แอดไมเซลและแอดโซลูบิไลเซชันด้วยโมเลกุลลิงเกอร์และสารลดแรงตึงผิวที่มีส่วนขยายบนพื้นผิวอะลูมินาออกไซด์

นางสาวอัมพิรา เจริญแสง

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ADMICELLES AND ADSOLUBILIZATION USING LINKER MOLECULES AND EXTENDED SURFACTANTS ONTO ALUMINUM OXIDE SURFACE

Miss Ampira Charoensaeng

A Dissertation Submitted in Partial Fulfillment of the Requirements
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THESIS TITLE	ADMICELLES AND ADSOLUBILIZATION USING LINKER MOLECULES AND EXTENDED SURFACTANTS ONTO ALUMINUM OXIDE SURFACE
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อัมพิรา เจริญแสง : แอดไมเซลและแอดโซลูบิไลเซชันด้วยโมเลกุลลิงเกอร์และสารลดแรงตึงผิวที่มีส่วนขยายบนพื้นผิวอะลูมินาออกไซด์ (ADMICELLES AND ADSOLUBILIZATION USING LINKER MOLECULES AND SURFACTANTS ONTO ALUMINUM OXIDE SURFACE) อ. ที่ปรึกษา : รศ. ดร. สุธา ขาวเธียร, อ. ที่ปรึกษาร่วม PROF. DAVID A. SABATINI, PH.D. 214 หน้า.

ตัวกลางสำหรับการดูดซับที่เพิ่มประสิทธิภาพด้วยสารลดแรงตึงผิว ได้มีการพัฒนาและนำมาใช้อย่างกว้างขวางในงานประยุกต์ทางด้านอุตสาหกรรมและสิ่งแวดล้อม สารลดแรงตึงผิวที่ดูดซับอยู่บนตัวกลางจะทำหน้าที่เพิ่มความสามารถในการดูดซับบนพื้นผิวของสารอินทรีย์ที่อยู่ในน้ำโดยผ่านกระบวนการแอดโซลูบิไลเซชัน สารลดแรงตึงผิวที่ใช้ในการศึกษานี้ คือ สารลดแรงตึงผิวชนิดผสมโมเลกุลลิงค์เกอร์ และสารลดแรงตึงผิวที่มีโพรพิลีนออกไซด์แทรกอยู่ระหว่างโมเลกุลเป็นส่วนขยาย ในงานวิจัยนี้ได้ศึกษาสมบัติของสารลดแรงตึงผิวชนิดผสมโมเลกุลลิงค์เกอร์และสารลดแรงตึงผิวชนิดที่มีส่วนขยาย ต่อการจัดเรียงตัวของแอดไมเซลและการเพิ่มการดูดซับสารอินทรีย์บนตัวกลางอะลูมิน่าชนิดประจุบวก โดยกระบวนการการดูดซับโดยการแอดโซลูบิไลเซชัน และการโซลูบิไลเซชัน ผลการศึกษาพบว่าในกระบวนการดูดซับ สารลดแรงตึงผิวชนิดผสมกับโมเลกุลลิงค์เกอร์มีระดับการดูดซับสูงสุดมีค่าสูงกว่าสารลดแรงตึงผิวชนิดที่มีส่วนขยาย แต่สารลดแรงตึงผิวที่มีส่วนขยายนั้นมีการใช้ปริมาณสารลดแรงตึงผิวในปริมาณต่ำกว่าเพื่อให้เกิดการดูดซับระดับปริมาณการดูดซับสูงสุด ในการศึกษากระบวนการแอดโซลูบิไลเซชัน และโซลูบิไลเซชันใช้สารอินทรีย์ 3 ชนิด ที่มีความเป็นขั้วต่างกัน ได้แก่ ฟีนิลเอทานอล สไตรีน และ เอทิลไซโคลเฮกเซน โดยประเมินประสิทธิภาพการดูดซับสารอินทรีย์จาก ค่าสัมประสิทธิการดูดซับสารอินทรีย์ในไมเซล และค่าสัมประสิทธิ์การดูดซับสารอินทรีย์ในแอดไมเซล จากผลการศึกษาพบว่าสารลดแรงตึงผิวชนิดที่มีส่วนขยายมีประสิทธิภาพการเพิ่มการละลายและการดูดซับของสารอินทรีย์บนตัวกลางมีค่าสูงกว่าสารลดแรงตึงผิวชนิดผสมโมเลกุลลิงค์เกอร์ และพบว่ากลุ่มโพรพิลีนออกไซด์ในสารลดแรงตึงผิวชนิดที่มีส่วนขยายจะมีผลต่อการเพิ่มการดูดซับสารอินทรีย์ที่มีความเป็นขั้วสูง (ฟีนิลเอทานอล) มากกว่าการเพิ่มจำนวนกลุ่มโพรพิลีนออกไซด์และจำนวนคาร์บอนส่วนหาง สำหรับสารอินทรีย์ที่มีความเป็นขั้วต่ำกว่า (เอทิลไซโคลเฮกเซน) เมื่อจำนวนกลุ่มของโพรพิลีนออกไซด์และจำนวนคาร์บอนส่วนหางของโมเลกุลสารลดแรงตึงผิวเพิ่มขึ้นจะทำให้ประสิทธิภาพการดูดซับเพิ่มมากขึ้น ผลการเปรียบเทียบความสามารถในการละลายของสารอินทรีย์ในแอดไมเซลต่ำกว่าในไมเซล ทั้งนี้เนื่องจากแอดไมเซลมีพื้นที่ในการละลายสารอินทรีย์น้อยกว่า จากการศึกษาพบว่าสารลดแรงตึงผิวชนิดที่มีส่วนขยายมีประสิทธิภาพในการเพิ่มการละลายและการดูดซับสารอินทรีย์บนตัวกลางอย่างเห็นได้ชัด และยังมีการสูญเสียสารลดแรงตึงผิวจากพื้นผิวน้อยกว่าเมื่อเทียบกับสารลดแรงตึงผิวชนิดผสมโมเลกุลลิงค์เกอร์ละสารลดแรงตึงผิวชนิดทั่วไป ดังนั้นตัวกลางสำหรับการดูดซับที่เพิ่มประสิทธิภาพด้วยสารลดแรงตึงผิวชนิดที่มีส่วนขยายสามารถนำไปใช้งานในด้านของการบำบัดน้ำเสีย และมลพิษทางน้ำใต้ดินที่มีปนเปื้อนไปด้วยสารอินทรีย์

ลายมือชื่อ Ampira Charoensaeng

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KEY WORD: ADMICELLE / ADSOLUBILIZATION/ EXTENDED SURFACTANT / LINKER MOLECULE / ADSOPTION

AMPIRA CHAROENSAENG : ADMICELLES AND ADSOLUBILIZATION USING LINKER MOLECULES AND EXTENDED SURFACTANTS ONTO ALUMINUM OXIDE SURFACE. THESIS ADVISOR : ASSOC. PROF. SUTHA KHAODHIAR, PH.D., THESIS CO-ADVISOR : PROF. DAVID A. SABATINI, PH.D., 214 PP.

Surfactant-modified adsorbents have been widely used for industrial and environmental applications. Surfactant aggregates adsorbed at the solid/liquid interface are capable of solubilizing organic solutes due to the partition of organic solute from the aqueous phase known as adsolubilization. The surfactants used in this study were linker-based surfactant system and extended surfactant which has propylene oxide group of intermediate polarity, inserted between head and tail of the surfactant molecule. The impact of linker-based and extended surfactant properties on admicelle formation and organic solute adsolubilization were evaluated through adsorption and adsolubilization and solubilization studies on positively charged aluminum oxide surface. While linker-based systems achieved a higher maximum adsorption than extended surfactants, the extended surfactants reached maximum adsorption at a lower aqueous surfactant concentration. The three organic solutes with varying the degree of polarity from high to low value including phenylethanol, styrene, and ethylcyclohexane were evaluated in solubilization and adsolubilization studies. The results are summarized by the extent of solute solubilization into micelle and admicelle, as captured through micellar partition coefficient, (K_{mic}) and admicellar partition coefficient (K_{adm}). The extended-surfactant-based micelle and admicelle system showed greater solubilization capacity than the linker-based system. For the high polarity solute (phenylethanol), the presence of propylene oxide group (PO) has a greater effect than the number of PO groups or the tail length, while for the low polarity solute (ethylcyclohexane) as the number of POs groups and the tail length increased, the adsolubilization capacity also increased. These results thus provide insights into linker-based and extended-surfactant-based admicellar systems and highlight the differences observed from admicelles based on conventional surfactant system. The comparison of adsolubilization capacity (K_{adm}) was lower than solubilization capacity (K_{mic}) due to the tighter packing density observed in the surface admicelles may have squeezed out the area where enhanced solubilization was experienced in micelles. The extended-based surfactant system demonstrated solubilization and adsolubilization enhancement and significantly lower desorption potential compared to the linker-based surfactant and conventional surfactant system. Thus, the surface modification by extended surfactants shows particular promise for treatment of groundwater and wastewater contaminated with organic solutes

Field of study Environmental Management Student's signature Ampira Charoensaeng

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Finally, I am proud to delicate this dissertation with respect to my beloved parents, Amporn and Poolsub Charoensaeng, and my brother for their love, encouragement, understanding, and their support through the year.

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Surfactant-modified colloidal materials have been widely used for industrial and environmental applications. Surfactant aggregates adsorbed at the solid-liquid interface are capable of solubilizing organic solutes due to the partition of organic solute from the aqueous phase. This phenomenon, known as adsolubilization has been widely studied in recent years. Adsolubilization process has been applied in many applications, including admicellar-enhanced chromatography (AEC), admicellar polymerization, adsolubilization of solid phase extraction (SPE) for pharmaceutical products, wastewater treatment, soil remediation, and landfill liner or subsurface barriers to mitigate contaminant transport. Classes of surfactant known as linker-based surfactant systems and extended surfactant based system have been introduced to improve the solubilization of organic solutes. The lipophilic linker (i.e., dodecanol) segregates near the surfactant tail and helps to improve the solubilization capacity. The linker molecule serves as a link between the surfactant tail and oil molecule through this association the linker molecule promotes orientation of oil molecules in the oil phase and increases interaction with segregation deeper into the oil side of interface. A novel surfactant, extended surfactant has a region of intermediate polarity of polypropylene oxide (PO), inserted between hydrophilic head and lipophilic tail of the surfactant structure. Due to their unique molecular structure, the extended surfactant shows the capability of solubilization of organic solute.

This research aims to enhance the ability of surfactant adsorbent materials to remove organic contaminant through the surfactant-based adsorption process. Since the linker-based surfactant system and extended surfactant system have shown improved solubilization in aqueous systems. However the performance of the surfactant systems have not been systematically studies. Thus, the purpose of this study is to evaluate the effect of linker-based surfactant system and extended- surfactant-based system to both surfactant adsorption and adsolubilization of organic solutes onto positively charged aluminum oxide surface. An increased understanding of the surfactant adsorption mechanism, both in adsorbed layer at liquid/solid interface and in aqueous micelles has implications in several applications including surfactant modified adsorbent for industrial application and environmental remediation. To our knowledge, this is the first time that extended-surfactant-based admicelles have been evaluated.

1.2 OBJECTIVES

The overall objective of this research is to evaluate the impact of external linker system, lipophilic linkers, and internal linker system, extended surfactants on the surfactant adsorption and adsolubilization of organic solutes onto positively charged aluminum oxide surface. The electrolyte concentration, solution pH, and temperature are controlled under constant condition in batch equilibrium systems. The specific objectives of this research are:

1) To evaluate the impact of internal and external linker system on adsorption and adsolubilization of polar and nonpolar organic solutes

2) To study the effect of number of propylene oxide (PO) group in anionic extended surfactants on the surfactant adsorption and adsolubilization of polar and nonpolar organic solutes

3) To study the effect of surfactant desorption of internal and external linker system adsorbed onto aluminum oxide surface.

4) To study surface characterization of adsorbed surfactant/admicelle onto solid surface.

1.3 SCOPES OF THE STUDY

This research aims to enhance the ability of adsorbent material to remove organic contaminant through the surfactant-based adsorption process. The surfactant adsorption, solubilization and adsolubilization isotherm of organic solutes is used to evaluate the impact of linker molecules and extended surfactants onto positively charged aluminum oxide surface, in batch adsorption/desorption experiments under constant solution pH of 7.0±0.5, electrolyte concentration of 0.001 M NaCl and room temperature (25±2^{o}C). The solubilization and adsolubilization of organic solutes with varying degree of polarity from polar to nonpolar are conducted to evaluate the solubilization capacity of organic solutes in micelle and admicelle, through micellar and admicellar partition coefficient (K_{mic} and K_{adm}), respectively. The adsorbed surfactant or admicelle onto solid surface were characterized by various characterization techniques.

1.4 HYPOTHESES

Based on surfactant adsorption phenomena, while the ionic head of surfactant affects the adsorption of the surfactant onto oppositely charged solid oxide surface, the hydrophobic tail of the surfactant plays role with the organic solute which partition to the adsorbed admicelles onto the solid surface. We hypothesize that the characteristic of hydrophobic region of admicellar system affect the adsolubilization capacity of organic solutes. Thus, we could formulate and modify the adsorbent materials to enhance the ability of adsolubilization which lead to removal efficiency of organic contaminants. The specific hypotheses of this research are:

1) Enhanced adsolubilization with linker/extended surfactant systems due to increased size of interior of admicelle.

2) Above some PO number the surfactant adsorption and thus adsolubilization will decrease due to increase area per molecule.

3) External linkers will have an intermediate effect between that if conventional and extended surfactant systems for polar solutes due to a less increase in palisade layer than for extended surfactants

4) Surface characteristic of adsorbed surfactant aggregates or admicelles can be visualized by SEM and/or AFM techniques.

CHAPTER II

THEORETICAL BACKGROUNDS AND LITERATURE REVIEWS

2.1 SURFACTANT PHENOMENA

Surfactants (*Surface active agents*) which are commonly known as soaps or detergents, are called **amphiphiles** because of their unique and interesting characteristic that they have both a polar, hydrophilic head group, (water-like) and a nonpolar, hydrophobic tail group (oil-like) in the same molecule. Because of their amphiphilic nature, surfactants accumulate in interfacial regions (e.g.; water-oil, water-air, liquid-solid interfaces) and thereby reduce the interfacial energy of these systems (Rosen, 1989). Surfactants are classified according to the nature of the hydrophilic portion of the molecule: anionic surfactants (negatively charged head groups), cationic surfactant (positively charged head groups), zwitterionic surfactant (negatively and positively charged head groups) and nonionic surfactant (non charged head groups).

Depending on the surfactant concentration in aqueous solution, surfactants are capable of forming many different types of aggregates. At low concentration, surfactants exist independent of one another in the solution phase and are called **monomers**. Surfactant monomers will accumulate at interfaces present in the system. When the surfactant concentration exceeds a certain level, surfactant monomers self-aggregate into spherical aggregates known as **micelles**. In a micelle, the individual monomers are oriented with their hydrophilic head group facing the water or aqueous phase and their hydrophobic tail group oriented into the interior of the spherical aggregates. Micelles form when the surfactant concentration first exceeds the **critical micelle concentration** (**CMC**), a value which varies depending on the surfactant. As additional surfactant is added above the CMC, the incremental surfactants go to form additional micelles (West and Harwell, 1992)

Surfactant micelles, with hydrophilic head group (polar moieties) at the exterior and hydrophobic tail group (non polar moieties) in the interior, exhibit certain unique properties. The polar exterior makes a micelle highly soluble in water, while the non-polar interior provide a hydrophobic sink for organic compounds, which can effectively increase the solubility of organic compounds. Therefore solubility of the organic contaminant increases with increasing the micelle concentration in the solution, adding surfactant concentration above the CMCs.

When a solid phase is added to the surfactant solution, the surfactants will adsorb at the solid-liquid interface. At low surfactant concentrations, surfactant begins to adsorb and form micelle-like structures are called **hemimicelles** and **admicelles**, depending on whether the aggregates have one or two surfactant layers (as shown in Figure 2-1). Once the CMC is reached, additional surfactant of surfactant does not increase the amount of adsorbed surfactants, but rather an increase in the concentration of micelles in aqueous solution. Similar in nature to a micelle, the adsorbed admicelle has ability to solubilizing organic solute as micelle in aqueous phase.

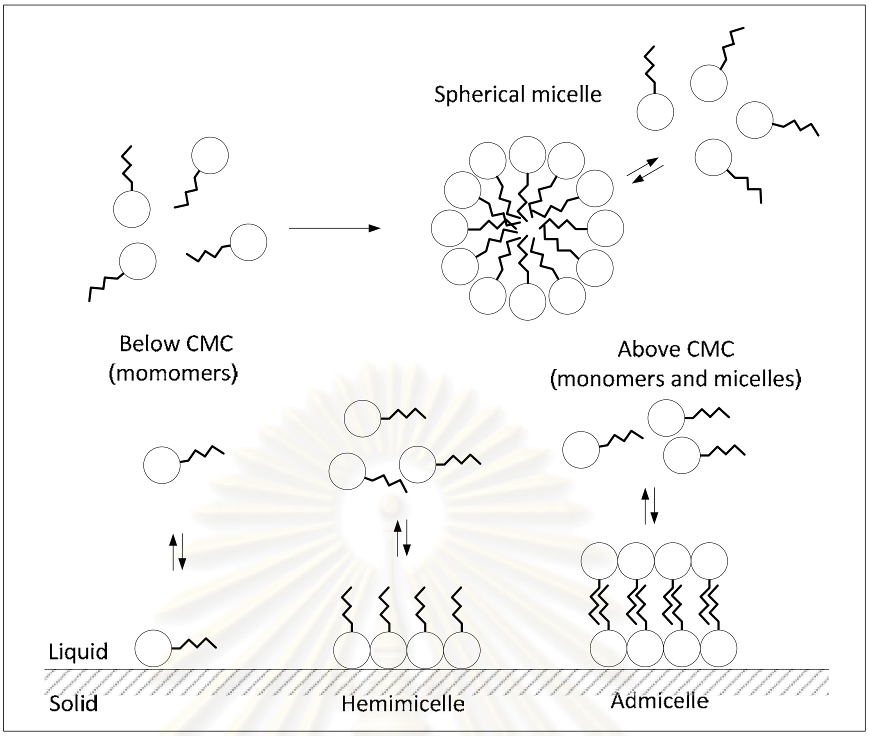


Figure 2-1 Example of surfactant micellization

2.2 ADSORPTION OF IONIC SURFACTANTS ONTO METAL OXIDE SURFACES

2.2.1 Surfactant Adsorption Phenomena

Surfactant adsorption onto metal oxide surfaces (e.g., aluminum oxide) is a complex process since adsorption can occur by ion exchange, ion pairing and hydrophobic bonding mechanisms. Surfactant adsorption at liquid-solid interfaces is characterized by adsorption isotherms (Rosen, 1989). The adsorption isotherm of ionic surfactants onto oppositely charged metal oxide surfaces is typically an **S-shaped isotherm** (Somasundaran and Fuerstenau, 1966; Scamehorn et al., 1982). Normally the S-shaped isotherm can be divided into four regions, as shown in Figure 2-1.

Region I corresponds to low aqueous surfactant concentration and thus low surfactant adsorption. This region is commonly referred to as the Henry's Law region because in this region monoisomeric surfactants are generally adsorbed in a linear manner. In the Henry's Law region, surfactants are adsorbed mainly by ion exchange, with the hydrophilic surfactant head groups adsorbing onto the solid surface. Adsorbed surfactants in this region are shown as being adsorbed independently without forming surfactant aggregates.

Region II is characterized by a sharply increased isotherm slope relative to the slope in the Region I, which is a general indication of the onset of cooperative effects between adsorbed surfactants: the surface coverage increases significantly due to surfactant tail-tail interactions between absorbing surfactants. This increase in slope indicates the beginning of bilayer surfactant adsorption resulting from interaction of the hydrophobic chains of oncoming surfactants with those of previous adsorbed surfactants. These aggregates, which occur at concentrations well below the critical micelle concentration (CMC) of the surfactant, are called admicelles or hemimicelles, depending on whether their structures are formed as being local **bilayers** or local **monolayers**, respectively. The admicelle is considered as a bilayer with the lower layer of head groups adsorbed onto the solid surface and the upper layer of head groups are facing to the solution. The hemimicelle is considered as a monolayer with the head group of surfactant adsorbs onto the solid surface while the tail group contacted with the solution.

Region III is characterized by a decrease in the isotherm slope relative to the slope in Region II. This decrease in slope is attributed to lateral electrostatic repulsion between adjacent surfactant adsorbing on the surface and/or the beginning of admicelle formation on lower energy surface patches.

Region IV is the plateau adsorption region for increasing surfactant concentration. Generally, the equilibrium surfactant concentration at the transition point from Region III to Region IV is approximately at the CMC of the surfactant. For the adsorption of surfactants from the aqueous solution, this will correspond to maximum bilayer coverage for ionic surfactants adsorbed on oppositely charged surfaces or to monolayer completion for adsorption on hydrophobic surfaces.

