สำนักงานวิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This work studied the adsorption kinetics of metal ions using Dowex50-x8 resin from single-ion and mixed-ion solutions of $Ca^{2+}/Mg^{2+}/H^{+}$ in both batch and fixed-bed operations. The experimental data, which included equilibrium pH values and metal concentrations, were collected by using pH electrode and atomic absorption spectrometer (AAS), respectively. The study started with a determination of the response time of the pH electrode in batch and flow systems. Batch adsorption experiments were then carried out in order to develop the relationship between the concentrations of metal ions on the resin and in the solution at equilibrium (q^e and c^e) and to find the adsorption rate constant (K). The flow characteristics of the column were then investigated. Subsequently, the model for the adsorption kinetics of ion exchange column in the mixed-ion system ($Ca^{2+}/Mg^{2+}/H^{+}$) with downflow or fixed-bed operation was developed and compared with the experimental data. Lastly, the competitive adsorption was examined. From the experimental results, conclusions were drawn as follows:

1. The response time is inversely proportional to the mixing speed. In other words, a high mixing speed gives a faster detection of the pH value of the solution because of the shear effect on the thickness of the stagnant layer around the resin particles. High mixing speeds caused the film to become thinner, thus increasing the mass transfer rate.

2. In both batch and continuous operations, the response time of the pH electrode was found to be in the range of 90-240 seconds, which was too high to accurately measure adsorption rates that occur roughly within 10-20 seconds. Therefore, samples were taken out manually for pH measurements.

3. The adsorption isotherm, which is the relationship between the concentrations of metal ions on the resin and in the solution at equilibrium, was constructed and appeared to follow a Freundlich-type isotherm:

$$q^e = \beta(c^e)^{1/n}$$

The β and n values under various systems are shown in Table 4.3.

4. The adsorption rate expression shown below was developed for describing the adsorption kinetics of ion exchange in fixed-bed operation.

$$r = \frac{dq}{dt} = K(q^e - q)$$

where

$$q^e = \beta(c^e)^{1/n}$$

The rate constant, K, value in the rate of adsorption equation of Ca^{2+} ion in mixed-ion solution is 0.0128 sec^{-1}.

5. From column dynamic studies, the flow characteristics of the column were found to be non-ideal PFR, which can be modeled by one CSTR and one ideal PFR in series with the hypothetical CSTR volume of 3.5 ml.

6. The kinetic model developed in this study for adsorption (Ca^{2+} ions in the mixed-ion solution) in fixed-bed operation was found to fit with the experimental data reasonably well although it was apparent that a small deviation occured at small values of time (up to 200 seconds).

7. From the competitive adsorption studies, the adsorption rates of Ca^{2+} ions both in single-ion and mixed-ion solutions were higher than those of Mg^{2+} ions.

The equilibrium adsorbed fraction of Ca^{2+} ions onto the resin was also higher than that of Mg^{2+} ions both in batch and fixed-bed systems. This is attributed to the higher selectivity of Dowex50-X8 resin towards Ca^{2+} ions than that of Mg^{2+} ions, so the resin prefers Ca^{2+} ions to Mg^{2+} ions. It was also noted that the rate of adsorption for both metal ions was found to increase with increasing the initial metal concentration in both batch and fixed-bed operations. This indicates that the mass transfer resistance in the liquid phase governs the adsorption rate.

8. From the desorption studies, the maximum desorption rate of Mg^{2+} ions was much higher than that of Ca^{2+} ions, indicating that Mg^{2+} ions were easily desorbed from the resin. This can be attributed to the low affinity of the resin towards Mg^{2+} ions as compared to Ca^{2+} ions. Mg^{2+} ions were less preferred by the resin (due to lower the selectivity value) than Ca^{2+} ions, so, the Mg^{2+} ions were released from the resin faster than Ca^{2+} ions.

5.2 Recommendations

1. The mathematical modeling for adsorption kinetics of mixed-ion solution appears to have limitations when used with low initial metal concentrations (e.g., < 0.05 N). The model shows some error in predicting the behavior of metal ion adsorption.

2. Modification of the existing data acquisition program is needed in order to be able to collect more accurate experimental data, because the present program cannot adjust the range of time to collect the experimental data in which the reaction occurs very fast (10-20 seconds).