일반강연 B-2

양이온 교환수지를 충진한 전기탈이온 장치에서의 전압-전류 곡선과 적정 전류밀도 선정에 관한 연구

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A study on the current-voltage relationships and the determination of optimum current density in a cation-exchange resin packed continuous electrodeionization (CEDI) system

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1. Introduction

This study investigated the relationship between current and voltage in a cation exchange resin packed CEDI system with $Co(NO_3)_2$ solution. Also, the determination of optimum current density base on current-voltage curve was examined.

2. Experimental

Cation exchange resin (IR120-Co, Rohm & Hass) packed 1 cell pair 3 compartments CEDI stack was prepared as Fig.1. CMX and AMX (Tokuyama Soda Co.) were used as cation- and anion-exchange membrane respectively. Na_2SO_4 1000ppm and H_2SO_4 0.01M were used as electrode rinsing and concentrate solution respectively. Both solution was circulated through each chamber with the flow rate of 2 ml/min. For I-V curve study 0, 5, 10, 100, 500 and 2000 ppm $Co(NO_3)_2$ solution were flushed into the diluate compartment with the flow rate of 2 ml/min. Constant stack current was applied by using power supply (Model 6613C, Agilent technology, USA) and voltage changes of the stack and the resin bed in the diluate compartment were measured. For the measuring of the voltage of the resin bed platinum wires (0.25 mm in diameter) were set up at five points. Each point was numbered from the top to the bottom. The CEDI system was operated with 10 ppm $Co(NO_3)_2$ solution under the current density of 1.3, 2.66, 6.8 and 7.78 A/m^2 for 8 hours. During the operation pH, conductivity and voltage changes were measured. For the analysis of removal rate of Co^{2+} and NO_3^- ions ICP-AES and IC were used respectively.

