EDR 공정을 이용한 수도수 중 경도 물질 제거에 관한 연구

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A study on removal of hardness materials from tap water using EDR process

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1. Introduction

Suspended and colloical matters, and multivalent salts near the saturation level can cause severe problems in electrodialysis due to precipitation on the membrane sufaces. To prevent the membrane scaling, the electrodialysis reversal (EDR) system has been used widely. The principle of EDR operating mode is illustrated in Figure 1. This figure shows a electrodialysis cell formed by a cation- and anion-exchange membrane between two electrodes. If an electric field is applied to a feed solution containing hardness materials and their counter anions, these components will migrate through the membrane

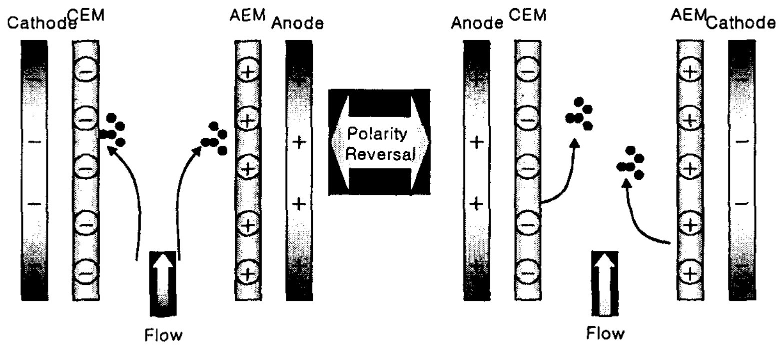

Figure 1. Schematic drawing illustrating the principle of electrodialysis reversal

and can be deposited on its surface. If the polarity is reversed the precipitate migrate away from the membrane back into the feed stream and the membrane properties are restored [1].

In this paper, a EDR system was manufactured and the possibility of the application of it to the hardness removal from a typical tap water was examined.

2. Experimental

The experiments were carried out using a EDR stack with three hydraulic stages in six cell pairs, giving a total membrane area of 600 cm^2. The stack had one pair of electrode made of platinized titinium. Cation and anion exchange membranes were CMX and AMX from Tokuyama Soda. Two groups of feed water were tested; systhesized solutions and tap water. The synthetic solutions were made to contain hardness materials ranging from 20 ppm to 300 ppm as $CaCO_3$ adding $CaCl_2 \cdot 2H_2O$, $MgCl_2 \cdot 6H_2O$, and Na_2SO_4 to distilled water. During the operation, the flow rate of concentrate and electrode rinse solution was maintained as 20 ml/min and the electrode solution flew from anode cathode always.

3. Results and Discussion

In order to understand the transport of scaling-causing hardness materials in a electrodilaysis system and to know the effect of divalent ions on the electric current the limiting current densities of the membranes in a tap water and NaCl solution were investigated.

Influent / Membrane	Tap Water	20% Tap Water
CMX	1.2	0.35
AMX	1.2	0.49
Influent / Membrane	0.6 mM NaCl	0.12 mM NaCl
CMX	1.1	0.45
AMX	1.3	0.70

(Unit: A/m^2)

Table 1. Limiting current density in various influents

When the conductivity of NaCl solution was the same with the original tap water (0.6 mM NaCl) the limiting current densities in two solutions were not different from each other. However, when the concentration was lowered to 20% of original one, the limiting current densities in a NaCl solution had the higher value. From this result, we could know that the transport of divalent ions in the last hydraulic stage of the electrodialysis cell which had the diluted tap water would be the more dominant resistance causing factor leading water splitting phenomena.

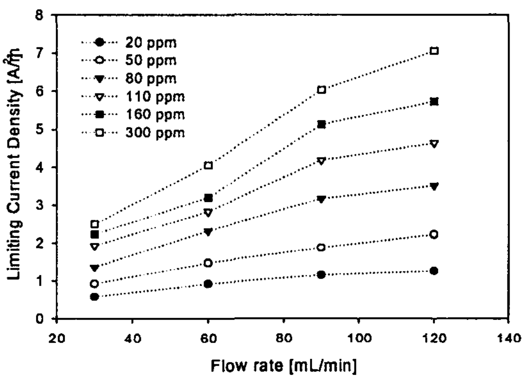

Figure 2. Limiting current density in a EDR cell; various flow rate and concentation

To achieve the optimal operation current for the EDR system, the limiting current density in the electrodialysis cell was investigated under the various influent conditions. As we can see in Figure 2, the limiting current density increased with the flow rate and the concentration of feed solution, and the influence of flow rate was more significant than that of the concentration.

We operated the EDR system for 20 minutes changing the influent water and electric current density. The ionic concentration in the feed water and treated water was analyzed using ionic chromatograph and the removal rates of cations are shown in the Figure 3. Under the given condition, the removal rate of hardness- causing materials (Ca, Mg) was higher than that of monovalent ion (Na). This result told us that the membranes used in the EDR operation were fairly effective to remove the divalent material and the system could be

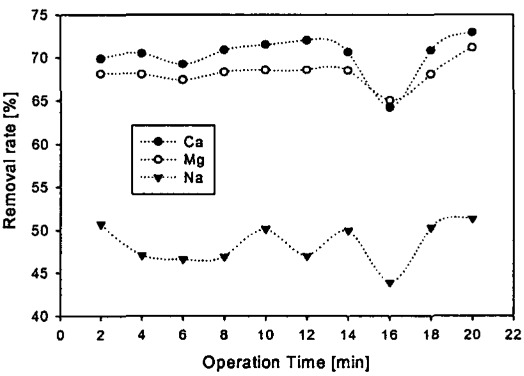

Figure 3. Removal rate of ion

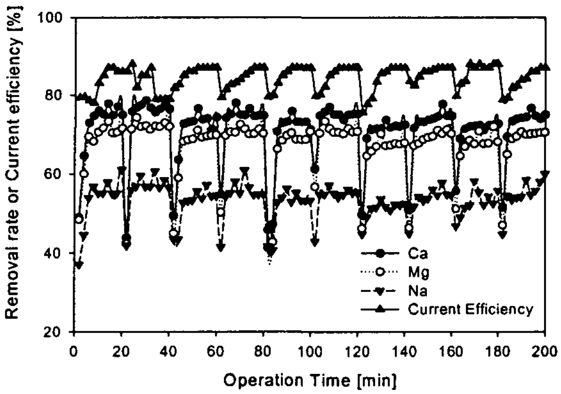

Figure 4. Hardness removal from tap water; removal rate of ions and current efficiency

used as the water softening process.

The system was operated using actual tap water as the feed solution and the result is displayed on Figure 4. As we can see in the Figure 4, the removal rate of hardness materials was maintained between 70 and 80 %, and was higher than that of sodium ion (55%). During the operation, the current effeiciency was considerably high as about 90 % and the membranes were preserved from membrane scaling by the periodic change (20 minute-interval) of the polarity reversal.

Through this application, we could suggest that the EDR system can be used as the effective hardness removal process for the tap water treatement without membrane scaling.

4. Conclusion

The single-pass ectrodialysis reversal unit was made and its application to the hardness removal from the relatively lower concentration solution was conducted. The tested system was sufficiently effective to remove hardness material from typical tap water and free from membrane scaling.

Acknowledgement

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Reference

1. H. Strathmann, *Ion-exchange membrane separation processes*, Elsevier Science (2004)