역전위전기탈이온 공정을 이용한 경도물질 제거

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A study on removal of hardness materials using the polarity reversal in an electrodeionization process

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1. Introduction

Ion exchange is broadly used due to ease of operation and high removal efficiency among hardness removal materials. When ion exchange capacity becomes saturated, however, the periodical regeneration of resins with high concentration of regenerating chemicals requires in the ion exchange process. As an alternative of ion exchange process, the electrodeionization (EDI), an ion exchange membrane separation process combined electrodialysis and ion exchange process, has been considered to remove hardness materials. However, the EDI process has disadvantages due to fouling of the colloidal particles or organics. Due to its environmentally friendly feature and good applicability, electrodeionization reversal (EDIR) process has been developed using the polarity reversal of electrodes.

In this study, the effect of flow rate, concentration and polarity reversal frequency on the process performance in EDIR was investigated for the removal of hardness ions from the synthetic water containing various hardness concentrations. From the investigation, it was practically applied to the demineralization of synthetic water after the optimal operating conditions for the EDIR process were determined. The study shows that the polarity reversal

of electrodeionization showed high hardness removal efficiency without scale formation as water softening process.

2. Experimental

EDIR system having 6 cell pairs was used to remove the hardness from the synthetic water for the EDIR setup. Cation exchange membrane, HCM4 (LEEE) made by our laboratory and commercial ion exchange membrane, NEOSEPTA AMX (ASTOM Co., Japan), were used. Amberlite IR120 Na^+ and IRA402 Cl^- (Rhom and Hass Co., France) were used as ion exchange resins. Fig. 1 shows the schematic illustration for the EDIR system operation. Feed solution was prepared in a synthetic solution by dissolving $CaCl_2$, $MgSO_4 \cdot 7H_2O$, and $NaHCO_3$ in tap water. Table 1 shows the composition of prepared synthetic solutions. The concentration of cationic species of feed solution was analyzed with an ion chromatography, DX 120 (Dionex, USA).

Table 1. Composition of synthetic water

Component	Amount
Conductivity (μS/cm)	672
pH	7.43
Ca^{2+} (mg/L)	17.70
Mg^{2+} (mg/L)	68.40
Total hardness (mg/L as $CaCO_3$)	250

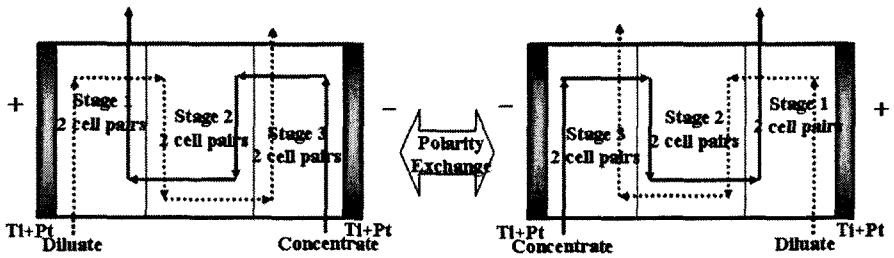

Fig. 1. Schematic illustration for the EDIR system operation

3. Result and discussion

The EDIR was operated at the DC constant voltage of 20 V to remove hardness ions from the synthetic solution. Only in the operation with the

regular polarity exchange, the product water was sampled 15 minutes later after every polarity reversal for ionic analysis. The electrode polarity was changed at twenty minutes interval. In the variations of the conductivity and pH of product solution, the conductivity measured 150 μS/cm continuously with operating time and the pH value of the product was stable between 6.5 and 7.0 without scaling.

Fig. 2 shows the removal efficiencies of Ca^{2+} and Mg^{2+} in EDIR system. The removal efficiencies for divalent ions showed higher values than sodium ions due to the higher ionic mobility. The removal efficiency of Ca and Mg was decreased until 4 hours. After 4 hours, the removal efficiency of Ca and Mg was stable with estimated values between 60 % and 70 %. The removal efficiency of Ca was higher than Mg due to the adsorption characteristic on the surface of ion exchange resin in EDIR system process. Even with increasing the operating time, the removal efficiencies of Ca^{2+} and Mg^{2+} kept high value. The EDIR system for removal of hardness did not show scale problems on the membrane surface even at the high hardness removal efficiency.

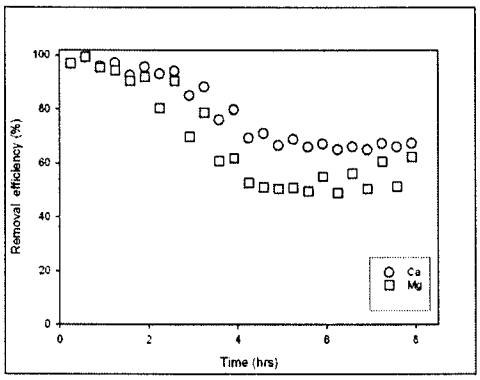

Fig. 2. Removal efficiency in synthetic solution with increasing time

4. Concluding remarks

The operation of EDIR systems using HCM4 made by our laboratory was studied as a process of ion exchange for removal of hardness ions in the

synthetic water containing 250 mg/L as $CaCO_3$. The results showed high removal efficiency of hardness materials with HCM4. The EDIR operation showed good process performances without scaling problem.

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