

ELECTROSORPTION OF COBALT AND STRONTIUM ON ACTIVATED CARBON FIBERS FOR THE TREATMENT OF DECONTAMINATION LIQUID WASTE

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Introduction

Radioactive solid waste arises during the maintenance and the repair of the nuclear power plants or the nuclear fuel cycle facilities. The solid waste can be recycle and the amounts of disposal waste can be reduced significantly by application of the proper decontamination technology such as chemical or electrochemical decontamination methods. Therefore, it is necessary to treat the secondary waste to increase the decontamination efficiency. One of the efficient methods to treat the secondary waste is the electrosorption which is related to the ion adsorption phenomena on the electrical double layer. The characteristics of the electrosorption is to control the selectivity of adsorbent on the adsorbate by changing the surface polarity of adsorbent. It was reported that the sorption capacity of the adsorbent could be increased remarkably by electrosorption compared with the ordinary sorption methods[1-3]. For the radio-nuclides which have not the same half-lives, it is safe and convenient methods to separate the radio-nuclides and manage respectively. In this study, it was investigated on the electrosorption and separation behaviors of activated carbon fibers(ACFs) for the treatment of decontamination liquid waste containing Co^{2+} and Sr^{2+} . Co^{2+} and Sr^{2+} ions are effectively removed by electrosorption on an pitch based activated carbon fibers. And the adsorbed Co^{2+} and Sr^{2+} ions on ACF electrode are easily desorbed by reversing the applying potentials. Complete separation of Co^{2+} and Sr^{2+} ions is achieved by electrosorption.

Experimental

The experimental system consists of a potentiostat(EG&G Model 273), a working electrode (ACF), and an electrochemical cell (EG&G Model G0096). The reference, counter, and working electrodes were dipped in the cell. A saturated calomel electrode(SCE) was used as the reference electrode. The counter electrode used a platinum wire representing a non-corrosive surface for the gas evolution reaction and was separated from the working electrode by a Vycor membrane(Vycor No 7930). A 0.01-0.1 N NaCl solution was used as electrolytes. The solutions of Co^{2+} , Sr^{2+} were made by mixing with the NaCl solution and was sparged by nitrogen gas for 30 minutes prior to the experiment because of the easy

reduction of dissolved oxygen in the solution. A constant size and amounts of ACF felt was wound around a graphite rod, which was used as a current collector and dipped in the concentration of 5mM solution with constant stirring of the electrolyte. The ACF felt electrode was kept under various potentials to remove the metal ions by electrosorption. Desorption was examined by first adsorbing at various negative potentials for constant periods, then reversing the electric potential back to various positive potentials.

Results and Discussion

The physical and electrochemical properties of ACF felt used as an electrode are listed in Table 1. ACF has a large BET specific surface area, and the most of the pores can be classified as a micropores which has an average pore radius of about 10\AA . It was reported that the electrical conductivity of carbons used in the electrosorption process is in the range from 0.1 to $1.0(\Omega\cdot\text{cm})^{-1}$. It is known that the good carbon electrode has electrical conductivity values more than $1.0(\Omega\cdot\text{cm})^{-1}$. The electrical conductivity values of ACF felt used in this experiment was $72(\Omega\cdot\text{cm})^{-1}$. We can infer that the ACF felt will be used as a good conductive electrosorption adsorbent[4-5]. The electrosorption tests on Co^{2+} ion was performed in the electric potential range from -0.05 to -0.3V using a 0.5g of ACF felt. Fig. 1 shows the adsorption % of Co^{2+} against the applied electric potential. Comparing the electrosorption rate, initial electrosorption rate at -0.3V is faster than that at -0.2V . However, the time for electrosorption equilibrium is 7 hrs for these two values of electric potentials(-0.3 and -0.2V). From the results, we determined the optimum electrosorption potential as -0.2V , taking into account of energy consumption. After the ACF electrode are fully saturated with Co^{2+} ions, desorption tests were performed in a reversed electrode potential. The desorption % of Co^{2+} ions against the initial solution pH under various applied electric potential is shown in Fig. 2. From the result, the desorption process occurs easily as the increase of the positive electric potential and the decrease of the solution pH. Comparing the desorbed portion of Co^{2+} ions at 0.5V , we find that the desorption at pH 3.5 is better than that at pH 5.0. But, the desorption of Co^{2+} ions did not occur completely. Comparing the desorbed portion