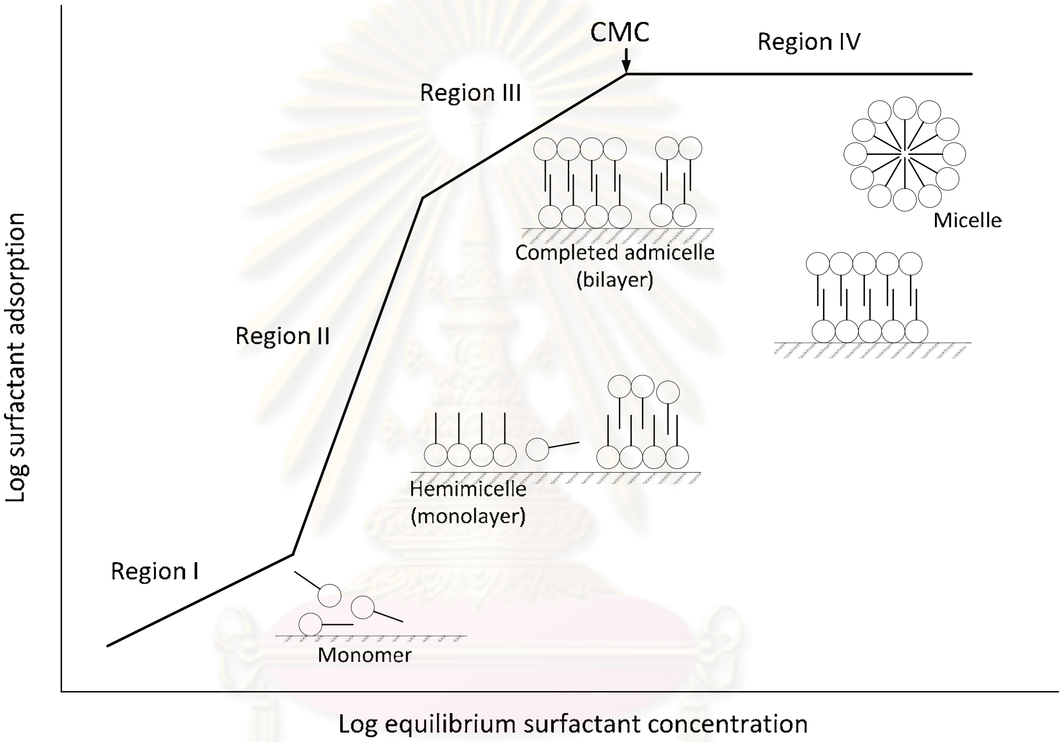


Figure 2-2 Schematic presentation of typical surfactant adsorption isotherm

Typically, adsorbed surfactant onto solid surface is quantified through calculation in Equation 2-1 (Lopata, 1988 and Fuangswasdi et al., 2006 a). In this equation, the adsorption of water or salt is assumed to be negligible and the adsorption of the surfactant is assumed to have no effect on solution density.

$$\Gamma_i = \frac{(C_i - C_f)V}{W_g} \tag{2-1}$$

Where;

Γ_i = Adsorption density of surfactant i (mole/g)

V = Volume of sample (liter)

C_i = Concentration of surfactant at initial (mole/liter)

C_f = Concentration of surfactant at equilibrium (mole/liter)

W_g = Weight of aluminum oxide (g)

2.2.2 Aluminum Oxide Surface Structure

The crystal structure of alpha alumina oxide (α-Al_2O_3) or alumina is made up of hexagonally packed oxygen atoms layers stacked on top of each other in an offset manner, with aluminum ions packed between the oxygen layers (Lopata, 1988) as shown in Figure 2-3

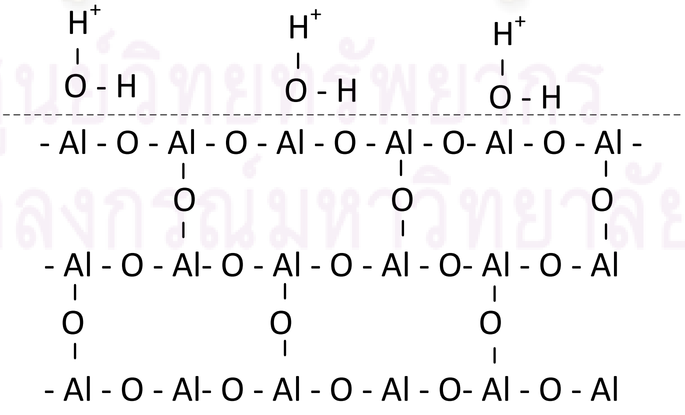


Figure 2-3 Schematics of crystal structure and surface layer of alpha aluminum oxide

Upon contact with water, the crystal surface forms a layer of hydroxyl ions by a two step process involving the chemical adsorption of monolayer of water and its dissociation. Since alumina surface is covered with hydroxyl groups, hydrogen and hydroxyl ions are potential determining ions for aluminum oxide. There is also a physically adsorbed layer of water molecules on top of the layer of hydroxyl ions. Therefore, the solution pH is critical for adsorption of ionic surfactants because it controls the charged of the alumina surface.

The solution pH at which alumina has a net surface charged density of zero is called the point of zero charge (PZC). The PZC of alumina at 25°C has been reported to be pH 9.1 (Sun and Jaffe, 1996). At a solution pH below the PZC (< 9.1), the alumina surface is positively charged; on the other hand, alumina surfaces once negatively charged when the solution pH is above the PZC (>9.1). Alumina has been extensively studied as a positively charged adsorbent for anionic surfactants and mixed anionic and nonionic surfactants (Scamehorn et al., 1989; Sun and Jaffe, 1996; Fuangswasdi et al., 2006a).

2.2.3 Parameters Affecting Surfactant Adsorption

The adsorption of surfactants at solid-liquid interfaces is strongly influenced by a number of parameters; 1) the nature of structural groups of the solid surface i.e., alumina, silica, and zeolite; 2) the molecular structure of surfactant being adsorbed; 3) the environment of aqueous solution i.e., solution pH, electrolyte concentration, and temperature. Together these parameters determined the mechanism, by which the adsorption occurs, and the efficiency and effectiveness of the surfactant adsorption (Rosen, 1989; Kitiyanan et al., 1995).

The nature of structural group of the solid surface (negatively charged aluminum oxide was used in this study) has already been mentioned above (section 2.2.2). The other parameters that effect surfactant adsorption are solution pH, electrolyte concentration and temperature are described below;

2.2.3.1 Solution pH

A solution pH usually causes marked changes in the adsorption of ionic surfactants on to charged solid surfaces. As the pH of the aqueous solution is lowered, alumina surface becomes more positive or less negative because of additional protons adsorbing form the solution, phase. This consequently increases the adsorption of anionic surfactants and decrease in the adsorption of cationic surfactants (Rosen, 1989). When anionic surfactants adsorb onto alumina, the equilibrium pH is usually higher than the initial solution pH because the anionic surfactants ion exchange with the adsorbed counter ions and hydroxyl ions on the alumina surface (see Figure 2-2). Therefore, the equilibrium pH and the surfactant adsorption are closely related to surfactant adsorption.

2.2.3.2 Electrolyte Concentration

Similar to micelle in aqueous solution, counter ions which are present in the surfactant solution are also present in the surfactant admicelles onto solid-liquid interface. Counter ions can affect the adsorbed surfactant by reducing the electrostatic charged repulsion between ionic surfactant head groups. When counter ions are present in the system, the admicelles are formed more easily due to the lower charged repulsion between ionic surfactant head group. Admicelle patches with the complete bilayer are also capable for larger aggregation number of surfactant admicelles. As concentration of counter ions in aqueous solution increased, the maximum surfactant adsorption also increased (Rosen, 1989).

2.2.3.3 Temperature

Temperature increases generally causes a decrease in the efficiency and effectiveness of adsorption of adsorption of ionic surfactants (Rosen, 1989; Saphanuchart et al., 2008). The effect of temperature is relatively small compare to that of solution pH. However, a rise in temperature usually results in an increase in the adsorption of non-ionic surfactants containing a polyelectrolyte chain as the hydrophobic group.

Surfactant adsorption onto solid oxide surfaces has been studied for various types of conventional surfactant systems i.e., anionic (Scamehorn et al., 1982; Sun and Jaffe, 1996), cationic (Kitiyanan et al., 1996; Dickson and O' Haver, 2002) and mixed surfactant systems to enhance their adsorption capacity (Harwell and Scamehorn, 1992). Mixed surfactant systems studied include mixed anionic and nonionic surfactant (Lopata, 1988), mixed anionic and cationic surfactant (Fuangswasdi et al., 2006 a and b), and mixed nonionic and linker molecules (Tan and O' Haver, 2004). Mixed anionic and cationic surfactant systems exhibit excellent synergism and the greatest diversion form ideal mixing behavior (Harwell and Scamehorn, 1992). Adsorption of mixed anionic and cationic surfactants has received limited attention (Huang et al., 1989; Fuangswasdi et al., 2006a) due to the tendency of precipitation of these systems. Recently, the adsorption of various lipophilic linker molecules in nonionic surfactants, polythoxylated octylphenols, on to silica surface has been investigated (Tan and O' Haver, 2004)

2.3 SOLUBILIZATION AND ADSOLUBILIZATION OF ORGANIC SOLUTES

Surfactant molecule consists of two-parts; hydrophilic head or water-like part and hydrophobic tail or oil-like part in the same molecule. When surfactant monomers form spherical aggregates (micelles), these aggregates are capable of solubilizing organic solutes.

In addition, adsorbed surfactant molecules onto solid-liquid surface act as two-dimensional aggregates or so called admicelle or hemimicelle**,** depending on whether they form monolayer or bilayer coverage. At high surfactant concentration, the surfactant bilayers arrange with the surfactant head group of bottom layer adsorbed onto solid surface and other head groups of the top layer positioned toward to the aqueous solution. The tail of surfactants forms a hydrophobic core to the adsorbed surfactant due to the tail-tail interactions. This admicelle core adsolubilizes organic solutes similar solubilization in micelles (Nayyar et al., 1994; Dickson and O'Haver, 2002); the partitioning of organic solutes into the interior of admicelles is known as the **adsolubilization** process (Scamehorn and Harwell, 1989). Generally, adsolubilization is the partition of organic solutes into the interior of adsorbed surfactant aggregates or **admicelle**. This phenomenon is the surface analog of **solubilization**, where the adsorbed surfactant bilayer plays the role of **micelle**. The phenomena of solubilization and adsolubilization are illustrated in Figure 2-4.

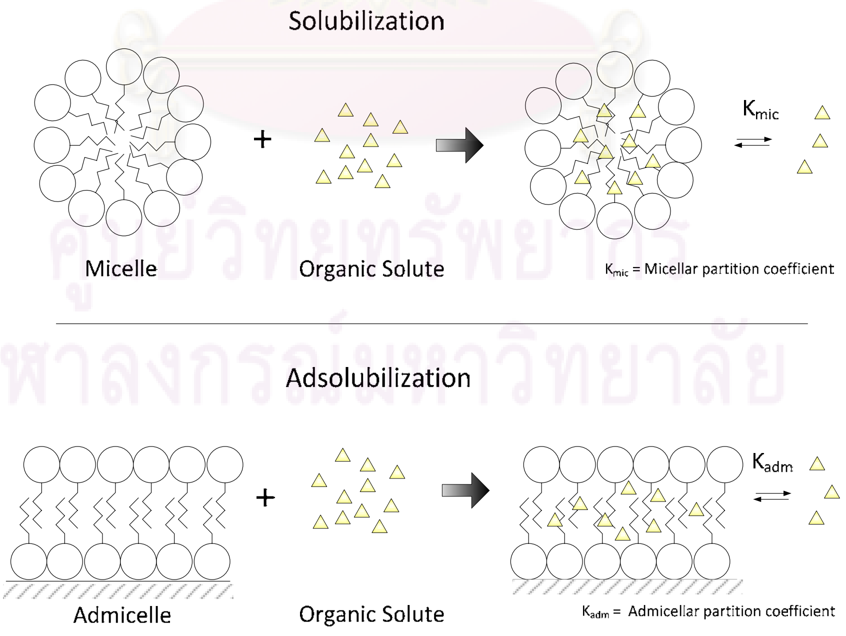


Figure 2-4 Phenomena of solubilization and adsolubilization

Similar in nature to a micelle, the admicelle is characterized by three-regions. The outer region, which consists of the surfactant head group, has the most polar or ionic nature. The inner region or the core region is non-polar due to the presence of the hydrocarbon chain of surfactant tail groups. The palisade region is the region between surfactant head groups and the core region and is thus intermediate in polarity as shown in Figure 2-5. Many researchers have been elucidated the locus of solubilization in the surfactant micelle and admicelle. Researchers have found that nonpolar organic solutes primarily partition into the core region, while polar organic solutes partition into the palisade region of the admicelle (Nayyar, et al., 1994; Kitiyanan et al., 1996; Dickson and O' Haver, 2002; Tan and O' Haver, 2004; Fuangswasdi et al., 2006b; Saphanuchart et al., 2008). Through the solubilization and the partition coefficient, the following trends have been observed: 1) If the solute partitions primarily into to the core, the partition coefficient increases with increasing mole fraction of solute in the admicelle, 2) If solute partition to the palisade layer, the partition coefficient decreases with increasing mole fraction of the solute, 3) If the solute partition into both the core and palisade region, the partition coefficient remains relatively constant with the mole fraction of solute solubilization (Edwards et al., 1991, Rouse et al., 1995).

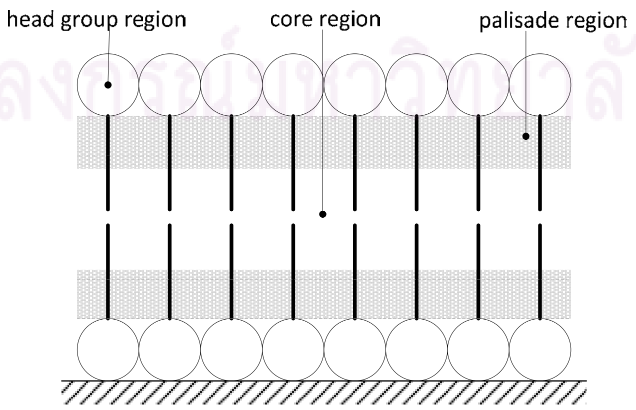


Figure 2-5 . The bilayer structure of surfactant admicelles at the solid-liquid interface

2.3.1 Micellar and Admicellar Partition Coefficients (K_{mic} and K_{adm})

From the partition of organic solute to micelle in aqueous solution, the **micellar partition coefficient (K_{mic})** is used to quantity the solubilization capacity (Edwards et al., 1991; Rouse et al., 1993 and Nayyar et al., 1994); and analogous to adsolubilization, **admicellar partition coefficient(K_{adm})**, can be used to evaluated solubilization capacity in adsorbed admicelle onto solid surface (Rouse et al., 1995; Kitiyanan et al., 1996; Dickson and O’ Haver, 2002; Tan and O’ Haver, 2004; Fuangswasdi et al., 2006a).

Many researchers have investigated the impact of various parameters effect on solubilization capacity, including the effect of surfactant concentration, solution pH, electrolyte concentration, and number of alkyl chain length of surfactant molecule. The measure of effectiveness of particular surfactant solubilization of organic solute is known as the **molar solubilization ratio (MSR)**. The MSR is defined as the number of moles of solute solubilizated per mole of micellar surfactant (Nayyar et al., 1994). The MSR can be calculated from Equation 2-2

$$MSR = \frac{(C_{mic} - C_{cmc})}{(S_{surf} - S_{cmc})} \qquad (2\text{-}2)$$

Where C_{cmc} is the solubility of organic solute in mole per liter at CMC; C_{mic} is the total solubility of the solute in micelle at the surfactant concentration higher than the CMC; and S_{surf} is the surfactant concentration at the C_{mic} is evaluated. The micellar partition coefficient, K_{mic} is an alternative approach to describe the partitioning of the various solutes into micellar system;

$$K_{mic} = \frac{X_{mic}}{X_{aq}} \qquad (2\text{-}3)$$

Where, X_{mic} is molar fraction of organic solute in to micelle and X_{mic} is relate to the MSR by the simple relation:

$$X_{mic} = \frac{(C_{mic} - C_{cmc})}{(C_{mic} - C_{cmc})+(S_{mic} - S_{cmc})} \tag{2-4}$$

$$X_{mic} = \frac{MSR}{[MSR+1]} \tag{2-5}$$

$$X_{aq} = \frac{C_{aq}}{C_{aq} + 55.55} \tag{2-6}$$

Where C_{aq} is molar concentration of the organic solute at aqueous solubility and 55.55 is represented 1/molar volume of water

Due to an analogous structure between micelle and admicelle, the admicellar partition coefficient (K_{adm}) is defined analogous to micellar partition coefficient (K_{mic}). K_{adm} is used to quantity the adsolubilization capacity and can be calculated from

$$K_{adm} = \frac{X_{adm}}{X_{aq}} \tag{2-6}$$

Where X_{adm} is the molar fraction of the organic solute in the admicelle phase and is calculated from;

$$X_{adm} = \frac{\left(C_0 - C_{eq}\right)}{\left(C_0 - C_{eq}\right) + \left(S_0 - S_{eq}\right)} \tag{2-7}$$

Where, C_0 and C_{eq} are the concentration of organic solute at initial and equilibrium, respectively. S_0 and S_{eq} are the concentration of surfactant added and present as monomer at equilibrium respectively. X_{aq} in admicellar system is calculate from concentration of solute at equilibrium (C_{eq})

$$X_{aq} = \frac{C_{eq}}{C_{eq} + 55.55} \tag{2-8}$$

Kitiyanan and co-workers (1996) investigate adsolubilization of styrene and isoprene of cationic surfactants onto silica. They found that the admicellar partition coefficient for styrene remained constant with the mole fraction of styrene increased and isoprene decreased with the mole fraction of isoprene increased. They concluded that styrene was partition primary both into the core and palisade layer of admicelles and isoprene was partition primary to the palisade layer.

Additional research investigated the nature of adsolubilization of organic solutes into admicelles (Esumi et al., 2000 and 2001, Tan and O' Haver, 2004 and Fuangswasdi et al., 2006b). Moreover, many researches focused on the effect of various parameters to maximum adsolubilization of organic solute on admicelle formation and adsolubilization; including the effect of surfactant structure (Tan and O' Haver, 2004; Fuangswasdi et al., 2006b), solution pH (Esumi et al., 2001), structure of organic solute (Kitiyanan et al., 1996; Dickson and O' Haver, 2002), electrolyte concentration (Pradubmook et al., 2003) and temperature (Saphanuchart et al., 2008). These research results demonstrate that the level of adsorbed surfactant depends on the amount of surfactant presence at the solid-liquid interface and the structure of adsorbed layer or adsorbent.

2.4 LINKER MOLECULES AND EXTENDED SURFACTANTS

Linker molecules and extended surfactants have been shown to enhance the solubilization capacity of microemulsions (Minana-Perez et al., 1995; Salager et al., 1998; Jayanti et al., 2002; Sabatini et al., 2003; Acosta et al., 2004; Szekeres et al., 2005; Childs et al., 2006). The lipophilic linker is an amphiphilic molecule (long chain linear alcohol such as dodecanol) that segregates near the surfactant tail and helps to improve the solubilization capacity. According to the needs of the specific microemulsion application, linker-based surfactant system is attractive because of their flexibility in tailoring the surfactant and linkers to the needs of a given application. In addition, linker molecules are normally less expensive than surfactant molecules.

2.4.1 Lipophilic Linker-Based Surfactant System

The concept of the lipophilic linker was first introduced by Graciaa, et al. (1993). The **lipophilic linker** is an amphiphilic molecule, such as a fatty alcohol, or long chain alcohol, acids or amines that segregate near the surfactant tail at a given interface (Figure 2-6). Linker molecules serve as a link between the surfactant tail and oil molecule in the oil phase. Through this association the linker molecule also promotes orientation of oil molecules in the oil phase. Graciaa and co-workers (1993) also found that long chain alcohols impact the accumulation of linker molecules at the interface in correlation with the number of carbons in alcohol chain length. They proposed that alcohol with two to four carbons show a co-solvent effect that decreases the surfactant interaction. Medium chain alcohols, with four to nine carbons, are considered co-surfactants that adsorb at the oil/water interface. On the other hand, alcohols with longer hydrocarbon chains, (e.g., ten or more carbons - decanol and higher), show an increased interaction with segregation deeper into the oil side of interface. A schematic depicting role of the lipophilic linker in enhancement of the solubilization capacity is shown in Figure 2-6 (adapted from Miñana-Perez et al., 1995).

Sabatini et al. (2003) applied the lipophilic linker to enhance the solubilization capacity of hexane, tricholoethylene (TCE) and tetrachloroethylene (PCE) in middle phase microemulsion using anionic surfactants, sodium dihexyl sulfosuccinate (SDHS), and n-alkyl alcohols as linker molecules. They found that the solubilization capacity increased with the increasing alkyl chain length of the alcohol linker molecule. Furthermore, the longer chain alcohol, dodecanol (C12) was more effective at linking oil molecules for hexane than for chlorinated hydrocarbon oils.

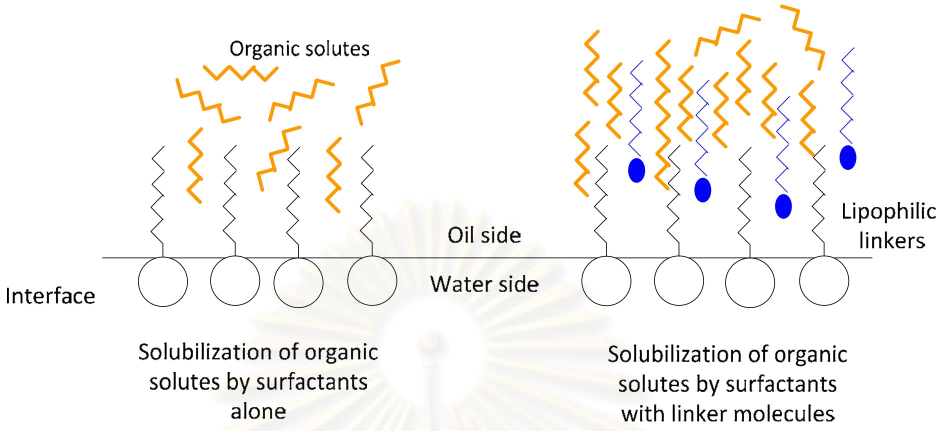


Figure 2-6 The Schematic of the role of the lipophilic linker in enhancement of the solubilization capacity of organic solutes (adapted from Miñana-Perez et al., 1995).

Tan and O'Haver (2003) investigated the impact of lipophilic linkers on adsorption and adsolubilzation of styrene in nonionic surfactant, polyethoxylate alkylphenols (Triton X). The adsorption isotherms of nonionic surfactant onto precipitated silica with and without linkers were compared. The results showed that the presence of lipophilic linkers increase the amount of adsorbed surfactants. They also examined the effect of increasing lipophilic linker chain length from C8 to C14. They found that the lipophilic linkers increase the amount of adsorbed surfactants with an increase the effect seen for linker chain length up to C12. Dodecanol appeared to be a best linker of increasing the adsorption capacity of polyethoxylate octylphenol surfactants.

