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REMOVAL OF INORGANIC IONS FROM AQUEOUS SOLUTION BY CAPACITIVE DEIONIZATION

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INTRODUCTION

Capacitive deionization (CDI) is one of the new technologies for removing dissolved salts from aqueous solutions. CDI is an electrosorption process that removes inorganic ions by charge separation and acts as a “flow through” capacitor [1]. This electrochemical process is energy-efficient because it is conducted at low voltages (1.0-1.4 V) without high-pressure pumps or thermal heaters. In this study, CDI system with high desalination capacity has been developed and several experiments have been conducted to determine optimum operating conditions using 2.0 M NaCl solution.

EXPERIMENTAL

The activated carbon cloth (ACC) made from phenolic resin was used as CDI electrode material. Specific surface area was obtained by the BET method. Acidity of ACC was determined according to the procedure by Boehm [2]. Table 1 shows the various properties for the ACCs. Adsorption of ions on electrodes was measured using bench-scale CDI apparatus shown in Fig. 1 and Fig. 2. Aqueous solution with an applied flow rate of 50-250 ml/min was pumped in by a peristaltic pump (PP-600DW, Poong lim Co., Korea) from the bottom and exited from the top of the stack. DC power at 0.6-1.8 voltages was applied by a rectifier (AGILENT E3633A, USA). CDI performance was conducted for 10 min at 1.4 V and 100 ml/min. Regeneration of the CDI unit was begun immediately after the sorption phase and continued for 5 min at the reversed bias of -1.4V.

RESULTS AND DISCUSSION

Fig. 3 shows the maximum salt removal rate for 2.0 M NaCl solution at feed flow rates of 50, 100, 150, 200, and 250 ml/min. As the flow rate increases, maximum salt removal rate decreases. At the flow rate of below 100 ml/min, the highest salt removal (SR) was reached. These results show that the salt removal rate depends on the residence time of solution on electrodes. To raise salt removal rate, more time available for mass transfer is needed. Considering both the SR and the amount of product water, it can be seen that optimum flow rate is 100 ml/min.

Fig 4 shows salt removal ratio for 2.0 M NaCl solution at applied DC voltages of 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, and 1.8 V. It is impossible to see a clear difference for SR at 1.4 and 1.6 DC voltage. However, the gas in product stream was observed in operating condition with applied DC voltage of above 1.6 V due to electrolysis. Considering both the SR and the energy consumption of CDI, it can be seen that optimum flow rate is reached at 1.4 DC voltage.
The highest salt removal rate is observed at electric field of DC 1.4V and flow rate of 100 ml/min. Maximum salt removal was about 95% at optimum operating conditions. The calculated energy consumption value was 2.0 Wh/L at the experimental conditions.

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Table 1. Main characteristics of ACC used for the electrode

	ACC
Commercial name	CH900-10
Thickness(mm)	0.6
Specific surface area(m2/g)	1117
Average Pore diameter(A)	23
Total acidity(meq/g)	1.079
Raw material	Phenolic-resin

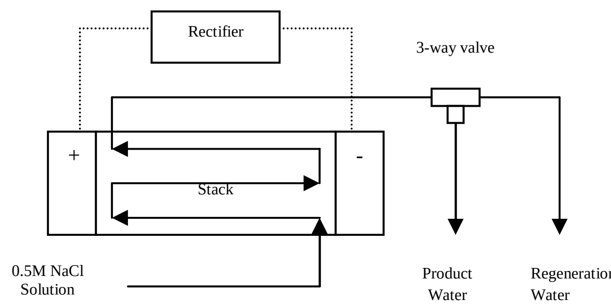

Fig.1. The flow diagram of CDI system

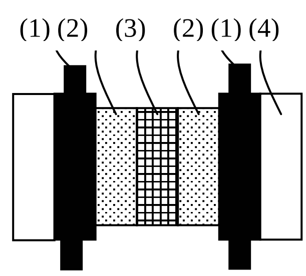

Fig.2. Schematic diagram of CDI stack: (1);current collector, (2);electrode, (3);flow spacer, (4);cell holder

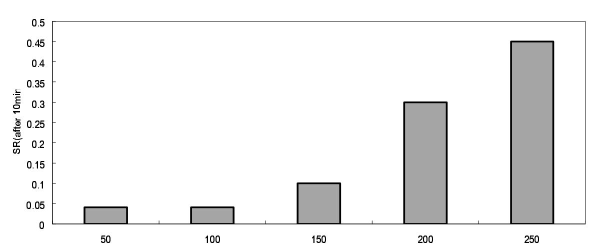

Fig.3. The effect of flow rate at DC 1.4V.

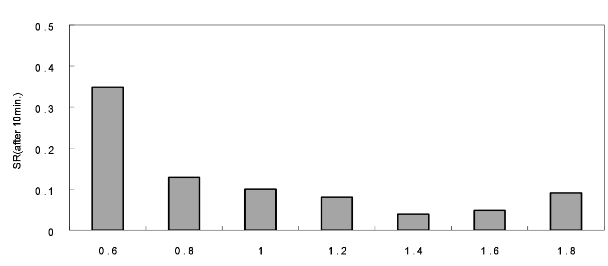

Fig.4. The effect of DC voltage at flow rate of 100 ml/min.