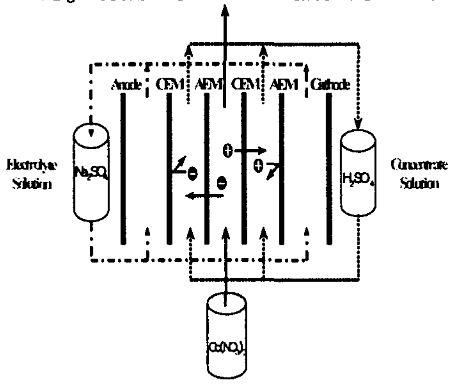

Fig.1 Stack configuration

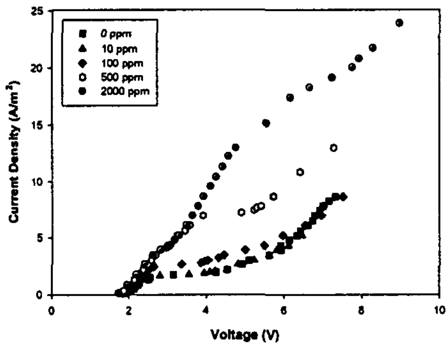

Fig.2 Current-voltage curve of the stack

3. Results and Discussion

3.1 Current-voltage relationships

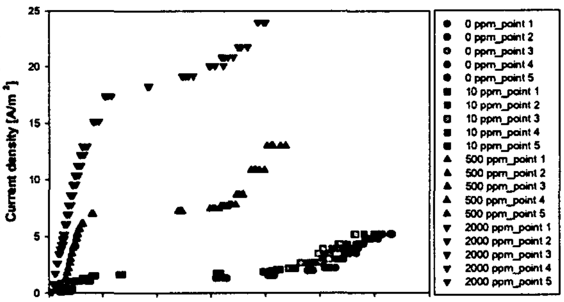

Fig.3 Current-voltage curve of the resin bed

Fig.2 and Fig.3 show the current density as a function of the voltage applied across the stack and the resin bed in the diluate compartment respectively. In the current versus voltage curve three distinct areas can be identified. In the first area, the current density is linearly increased with the applied voltage until the limiting current density is reached. The current applied across the stack is used for the transport of ions in the influent. In this area transported ions can be compensated by ions from the continuously flushed influent. In the second area, a further increase in the applied voltage does not lead to an increase in the current density. Ions from the influent can not compensate transported ions any more. For the flow of more current, more ions are required. More ions for the current flow can be supplied by H^+ and OH^- ions that are produced by water splitting in the bipolar interface between cation-exchange resin and anion-exchange membrane. However, for the water splitting to be occurred enough potential gradient is required. Thus the steady state is maintained until the potential gradient reaches enough value for the water splitting. In the third area, water dissociation starts to occur and the current density is linearly increased again with the applied voltage as does in the first area. The gaps of the voltage of the resin bed at five points are trivial in the first and the second areas. However the gaps are increased in a remarkable quantity in the third area. As the current density is increased most ions in the influent are transported in the lower part of the resin bed and the water splitting region in the upper part is extended.

3.2 The effect of the current density on the CEDI operation

Fig.4 shows the removal rate of Co^{2+} and NO_3^- ions in the CEDI system operated with 10 ppm $Co(NO_3)_2$ solution. The Fig.2 shows that three distinct areas are identified on the basis of 2.66 A/m^2 and water splitting starts to occur over that current density in the CEDI system with 10 ppm $Co(NO_3)_2$ solution. Over the current density of 2.66 A/m^2, Co^{2+} ions were removed completely but under that current density the removal rate was about 97%. The removal rates of NO_3^- ions were increased as the current density was increased from 15% to 30%. The conductivity of the effluent was decreased as the current density was increased. The pH of the effluent was decreased as the current density was increased from 1.3 to 6.8 A/m^2, however it was increased again as the current density was increased to 7.78 A/m^2. As the current density

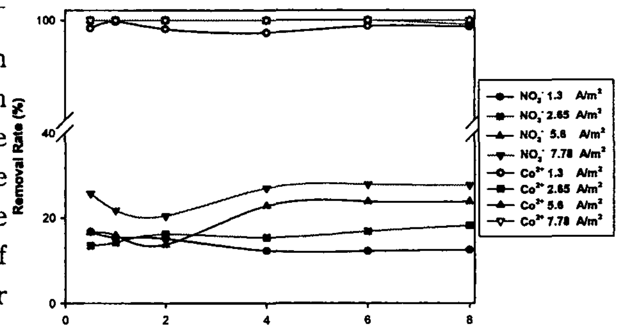

Fig.4 Co^{2+} & NO_3^- Removal rate

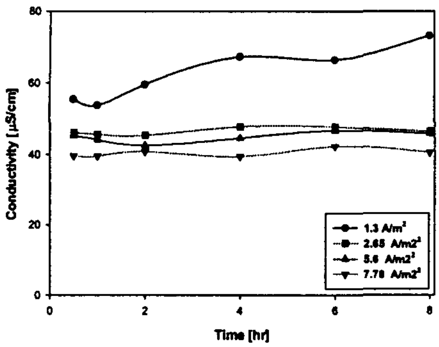

Fig.5 Conductivity variation of the effluent

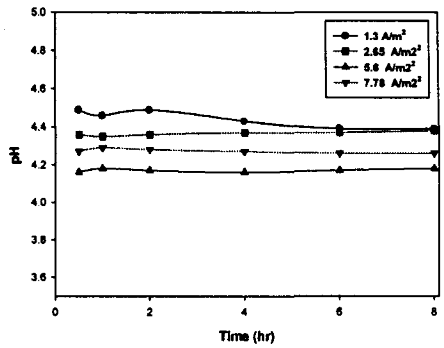

Fig.6 pH variation of the effluent

was increased the extent of water dissociation was also increased and caused the decrease of pH. However under much higher current density high electric field was induced and it leaded to high migration velocity. This caused the removal of H^+ ions and the increase of pH. By these results we could confirm that the I-V curve measurement gives the standard for the operation.

4. Conclusions

The current-voltage curve in cation exchange resin packed CEDI system showed three distinct areas. The water splitting occurred in the third area and the operation over this current density showed complete caobalt ion removal.

5. Acknowledgement

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6. References

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