A major disadvantage of the linker system is that not all of the linker molecule will necessarily segregate near the interface or surfactant tails due to relative partitioning among the multiple phases. An alternative to mitigate this partition effect is the use of extended surfactants (Miñana-Perez et al., 1995; Sabatini et al., 2003; Fernández et al., 2005), as discussed below.

2.4.2 Extended Surfactant-Based System

One of the main disadvantages of the linker based systems is that not all of the linker molecule will segregate near the interface or surfactant tails. One method to overcome this partitioning effect is the use of extended surfactants (Sabatini et al., 2003). The extended surfactants, so-called internal linker system and commonly known as extended surfactant system.

A new class of surfactants known as **extended surfactants** has been proposed to enhance solubilization of organic solutes (Miñana-Perez et al., 1995; Salager et al., 2005; Witthayapanyanon et al., 2006). Extended surfactants have a group of intermediate polarity, such as polypropylene oxides or poly ethylene oxides, inserted between the hydrocarbon tail and head group (Sabatini et al., 2003) and thus have been referred as internal linker systems. Due to their unique molecular structure, extended surfactants extend further into the oil phase, thereby providing a smoother transition from water to oil phases and providing a more suitable region for solubilizing both hydrophilic and lipophilic solutes (Witthayapanyanon et al., 2006).

Minna-Perez et al. (1995) evaluated the ability of extended surfactants, alkyl polypropylene oxide ether sulfates, to enhance the solubilization of polar oils. They found that the CMC and the cloud point changed with the number of propylene oxide groups per molecule. The CMC of the extended surfactants was observed to decrease with increasing propylene oxide number (PON). They noted that the solubilization of oil (ethyl oleate, hexadecane and Soja oil) increase as PON increases.

Jayanti et al. (2002) evaluated the performance of custom-made branched alcohol propoxylated sulfate surfactant in term of enhanced solubilization, microemulsion, and viscosity. They found that this class of surfactants can be tailored to specific non aqueous phase liquids (NAPLs) and these surfactants exhibit excellent surfactant-enhanced aquifer remediation (SEAR) performance. The results also showed that the branched alcohol propoxylated sulfate form low-viscosity microemulsion and provide high contaminant solubilization.

Witthayapanyanon and co-workers (2006) formulated ultralow interfacial tension (IFT) system using extended surfactants for a wide range of oils, ranging from polar to nonpolar oils. They found that extended surfactants have a lower CMC as compared to the conventional surfactants. They also found that the extended surfactants can produce ultralow IFT for a wider range of oils, using only low levels of extended surfactants. A major disadvantage of the extended surfactants is that they have a tendency to form gel phases at moderate surfactant concentrations (Sabatini et al., 2003; Witthayapanyanon et al., 2006). Nevertheless, these novel propoxylated sulfate surfactants are simple to manufacture and environmentally acceptable for groundwater remediation (Sabatini et al., 2003).

CHAPTER III

METHODOLOGY

3.1 MATERIALS

3.1.1 Surfactants

The surfactants in this study are divided into two systems; external linker-based systems (i.e., lipophilic linker) and internal linker-based systems (i.e., extended surfactants).

***External linker system*:** Sodium dodecyl sulfate (SDS) was selected as a conventional anionic surfactant with a C12 alkyl chain length. SDS (98%) was purchased from Sigma Company. n-dodecanol, a long chain linear alcohol with an alkyl chain length of 12, was used as a lipophilic linker. n-dodecanol (98%) was purchased from Arcos chemical company.

***Internal linker system*:** The extended anionic surfactants evaluated in this research were alkyl propoxylated sulfates of the Alfoterra® series with distribution of alkyl chain length of 12 and 13 , and 14 and 15 with varying numbers of propylene oxide groups (PO); these surfactants were obtained from SASOL North America Inc. Table 3-1 summarizes the surfactants that were evaluated in this study.

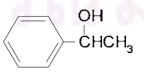
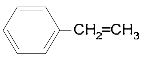
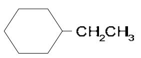
Table 3-1 Surfactant properties

Surfactants	Type	Formula	Carbon
External linker-based surfactant system (conventional surfactant and lipophilic linker)			
Sodium dodecyl sulfate, SDS	Anionic conventional	$C_{12}H_{25}OSO_3Na$	12
Sodium dodecyl sulfate, SDS and n-dodecanol 10:1 M/M	Lipophilic linker	$C_{12}H_{26}OH$	12
Extended surfactant-based system (extended surfactants)			
Alkyl propoxylated sulfate C12-13 (n = 3,5,8)	Anionic extended	$C_{12,13}$-(PO)n-SO_4Na	12-13
Alkyl propoxylated sulfate C14-15 (n = 3,5,8)	Anionic extended	$C_{14,15}$-(PO)n-SO_4Na	14-15

3.1.2 Organic Solutes

Three organic solutes with different polarities were selected in this study. Styrene (99%) and 1-Phenylethanol (>98%) was purchased from Fluka chemical company, and. Ethylcyclohexane (99%) was purchased from Arcos chemical company. Table 3-2 summarizes the properties of organic solutes.

Table 3-2 Organic solute properties’ [b]

Organic solutes	Molecular		MW	Water solubility (mg/L)	Log K_{ow}	Density 25 °C (g/mL)	Dipole moment
	Formula	Structure					
Phenylethanol	$C_6H_5CH(OH)CH_3$		122.16	1950	1.42[a]	1.01	1.65
Styrene	$C_6H_5CH=CH_2$		104.15	312	2.95[b]	0.91	0.13
Ethylcyclo-hexane	$C_6H_{11}C_2H_5$		112.40	2.92	3.44[c]	0.79	0.00

a http://agrippina.bcs.deakin.edu.au/bcs_admin/msds/msds_docs/1-Phenylethanol.pdf

b http://www.epa.gov/OGWDW/dwh/t-voc/styrene.html

c for cyclohexane (Schwarzenbach, R. P.; Gschwend, P. M.; Imboden, D. M.(1993). Environmental Organic Chemistry. John Wiley & Son, Inc)

3.1.3 Solid Oxide Surface

Aluminum oxide (Al_2O_3) was purchased from Aldrich chemical company and used as received. The specific surface area reported from the manufacturer is 155 m^2/g and the point of zero charge (PZC) pH of alumina is 9.1 (Sun and Jaffe, 1996).

Table 3-3 Aluminum oxide property

Alumina oxide (Alumina, Al_2O_3)[a]		
Surface area (m^2/g)	**Av particle size** (mesh)	**Pore size** (A^o)
155	150	58

[a] Data from Fisher Scientific Co Inc

The electrolyte concentration was controlled using sodium chloride (NaCl). The solution pH was adjusted using sodium hydroxide (NaOH) and hydrochloric acid (HCl) (MERCK). All chemicals were used as received. All solutions were prepared with purified water having a resistance of 18.2 MΩ.

3.2 EXPERIMENTAL SECTION

The experimental setup in this study was divided into three sections; adsorption adsolubilization and solubilization study. All experiments were performed under constant temperature (25$\pm$2°C). The ionic strength of the solution was adjusted to 0.001 M by adding sodium chloride (NaCl) and the solution pH was adjusted at neutral pH (7.0 $\pm$ 0.5) by adding HCl and NaOH solution.

3.2.1 CMC Measurements

The critical micelle concentrations (CMC) of the surfactant systems in this research were determined using a Wilhelmy plate tensiometer (DCAT 11, Data Physics) with a platinum plate at room temperature (25±2°C) and electrolyte concentration of 0.001 M NaCl. For each surfactant system solution was prepared by adding surfactant stock solution to each vial with DI water containing 0.001 M NaCl.

3.2.2 Adsorption Study

Adsorption isotherms were conducted at a constant room temperature (25±2°C), at an electrolyte concentration of 0.001 M NaCl and at a solution pH 7.0 ± 0.5. The adsorption studies were conducted in 40 mL vials using a constant volume of 40 mL of surfactant solution and different amounts of alumina. The solution was equilibrated by shaking at 150 rpm for at least 48 hours. After twelve hours of orbital shaking, the solution pH was measured and adjusted using NaOH and/or HCl solution. This process was repeated, but with a minimum waiting time of 3 hours, until the solution pH remained constant at the desired level. After equilibration, the solution was centrifuged to remove the alumina. The aqueous surfactant concentration was then analyzed.

$$\Gamma_i = \frac{(C_i - C_f)V}{W_g} \qquad (3\text{-}1)$$

Where;

Γ_i = Adsorption density of surfactant i (mole/g)
V = Volume of sample (liter)
C_i = Concentration of surfactant at initial (mole/liter)
C_f = Concentration of surfactant at equilibrium (mole/liter)
W_g = Weight of aluminum oxide (g)

Equation 3-1 was used to calculate the adsorption of the surfactant on the mineral oxide surface. In this equation, the adsorption of water or salt is assumed to be negligible and the adsorption of the surfactant is assumed to have no effect on solution density (Lopata, 1988).

3.2.3 Adsolubilization Study

Adsolubilization isotherms were conducted at room temperature (25±2^{o}C), an electrolyte concentration of 0.001 M NaCl and at a solution pH of 7.0 ± 0.5. In order to determine the solute adsolubilization, feed solutions with known surfactant concentrations were added to solutions containing a known mass of alumina and with varying styrene concentration. The equilibrium aqueous surfactant concentration was selected at 90-95 percent of the CMC (transition point between Region III and Region IV) to insure that the system equilibrated very near but just below the CMC which assured that no micelles were present in aqueous solution at equilibrium. Equilibrium was achieved by shaking for 48 hours as in the adsorption studies with subsequent centrifugation to remove the aluminum oxide; pinacyanol chloride was used as an indicator to ensure that micelles were not present. In absence of micelles, pinacyanol chloride yields a violet color. At surfactant concentration in aqueous solution above the CMC, the blue color is observed. Analogous nature of micelle as admicelle, the blue color is observed in adsorbed admicelles on the surface of alumina (Kittyanan et al., 1996). The concentrations of surfactant and organic solute in aqueous phase were then analyzed. The amount of adsolubilization was calculated from the initial and equilibrium concentrations.

3.2.4 Solubilization Study

Solubilization studies were conducted at room temperature (25±2^{o}C), electrolyte concentration of 0.001 M NaCl and a solution pH of 7.0±0.5 with the maximum solubilization (adapted from Nayyar et al (1994). An individual system consists of a 40 mL solution containing deionized water with 0.001 M NaCl, organic solute and surfactant system. All vials were sealed with Teflon-line screw cap (PTFE) to prevent solute from the solution. The surfactant concentration was varied from below to above the CMC. The solute was added to maintain excess product at least three times its solubility limits after achieving solubilization equilibrium. The solution was equilibrated by shaking at 150 rpm for 48 hours. The organic solute was allowed to phase separate, and then the solution was analyzed.

3.3.5 Desorption of Surfactant Adsorption

The desorption study was determined through dilution technique (Huang et al., 1996). The surfactant concentration just below the CMC (90-95% below the transition point of adsorption isotherm) was selected. After adsorption study, desorption study were conducted by adding the same volume of diluents adjusted to the system with constant of electrolyte concentration (0.001 M NaCl) and solution pH of 7.0±0.5 as the same volume of supernatant was removed. Thus the solid to liquid ratio remained constant as the washing step was achieved sequential washing. Then the vials were shaken for 48-hours for desorption process as the same as the equilibrium time in adsorption study. Several of washing steps of surfactant desorption solutions with alumina fine particles in 40 mL vial were achieved. The surfactant concentration in each vials were then analyzed to determine the amount of surfactant concentration, desorbed from the surface. The zetapotential of alumina particles was measured by zeta potential meter and zetapotential measurement

3.3 ANALYTICAL METHODS

All surfactants were analyzed using ion chromatography, IC (ICS-2500, Dionex) following previous works (Doan et al., 2003; Fuangswasdi et al., 2006 a and b). All anionic surfactants in this study were analyzed using a coupling agent, tetrabutyle ammonium hydroxide (TBAOH). The natural complex was separated with reverse phase column (NS1, Dionex) and the acetronitrile-water mobile phase, the complex was eluted from the column and de-coupled by ionic suppression (ASRS ultra II - anionic suppressor, Dionex) and finally detected by an electrical conductivity detector (ECD).

Phenylethanol was analyzed using IC (ICS-2500, Dionex) with a UV detector operating at 247 nm. Styrene was analyzed by HPLC (LC 1100, Agilent) with methanol and water (70:30) as the mobile phase and without an analytical column and detected by diode array detector operating at 247 nm. Ethylcyclohexane was analyzed using gas chromatography, GC (6890N, Agilent) with HP-5 column (Agilent) at temperature of 275^{o}C and detected by Flame Ionization detector (FID).

CHAPTER IV

STYRENE SOLUBILIZATION AND ADSOLUBILIZATION ON ALUMINUM OXIDE SURFACE USING LINKER MOLECULE AND EXTENDED SURFACTANTS

4.1 ABSTRACT

The impact of lipophilic linker and extended surfactant properties on admicelle formation and styrene adsolubilization were evaluated through adsorption and adsolubilization studies on aluminum oxide. While linker-based systems achieved a higher maximum adsorption than extended surfactants, the extended surfactants reached maximum adsorption at a lower aqueous surfactant concentration. Results of solubilization and adsolubilization studies are summarized by the extent of solute solubilization into micelle and admicelle, as captured through micellar partition coefficient (K_{mic}), and admicellar partition coefficient (K_{adm}). The extended-surfactant-based micelles showed greater solubilization capacity than linker-base micelles. Relative to effect of the number of propoxy groups for extended surfactants with the same alkyl chain length, the results show that the solubilization capacity increases when the PO number increased for both C12,13 and C14,15 based surfactant series. Thus, adsolubilization using extended-surfactant-based admicelles showed adsolubilization enhancement while requiring lower amount of surfactants to form admicelles. These results thus provide insights into external and internal linker-based and extended-surfactant-based admicellar systems and highlight the differences observed from admicelles based on conventional surfactant systems.

4.2 INTRODUCTION

Surfactant-modified colloidal materials have been widely used for industrial and environmental applications (West and Harwell, 1992; Rouse et al.; 1996; Kitiyanan et al., 1996; Sun and Jaffe, 1996; Karapanagioti et al., 2005; Adak and Pal, 2006; Adak et al., 2006). Surfactant aggregates adsorbed at the solid-liquid interface are capable of solubilizing organic solutes due to partitioning from the aqueous phase into the admicelle. This phenomenon, known as adsolubilization (Scamehorn and Harwell, 1989), has been widely studied in recent years. Adsolubilization has been used in many applications, including admicellar-enhanced chromatography (AEC), which is a fixed-bed separation process based on the use of surfactant to induce organic solute adsorption from an aqueous stream (Harwell and O'Rear, 1989). Admicellar polymerization is a process which 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 applications include water treatment (Adak and Pal, 2006 and Adak et al., 2006), soil remediation for treating wastes, and landfill liner or subsurface barriers to mitigate contaminant transport (Sun and Jaffe, 1996; Karapanagioti et al., 2005; Adak and Pal, 2006; Adak et al., 2006; Fuangswasdi et al., 2007).

4.3 BACKGROUND

4.3.1 Surfactant Phenomena

Surfactants, commonly known as soaps or detergents, are amphiphilic molecules because they have both a polar, hydrophilic head group (water-like) and a nonpolar, hydrophobic tail group (oil-like) in the same molecule. Because of their amphiphilic nature, surfactants accumulate in interfacial regions (e.g.; water-oil, water-air, liquid-solid interfaces) and thereby reduce the interfacial energy of these systems (Rosen, 1989). Depending on the aqueous surfactant concentration, surfactants are capable of forming many different types of aggregates. At low concentration, surfactants exist independent of one another in the solution phase and are called monomers. Surfactant monomers will accumulate at interfaces present in the system. When the surfactant concentration exceeds a certain level, surfactant monomers self-aggregate into spherical aggregates known as micelles. In a micelle, the individual monomers are oriented with their hydrophilic head group facing the water or aqueous phase and their hydrophobic tail group oriented into the interior of the spherical aggregates. Micelles form when the surfactant concentration first exceeds the critical micelle concentration (CMC), a value which varies depending on the surfactant structure. As additional surfactant is added above the CMC, the incremental surfactants go to form additional micelles.

When a solid phase is added to the surfactant solution, surfactant will adsorb at the solid-liquid interface. At low surfactant concentrations, the surfactant begins to adsorb and form micelle-like structures called hemimicelles or admicelles, depending on whether the aggregates have one or two surfactant layers (Rosen, 1989). Once the CMC is reached, additional aqueous surfactant does not increase the amount of adsorbed surfactants but rather increases the concentration of micelles in aqueous solution. Surfactant micelles, with hydrophilic head groups (polar moieties) at the exterior and hydrophobic tail groups (non-polar moieties) in the interior, exhibit certain unique properties. The polar exterior makes a micelle highly soluble in water, while the non-polar interior provides a hydrophobic sink for organic compounds, which can effectively increase the solubility of organic compounds. Therefore, the solubility of organic contaminants increases with increasing micelle concentration in the solution, i.e., adding additional surfactant above the CMC.

4.3.2 Adsorption of Ionic Surfactants onto Metal Oxide Surfaces

Surfactant adsorption onto metal oxide surfaces (e.g., aluminum oxide) is a complex process since adsorption can occur by ion exchange, ion pairing and hydrophobic bonding mechanisms. Surfactant adsorption at liquid-solid interfaces is characterized by an adsorption isotherm (Rosen, 1989). The adsorption isotherm of ionic surfactants onto oppositely charged metal oxide surfaces is typically an S-shaped isotherm (Somasudaran and Fuerstenau, 1966; Scamehorn et al., 1982) which can be divided into four regions, as shown in Figure 4-1.

Region I corresponds to low aqueous surfactant concentration and thus low surfactant adsorption. This region is commonly referred to as the Henry's Law region because, in this region, monoisomeric surfactants are generally adsorbed in a linear manner. In the Henry's Law region, surfactants are adsorbed mainly by ion exchange, with the hydrophilic surfactant head groups adsorbing onto the solid surface. Adsorbed surfactants in this region are envisioned to adsorb independently without forming surfactant aggregates.

Region II is characterized by a sharply increased isotherm slope relative to the slope in the Region I, which is a general indication of the onset of cooperative effects between adsorbed surfactants, i.e. the surface coverage increases significantly due to surfactant tail-tail interactions between absorbing surfactants. This increase in slope indicates the beginning of bilayer surfactant adsorption resulting from interaction of the hydrophobic chains of oncoming surfactants with those of previous adsorbed surfactants. These aggregates, which occur at concentrations well below the critical micelle concentration (CMC) of the surfactant, are called **admicelles** or **hemimicelles**, depending on whether their structures are formed as local bilayers or local monolayers, respectively. The admicelle is considered as a bilayer with the lower layer of head groups adsorbed onto the solid surface and the upper layer of head groups oriented towards the solution. The hemimicelle is considered as a monolayer with the head group of surfactant adsorbs onto the solid surface while the tail group contacted with the solution.

Region III is characterized by a decrease in the isotherm slope relative to the slope in Region II. This decrease in slope is attributed to lateral electrostatic repulsion between adjacent surfactant adsorbing on the surface and/or to the beginning of admicelle formation on lower energy surface patches.

Region IV is the plateau adsorption region for increasing surfactant concentration. Generally, the equilibrium surfactant concentration at the transition point from Region III to Region IV is approximately the CMC of the surfactant. This corresponds to maximum bilayer coverage for ionic surfactants adsorbed on oppositely charged surfaces or to monolayer completion for adsorption on hydrophobic surfaces.

Surfactant adsorption onto solid oxide surfaces has been studied for a range of surfactant systems i.e., anionic (Scamehorn et al., 1982; Sun and Jaffe, 1996), cationic (Kitiyanan et al., 1996; Dickson and O' Haver, 2002) and mixed surfactant systems to enhance their adsorption capacity (Harwell and Scamehorn, 1992). Mixed surfactant systems studied include mixed anionic and nonionic surfactant (Lopata, 1988), mixed anionic and cationic surfactant (Fuangswasdi et al., 2006 a and b), and mixed nonionic and linker molecules (Tan and O' Haver, 2004). Mixed anionic and cationic surfactant systems exhibit excellent synergism and the greatest diversion form ideal mixing behavior (Harwell and Scamehorn, 1992). Adsorption of mixed anionic and cationic surfactants has received limited attention due to the tendency of these systems to precipitate (Huang et al., 1989; Capovilla et al., 1991; Fuangswasdi et al., 2006a).

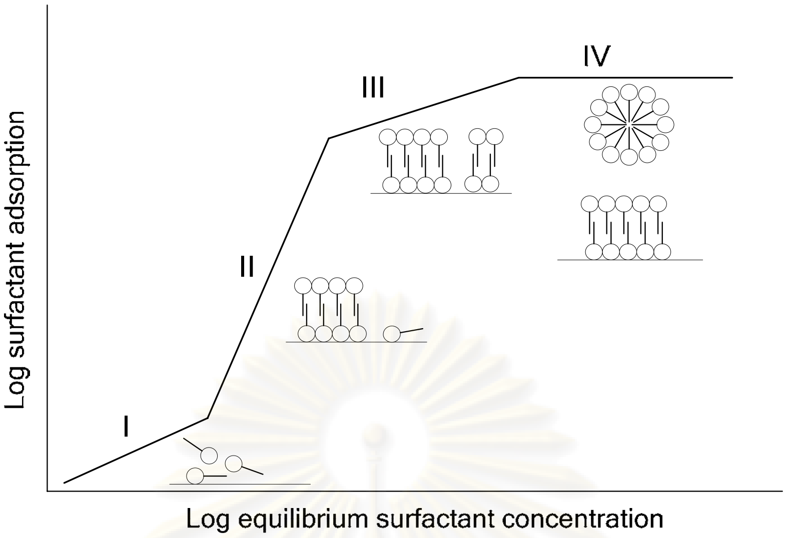


Figure 4-1 Schematic presentation of typical surfactant adsorption isotherm

4.3.3 Solubilization and Adsolubilization of Organic Solutes

The hydrophobic core of an admicelle is ideal for solubilizing organic solutes, a process known as **adsolubilization**. Normally, adsolubilization is the partition of organic solutes into the interior of adsorbed surfactant aggregates. This phenomenon is the surface analog of **solubilization**, where the adsorbed surfactant bilayer plays the role of the micelle. The phenomena of solubilization and adsolubilization are illustrated in Figure 4-2. Similar in nature to a micelle, the admicelle is characterized by three-regions. The outer region, which consists of the surfactant head group, has the most polar or ionic nature. The inner region or the core region is non-polar due to the presence of the hydrocarbon chain of surfactant tail groups. The palisade region is the region between surfactant head groups and the core region and is thus intermediate in polarity.

