# CHAPTER 1

## INTRODUCTION

### 1.1 Background

Recently, surfactant-based processes have been widely studied for use in environmental applications, including surfactant-based separation processes, micellar enhanced solubilization for enhanced contaminant extraction, and surfactant-modified materials for treating wastes and for landfill liners or subsurface barriers to reduce contaminant transport (Harwell and O' Rear, 1989; Rouse et al., 1996; Sun and Jaffe, 1996; Butler and Hayes, 1998; Sabatini et al., 2000; Cheng and Sabatini, 2001). In all of these applications, surfactant adsorption onto solid surfaces is of interest. When undesirable, surfactant adsorption can render a design ineffective and significantly increase dosage requirements and thus hinder the economics of the system.

Conversely, surfactant aggregates adsorbed at the solid-liquid interface can act as two-dimensional solvents, and organic solutes can partition into the adsorbed surfactants. This phenomenon, known as adsolubilization, has been widely studied in recent years (Harwell and O' Rear, 1989). Adsolubilization has been used in many applications such as admicellar-enhanced chromatography (AEC), which is a new fixed-bed separation process based on using surfactants to induce adsorption of organic solute from the aqueous stream. Admicellar polymerization is a key process that may be used to form ultra-thin films on a substrate. Adsolubilization of pharmaceutical products by food-grade surfactants can be applied in pharmaceutical formulations. Other potential applications include water and soil remediation and surfactant-enhanced oil recovery.

In all of these applications of admicelles, this goal is to maximize surfactant adsorption on the solid surface while minimizing the amount of surfactant required to maintain the level of surfactant adsorption. Since the maximum surfactant adsorption occurs at the surfactant critical micelle concentration (CMC), the goal can be achieved by minimizing the CMC of the surfactant. Since the CMC of mixed anionic and cationic surfactants is much lower than otherwise possible, these systems will be evaluated in the current research.

Mixed anionic and cationic surfactant systems exhibit the greatest synergism when it comes to reducing the CMC. The CMC of the mixed surfactant systems can be reduced by as much as two to three orders of magnitude as compared to the single surfactant system. Despite this exciting potential synergism, the tendency of mixed anionic and cationic surfactant system to precipitate has limited their use in many applications. However, a great deal of recent research studies on mixed anionic and cationic surfactant systems has found ways to mitigate the precipitation potential (Li et al., 1999; Marques et al., 1993). Previous research demonstrated that mixed anionic and cationic surfactants having twin-head anionic surfactants and conventional cationic surfactants were less susceptible to precipitation in solution due to the different structure of each surfactant (Doan et al., 2002).

The purpose of this research is to maximize surfactant adsorption onto alumina while minimizing the aqueous surfactant concentration by using mixed anionic and cationic surfactants. Maximum surfactant adsorption is achieved because mixed anionic and cationic surfactants increase the adsolubilization capacity of organic solutes of the mixed adsorbed surfactant aggregates onto alumina. These results can be useful in many fields including surfactant-enhanced contaminant remediation, surfactant modification to surfaces, nano-templating and surfactant-enhanced oil recovery.

## 1.2 Objectives

The main objective of this study is to investigate the adsorption characteristics of mixed anionic and cationic surfactants, twin-head anionic surfactant and conventional cationic surfactant system, onto positively charged alumina in batch equilibrium experiments. The electrolyte concentration, solution pH, and temperature are fixed as constant parameters. The specific objectives of this study are:

1. To investigate how the mole ratio of anionic and cationic surfactants in solution affects the adsorption of the anionic and cationic surfactants onto alumina.
2. Identify the critical micelle concentrations (CMCs) of mixed anionic and cationic surfactants onto alumina surface through establishing the point of plateau adsorption in batch studies.
3. To investigate the solubilization and adsolubilization of organic solutes with polar and nonpolar organic solutes by mixed anionic and cationic surfactant system