochemical properties of silica for anion exchange membranes. The electro dialysis performance was compared with fouling characteristics measured in the study.

2. Experimentals

As a synthetic foulant, silica sol, Ludox HS-40[®](DuPont, USA) has a diameter 12 nm and the isoelectric point of pH 3.[1] For the characterization of silica sol, the acidity by the potentiometric titration and the zeta potential using an electrophoretic apparatus. As characteristics of anion exchange membranes, AMX, AM-1, ACM, (NEOSEPTA[®], Tokuyama Corp., Japan) and AMV (SELEMION[®], Asahi Glass, Japan), the following properties were characterized: (i) exchange capacity, (ii) electric resistance with a LCZ meter, (iii) contact angle, and (iv) the zeta potential by a streaming potential cell (BI-EKA, USA).

For observation of fouling phenomena, 2 cell pairs of AMX, AM-1, ACM, and AMV with a cation exchange membrane, CMX, were assembled in TS-1(Tokuyama Corp., Japan). The diluate solution was 5.0 L of 0.1 M NaCl containing 0.4 wt% of silica sol as a diluate solution. Performances of the membranes were compared in terms of removal rate of conductivity in diluate solution, cell resistance, and rejection of silica sol in electro dialysis.

3. Results and Discussion

Through the characterization of silica sol, it was observed that the acidity of silica sol, based on the amount of added volume of a titrant, mainly consists of the hydroxy group with 97 % of the charged group in the charge density 0.72 meq/g. Silica sol seemed to give less fouling

effects on anion exchange membranes than humate due to a lower charge density.[3] Through the zeta potential by the electrophoretic mobility, the pH effects on the zeta potential of silica sol in 0.01 M KCl solution were investigated. The zeta potential is highly negative and the repulsive electrostatic forces dominate at a high pH, while it becomes relatively positive at a lower pH, with the attractive van der Waals force being dominant.[5]

Table 1 shows the results of characterization of anion exchange membranes. The changes of the electric resistance, a measure of irreversible tendency, showed somewhat increases even after electro dialysis. Significant increases were observed for AM-1 and AMX in the exchange capacity, while ACM and AMV decreased slightly. The change of the contact angle, a measure of hydrophobicity, did not show significant difference for all anion exchange membranes. Little change in the zeta potentials by the streaming potential were observed except for AMV which showed a decreased zeta potential due to deposition of silica sol. Despite of low fouling potentials, AMV has the highest fouling tendency in Table 1. And ACM is thought to have a high fouling potential with characteristics irrespective of foulant.[3]

Little difference through electro dialysis experiments was found in the time course of conductivity and NaCl concentration in the diluate solution, showing low fouling tendencies for four anion exchange membranes. Higher increased rates of cell resistance in ACM and AMV were observed, which corresponds to expected fouling tendency in Table 1. Through investigation of silica sol after electro dialysis, silica sol was rejected 93-96 % in diluate solutions. However, 4.6 % of silica sol moved into concentrate solution through AM-1, while 0.4 -0.8 wt% transported through the other three membranes. As a result, AM-1 showed the least irreversible fouling on the membrane surface, which is a good explanation for a highly increased exchange capacity.

4. Conclusion

It was shown that fouling in electro dialysis is related to the electrochemical properties of foulant and membranes through characterization of anion exchange membranes and silica sol. Fouling

potentials of anion exchange membranes were predicted in electro dialysis of NaCl containing silica sol. Of anion exchange membranes, ACM and AMV had a higher fouling potential. In electro dialysis experiments, AMV and ACM showed higher increased rate of cell resistance despite low fouling tendency. From investigation of the distribution of silica sol after electro dialysis, AM-1 showed the largest amount transported into concentrate solution, and the least irreversible fouling.

Acknowledgement

본 연구는 2000년 한국과학재단 특정기초연구지원사업비 지원으로 수행되었습니다. 이에 감사드립니다.

References

1. X. Zhu and M. Elimelech, *Env. Sci. Tech.*, **31**, 3654-3662(1997).
2. G. Belfort, D.H. Robert and A.L. Zydney, *J. of Mem Sci.*, **96**, 1-58(1994).
3. H.J. Lee, S.H. Moon and S.P. Tsai, *J. of Mem. Sci.*, submitted.
4. J. Mallevialle, P.E. Odendaal and M.R. Wiesner, *Water treatment membrane processes*, McGraw-Hill, Chapter 12, 1996.
5. A. Jönsson and B. Jönsson, *Separation Science and Technology*, **31(19)**, 2611-2620(1996).

Table 1. Characterization of anion exchange membranes

Mem.	Fouling status	Electrical resistance (Ohm cm^2)	Contact angle (Degree)	Exchange capacity (meq/g mem)	Zeta potential by streaming potential (mV)
AMX	Virgin	2.7	67	1.7	4.9
	Fouled	3.2	64	2.4	3.7
AM-1	Virgin	1.3	77	2.7	5.4
	Fouled	1.4	77	5.1	5.0
ACM	Virgin	4.8	84	3.9	5.6
	Fouled	5.1	85	3.8	5.4
AMV	Virgin	1.7	72	3.1	6.4
	Fouled	1.9	69	2.5	4.6