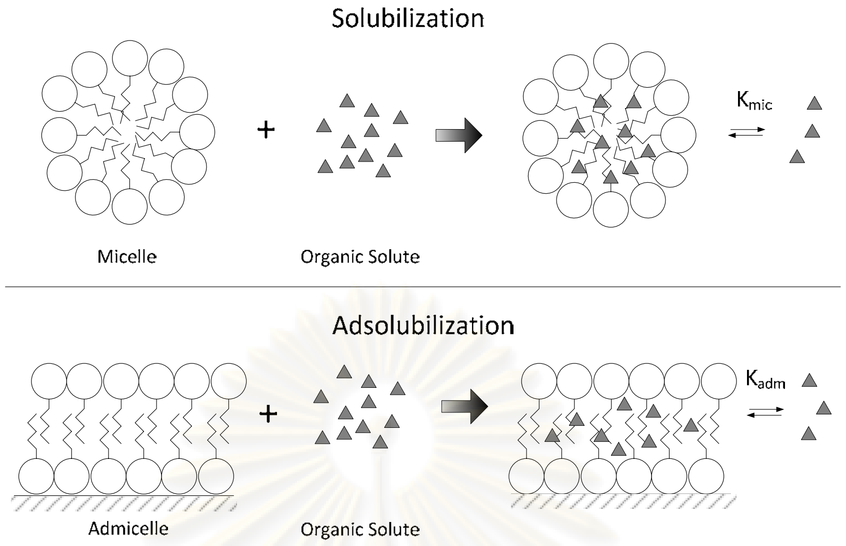


Figure 4-2 Phenomena of solubilization and adsolubilization

The admicellar partition coefficient (K_{adm}) is used to quantity the adsolubilization capacity and, analogous to solubilization in micelles (K_{mic}), can be used to identify the locus of solubilization (Edwards et al., 1991; Nayyar et al., 1994; Rouse et al., 1995; Kittiyanan et al, 1996; Dickson and O' Haver, 2002). Through the solubilization and the partition coefficient, the following trends have been observed: 1) If the solute partitions primarily into the core, the partition coefficient increases with increasing mole fraction of solute in the admicelle, 2) If solute partition to the palisade layer, the partition coefficient decreases with increasing mole fraction of the solute, 3) If the solute partition into both the core and palisade region, the partition coefficient remains relatively constant with respect to mole fraction of solute in the admicelle

Research has investigated the nature of adsolubilization of organic solutes into admicelles (Esumi, 2000; Esumi et al., 2001; Tan and O' Haver, 2004; Fuangswasdi et al., 2006b). Other researchers investigated the effect of surfactant concentration, solution pH

(Esumi et al., 2001), and structure of organic solute (Kitiyanan et al., 1996; Dickson and O' Haver, 2002) on admicelle formation and adsolubilization. These research results demonstrate that the level of adsorbed surfactant depends on the amount of surfactant present at the solid-liquid interface and the structure of adsorbed layer or adsorbent.

4.3.4 Linker Molecules and Extended Surfactants

Recently, linker molecules and extended surfactants (Minana-Perez et al., 1995; Jayanti et al., 2002; Sabatini et al., 2003; Acosta et al., 2004; Szekeres et al., 2005; Childs et al., 2006) have been shown to enhance the solubilization capacity of microemulsions. The lipophilic linker is an amphiphilic molecule, e.g. long chain linear alcohol such as dodecanol that segregates near the surfactant tail and helps to improve the solubilization capacity. According to the needs of the specific microemulsion application, linker-based surfactant systems are attractive because of their flexibility in tailoring the surfactant and linkers to the needs of a given application. In addition, linker molecules are normally less expensive than surfactant molecules.

The concept of the lipophilic linker was first introduced by Graciaa and co-workers (Graciaa et al., 1993a and b). The lipophilic linker is an amphiphilic molecule, such as a fatty alcohol, or long chain alcohol, acid or amine that segregate near the surfactant tail at a given interface. Linker molecules serve as a link between the surfactant tail and oil molecule in the oil phase. Through this association the linker molecule also promotes orientation of oil molecules in the oil phase. They also found that long chain alcohols impact the accumulation of linker molecules at the interface in correlation with the number of carbons in alcohol chain length. They proposed that alcohol with two to four carbons show a co-solvent effect that decreases the surfactant interaction. Medium chain alcohols, with four to nine carbons, are considered co-surfactants that adsorb at the oil/water interface. On the other hand, alcohols with longer hydrocarbon chains, (e.g., ten or more carbons - decanol and higher), show an increased interaction with segregation deeper into the oil side of interface. A schematic depicting the role of the lipophilic linker in enhancement of the solubilization capacity is shown in Figure 4-3 (adapted from adapted from Miñana-Perez et al.,1995).

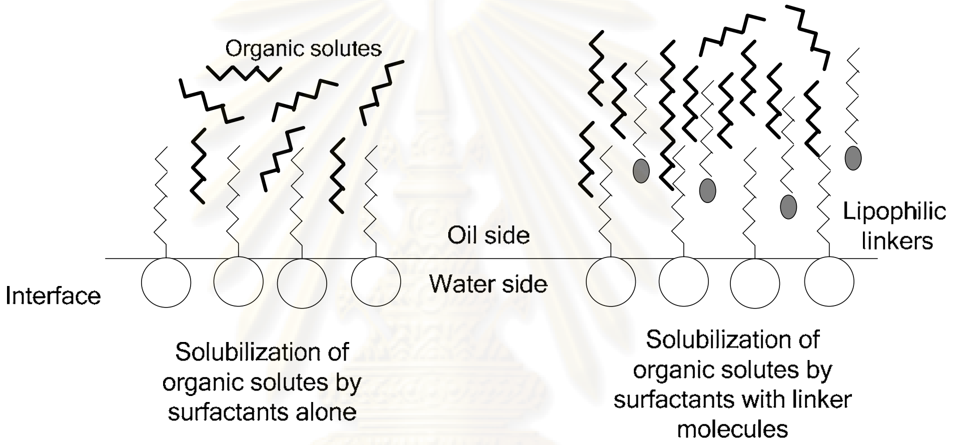


Figure 4-3 The schematic of the role of the lipophilic linker in enhancement of the solubilization capacity of organic solutes

A major disadvantage of linker-based systems is that not all of the linker molecule will necessarily segregate near the interface; rather, some fraction of the linker may partition between the multiple phases. One approach to avoid this partition effect is the use of extended surfactants (Miñana-Perez et al., 1995; Sabatini et al., 2003; Fernández, et al., 2005), as discussed below.

A new class of surfactants known as extended surfactants has been proposed to enhance solubilization of organic solutes (Miñana-Perez et al., 1995 and Witthayapanyanon et al., 2006). Extended surfactants have a region of intermediate polarity, such as polypropylene oxide or poly ethylene oxides, inserted between the surfactant hydrocarbon tail and head group (Sabatini et al., 2003) and thus have been referred to as internal linker systems. Due to their unique molecular structure, extended surfactants protrude further into the oil phase, thereby providing a smoother transition from water to oil phases while also providing a more suitable region for solubilizing both hydrophilic and lipophilic solutes (Witthayapanyanon et al., 2006). Witthayapanyanon and co-workers (2006) formulated ultralow interfacial tension (IFT) system using extended surfactants for a wide range of oils, including both polar and nonpolar oils. They found that extended surfactants have a lower CMC as compared to conventional surfactants. They also found that the extended surfactants can produce ultralow IFT for a wider range of oils, using only low levels of extended surfactants. A major disadvantage of the extended surfactants is that they have a tendency to form gel phases at moderate surfactant concentrations (Sabatini et al, 2003). Recently, several researches have demonstrated the benefit of using extended surfactant in both industrial (Witthayapanyanon et al., 2006) and environmental remediation (Jayanti et al., 2002; Childs et al., 2006)

The goal of this study is to evaluate the ability of lipophilic linkers and extended surfactants to enhance surfactant adsorption and adsolubilization. The adsorption of anionic surfactants will be studied with positively charged aluminum oxide (Al_2O_3); adsolubilization will be studied with styrene. To our knowledge, this is the first time that extended-surfactant-based admicelles have been evaluated. The specific hypotheses of this research are enhanced adsolubilization will occur with linker/extended-surfactant-based admicellar systems due to increased size of admicelle interior. Above a certain number of

PO groups, the surfactant adsorption and thus adsolubilization will decrease due to increased area per molecule caused by coiling of the PO groups.

For polar solutes, linker-based systems will have an intermediate solubilization /adsolubilization potential as compared to conventional and extended surfactant systems due to an intermediate size of the palisade layer (larger than for conventional surfactants but smaller than for extended surfactants).

4.4 EXPERIMENTAL SECTION

4.4.1 Materials

The surfactants in this study are divided into two systems; external linker systems (i.e., lipophilic linker) and internal linker systems (i.e., extended surfactants). **External linker system:** Sodium dodecyl sulfate (SDS) was selected as a conventional anionic surfactant with a C12 alkyl chain length. SDS (98%) was purchased from Sigma Company. N-dodecanol, a long chain linear alcohol with an alkyl chain length of 12, was used as a lipophilic linker. N-dodecanol (98%) was purchased from Arcos chemical company. **Internal linker system:** The extended anionic surfactants evaluated in this research were alkyl propoxylated sulfates of the Alfoterra® series with distribution of alkyl chain length of 12 and 13 , and 14 and 15 with varying numbers of propylene oxide groups (PO); these surfactants were obtained from SASOL North America Inc. Table 4-1 summarizes the surfactants that were evaluated in this study. Styrene (99%) was purchased from Fluka chemical company.

Aluminum oxide (Al_2O_3) was purchased from Aldrich chemical company and used as received. The specific surface area reported from the manufacturer is 155 m^2/g and the point of zero charge (PZC) pH of alumina is 9.1 (Sun and Jaffe, 1996) . The electrolyte concentration was controlled using sodium chloride (NaCl). The solution pH was adjusted using NaOH and HCl (MERCK). All chemicals were used as received. All solutions were prepared with purified water having a resistance of 18.2 MΩ cm.

Table 4-1 Surfactant properties

Surfactants	Type	Formula	Carbon
External linker system (conventional surfactant and lipophilic linker)			
Sodium dodecyl sulfate, SDS	Anionic conventional	$C_{12}H_{25}OSO_3Na$	12
Sodium dodecyl sulfate, SDS and n-dodecanol	Lipophilic linker	$C_{12}H_{26}OH$	12
Internal linker system (extended surfactants)			
Alkyl propoxylated sulfate C12-13 (n = 3,5,8)	Anionic extended	$C_{12,13}$-$(PO)_n$-SO_4Na	12-13
Alkyl propoxylated sulfate C14-15 (n = 3,5,8)	Anionic extended	$C_{14,15}$-$(PO)_n$-SO_4Na	14-15

4.4.2 Methods

4.4.2.1 CMC Measurements

The critical micelle concentrations (CMC) of the surfactant systems in this research were determined using a Wilhelmy plate tensiometer (DCAT 11, Data Physics) with a platinum plate at room temperature (25±2°C) and at an electrolyte concentration of 0.001 M NaCl.

4.4.2.2 Adsorption Study

Adsorption isotherms were conducted at a constant room temperature (25±2°C), at an electrolyte concentration of 0.001 M NaCl and at a solution pH 7.0±0.5. The adsorption studies were conducted in 40 mL vials using a constant volume of 40 mL of surfactant solution and different amounts of alumina. The solution was equilibrated by shaking at 150 rpm for at least 48 hours. After twelve hours of orbital shaking, the solution pH was measured and adjusted using NaOH and/or HCl solution. This process was repeated, but with a minimum waiting time of 3 hours, until the solution pH remained constant at the desired level. After equilibration, the solution was centrifuged to remove the alumina. The aqueous surfactant concentration was then analyzed. All surfactants in this study were analyzed using Ion Chromatography, IC (ICS-2500, Dionex) with a reverse phase column (Doan et al., 2003; Fuangswasdi et al., 2006 a and b)

4.4.2.3 Adsolubilization Study

Adsolubilization isotherms were conducted at room temperature (25±2^{o}C), an electrolyte concentration of 0.001 M NaCl and at a solution pH of 7.0±0.5. In order to determine the solute adsolubilization, feed solutions with known surfactant concentrations were added to solutions containing a known mass of alumina and with varying styrene concentration. The equilibrium aqueous surfactant concentration was selected at 90-95 percent of the CMC to insure that the system equilibrated very near but just below the CMC which assured that no micelles were present in aqueous solution at equilibrium. Equilibrium was achieved by shaking for 48 hours as in the adsorption studies with subsequent centrifugation to remove the aluminum oxide; pinacyanol chloride was used as an indicator to ensure that micelles were not present. In absence of micelles, pinacyanol chloride yields a violet color (Nayyar et al., 1994; Kittyanan et al., 1996). The concentrations of surfactant and styrene in aqueous phase were then analyzed. The amount of adsolubilization was calculated from the initial and equilibrium concentrations. Styrene was analyzed by HPLC (LC 1100, Agilent) with a diode array detector operating at 247 nm with methanol and water (70:30) as the mobile phase and without a column.

4.4.2.4 Solubilization Study

Solubilization studies were conducted at room temperature (25±2^{o}C), electrolyte concentration of 0.001 M NaCl and a solution pH of 7.0±0.5 with the maximum solubilization (adapted from Nayyar et al., 1994). An individual system consists of a 40 mL solution containing deionized water, organic solute and surfactant. The all vial was sealed with Teflon-line screw cap to prevent solute from the solution. The surfactant concentration was varied from below to above the CMC. The solute was added to maintain excess product at least three times its solubility limits after achieving solubilization equilibrium. The solution was equilibrated by shaking at 150 rpm for 48 hours. The amount of solubilized styrene was calculated by mass balance of styrene.

4.5 RESULTS AND DISCUSSION

4.5.1 Critical Micelle Concentration Measurement

Surface tension measurements were conducted at 0.001 M NaCl and at room temperature (25±2^{o}C). The break in the curve of the plot of surface tension versus logarithm of surfactant concentration is the CMC of the surfactant system (see Figure 4-4). For the external linker system, the CMC of SDS/dodecanol is slightly lower than SDS alone (3.0 mM versus 5.0 mM, respectively; see Figure 4-4 and Table 4-2). However, the CMC of extended surfactants is one to two orders of magnitude lower than SDS/dodecanol systems (0.01 to 0.20 mM versus 3.0 mM, respectively; see Table 4-2). With increasing number of propylene oxide groups (PO), extended surfactants from both the C12,13 series and C14,15 series demonstrated decreasing CMC values; this is expected since the PO groups are slightly hydrophobic. Extended surfactants with the same number of PO groups but with longer tails exhibited lower CMC values; i.e., the C14,15 series exhibited lower CMC values than the

C12,13 series - see Table 4-2). These trends are expected and are consistent with literature results (Minana-Perez et al., 1995; Fernández et al., 2005).

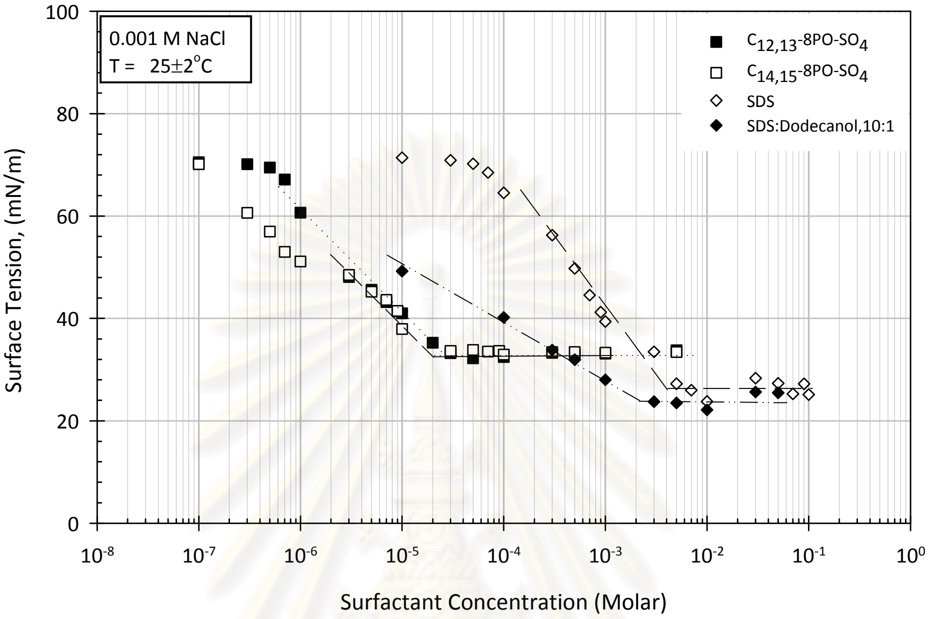


Figure 4-4 The surface tension of linker molecule, SDS/dodeocanol versus extended surfactant, $C_{12,13}$-8PO-SO_4 and $C_{14,15}$-8PO-SO_4 (See Table 4-3 for the CMC values).

The surface concentration (Γ) and effective area per surfactant molecule at the water-air interface were calculated from Figure 4-4 using the Gibbs equation (Rosen, 1989; see – equation in Appendix I). In addition to CMC values , Table 4-2 also summarizes the effective areas per molecule of surfactants used in this study. The results for both sets of extended surfactants (C12,13 series and C14,15 series) show that the effective area per molecule increases with increasing PO number in the extended surfactant molecule and is higher than for SDS, likely due to increased coiling as the number of PO groups increases.

Table 4-2 CMC values and effective areas per molecule for linker-based and extended-surfactant-based systems at 0.001 M NaCl and 25±2°C at liquid-air interface

Surfactants	HLB	CMC (mM)	Slope		Γ (mmol/1000m^2)	Effective area per molecule (A^{o2})
			Slope^{*a}	r^2		
External linker						
SDS alone	40.00	5.00	-9.19	0.99	1.85	89.5
SDS/dodecanol, 10:1 M/M	-	3.00	-4.57	0.99	0.92	-
Internal linker, extended surfactant C12,13 series						
$C_{12,13}$-3(PO)-SO_4	39.55	0.20	-7.55	0.99	1.52	109
$C_{12,13}$-5(PO)-SO_4	39.25	0.10	-7.18	0.99	1.45	115
$C_{12,13}$-8(PO)-SO_4	38.80	0.02	-6.75	0.99	1.36	122
Internal linker, extended surfactant C14,15 series						
$C_{14,15}$- 3(PO)-SO_4	38.60	0.03	-11.49	0.96	2.32	71.6
$C_{14,15}$-5(PO)-SO_4	38.30	0.02	-8.97	0.97	1.81	91.8
$C_{14,15}$-8(PO)-SO_4	37.85	0.01	-6.67	0.94	1.26	131.0

[a] from Figure 4-4
HLB = Hydrophobic Liphophilic Balance

4.5.2 Adsorption Study

4.5.2.1 Adsorption Isotherms of Surfactant/Linker and Extended Surfactant System

Adsorption isotherms of the surfactant/linker and two of the extended surfactant systems ($C_{12,13}$-8PO-SO_4 and $C_{14,15}$-8PO-SO_4) are shown in Figure 4-5. For all systems, the adsorption increases with increasing surfactant concentration according to the S shaped isotherm described previously.

For the SDS/dodecanol system, the isotherm shows the characteristic Region II, III, and IV as expected from theory and previous studies (Scamehorn, 1989); the detection limits for this system did not allow measurement in Region I. The transition point between Region III and IV of the SDS/dodecanol adsorption isotherm (2.0 mM) is similar to the CMC of the system based on surface tension measurements (3.0 mM) (See in Table 4-2 and Table 4-3, respectively).

