Abstract of Doctoral Thesis

Title：Development and Application of Capacitive Deionization System

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Capacitive deionization (CDI) technique having higher efficiency and lower operation cost in comparison with the reverse osmosis technique was investigated. We have developed a simple and inexpensive hydrophilic activated-charcoal based electrode for capacitive deionizer cell system and examined its physical and electrochemical properties. The electrochemical properties of the developed electrode were characterized using a three-electrode cyclic voltammetry system, which showed that chemically modified activated-charcoal based electrodes demonstrated an increase in capacitance. An asymmetrical distribution of capacities of both electrodes was found to be ideal wherein no electrochemical reactions took place at the electrode surface. The electrode capacities were defined based on the difference between the rest potential of the electrodes and the oxidation-reduction potential of the solution. Furthermore, the ion removal capacity of the electrode was evaluated using NaCl solution with a conductivity of 11 mS/cm. The electrode with a thickness ratio of 2.5:1 (anode: cathode) exhibited high ion removal capacity up to 0.034 mol/m2.

The ion adsorption/desorption mechanisms of CDI stack equipped with the developed activated-charcoal electrodes, having either uni-polar or bi-polar circuit structures, were evaluated. The experimental results showed that the CDI stack with a bi-polar circuit consumes 70 % less energy than of that with a uni-polar connection. As for operation of the processing fluid, a combined flow-through and batch processing operation for ion adsorption and desorption processes shows the best working efficiency for throughput. Furthermore, the energy recovery by discharging the stored energy of the ion desorbing electrode pair to another pair for ion adsorption by switching four-CDI cells for both the discharge and the charge sides was 81 % at the maximum.

In Japan, 50 million tons of municipal solid wastes (MSW) are incinerated and 10 % of residual incineration ashes are buried in landfills. However, landfills are becoming difficult and problematic due to high cost, environmental issues, lack of available land and strict laws. To promote recycling of an incineration ash as a raw material for cement plants, the closed washing system of incineration ashes for removing chloride has been investigated by applying a developed CDI system. It is demonstrated that CDI system has higher efficiency and lower operation cost in comparison with the reverse osmosis technique.