CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this study, we studied the effect of various nonionic surfactants, Brij 30, Tween 80 and Triton X-100, on solubilization and biodegradation of petroleum hydrocarbons in the oil sludge obtained from PTT PLC. The experiments were divided into 2 parts: Solubilization and Biodegradation. In the solubilization studies, effect of the three surfactants on enhancing solubility of hydrocarbons in aqueous was examined at various concentrations. % enhanced solubilization was calculated for total hydrocarbons present in the sludge as well as individual hydrocarbon by using a combination of Total Petroleum Hydrocarbon (TPH) extraction and GC/MS analysis. In the biodegradation studies, batch liquid degradation experiments were carried out using two types of microorganisms; indigenous bacteria originally present in the oil sludge and *Pseudomonas aeruginosa* isolated from petroleum-contaminated site in Thailand. The growth and TPH degradation in the cultures containing different nonionic surfactants were monitored during the course of the biodegradation and compared with the results in the control experiments (no addition of surfactant).

From the solubilization studies, it was found that the addition of nonionic surfactant greatly enhanced the solubilization of hydrocarbons in the oil sludge. The enhancement of the hydrocarbon solubilization increased with increasing surfactant concentration and reached its maximum value at a specific concentration or optimal concentration well above the critical micelle concentration of each surfactant. Increasing surfactant concentration beyond the optimal concentration caused a decrease in the solubilization which may be due to the emulsion stability and partial flocculation of hydrocarbons. Among three surfactants used, Brij 30 was shown to have greater effect on enhancing solubilization than Triton X-100 and Tween 80, but at much higher concentration. The enhancement of solubilization was in the order of Brij 30 > Triton X-100 > Tween 80 which can be attributed to the POE chain and HLB of the surfactant. The degree of enhancement of the solubilization of hydrocarbons was correlated with their water solubility, which nonpolar solutes are

generally less soluble in micelles than the polar compounds. Therefore the solubility capacity is in the order aromatic > cyclic aliphatic > linear aliphatic as observed in this study.

From the biodegradation studies, the indigenous bacteria presented in the sludge was shown to be able to degrade hydrocarbons in the sludge to some extents even without addition of surfactant. However, the biodegradation was greatly enhanced by the addition of the nonionic surfactant, especially Brij 30 and Tween 80. Similar results were observed in the biodegradation of hydrocarbons by *P. aeruginosa*. But using Tween 80 was the most suitable because the highest amount of TPH degradation per weight of nonionic surfactants and the amount of TPH degradation per weight of nonionic surfactants at 7 days both of microorganisms. The results also showed the evidence that the microorganisms could degrade and utilize one of the three nonionic surfactants, Triton X-100, as a carbon source for their growth, leading to lowest extent of biodegradation.

5.2 Recommendations

This study demonstrated that the addition of nonionic surfactant at the appropriate concentration greatly enhanced both solubilization and biodegradation of hydrocarbons in the oil sludge as accessed by batch liquid experiments. In order to apply to industrial applications, the surfactant-enhanced biodegradation should be further studied in a semi-batch or continuous reactor. In addition, other types of microorganisms or mixed cultures could be explored in both batch and continuous modes of operations.