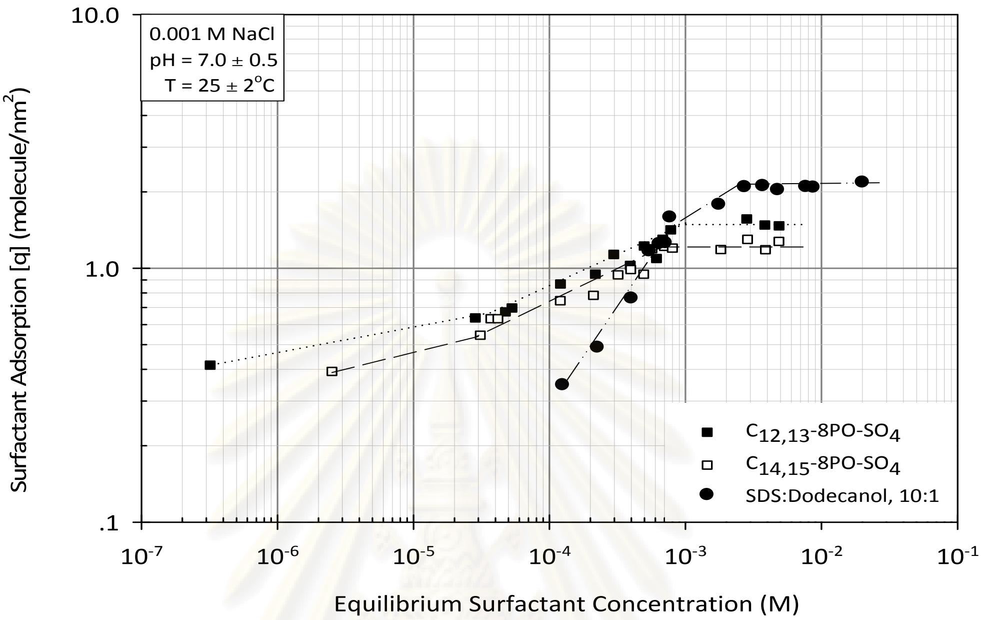


Figure 4-5 Adsorption isotherms of 10:1 SDS/dodecanol system and extended surfactant systems, in 0.001 M NaCl and solution pH 7.0 ± 0.5

By comparison, the isotherms of the extended surfactants, $C_{12,13}$-8PO-SO_4 and $C_{14,15}$-8PO-SO_4, show that the transition point between region III and IV occurs at an equilibrium surfactant concentration of 0.8 mM and 0.7 mM (Figure 4-5 and Table 4-3), which is 40 times and 80 times higher than CMC value (0.02 mM and 0.01 mM), respectively. The amount of adsorbed surfactant at plateau region of the SDS/dodecanol and $C_{12,13}$-8PO-SO_4 are 2.10 molecule/nm^2 and 1.51 molecule/nm^2, respectively (Table 4-3). Thus, while the maximum amount of adsorbed surfactant for SDS in the SDS/dodecanol system is slightly higher than for the extended surfactant, $C_{12,13}$-8PO-SO_4, the extended surfactant requires a much lower equilibrium surfactant concentration to reach the plateau adsorption region than does the SDS/dodecanol system (0.8 mM versus 3.0 mM, respectively; Table 4-3).

As mentioned above, the transition point of extended surfactant plateau adsorption occurs at higher surfactant concentration than the critical micelle concentration determined from surface tension measurement. Fundamentally, the conventional surfactant adsorption should plateau at the CMC of the surfactant since there is no driving force for additional adsorption above the CMC (Rosen et al., 1989). From Table 4-2 and Table 4-3, we do note that the area per molecule based on adsorption is significantly lower than that calculated for the air-water interface for $C_{12,13}$-8PO-SO_4 (69 versus 122 A^{o2}/molecule, respectively). It could be that the higher transition concentration is necessary to produce the tighter packing density observed at the solid-liquid interface than what was observed at the liquid-air interface. Since this phenomenon was not a focus of the current research, no further evaluation was made although it should be evaluated in future research

Table 4-3 Transition point and average maximum adsorption of adsorption isotherms of all surfactants at solid-liquid interface

Surfactants	**Transition point** ^{a} (mM)	**Maximum adsorption (q_{Max})**			**Effective area per molecule** (A^{o2})^c
		mole/gram × 10^{-4}	molecule/nm^2	A^{o2}/ molecule^b	
External linker system					
SDS	2.0	3.78 ± 0.13	1.46 ± 0.05	68.5	89.5
SDS/dodecanol, 10:1 M/M	3.0	5.41 ± 0.11	2.10 ± 0.04	47.6	-
Internal linker system, Extended surfactants C12,13 series					
$C_{12,13}$-3PO-SO_4	0.8	3.37 ± 0.15	1.31 ± 0.05	76.3	109
$C_{12,13}$-5PO-SO_4	0.8	3.55 ± 0.19	1.39 ± 0.07	73.0	115
$C_{12,13}$-8PO-SO_4	0.8	3.87 ± 0.24	1.51 ± 0.09	69.1	122
Internal linker system, Extended surfactants C14,15 series					
$C_{14,15}$- 3PO-SO_4	0.7	3.59 ± 0.10	1.39 ± 0.04	72.0	71.6
$C_{14,15}$-5PO-SO_4	0.7	3.50 ± 0.13	1.36 ± 0.05	73.5	91.8
$C_{14,15}$-8PO-SO_4	0.7	2.88 ± 0.12	1.12 ± 0.04	89.0	131.0

[a] Point where adsorption isotherm plateaus

[b] Calculate from adsorption at solid-liquid interface

[c] Calculate from surface tension measurement at liquid air interface (Rosen et al.,1989)

Base on monolayer coverage at liquid-solid interface, for instance; extended surfactant, $C_{12,13}$ -8PO-SO_4 gives an area coverage of 1.51 molecule/nm^2 or 69.1 A^{o2}/molecule. The effective area per head group of surface saturation at liquid-air interface from surface tension measurement is 122 A^{o2} (Table 4-3). If the admicelles are presented overall surface, the area per molecule of $C_{12,13}$ -8PO-SO_4 should be ≅ 60 A^{o2}. Therefore, the extended surfactant aggregates on alumina surface is expected to form a bilayer aggregates or admicelles. However, the area of surface coverage of surfactant aggregates at solid-liquid interface is slightly larger comparing to effective area per head calculated from complete bilayer coverage at liquid-air interface. This explanation could be due to head of surfactant molecule is too large to adsorb in a narrow pore of metal oxide surface (Kitiyanan et al., 1996)

4.5.3 Adsorption Isotherms of Extended Surfactants with Varying Number of Propylene Oxide Group

The adsorption isotherms of C12,13 extended surfactants with different number of PO groups are shown in Figure 4-6 while Figure 4-7 shows similar isotherm data for C14,15 surfactants with varying number of PO groups. Table 4-3 summarizes the adsorption capacity of extended surfactants in this study. From Figure 4-7, all of the adsorption isotherms have a similar shape. However, analytical limits prevented measurement of surfactant concentrations in Region I. For extended surfactants in the C12,13 series, the extended surfactant with 8 PO groups, ($C_{12,13}$-8PO-SO_4), showed the highest maximum adsorption capacity in the plateau region (1.51 molecule/nm^2) and also higher than C14,15 series (Table 4-3). Extended surfactants with 3 and 5 PO groups showed no significant difference in adsorption capacity at the plateau region for either class of extended surfactants. The effect of PO groups differs between the C12,13 series and C14,15 series.

For the C12,13 series, the surfactant with 8 PO groups provides the highest adsorption in the extended surfactant series while for C14,15 with 8 PO groups showed the lowest adsorption. It was anticipated that the surfactant with 8 PO groups would experience more coiling and thus higher area per head group as observed in surface tension measurements and for the C14-15 extended surfactant. The reason for the deviation in the C12,13 extended surfactant results are unclear and will be further evaluated in future research.

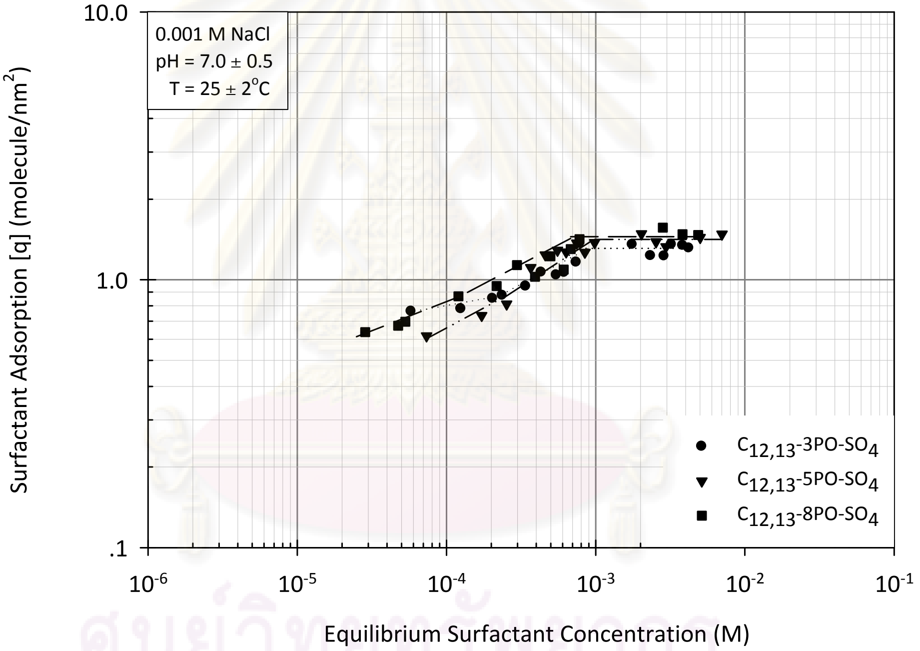


Figure 4-6 Adsorption isotherms of extended surfactants with different PO numbers, C12,13 series in 0.001 M NaCl and solution pH 7.0±0.5

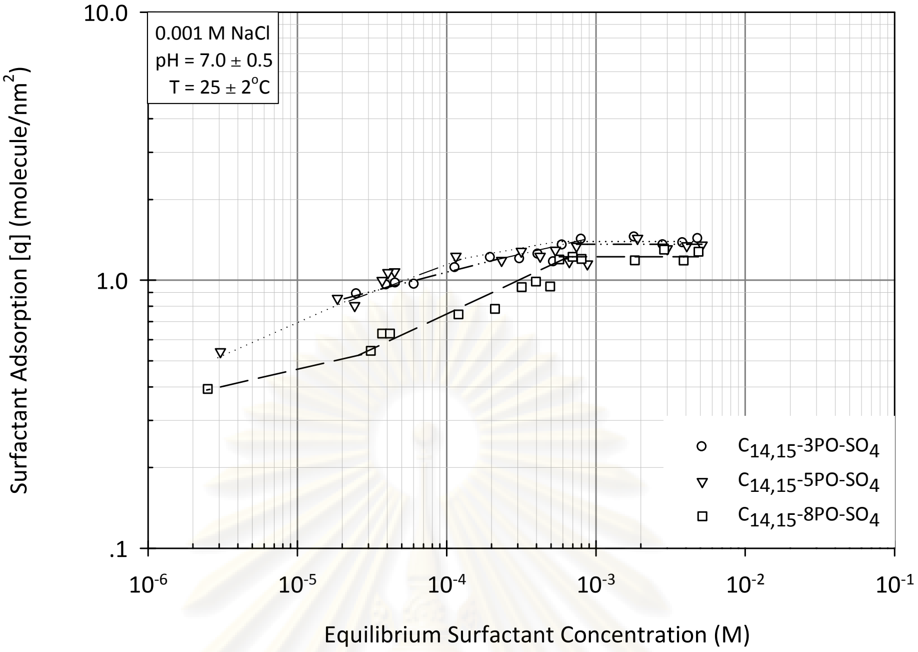


Figure 4-7 Adsorption isotherms of extended surfactants with different PO numbers, C14,15 series in 0.001 M NaCl and solution pH 7.0±0.5

4.5.4 Solubilization Study

The solubilization capacity of a particular surfactant for a given solute can be quantified by the molar solubilization ratio, (MSR). MSR is the number of moles of organic solute solubilized per mole of surfactant added in the solution, and is obtained from the slope of the curve that plots solubilizate concentration versus surfactant concentration. MSR may be calculated as follows (Edward et al., 1991; Nayyar et al., 1994; Rouse et al, 1995);

$$\mathrm{MSR} = \frac{(C_{mic} - C_{cmc})}{(S_{surf} - S_{cmc})}$$

Where; C_{cmc} is solubility of organic solute at the CMC (mol/l), C_{mic} is total apparent solubility of organic solute in micelle (mol/l), and S_{surf} is concentration of surfactant above the CMC.

Another measurement of solubilization is the micellar partition coefficient (K_{mic}). K_{mic} represents the partitioning of organic solute between surfactant micelle and the aqueous phase. K_{mic} is the ratio of the mole fraction of the organic solute in the micellar phase to the mole fraction of organic solute in aqueous phase and may be expresses as follows

$$K_{mic} = \frac{X_{mic}}{X_{aq}}$$

$$X_{mic} = \frac{MSR}{[1+MSR]}$$

Here, X_{mic} and X_{aq} are the mole fraction of organic solute in the micelles and aqueous phase, respectively. X_{aq} are calculated from concentration of solute at aqueous solubility

$$X_{aq} = \frac{C_{aq}}{C_{aq} + 55.55}$$

The solubilization capacity of styrene as a function of surfactant concentration is shown in Figure 4-8 for the external linker system versus extended surfactants. The extended surfactant micelles show greater solubilization capacity than the linker- based system. The molar solubilization ratio (MSR) and micellar partition coefficient (K_{mic}) were calculated to evaluate the extent of styrene solubilization in micelles and are shown in Table 4-4. The MSR was calculated from the slope of the graph in Figure 4-8. The results show that styrene solubilization capacity of extended-surfactant-based micelles is greater than that of linker-based micelles. The MSR of styrene for the C14,15 extended surfactant is slightly higher than for the C12,13 extended surfactant (Figure 4-8 and Table 4-4). Figure 4-9 shows the solubilization capacity of surfactants with varying PO groups in the C14,15 extended surfactants. It was found that the solubilization capacity increases slightly as PO number increases due to increases in hydrophobicity of micelles, as expected. Table 4-4 summarizes solubilization capacity for styrene by the linker –based system and the extended surfactant systems.

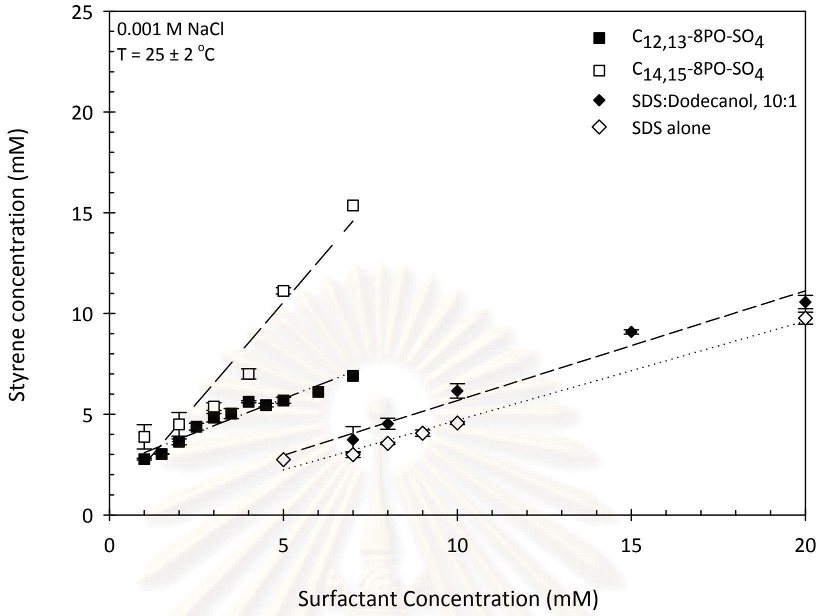


Figure 4-8 The solubilization capacity of external linker system, SDS dodecanol versus extended surfactants, $C_{12,13}$-8PO-SO_4 and $C_{14,15}$-8PO-SO_4

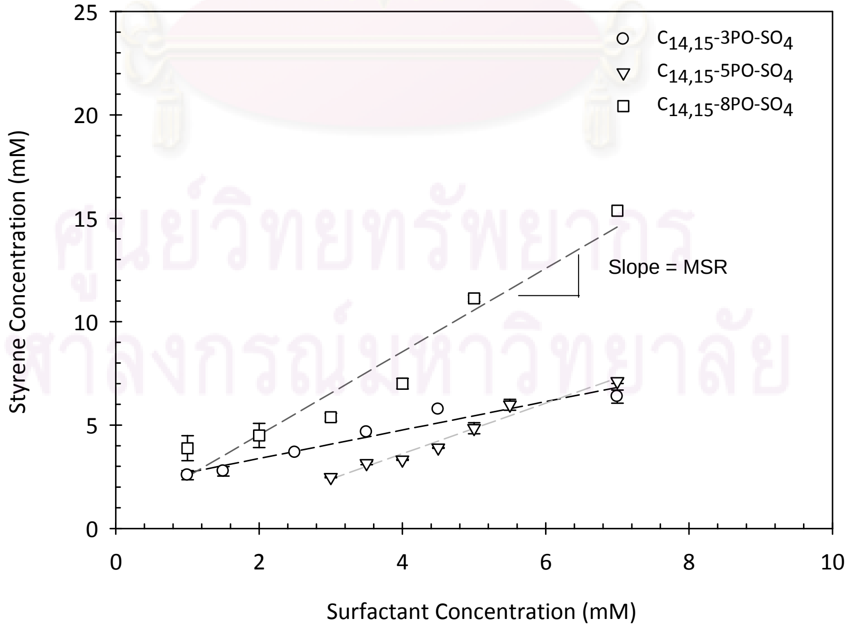


Figure 4-9 The solubilization capacity of extended surfactants with different PO numbers, $C_{14,15}$-3PO-SO_4 , $C_{14,15}$-5PO-SO_4 , and $C_{14,15}$-8PO-SO_4

Table 4-4 Solubilization and adsolubilization capacity of external linker system and internal linker system for styrene

Surfactants (0.001M NaCl)	**Micellar system**					**Admicellar system**			
	MSR	r^2	X_{mic}	K_{mic}	$\log K_{mic}$	ads q_{max} (g/mole)× 10^{-4}	K_{adm}	r^2	$\log K_{adm}$
External linker system									
SDS	0.31	0.96	0.23	4400	3.64	3.78	10700	0.94	4.06
SDS:dodecanol	0.50	0.97	0.33	6240	3.80	5.41	12600	0.98	4.10
Internal linker system, extended surfactant C12,13 series									
$C_{12,13}$-3(PO)-SO_4	0.40	0.94	0.28	5300	3.73	3.37	12800	0.98	4.11
$C_{12,13}$-5(PO)-SO_4	0.56	0.90	0.36	6670	3.82	3.55	10700	0.98	4.03
$C_{12,13}$-8(PO)-SO_4	0.67	0.93	0.40	7480	3.87	3.87	14400	0.99	4.16
Internal linker system, extended surfactant C14,15 series									
$C_{14,15}$- 3(PO)-SO_4	0.70	0.96	0.41	7680	3.89	3.59	12900	0.98	4.11
$C_{14,15}$-5(PO)-SO_4	1.22	0.96	0.55	10300	4.01	3.50	9120	0.98	3.96
$C_{14,15}$-8(PO)-SO_4	1.94	0.94	0.66	12300	4.09	2.88	11700	0.97	4.07

4.5.5 Adsolubilization Study

This study also examined adsolubilization of organic solute into adsorbed surfactant onto alumina surface. The parameters studied are analogous to those used in solubilization studies. The molar fraction of organic solute partition into adsorbed admicelle, X_{adm} is defined similar to X_{mic} (Edward et al., 1991; Nayyar et al.,1994; Rouse et al., 1995)

$$X_{adm} = \frac{(C_0 - C_{eq})}{(C_0 - C_{eq}) + (S_0 - S_{eq})}$$

Where, C_0 and C_{eq} are the concentration of organic solute initials, and at equilibrium, respectively. S_0 and S_{eq} are the concentration of surfactant added and present as monomer respectively. The admicellar partition coefficient, K_{adm}, is defined analogous to K_{mic}, as follows:

$$K_{adm} = \frac{X_{adm}}{X_{aq}}$$

$$X_{aq} = \frac{C_{eq}}{C_{eq} + 55.55}$$

Here, 55.55 represent 1/molar volume of water and X_{aq} is calculated from solute concentration at equilibrium (C_{eq}) for admicellar system. The adsolubilization isotherms plotted versus mole fractions of organic solute in admicelle versus mole fraction of organic solute in aqueous phase (X_{aq}) (Figure 4-10) were used to evaluate the degree of styrene adsolubilization.

The external linker system, containing dodecanol produces slightly higher adsolubilization capacity (K_{adm}) than the conventional surfactant, SDS alone (Table 4-4). This could be due to the lipophilic linker molecule increasing the hydrophobicity of the hydrophobic core of the adsorbed admicelle through tighter packing of the surfactant aggregates.

Comparing adsolubilization capacities between linker-based and extended-surfactant-based admicelles from Table 4-4 and Figure 4-10, we see no significant variation in K_{adm} values. This is surprising, given that a slight increase in micelle solubilization (K_{mic}) was observed with increasing number of PO groups. However, the tighter packing density observed in the surface admicelles may squeeze the area where enhanced solubilization was realized in micelles. When comparing the adsolubilization results, the maximum adsorption capacity of extended surfactants occurred at lower surfactant concentrations than the SDS and SDS-linker systems. It is thus observed that PO groups in extended-surfactant-based admicelles will improve the overall adsolubilization process by reducing the amount of surfactant needed to reach maximum adsorption.

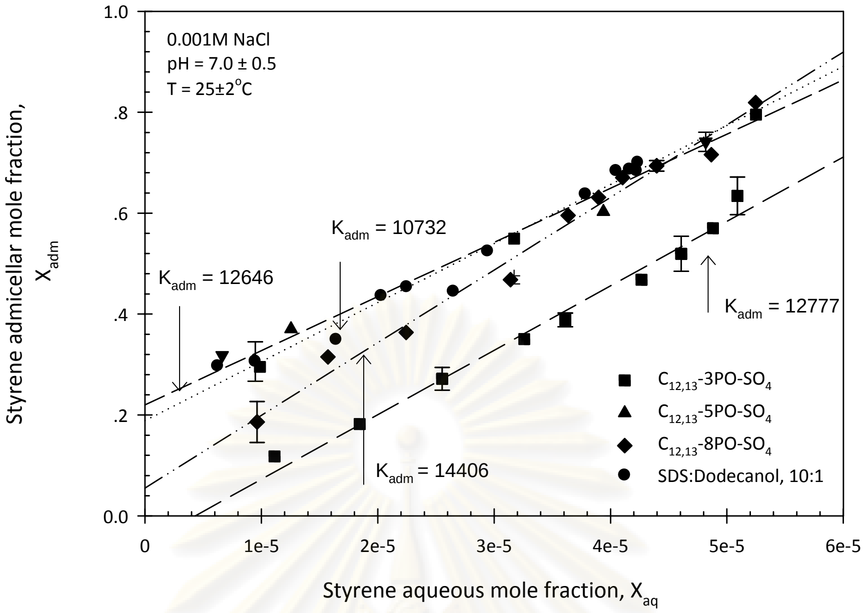


Figure 4-10 Adsolubilization capacities of external linker, SDS/Dodecanol, 10:1 molar ratio and extended surfactants, C12,13 series with different PO numbers.

