CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this study, the adsorption of reactive red 180 (RR180) and Cu^{2+} ions onto cross-linked chitosan beads (CCB) was investigated in both batch and fixed-bed modes of operation. The experimental work could be divided into three phases, which included CCB preparation, batch adsorption and column operation. The experiments started with casting of chitosan beads from fresh chitosan flake, followed by cross-linking with glutaldehyde to enhance the acid tolerance and mechanical strength of the beads. Batch adsorption experiments were carried out in both single- and mixed-ion systems in order to investigate the adsorption characteristics of CCB and the simultaneous removal of reactive dye and metal ions at difference contaminant concentration and different pH values. The kinetic data were used to determine the initial adsorption rate and the adsorption rate constant while the adsorption isotherms were generated from the equilibrium data to evaluate the adsorption capacity and the adsorption affinity of CCB. In the last part of the study, a glass column packed with CCB was built and used to conduct a preliminary study on the continuous treatment of a simulated textile waste stream. From the experimental results obtained in this study, the conclusions are summarized as follows:

1. The CCB can be easily prepared by using a simple procedure. The beads were found to be quite stable even in acidic solutions, and their physical and chemical properties can simply be modified during the preparation to be suitable for the application in the treatment of textile wastewater.

2. The rates of adsorption of RR180 and Cu^{2+} by CCB in both single- and mixed-ion systems are relatively slow, which has been shown to be due to diffusion limitation by the internal diffusion in the pores of CCB. Waste species such

as dye and metal ions need to diffuse through the internal pore inside CCB to get adsorbed on the sorption sites.

3. From the batch equilibrium studies, the adsorption of both dye and Cu^{2+} were found to be adequately described by Langmuir isotherms, and thus, the maximum adsorption capacity (q) and the adsorption affinity (K_L) can be determined. The adsorption capacities of CCB were quite comparable to those obtained from other natural and natural-derived adsorbents (e.g., activated carbon).

4. The adsorption of RR180 and Cu^{2+} in both single- and mixed-ion systems had strongly pH-dependent characteristics. The higher the pH, the lower adsorption capacity of RR180 was observed. In contrast, more Cu^{2+} ions were adsorbed when pH of the system increases. This can be expected to be due to the protonation and deprotonation of the amine sorption sites on CCB.

5. In mixed-ion systems, the presence of Cu^{2+} was found to enhance the RR180 adsorption by CCB, which was thought to be due to the formation of the polymer-copper atom-dye coordination linkage as reportedly observed in other studies.

6. In the column study, it was observed that the adsorption requires a long time to achieve a good separation because of the adsorption characteristics of CCB, which slowly adsorbed RR180 and Cu^{2+}. Consequently, low volumetric flow rate and low initial waste concentration were inevitably required for CCB column operation which makes the continuous treatment of textile wastewater not quite practical in the present study.

5.2 Recommendations

1. The adsorbent particle size is one of the most important parameter, which strongly affects the adsorption behavior. Reducing the size of the adsorbent particles increases the adsorption performance by improving a mass transfer limitation. Besides, the smaller size can reduce void fraction in case of fixed-bed operation that may enhance the separation in the column operation.

2. To overcome the low adsorption rate of RR180 and Cu^{2+} on CCB, further modifications of the cross-linked chitosan should be considered. This may include lowering degree of cross-linking or using a new cross-linking agent. This modification not only increases the adsorption rate but the adsorption capacity may also be improved such that the cross-linked chitosan bead becomes more applicable for a continuous treatment of textile wastewater.