of Co^{2+} ions at 0.7V, the desorption at pH 5.0 occurs easily. From the result, the determining factor for desorption is the applied electric potential rather than the solution pH. The optimum desorption electric potential and solution pH were determined as +0.7V and 5.0, respectively.

The portion of adsorbed Sr^{2+} ions against the applied electric potential is shown in Fig. 3. 100% of the Sr^{2+} ions are adsorbed on the electrode surface in all range of investigated negative electric potential except at -0.2V . Because the time to reach adsorption equilibrium is long at -0.4V , it is chosen the optimum adsorption electric potential of Sr^{2+} ions as -0.5V . After 0.5g of ACF felt was fully adsorbed with Sr^{2+} ions at -0.5V and the initial solution pH 5.0, the desorption test on the ACF felt was performed by reversing the applied electric potential. The desorption portion of Sr^{2+} ions against solution pH in the applied electric potential range from +0.3 to +0.75V is shown in Fig. 4. The amount of adsorbed Sr^{2+} ions and adsorption rate are increased with the applied electric potential, but decreased with the solution pH. Fig. 5 shows the removed portion of Co^{2+} and Sr^{2+} ions from binary component solution against the applied electric potential. The characteristics of electrosorption of Co^{2+} ions is similar to the singular component system in which only Co^{2+} ions exist. However, the sorption process of Sr^{2+} ions occurs after the adsorption reaction of Co^{2+} ions proceed. From these results, it was found that Co^{2+} ions are more competitive than Sr^{2+} ions in the sorption on the active sites of ACF adsorbent, and that Co^{2+} and Sr^{2+} ions are easily separated by electrosorption process. Because the adsorption characteristics of Co^{2+} and Sr^{2+} ions are similar at -0.2V and -0.4V , the electrosorption process will be beneficial at the applied electric potential of -0.2V .

Conclusions

Co^{2+} and Sr^{2+} ions in liquid waste resulting from wet decontamination are effectively removed by electrosorption on an electrode made of pitch based activated carbon fibers. And the adsorbed Co^{2+} and Sr^{2+} ions on ACF electrode are easily desorbed by reversing the applying potential. Complete separation of Co^{2+} and Sr^{2+} ions is possible by electrosorption since high selectivity of electrosorption of Co^{2+} and Sr^{2+} ions is achieved.

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Acknowledgements

This project has been carried out under the Nuclear R & D Program funded by the Ministry of Science and Technology.

Table 1. Properties of ACF felts

Physical property		Electro/chemical property	
Specific S/A (m^2/g)	1950	Conductivity ($\text{ohm}\square\text{cm}$) ⁻¹	72
Total pore vol.(cc/g)	0.94	pH	6.4
Micro pore vol.(cc/g)	0.77	Surface acidity (meq/g)	0.38

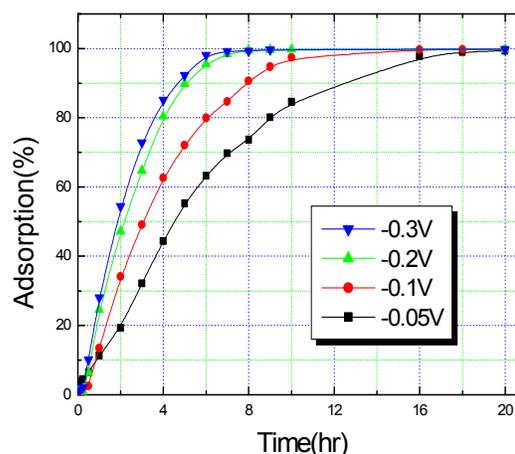


Fig.1. Electro-adsorption % of Co^{2+} with variation of potentials at 0.5g ACF.