The effects of the number of carbon chain length as well as the number of PO group are shown in Table 4-4. Both C12,13 and C14,15 extended surfactants with 3 PO groups have similar adsolubilization capacity. Both C12,13 and C14,15 extended surfactants with 5 PO groups have the lowest adsolubilization capacity in their system. The 8 PO numbers show the highest adsolubilization capacity. These differences could be due to higher adsorption capacity which provided a larger hydrophobic site for solubilizing styrene into adsorbed admicelles on alumina.

CHAPTER V

SOLUBILIZATION AND ADSOLUBILIZATION OF POLAR AND NONPOLAR ORGANIC SOLUTES BY LINKER MOLECULES AND EXTENDED SURFACTANTS

5.1 ABSTRACT

Adsolubilization reaches its maximum when surfactant adsorbed onto the solid-liquid interface achieves complete bilayer or maximum adsorption. The attempt to enhance the adsolubilization of organic solute is accomplished by increasing interaction between the hydrophobic core of adsorbed admicelle and the organic solute. Solubilization and adsolubilization were studied with linker-based and extended-surfactant-based systems. Extended surfactants have propylene oxide (PO) groups of intermediate polarity inserted between hydrophobic and lipophilic moieties in the surfactant molecule. This study evaluated the adsolubilization of polar (phenylethanol) and nonpolar (ethylcyclohexane) solutes into conventional linker-based and extended-surfactant-based admicelles. The results demonstrated that the extended-surfactant-based systems showed higher solubilization capacity than the conventional surfactant, SDS and SDS with linker. For the polar solute, the presence of propylene oxide group (PO) has a greater effect than the number of PO groups or the tail length, while for the nonpolar solute as the number of POs groups and the tail length increased, the adsolubilization capacity also increased. Preliminary explanation for these observations is provided; they should be further studied in future research.

5.2 INTRODUCTION

Surfactant molecule consists of two parts; the hydrophilic head or water-like portion and the hydrophobic tail or oil-like portion of the same molecule. When surfactant monomers form spherical aggregates (**micelles**), these aggregates are capable of solubilizing organic solutes. In addition, surfactant molecules adsorbed onto a solid-liquid surface act as two-dimensional aggregates known as **hemimicelles** or **admicelles,** depending on whether they form monolayer or bilayer coverage, respectively. At high surfactant concentration, surfactant bilayers form with the surfactant head groups of the bottom layer adsorbed onto the solid surface and the head groups of the top layer positioned toward the aqueous solution. The surfactant tails in the absorbed layer form a hydrophobic core to the admicellar system. This admicelle core adsolubilizes organic solutes in a process similar to solubilization in micelles (Nayyar et al., 1994; Dickson and O'Haver, 2002). The partitioning of organic solutes into the interior of admicelles is called the **adsolubilization** process (Scamehorn and Harwell, 1989). Admicelle-modified surfaces have a great potential for industrial and environmental application such as admicellar-enhanced chromatography (Harwell and O'Rear, 1989), admicellar polymerization and application in environmental remediation (Sun and Jaffé, 1996; Karapanagioti et al., 2005; Adak and Pal, 2006; Adak et al., 2006; Fuangswasdi et al., 2006), including surfactant-modified surfaces for treating waste streams containing organic pollutants (Adak and Pal, 2006).

Many researchers have investigated the impact of various parameters on solubilization and adsolubilization capacity, including the effect of surfactant concentration, solution pH, electrolyte concentration, and surfactant properties. (Scamehorn and Harwell, 1989; Rouse et al., 1995; Kitiyanan et al., 1995; Sun and Jaffé, 1996; Esumi at al, 2000; Esumi, 2001; Dickson and O' Haver, 2003, Tan and O' Haver, 2004; Fuangswasdi et al., 2006 a and b; Saphanuchart et al., 2008). One measure of surfactant solubilization is the molar solubilization ration (MSR) (Rouse et al., 1995; Fuangswasdi et al., 2006 a and b). The MSR is defined as the number of moles of solute solubilized per mole of surfactant added to solution (Edward et al., 1991; Fuangswasdi et al., 2006b; Swe et al., 2006). The MSR can be calculated from Equation 1.

$$MSR = \frac{(C_{mic} - C_{cmc})}{(S_{surf} - S_{cmc})} \qquad (5\text{-}1)$$

where S_{cmc} is the solubility of organic solute in mole per liter at CMC; S_{mic} is the total solubility of the solute in micelle at the surfactant concentration higher than the CMC; and C_{surf} is the surfactant concentration at the S_{mic} is evaluated. The micellar partition coefficient (K_{mic}) describes the partitioning of the various solutes into the micellar system;

$$K_{mic} = \frac{X_{mic}}{X_{aq}} \qquad (5\text{-}2)$$

where, X_{mic} is molar fraction of organic solute in the micelle. X_{mic} is related to the MSR by the simple relationship :

$$X_{mic} = \frac{MSR}{[MSR+1]} \qquad (5\text{-}3)$$

and X_{aq} is defined by :

$$X_{aq} = \frac{C_{aq}}{C_{aq} + 55.55} \qquad (5\text{-}4)$$

where C_{aq} is molar solubility of the organic solute in the aqueous phase and 55.55 is 1/molar volume of water

Based on the analogous structure of micelles and admicelles, the admicellar partition coefficient (K_{adm}) quantifies the adsolubilization capacity. K_{adm} can be calculated from

$$K_{adm} = \frac{X_{adm}}{X_{aq}} \tag{5-5}$$

where X_{adm} is the molar fraction of the organic solute in the admicelle phase and is calculated from;

$$X_{adm} = \frac{\left(C_0 - C_{eq}\right)}{\left(C_0 - C_{eq}\right) + \left(S_0 - S_{eq}\right)} \tag{5-6}$$

Where, C_0 and C_{eq} are the concentration of organic solute at initial and equilibrium, respectively. S_0 and S_{eq} are the concentration of surfactant added and present as monomer, respectively.

Numerous researchers have evaluated the locus of solubilization in surfactant micelles and admicelles. Researchers have found that nonpolar organic solutes primarily partition into the core region, while polar organic solutes partition into the palisade region of the admicelle (Nayyar et al.,1994; Kitiyanan et al.,1996; Esumi, 2001; Fuangswasdi et al., 2006; Saphanuchart et al.,2008). Solubilization and adsolubilization have shown the following trends; 1) If the solute partitions primarily into to the core, the partition coefficient increases with increasing mole fraction of solute in the admicelle (X_{adm}), 2) If the solute partitions to the palisade layer, the partition coefficient decreases with increasing mole fraction of the solute (X_{adm}), 3) If the solute partitions into both the core and palisade region, the partition coefficient remains relatively constant with the mole fraction of solute solubilization (Edwards et al., 1991; Rouse et al., 1995; Kitiyanan et al., 1995; Dickson and O' Haver, 2002; Tan and O' Haver, 2004; Fuangswasdi et al., 2006b).

Recently, new surfactants and surfactant additives have been proposed, i.e., linker-based surfactant systems (Salager et al., 1998; Acosta et al., 2004; Szekeres et al., 2005) and extended surfactant systems. These systems have been introduced to improve the solubilization of organic solutes (Minana-Perez et al., 1995; Jayanti et al., 2002; Sabatini et al., 2003; Salager et al., 2005; Childs et al., 2006). The lipophilic linker (e.g. dodecanol) segregates near the surfactant tail and helps improve the solubilization capacity. The linker molecule serves as a link between the surfactant tail and oil molecules. Through this association, the linker molecule promotes orientation of oil molecules in the oil phase and increases interaction deeper into the oil side of the interface (Graciaa et al., 1993; Salager et al., 1998).

Extended surfactants (Fernández et al., 2005 a and b, Sabatini et al., 2003; Witthayapanyanon et al., 2006) have a region of intermediate polarity of polypropylene oxide (PO) inserted between hydrophilic head and lipophilic tail of the surfactant molecule (Sabatini et al., 2003). Due to their unique molecular structure, extended surfactants show the capability of further reducing surface tension and interfacial tension at low-surfactant concentrations (Witthayapanyanon et al., 2006). Witthayapanyanon and co-workers (2006) demonstrated that the extended surfactant produces ultra low interfacial tension (IFT) for a wider range of organic solvents.

In our previous work (Chapter 4), we evaluated the adsorption of extended surfactants onto aluminum oxide surfaces and subsequent adsolubilization of styrene. The goal of this study is to evaluate the adsolubilization of a more polar and a more nonpolar solute into extended-surfactant-based admicelles to gain a better understanding of the interior of the admicellar structure. In this study, the solubilization and adsolubilization of solutes with similar structure but varying degree of polarity are evaluated in extended surfactant and linker-based admicelles. To our knowledge, this and our previous work are the first attempt to study adsolubilization in the extended-surfactant and linker-based admicelles. The number of carbons in the surfactant alkyl chain is varied in order to evaluate the effect of admicelle tail length. The main objective of this study is to compare the solubilization and adsolubilization of extended surfactants versus SDS alone and SDS plus linker molecule systems using polar and nonpolar solutes. In particular, this research focuses on (i) the effect of propylene oxide groups in extended surfactants versus SDS plus hydrophobic linker admicelles, (ii) and the effect of number of PO groups, (iii) the effect of tail length on solubilization and adsolubilization of polar and nonpolar solutes.

5.3 METHODOLOGY

5.3.1 Materials

The surfactants studied in this research are divided into two systems; external linker systems (i.e., lipophilic linker-based systems) and internal linker systems (i.e., extended surfactants). ***External linker system:*** Sodium dodecyl sulfate (SDS) was selected as a conventional anionic surfactant with a C12 alkyl chain length. SDS (98%) was purchased from Sigma Company. n-dodecanol, a long chain linear alcohol with an alkyl chain length of 12, was used as a lipophilic linker. n-dodecanol (98%) was purchased from Arcos chemical company. ***Internal linker system:*** The extended anionic surfactants evaluated in this research were alkyl propoxylated sulfates of the Alfoterra® series with distribution of alkyl chain length of 12 and 13, and 14 and 15 carbons with various number of propylene oxide (PO) groups; these surfactants were obtained from SASOL North America Inc. Table 5-1 summarizes the surfactants and their properties evaluated in this study.

Phenylethanol and ethylcyclohexane were selected as solutes to represent a range of polarity and hydrophobicity (see -dipole moment and log K_{ow} in Table 5-2). Phenylethanol was purchased from Fluka chemical company and ethylcyclohexane was purchased from Arcos chemical company at purity of 99%. Table 5-2 summarizes the properties of organic solutes evaluated in this study. Styrene results were reported from previous research for comparison proposes; it has an intermediate polarity to phenylethanol and ethylcyclohexane (see Table 5-2).

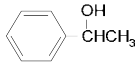
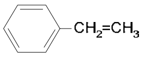
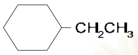
Aluminum oxide (Al_2O_3) was purchased from Aldrich chemical company and used as receive. The specific surface area reported from the manufacturer is 155 m^2/g and the point of zero charge (PZC) of alumina is 9.1 (Sun and Jaffé, 1996). The electrolyte concentration was controlled using sodium chloride (NaCl). The solution pH was adjusted using NaOH and HCl. All chemicals were used as received. All solutions were prepared with purified water having a resistance of 18.2 ΩM cm.

Table 5-1 Surfactant properties

Surfactant	**Type**	**Formula**	**Moles PO**	**MW**	**CMC**[a] (mM)
External linker (***C12***)					
SDS alone	Anionic	$C_{12}H_{25}OSO_3Na$	-	288	5.00
SDS/dodecanol, 10:1 M/M	Linker molecule	$C_{12}H_{25}OSO_3Na$/ $C_{12}H_{26}OH$	-		3.00
Internal linker, extended surfactant C12,13 series					
Alkyl propoxylated sulfate C12-13 (n = 3,5,8)	Anionic extended	$C_{12,13}$-3(PO)-SO_4Na	3	469	0.20
		$C_{12,13}$-5(PO)-SO_4Na	5	570	0.10
		$C_{12,13}$-8(PO)-SO_4Na	8	713	0.02
Internal linker, extended surfactant C14,15 series					
Alkyl propoxylated sulfate C14-15 (n = 3,5,8)	Anionic extended	$C_{14,15}$- 3(PO)-SO_4Na	3	483	0.03
		$C_{14,15}$-5(PO)-SO_4Na	5	595	0.02
		$C_{14,15}$-8(PO)-SO_4Na	8	715	0.01

a - from surface tension measurement at 0.001 M NaCl and 25±2 °C

Table 5-2 Organic solute properties

Organic solutes	Molecular		MW	Water solubility	Log K_{ow}	Density 25 °C	Dipole moment	X_{aq}
	Formula	Structure		(mg/L)		(g/mL)		
Phenylethanol	$C_6H_5CH(OH)CH_3$		122.16	1950	1.42[a]	1.01	1.65	2.87E-04
Styrene	$C_6H_5CH=CH_2$		104.15	312	2.95[b]	0.91	0.13	5.39E-05
Ethylcyclo-hexane	$C_6H_{11}C_2H_5$		112.40	2.92	3.44[c]	0.79	0.00	4.68E-07

a http://agrippina.bcs.deakin.edu.au/bcs_admin/msds/msds_docs/1-Phenylethanol.pdf

b http://www.epa.gov/OGWDW/dwh/t-voc/styrene.html

c for cyclohexane (Schwarzenbach, R. P.; Gschwend, P. M.; Imboden, D. M.(1993). Environmental Organic Chemistry. John Wiley & Son, Inc)

*For comparison purpose, styrene results are reported from Chapter 4

5.3.2 Experimental Methods

5.3.2.1 Solubilization Study

Solubilization studies were conducted using the solubilization method (Nayyar et al., 1994) at a constant room temperature (25±2°C), an electrolyte concentration of 0.001 M NaCl and a solution pH of 7.0±0.5. The surfactant concentration was varied from below to above the CMC. The solution was equilibrated by shaking for 48 hours with subsequent analysis.

5.3.2.2 Adsolubilization Study

Adsolubilization isotherms were conducted at a constant room temperature (25±2 °C), an electrolyte concentration of 0.001 M NaCl and a solution pH of 7.0 ± 0.5 according to environmental parameter in Fuangswasdi and co-worker (2006 a and b). In order to determine the adsolubilization capacity of the organic solute, feed solutions with known surfactant concentrations were added to aluminum oxide of known mass with varying solute concentrations. The surfactant concentration was selected to insure that the system equilibrated just below the CMC (90-95% of CMC) to ensure maximum surfactant adsorption but that no micelles were present in aqueous solution at equilibrium. Equilibrium was achieved by shaking for 48 hours as in the adsorption studies with subsequent centrifugation to remove the aluminum oxide; pinacyanol chloride was used as an indicator to ensure that no micelles were present in solution (Kitiyanan et al., 1995; Pongprayoon et al., 2002). Aqueous surfactant and organic solute concentrations were then analyzed. The amount of adsolubilization was calculated by mass balance based on initial concentration and equilibrium concentration of surfactant and solute.

5.3.2.3 Analytical Measurements

All surfactants were analyzed using ion chromatography, IC (ICS-2500, Dionex) with a reverse phase column NS1 (Dionex) and electro conductivity detector (ECD) (Doan et al., 2003; Fuangswasdi, 2006a and b). Phenylethanol was analyzed using IC (ICS-2500, Dionex) with a UV detector operating at 247 nm. Ethylcyclohexane was analyzed using gas chromatography, GC (6890N, Agilent) with HP-5 column (Agilent) at temperature of 275^{o}C and detected by Flame Ionization detector (FID).

5.4 RESULTS AND DISCUSSION

5.4.1 Solubilization study

5.4.1.1 Phenylethanol solubilization

Figure 5-1 shows the solubilization isotherms of phenylethanol by the linker-based (SDS/dodocanol molar ratio 10:1) and extended-surfactant-based systems, ($C_{12,13}$-3PO-SO_4 and $C_{14,15}$-3PO-SO_4). The solubilization isotherm plots the aqueous phenylethanol concentration versus the aqueous surfactant concentration. The transition point where the solute concentration begins to increase corresponds approximately to the CMC of the surfactant system (Fuangswasdi et al., 2006). However, it should be noted that the CMC of the surfactant system can be affected by the presence of the solute. At low surfactant concentration (below the transition point), the phenylethanol solubility is constant and approximately equal to its aqueous solubility (Fuangswasdi et al., 2006). At higher surfactant concentration (above the CMC), the solubility increases through phenyl ethanol solubilization in surfactant micelles. The slope of this region is used to calculate the molar solubilization ratio (MSR) indicating the moles of organic solute (solubilizate) per mole of the micellar surfactant. The MSR is used to calculate the micellar partition coefficient (K_{mic}) (see equation 2 to 4) using a X_{aq} value for phenylethanol of 2.87 x10^{-4} (see - Table 5-3).

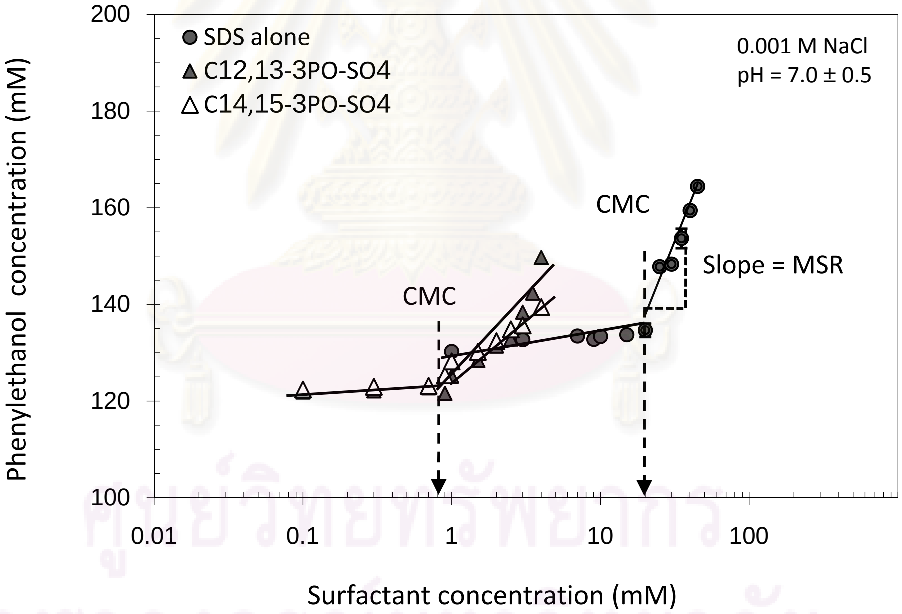


Figure 5-1 Solubilization isotherms of phenylethanol in linker-based and extended surfactant-based micellar systems (0.001 M NaCl)

The results from Table 5-3 show that the log K_{mic} values of phenylethanol with extended surfactant systems (3.42 to 3.49) are higher than the conventional anionic surfactant system, SDS (3.26) or even the linker-based system, SDS/dodecanol molar ratio

10:1 (3.29). The fact that the extended surfactant systems have higher log K_{mic} values than linker molecule systems indicates that the presence of propylene oxide groups in the extended surfactants enhance the solubilization capacity.

Phenylethanol solubilization isotherms of the extended surfactants C12,13 with varying PO numbers are shown in Figure 5-2 for supra – CMC concentrations. The MSR and log K_{mic} values of extended surfactant systems with different PO numbers are summarized in Table 5-3. The solubilization capacity (log K_{mic}) was relatively constant (3.46 to 3.42) with increasing PO number for C-14,15 extended surfactants. Similar results were observed for the extended surfactant of C12,13 series, where the log K_{mic} values range from 3.49 to 3.42. It thus appears that, while the presence of the PO groups increases the hydrophobicity and solubilization of the micelles versus no PO groups (see - SDS results discussed above), variations in the number of PO groups has a lesser effect on solubilization.

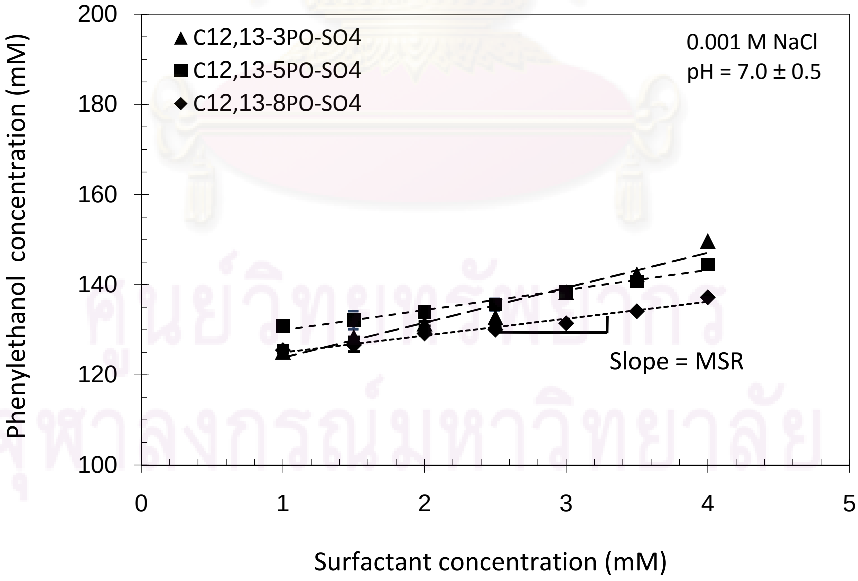


Figure 5-2 Solubilization capacity (MSR) of phenylethanol by extended surfactants C12,13 with 3, 5 and 8 PO numbers (0.001 M NaCl)

Since, phenylethanol is a polar organic solute, it was expected to partition primarily into the palisade region. From the Table 5-3, as the carbon chain length increased from C12,13 to C14,15 for the extended surfactants, the log K_{mic} values remain virtually the same, indicating that the hydrophobicity of the core does not significantly impact the solubilization of polar phenyl ethanol.

