CHAPTER VII
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Cloud point extraction (CPE) of various organic compounds from aqueous solutions using t-octylphenolpolyethoxylate nonionic surfactant in continuous operation was studied and compared with batch experiments. The CPE performance increased as the degree of hydrophobicity of solutes or K_{ow} increased; and logarithm of CPE partition ratio and logarithm of HTU are linear functions of the logarithm of K_{ow} for various types of solutes. The K_{ow} can be used as a parameter to predict the extraction and partition performance of the solute system in the CPE process, especially for the solutes with same homologous structure. In addition, the CPE performance in continuous operation decreased as the concentration of toluene in wastewater feed was in a higher range, due to the poor phase separation in the extraction column. In contrast, the solute concentration did not significantly affect the solute partition ratio for batch experiments.

Effects of alcohol ethoxylate (AE) nonionic surfactant molecular structure, which are degree of polymerization in the polyethoxylate group (EO number), hydrophobe size (alkyl carbon number) as well as the hydrophobe branching, on CPE of phenol were systematically investigated in batch experiments. The only surfactant structural property which the phenol solubilization equilibrium constant depended on was EO number for both homogeneous and commercial AE surfactants. Phenol partition ratio depended on EO number and fractional coacervate volume at a specified temperature and added electrolyte concentration and could be easily predicted by a proposed equation when only one simple parameter: fractional coacervate volume needed to be measured. The fractional phenol extraction did not depend greatly on surfactant structure. For practical CPE of water containing phenol, an AE surfactant with low EO number (e.g. 5) and a normal commercial range of alkyl carbon numbers (9-13) was recommended for use.

In order to reduce entrainment of coacervate droplets in the rotating disc contactor, it was found that the lower in surfactant feed location did not help the

alleviation of the entrainment, on the other hand declined the toluene extraction efficiency due to the shorter in the contact time between the coacervate stream with wastewater. The designed coacervate settling unit showed high potential in the separation of the coacervate droplets from the dilute phase after the CPE. It was found that the surfactant removal efficiency of the unit is mainly dependent on the settling temperature and residence time; and the optimum conditions were found to be at 40 °C and 60 minutes, respectively which up to 60% of surfactant removal achieved.

7.2 Recommendations

The classes and types of contaminants should be expanded for both continuous CPE and nonionic surfactant molecular structure property studies. The general model and correlation of various contaminants and surfactant molecular structures with CPE efficiency are expected.

An improvement in efficiency of coacervate settling unit for a reduction of surfactant entrainment should be further studied. Multiple settling units could be applied in order to further treat and purify the dilute phase containing less concentrated coacervate from the former unit. Effects of unit size and design (volume, depth, width, length) should be investigated. A new design of the settling unit should be done to minimize the settling disturbance. It is also recommended that the gravitational force should be applied to the column to enhance the settling of the coacervate droplet, or a hydro-cyclone separator may be used to collect the dilute phase stream.

The distributions and correlations of coacervate droplets size, surface area with mass transfer coefficient or HTU and with independent parameters like rotator speed in CPE unit are suggested for a further study.

From the extraction results, it was observed that the high water solubility solutes such as phenol, catechol, and DCE provide very low extraction efficiency in both batch and continuous operations, as their solubilization is limited. The idea of adjusting the property of the nonionic surfactant to increase the solubilization of the polar oils by adding some additives in order to improve the extraction efficiency is

proposed, also a study of new surfactant systems, eg. cationic-anionic surfactant mixtures.