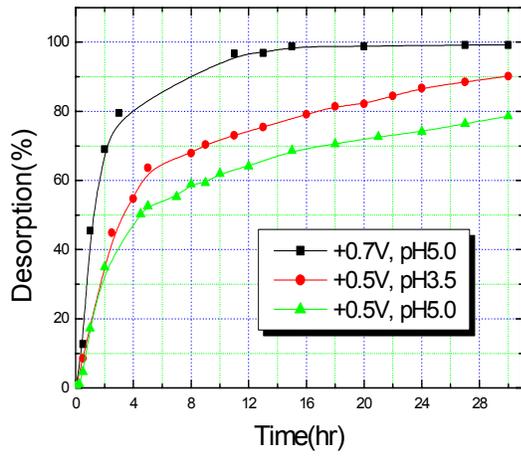


Fig. 2. Desorption % of Co^{2+} with Variation of pH and potentials.

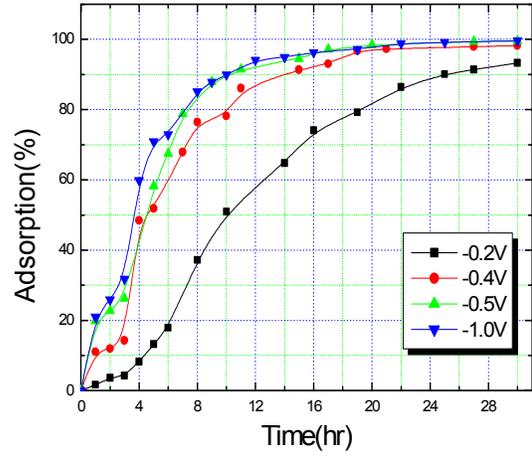


Fig. 3. Electro-adsorption % of Sr^{2+} with Variation of potentials at 0.5g ACF.

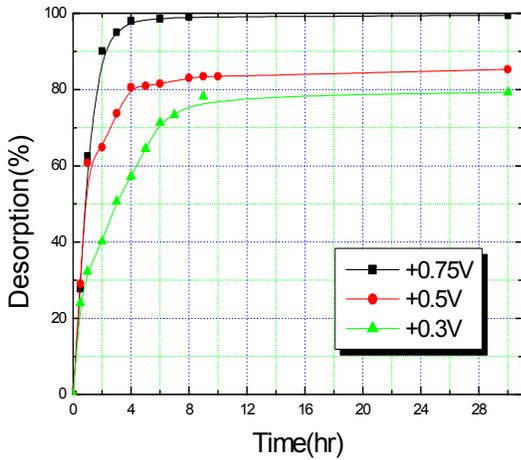


Fig. 4. Desorption % of Sr^{2+} with variation of pH and potentials.

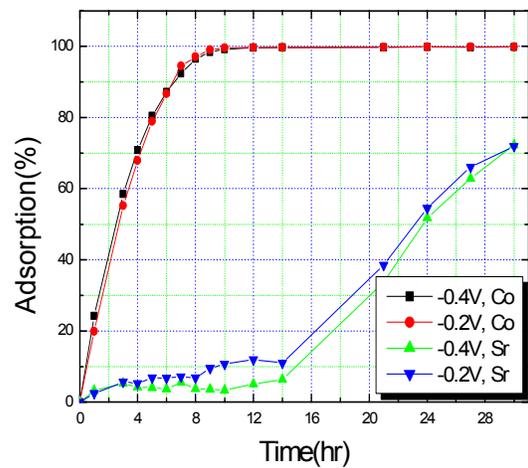


Fig.5. Electro-adsorption % of Co^{2+} and Sr^{2+} in binary systems.