5.4.1.2 Ethylcyclohexane Solubilization

Solubilization isotherms of ethylcyclohexane by C14,15 extended surfactant systems are shown in Figure 5-3 and the log K_{mic} values are summarized in Table 5-3. The log K_{mic} values of extended surfactant systems (5.94-6.07) are higher than linker-based system, SDS/dodecanol molar ratio 10:1 (5.34) and conventional surfactant system, SDS alone (5.30). Again, this provides evidence of the solubility enhancement realized by adding PO groups to the surfactants similar to results for phenylethanol solubilization above. Relative to the impact of the number of PO groups on the solubilization of ethylcyclohexane, the result shows that as the number of PO groups increases, the ethylcyclohexane solubilization for both C12,13 and C14,15 extended surfactant series increases slightly. In addition the log K_{mic} values of C14,15 extended surfactant systems are slightly higher than C12,13 series. Thus, the longer tail enhances the incorporation of the nonpolar solute into the core region (Dickson and O' Haver, 2002). But once again, the greater increase occurs when going from no PO groups to including POs- varying the number of PO groups has a lesser effect in solubilization (log K_{mic}). The solubilization capacity (log K_{mic}) of phenylethanol (highly polar) is slightly lower than styrene (slightly polar – see dipole moments in Table 5-2) (styrene data are shown in Table 5-3). In all cases, K_{mic} values of extended surfactants greater than conventional and conventional with linker molecules. This can be attributed to the increased hydrophobicity of the surfactant with addition of PO groups, the larger micelles and thus improved solubilization for longer ("extended") surfactants and possibly to an increase in the polarity of the palisade layer due to the presence of the PO groups.

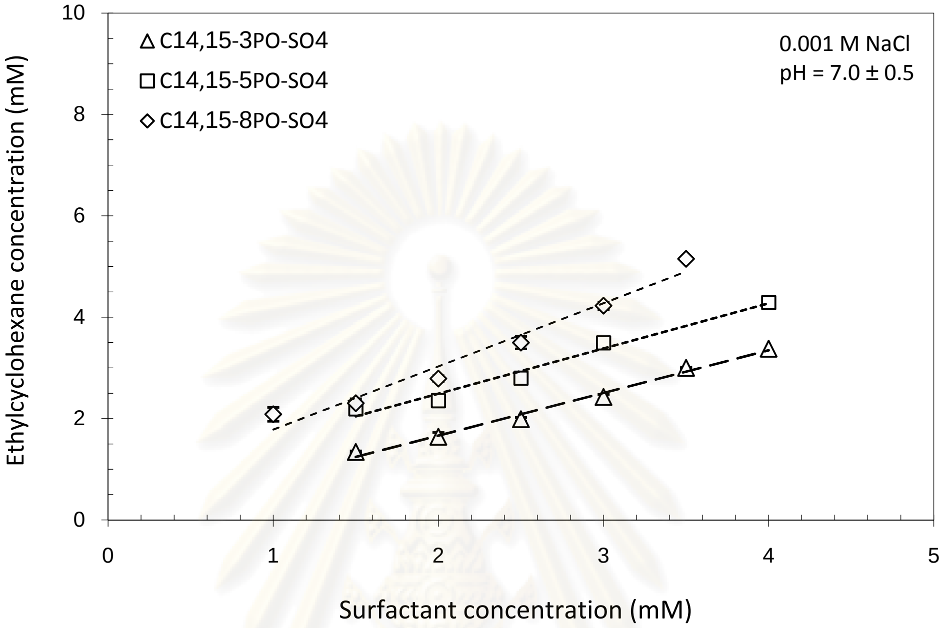


Figure 5-3 Solubilization capacity (MSR) of ethylcyclohexane by extended surfactant C14,15 with 3, 5 and 8 PO numbers

Table 5-3 Summarizes of organic solute solubilization capacities, molar solubilization ratio (MSR) and partition coefficient (K_{mic})

Surfactants (0.001M NaCl)	**HLB**[a]	**Phenylethanol** (X_{aq} = 2.87 x 10^{-4})					**Styrene**[b] (X_{aq} = 5.39 x 10^{-5})					**Ethycyclohexane** (X_{aq} = 4.68 x 10^{-7})				
		MSR	r^2	X_{mic}	K_{mic}	logK_{mic}	MSR	r^2	X_{mic}	K_{mic}	logK_{mic}	MSR	r^2	X_{mic}	K_{mic}	logK_{mic}
SDS		1.08	0.96	0.52	1810	3.26	0.31	0.96	0.23	4400	3.64	0.10	0.98	0.09	199000	5.30
SDS:dodecanol		1.25	0.96	0.56	1940	3.29	0.50	0.97	0.33	6240	3.80	0.11	0.96	0.10	217000	5.34
$C_{12,13}$-3(PO)-SO_4Na	39.55	7.45	0.95	0.88	3070	3.49	0.40	0.94	0.28	5300	3.73	0.69	0.97	0.41	874000	5.94
$C_{12,13}$-5(PO)-SO_4Na	39.25	4.45	0.95	0.82	2850	3.45	0.56	0.90	0.36	6670	3.82	0.72	0.98	0.42	893000	5.95
$C_{12,13}$-8(PO)-SO_4Na	38.70	3.74	0.95	0.79	2750	3.44	0.67	0.93	0.40	7480	3.87	0.81	0.98	0.45	954000	5.98
$C_{14,15}$- 3(PO)-SO_4Na	38.60	4.78	0.95	0.83	2880	3.46	0.70	0.96	0.41	7680	3.89	0.84	0.98	0.46	977000	5.99
$C_{14,15}$-5(PO)-SO_4Na	38.30	4.09	0.98	0.80	2800	3.45	1.22	0.96	0.55	10300	4.01	0.89	0.98	0.47	1010000	6.00
$C_{14,15}$-8(PO)-SO_4Na	37.85	3.13	0.96	0.76	2640	3.42	1.94	0.94	0.66	12300	4.09	1.25	0.96	0.55	1190000	6.07

a HLB = Hydrophilic-lipophilic balance
b styrene results summarized from Chapter 4

5.4.2 Adsolubilization Study

5.4.2.1 Phenylethanol Adsolubilization

The adsolubilization capacities (log K_{adm} values) of phenylethanol in linker-based and extended surfactant-based systems are summarized in Table 5-4. Figure 5-4 shows the adsolubilization of phenylethanol in extended surfactant of the C14,15 series versus aqueous phenylethanol concentration. The results in Figure 5-4 show that as the equilibrium concentration of phenylethanol increased, the adsolubilization per gram of aluminum oxide increased for all surfactant system. In the absence of surfactant, the adsorption of phenylethanol was negligible with the aluminum oxide surface.

From Table 5-4, we once again observe that the K_{adm} values for extended surfactants are greater than for SDS alone and SDS/linker systems. Thus, as with micelles above, the PO groups improve the adsolubilization of phenylethanol in admicelles.

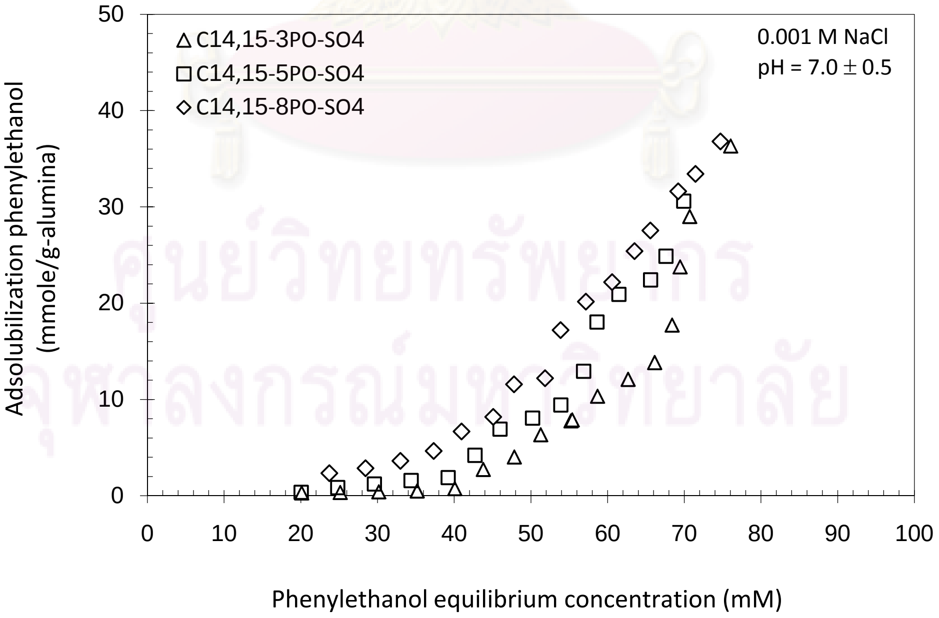


Figure 5-4 Adsolubilization isotherm of phenylethanol by extended surfactant C14,15 with 3, 5 and 8 PO numbers

Figure 5-5 shows the adsolubilization isotherms (X_{adm} vs X_{aq}) of phenylethanol by C14,15 extended surfactants with varying PO numbers. As the PO number increases, the adsolubilization of phenylethanol decreases (2.95 to 2.45 for C 12,13 and 2.35 to 2.44 for C 14,15, respectively – see Table 5-4) with the greater decrease occurring from 5 to 8 POs. Due to the polar nature of phenylethanol, it was expected to partition into the palisade region of admicelle. Polarity alone would suggest that the K_{adm} would increase with increasing the number of POs, the opposite of what was observed. At the same time, with increasing number of POs the surfactant coiling increases, as confirmed by larger areas per head group (as discussed in previous chapter). This would tend to “squeeze out” the cavities in the palisade layer where the polar solute would segregate. From our results, the coiling effect seems to dominate versus the polarity effect –this should be further evaluated in future research

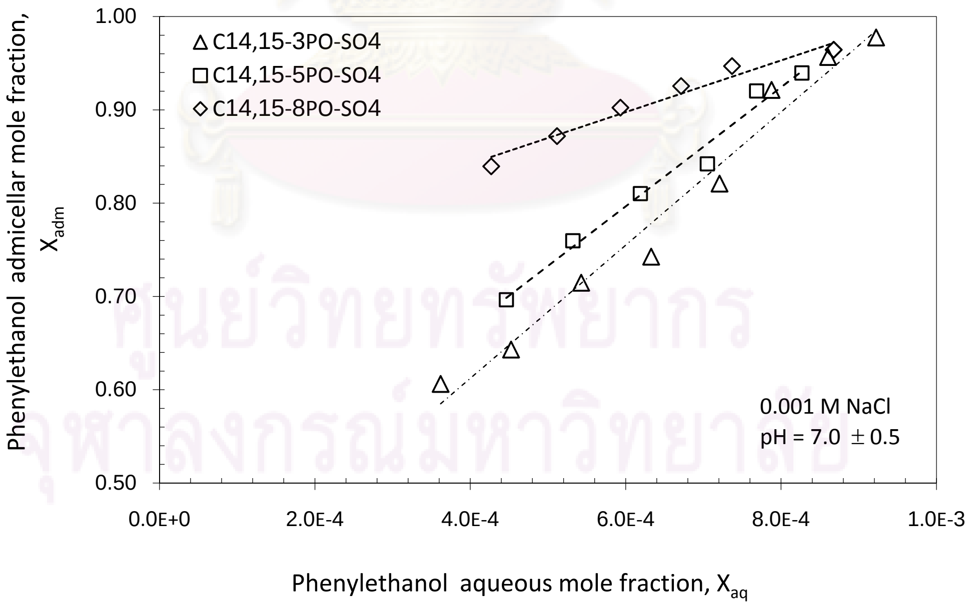


Figure 5-5 Adsolubilization capacity (K_{adm}) of phenylethanol by extended surfactant C14,15 with 3, 5 and 8 PO numbers

For the effect of carbon chain length in the surfactant tail, the extended surfactant with longer chain but the same PO number (C14,15 extended surfactants) has virtually the same K_{adm} values as compared to C12,13 extended surfactant series; the greater effect is observed for increasing number of PO groups, as discussed above. .

5.4.2.2 Ethylcyclohexane Adsolubilization

The ethylcyclohexane adsolubilization isotherms by extended surfactant C14,15 series are shown in Figure 5-6. The adsolubilization potential (K_{adm}) of ethylcyclohexane in extended surfactant systems is summarized in Table 5-4. In the absence of adsorbed surfactant, the adsorption of ethylcyclohexane onto aluminum oxide was negligible. As expected, with increasing aqueous concentration of ethylcyclohexane the amount of adsolubilized ethylcyclohexane increases for all three surfactants (Figure 5-6). The results show that the adsolubilization capacity of ethylcyclohexane was greater for the 8 PO surfactant than for 3 POs for both C12,13 and C14,15 series. This indicated that the adsolubilization of ethylcyclohexane, a hydrophobic solute, becomes more favorable due to the hydrophobicity of the 8PO group. In addition, the adsolubilization for ethylcyclohexane in C14,15 extended surfactant was greater than for the C12,13 series (Table 5-4). As the carbon chain length increases from C12,13 to C14,15 carbons, the adsolubilization of ethylcyclohexane becomes more favorable, once again due to the hydrophobicity of the admicelles. The adsolubilization of conventional surfactant, SDS and linker molecule, SDS/dodecanol, are not available because the amount of adsolubilization was too small to quantify – illustrating the significant advantage of the extended surfactants in adsolubilization.

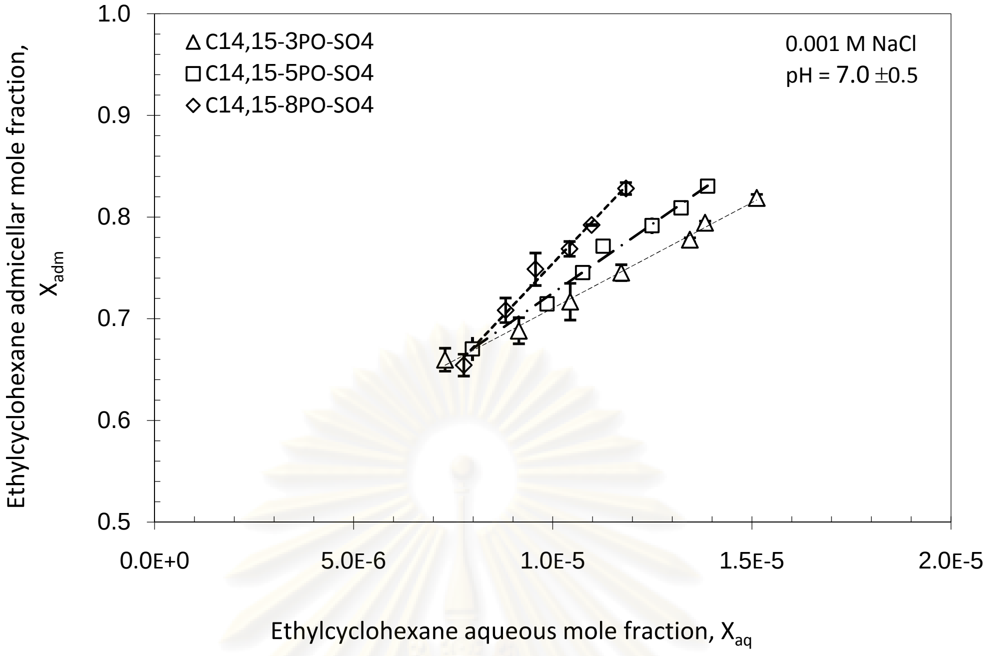


Figure 5-6 Adsolubilization capacity (K_{adm}) of ethylcyclohexane by extended surfactant C14,15 with 3, 5 and 8 PO numbers

Due to the water solubility of the solutes, the polar phenylethanol has high solubility in water (X_{aq} = 2.87 x 10^{-4}) followed by styrene (X_{aq} = 5.39 x 10^{-5}) with ethylcyclohexane (X_{aq} = 4.68 x 10^{-7}) being the least soluble. Thus, phenylethanol (strongly polar) prefers to solubilize in the aqueous phase rather than partition into the admicelles resulting in the lowest K_{adm} values (range from 1.76-2.95) while the highest log K_{adm} values are experienced for the least soluble ethylcyclohexane (range form 3.97-4.92).

Comparing the micellar and admicellar partition coefficients (log K_{mic} and K_{adm} – in Tables 5-3 and 5-4, respectively) shows that the admicellar systems (log K_{adm}) are less efficient at solubilizing organic solutes than the micellar system (log K_{mic}). This could be due to the fact that the coiling of PO groups in extended surfactants packs more efficiently into three dimensional micelles than into the more planar, two dimensional admicelles. Thus, it observed that the partition of organic solutes into extended surfactant micelles and admicelles depends on degree of organic solute polarity and the number of PO groups inserted in the extended surfactant.

Table 5-4 Summarizes of adsolubilization capacities (K_{adm}) of polar to nonpolar solutes

Surfactants (0.001M NaCl)	**HLB**	**ads q_{max}** (g/mole)× 10^{-4}	**Phenylethanol**			**Styrene***			**Ethylcyclohexane**		
			K_{adm}	r^2	$\log K_{adm}$	K_{adm}	r^2	$\log K_{adm}$	K_{adm}	r^2	$\log K_{adm}$
SDS		3.78	57	0.83	1.76	10700	0.94	4.06	NM	NM	NM
SDS/dodecanol		5.41	157	0.97	2.20	12600	0.98	4.10	NM	NM	NM
$C_{12,13}$-3(PO)-SO_4Na	39.55	3.37	899	0.96	2.95	12800	0.98	4.11	9320	0.96	3.97
$C_{12,13}$-5(PO)-SO_4Na	39.25	3.55	715	0.96	2.85	10700	0.98	4.03	9430	0.97	3.97
$C_{12,13}$-8(PO)-SO_4Na	38.70	3.87	282	0.95	2.45	14400	0.99	4.16	13500	0.98	4.13
$C_{14,15}$- 3(PO)-SO_4Na	38.60	3.59	713	0.98	2.85	12900	0.98	4.11	20800	0.99	4.32
$C_{14,15}$-5(PO)-SO_4Na	38.30	3.50	609	0.98	2.78	9120	0.98	3.96	27200	0.99	4.43
$C_{14,15}$-8(PO)-SO_4Na	37.85	2.88	277	0.97	2.44	11700	0.97	4.07	41400	0.98	4.62

NM = not measureable

*Styrene results summarized from chapter 4

The adsolubilization by linker-based (SDS/dodecanol) and extended surfactant ($C_{12,13}$-PO_n-SO_4 and C14,15-PO_n-SO_4) systems onto positively charged alumina surface were studied to understand its mechanisms. The results indicate that as the numbers of PO group and the hydrophobicity in extended surfactant increase, adsolubilization capacity (K_{adm}) of non polar solute (ethylcyclohexane) increase significantly. Thus, it is expected to partition into the core region of the admicelles. As a result, the extended surfactant with higher amount of PO groups could be effectively used to remove non-polar compound such as polyaromatic hydrocarbons (PAHs). On the other hand, as the numbers of PO group decrease, the adsolubilization capacity (K_{adm}) of high polarity solute (phenylethanol) slightly increase. The high polarity organic compound is expected to partitioning into palisade layer. This could be inferred that non-polar solute prefer to adsolubilized in small PO group or low hydrophobicity surfactant. In environmental application, the extended surfactant with lower numbers of PO group could be applied to remove polar compound such as chlorinated solvent. However, no significantly trend was observed from intermediate polarity solute (styrene) with increasing number of PO group.

In addition, correlation of the partition coefficient (K) values between solutes with different degree of polarity, it can be clearly seen that micellar partition coefficient (K_{mic}) relate to hydrophobicity of surfactant admicelles which lead to increase partitioning of non-polar solute and squeeze out the partitioning of polar solute (X_{mic}). Moreover, K_{mic} also depends on water solubility of organic solute. The higher water solubility solute (phenylethanol) – higher X_{aq} (2.87×10^{-4}) causes K_{mic} value smaller than non polar solute (ethylcyclohexane) – lower X_{aq} ($= 4.68 \times 10^{-7}$); as the fact that it is higher on absolute basis, it is lower on a relative basis (Nayyar et al, 1991). However, the point to be address here is that amount organic solute solubilized in micellar /admicellar systems depend on hydrophobicity of surfactant system and solute properties (i.e., molecular size, degree of polarity and water solubility).

In terms of using surfactant-modified adsorbent for practical environmental application, this result indicated that the extended surfactant system provide higher adsolubilization for the low polarity solute or hydrophobic organic compounds (i.e. PAHs). On the other hand, external linker-based system (i.e., SDS/dodecanol – low cost surfactant formulations) could be applied for treating polar organic or hydrophilic organic compounds (i.e., alcohol or phenol groups) in economics of scale.

CHAPTER VI

LOCALIZATION OF ORGANIC SOLUTES, DESORPTION AND SURFACE CHARACTERIZATION

6.1 THE LOCALIZATION OF ORGANIC SOLUTES

6.1.1 Introduction

Several studies have attempted to indentify the partitioning locus of various organic solutes in admicelles (Rouse et al., 1993; Kittiyanan et al., 1996; Dickson and O'Haver, 2003; Fuangswasdi et al., 2006b). Based on an analogous structure of micelles and admicelles, the admicellar partition coefficient (K_{adm}) is used to identify the partitioning locus of organic solute between adsorbed admicelle and aqueous phase. In general, K_{adm} is calculated as follows;

$$K_{adm} = \frac{X_{adm}}{X_{aq}}$$

where, X_{adm} is the molar fraction of the organic solute in the admicelle phase
X_{aq} is the mole fraction of organic solute in aqueous phase.

Some studies (Nayyar et al., 1994; Kittiyanan et al., 1996; Dickson and O'Haver, 2003; Fuangswasdi et al., 2006b) have demonstrated that the trend of the plot of the partition coefficient (K_{adm}) versus mole fraction of organic solute in the admicelle can be used to identify the locus of the partitioning of solute in the admicelle (i.e., palisade and core regions – see Figure 2-5). The locus of the organic solute turn depends on the polarity of the adsolubilizates. Researchers found that nonpolar organic solutes primarily partition into the core region, while polar organic solutes partition into the palisade region of the admicelle.

