CHAPTER I
INTRODUCTION

Detergency of oily soil, is a complex dynamic process that is affected by several factors such as interfacial tension (IFT) of the system, time, washing temperature, hydrodynamic force exerted during the wash process, the surface characteristics of substrates, water hardness, etc (Azemar, 1996; Verma and Kumar 1998; Whang *et al.,* 2001). In detergency, the term "soil" can be classified into three categories: particulates (solid, usually inorganics), oils (liquid, usually organic), and stains (unwanted dyestuffs) (Carroll, 1996). Oily soil is among the most difficult to remove. Due to the great variability inherent in the substrates and oily soils, detergency cannot be described by a single mechanism but rather involves a number of different and potentially simultaneous mechanisms, depending on the nature of the substrate and the oily soil (Rosen, 2004).

Several mechanisms involve oily soil removal, including roll-up, snap off, and emulsification-solubilization. The roll-up mechanism is facilitated by an increase in contact angle exhibited between the oil droplet and the substrate in the presence of the washing solution (Verma and Kumar 1998). Other mechanisms such as solubilization-emulsification are believed to play an important role in the detergency process as well (Rosen, 2004; Kissa, 1987). Low or ultralow oil/water IFT and high solubilization can be achieved in the Winsor Type III microemulsions region. The correlation between microemulsion formation and detergency has been intensively studied (Bityut and Satya, 2001; Dillan *et al.,* 1980; Rybinski, 2002; Tongcumpou *et al.,* 2003a; Tongcumpou *et al.,* 2003b; Tongcumpou *et al.,* 2005). It has been shown that the maximum detergency corresponds to the optimum conditions of the system where the minimum oil/water IFT of the microemulsion exists (Robbins, 1977). For a nonionic surfactant system, the optimum occurs at the phase inversion temperature (PIT). In a system with ionic surfactants, the salt concentration at optimum, which is known as the optimum salinity, produces minimum IFT (Broze, 1994).

Hydrophilic and lipophilic linkers are molecules which can decrease the rigidity and increase the thickness, respectively, of the interfacial layer between the oil and water phases which can result in more rapid microemulsion formation and lower oil/water IFT in microemulsion systems (Acosta *et al.,* 2002a; Acosta *et al.,* 2002b; Acosta *et al.,* 2003; Graciaa *et al.,* 1993a; Graciaa *et al.,* 1993b). In previous studies (Tongcumpou *et al.,* 2003a; Tongcumpou *et al.,* 2003b; Tongcumpou *et al.,* 2005), formulations of mixed surfactants based on the linker concept were used to form microemulsions with both motor oil and hexadecane in detergency studies. Three surfactants used, in decreasing order of hydrophilicity, were: alkyldiphenyl oxide disulfonate (ADPODS), sodium dioctyl sulfosuccinate (AOT), and sorbitan monooleate (Span 80). The mixture of these three surfactants exhibited both ultralow IFT and relatively high solubilization with both studied oils (Tongcumpou *et al.,* 2003a). For this primarily anionic surfactant system, as salinity increased, the system transitioned from a Winsor Type I to III to II microemulsion. In a Type I system, the surfactant is mostly in a water phase in equilibrium with an excess oil phase. In a Type III system, a third or middle phase containing the surfactant is in equilibrium with an excess water and oil phases. In a Type II system, the surfactant is present mostly in the oil phase in equilibrium with an excess water phase. The lowest IFT was found in the Winsor Type III region. The supersolubilization region, which is in the Winsor Type I microemulsion region close to the transition zone between the Winsor Type I and Winsor Type III microemulsion regions, was found to achieve oil removal almostly as high as that for a Winsor Type III system (Tongcumpou *et al.,* 2003b). Under the Winsor Type III microemulsion condition, the low oil removal in the wash step was due to the spreading effect (Tongcumpou *et al.,* 2005).

In previous studies, the optimum salinity was found to be 16% NaCl (Tongcumpou *et al.,* 2003a), which is quite high for this primarily anionic surfactant system of 3% AOT, 2% ADPODS and 2% Span 80. As a consequence, in this follow up study, the surfactant composition was adjusted in an effort to reduce this optimum salinity based on the linker concept of microemulsion formation with motor oil.

From previous work, in both the supersolubilization and middle phase regions, the oil removal in the rinse step was found to be as high as that in the wash step, in contrast to the commercial detergent where soil removal occurs predominantly in the wash step (Tongcumpou *et al.,* 2003b). In order to further evaluate this unique aspect of microemulsion-based detergency, in the first part of this study, the oil/water IFT was related to the oil removal in the rinse step and the effects of the volume rinsing water and number of rinses on the soil removal was studied. For the second part, the concentrations of surfactant in both the washing and rinsing baths were investigated in order to study the effect of surfactant partitioning onto either the soiled and unsoiled fabric on the washing performance. Moreover, to follow up the first part of this work on studying the effect of rinsing method, the concentration of surfactant in each step at different rinse cycle designs was measured in order to determine the proper amount of rinsing water used to achieve acceptable residual surfactant left on the fabric/soil surface with a high oil removal as described in Chapter V. For Chapter VI, the effects of water hardness and builder on the phase behavior and detergency performance were investigated. Moreover, the overall conclusions and recommendations are summarized in Chapter VII.

Beyond the research work described in this book, palm oil, a vegetable oil, was also studied for detergency. In this work, the palm oil removal from fabric using mixed surfactants under microemulsion conditions was investigated.