CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The adsorption kinetics of a cation exchange resin was studied in both batch and continuous flow systems using both single-ion and mixed-ion metal solutions. The exchange between Ca^{2+} (for a single-ion system) or Ca^{2+} / Mg^{2+} (for a mixed-ion system) in the solution and H^{+} on the resin was investigated in these studies under various conditions. The experimental data were collected, which included equilibrium pH values and metal concentrations. The experimental data were used to develop a simple model for the adsorption rate, to study the flow characteristics of the column, and to investigate the competitive adsorption. From the experimental results, conclusions were drawn as follows:

1. The higher the mixing speed, the lower the response time constant; in another word, it was then more efficient to measure the pH value of the solution because of the effect of the mixing speed on reducing 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 100-150 sec, which was too high, because it was impossible to measure adsorption rates that occur roughly within 10-20 sec with a pH electrode that takes 100-150 sec to respond.

3. The adsorption rate expression as shown below was developed for describing the adsorption kinetics of ion exchange in continuous systems in the case of initial concentrations of cation less than 1.7 meq/ml.

$$\frac{dq}{dt} = K(q^e - q), \quad K = 3.1222$$

where

$$q^e = \beta (c^e)^{\frac{1}{n}} \qquad \beta = 0.364219 \quad , \quad n = 2.45$$

4. Regarding flow characteristics, the column was found to be a non- ideal CSTR and could be modeled as one CSTR and one ideal PFR in series with a CSTR volume of 2.5 ml.

5. From the adsorption studies, the adsorption rate of Ca^{2+} ions in both single-ion and mixed-ion solution was higher than that of Mg^{2+} ions. The equilibrium adsorbed fraction of Ca^{2+} ions onto the resin was also higher than that of Mg^{2+} ions in both 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 the Ca^{2+} ions to Mg^{2+} ions.

6. 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 toward Mg^{2+} ions as compared to Ca^{2+} ions. The 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. The time

when the maximum desorption rate occurred for Mg^{2+} ions was also lower than that of Ca^{2+} ions.

5.2 Recommendations

1. The faster response pH electrode (response time constant within 10-20 sec) should be used for pH measurement because it is then possible to measure adsorption kinetics of an ion-exchange occurring in the column that occur around 10-20 sec.

2. The adsorption rate expression should be further developed, especially for the metal concentration close to 1.7 meq/ml.

3. The mathematical modeling for adsorption kinetics of mixed-ion solution should be studied.

4. The adsorption kinetics of both fluidized-bed and fixed-bed should be compared by setting equal amount of resin in the column.