According to this theory, the adsolubilization showed the following trends (Nayyar et al., 1994; Kittiyanan et al., 1996; Dickson and O' Haver, 2002)

1) If the solute partitions preferentially into the core, the partition coefficient increases with increasing mole fraction of solute in the admicelle (X_{adm}),
2) If the solute partitions to the palisade layer, the partition coefficient decreases with increasing mole fraction of the solute (X_{adm}),
3) If the solute partitions into both the core and palisade region, the partition coefficient remains relatively constant with the mole fraction of solute solubilization

In addition, certain influence parameters that affect adsolubilization have been investigated including; surfactant concentration, solution pH, electrolyte concentration, and surfactant properties. The admicelle shape also plays a role in adsolubilization potential because the shape determines the packing density of surfactant molecule in admicelles resulting in different potential to solubilized organic solutes (Saphanuchart et al., 2007 and 2008). This study investigated the locus of organic solute with different degree of polarity from polar to nonpolar in extended surfactant based and linker-based surfactant admicelles onto alumina surface.

6.1.2 Results and discussion

Three organic solutes with varying degree of polarity from high to low polarity including phenylethanol, styrene, and ethylcyclohexane were evaluated. The locus of three organic solutes partitioning was evaluated by the shape of the graph which plotted between admicellar partitions coefficients (K_{adm}) versus solute admicellar mole fraction (X_{adm}) as shown in Figures 6-1 to 6-9. Phenylethanol is a high polarity solute (dipole moment = 1.65), and the partition coefficient (K_{adm}) decreased as mole fraction of the solute in admicelle increased. Figures 6-1 and 6-2 show the trend of the partitioning of phenylethanol in extended surfactant-based admicelles consistent with the theory that polar solute will partition to the palisade region. The results indicated that the phenylehtnaol partitions into the palisade layer.

Styrene, intermediate polarity (dipole moment = 0.13), the K_{adm} slightly decrease with increasing the mole fraction of the solute in admicelle at the low styrene concentration and then nearly constant at higher concentration (Figure 6-4 and Figure 6-6). This was implies that styrene adsolubilized into both palisade layer and the core of the admicelle at higher concentration. This is consistent with the previous work (Kitiyanan et al., 1995) demonstrating that styrene initially partitions into both the palisade layer and the core of the CTAB admicelles. But, the K_{adm} of styrene for extended surfactant with $C_{12,13}$-3PO-SO_4 remains constant at low surfactant loading comparing to the others system. For all surfactant systems evaluated in this study, styrene is likely to partition to palisade layer of admicelle.

The admicellar partition coefficient of ethylcyclohexane, low polarity solute (dipole moment = 0), decreased with the admicellar mole fraction increased. From the trends that observed in Figures 6-7 and 6-8, it is implied that the ethylcyclohexane partitions into the palisade regions. Ethylcyclohexane was expected to locate near the core according to the theory. However, it was found to locate near the palisade region in this study. For the three organic solutes, we found that all of them partition into palisade region. The results of the solutes with high polarity and intermediate polarity are consistent with previous study. On the other hand, the fact that the solute with weak polarity also partitioned to palisade regions is unique. The reason could be due the characteristic of the extended surfactant with PO group, and the structure of and smaller molecular size of the solute which could make solute molecule escape from the hydrophobic core regions.

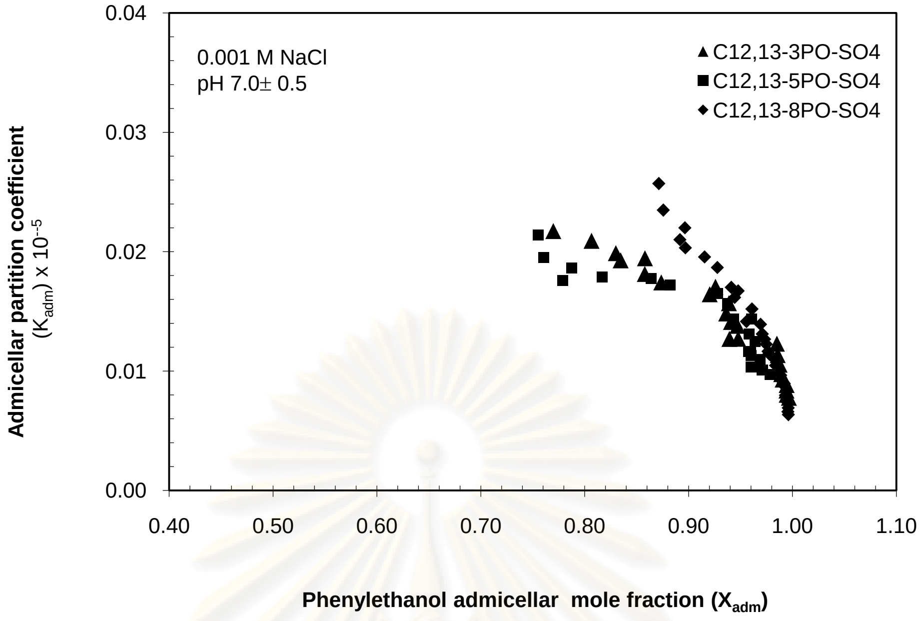


Figure 6-1 Phenylethanol adsolubilization partition coefficient versus phenylethanol mole fraction in admicelle of extended surfactants C12,13 with 3, 5 and 8 PO numbers

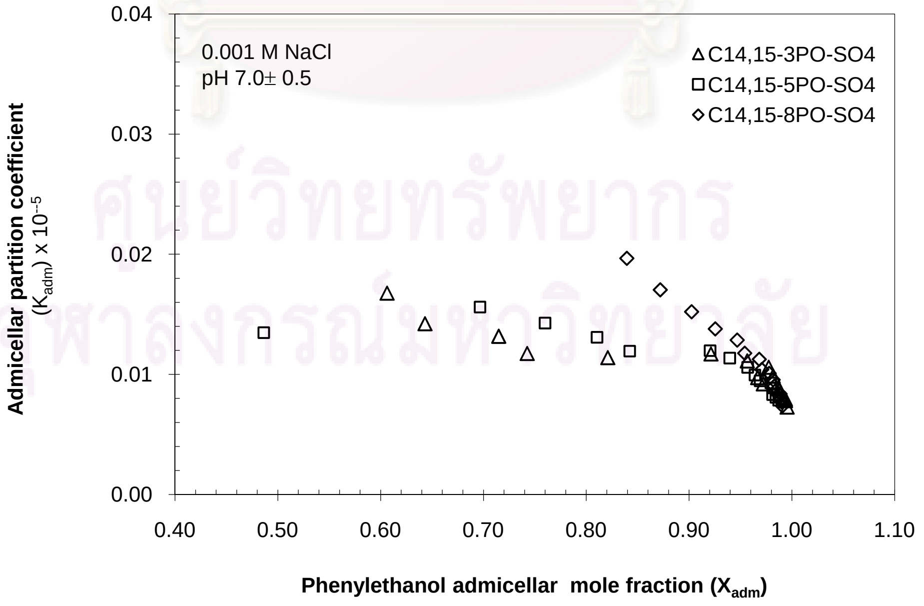


Figure 6-2 Phenylethanol adsolubilization partition coefficient versus phenylethanol mole fraction in admicelle of extended surfactants C14,15 with 3, 5 and 8 PO numbers

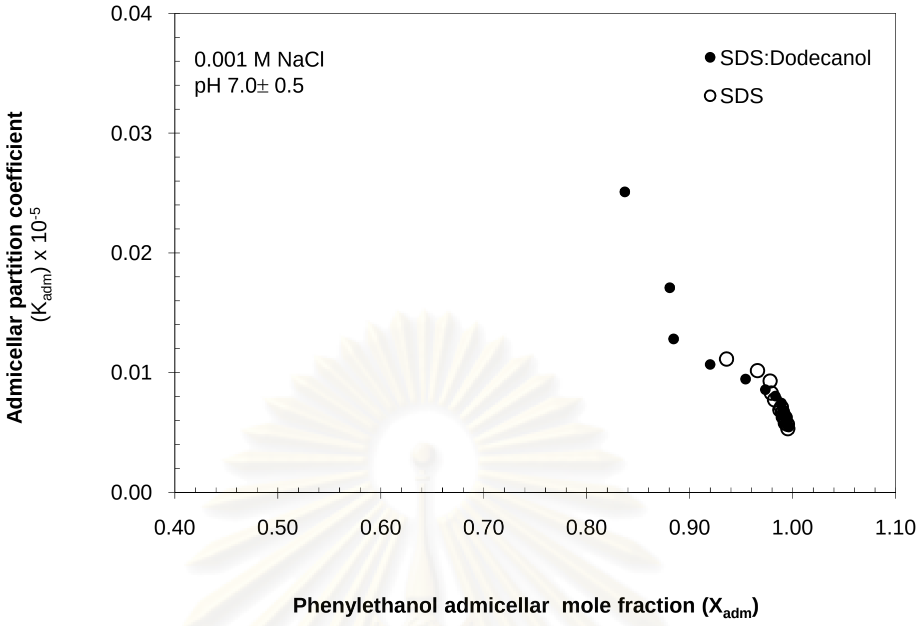


Figure 6-3 Phenylethanol adsolubilization partition coefficient versus phenylethanol mole fraction in admicelle of extended surfactant with linker-based surfactant system, SDS:dodecanol 10:1 molar ration and conventional surfactant , SDS alone

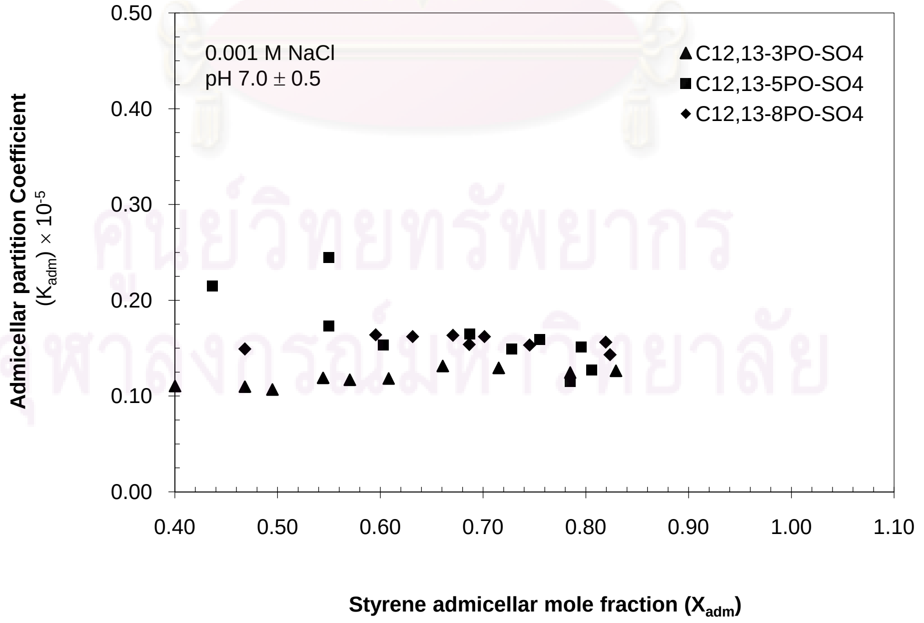


Figure 6-4 Styrene adsolubilization partition coefficient versus styrene mole fraction in admicelle of extended surfactant C12,13 with 3, 5 and 8 PO numbers

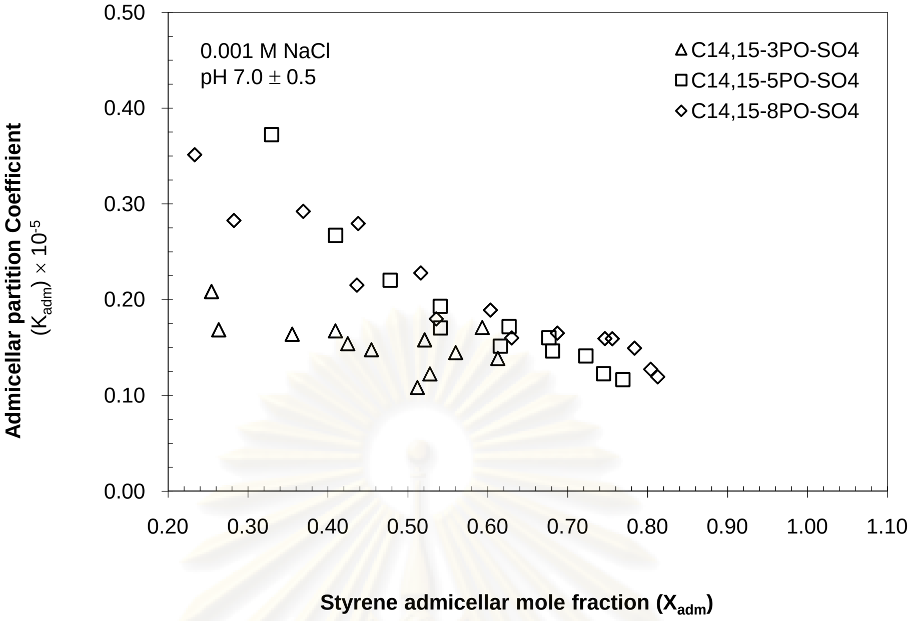


Figure 6-5 Styrene adsolubilization partition coefficient versus styrene mole fraction in admicelle of extended surfactant C14,15 with 3, 5 and 8 PO numbers.

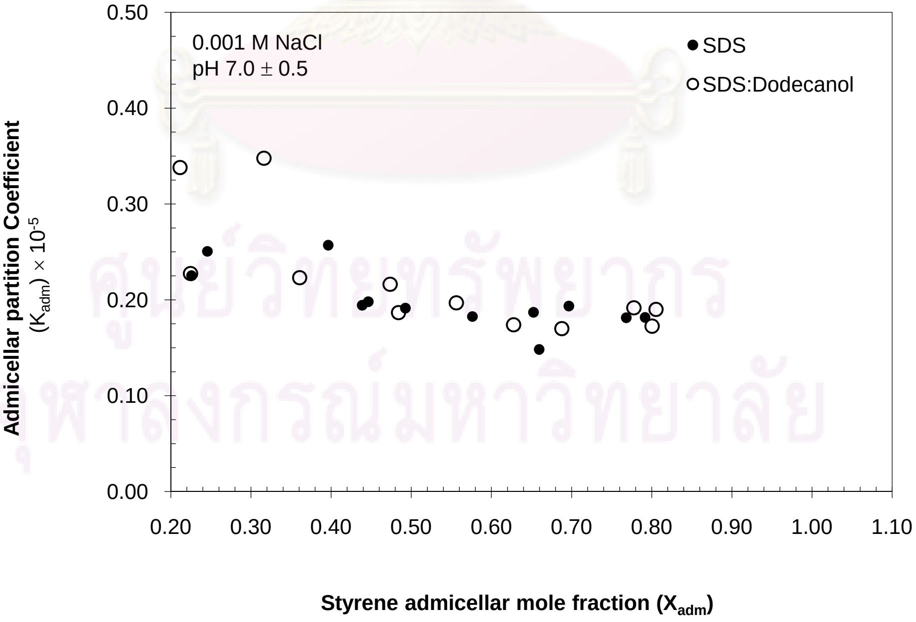


Figure 6-6 Styrene adsolubilization partition coefficient versus styrene mole fraction in admicelle of extended surfactant with linker-based surfactant system, SDS:dodecanol 10:1 molar ration and conventional surfactant , SDS alone

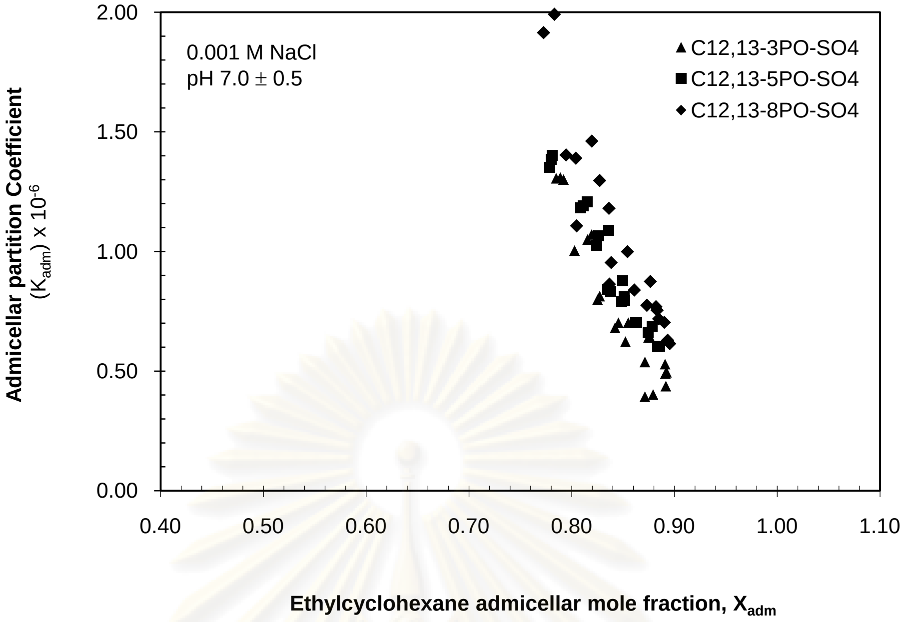


Figure 6-7 Ethylcyclohexane adsolubilization partition coefficient versus ethylcyclohexane mole fraction in admicelle of extended surfactant C12,13 with 3, 5 and 8 PO numbers.

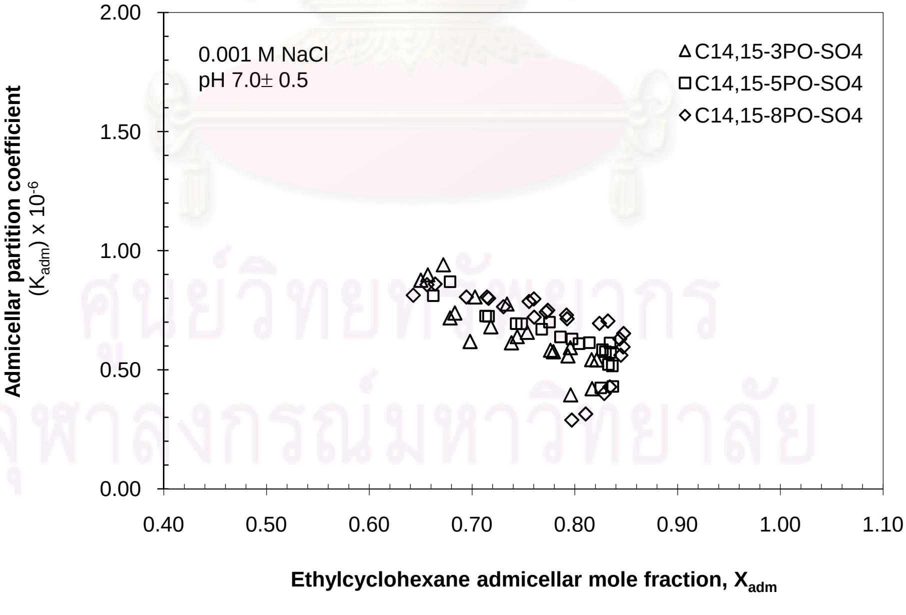


Figure 6-8 Ethylcyclohexane adsolubilization partition coefficient versus ethylcyclohexane mole fraction in admicelle of extended surfactant C14,15 with 3, 5 and 8 PO numbers.

6.2 DESORPTION STUDY

6.2.1 Introduction

Although, adsorption of surfactant at solid-liquid process seems to utilize in many important environmental and industrial applications, a major the limitation of using surfactant modified absorbent in various applications is the loss of absorbed surfactant monomer in aqueous solution and subsequent surfactant desorption from the surface (Huang et al., 1997,Fuangswasdi at al. 2007b, Attaphong, 2007). The adsorption of most surfactants on metal oxide surface such as alumina and silica is usually due to physical adsorption (Huang et al., 1997) i.e., electrostatic attraction. Non equilibrium affects due to changes in aqueous condition i.e., solution pH, ionic strength can make adsorption/desorption process more complex (Huang at al., 1997). While the adsorption of surfactant has been extensively investigated, there are only a few studies on the surfactant desorption behavior. Huang and Somasundaran (1996) noted that the desorption process of conventional cationic surfactant onto negatively charged alumina (solution pH of 10) is not reversible (at high concentration and some positive effects in the low concentration range). They concluded that this can be attributed to changes in the pattern of the adsorbed layer upon aqueous dilution and the activation energy required for the structure of surfactant aggregates. In this study, the surfactant desorption potential was evaluated to achieve a possibility to applied surfactant modified absorbent in various environmental and industrial applications.

6.2.2 Experimental Section

6.2.2.1 Materials

The surfactants studied in this research are divided into two systems; linker-based surfactant systems (SDS/dodecanol) and extended-based surfactant system. External linker system: Sodium dodecyl sulfate (SDS) was selected as a conventional anionic surfactant with a C12 alkyl chain length. SDS (98%) was purchased from Sigma Company. n-dodecanol, a long chain linear alcohol with an alkyl chain length of 12, was used as a lipophilic linker. n-dodecanol (98%) was purchased from Arcos chemical company. Internal linker system: The extended anionic surfactants evaluated in this research were alkyl propoxylated sulfates of the Alfoterra® series with distribution of alkyl chain length of C12,13, and C14,15 carbons with various number of propylene oxide (PO) groups; these surfactants were obtained from SASOL North America Inc.

Aluminum oxide (Al_2O_3) was purchased from Aldrich chemical company. The specific surface area reported from the manufacturer is 155 m^2/g and the point of zero charge (PZC) of alumina is 9.1 (Sun and Jaffé, 1996). The electrolyte concentration was controlled at 0.001 M NaCl. The solution pH was adjusted using NaOH and HCl. All chemicals were used as received. All solutions were prepared with purified water having a resistance of 18.2 ΩM cm.

6.2.2.2 Desorption of Surfactant Adsorption

The desorption study was determined through dilution technique (Huang et al., 1996). The surfactant concentration just below the CMC (90-95% below the transition point of adsorption isotherms) was selected. After adsorption was completed, the desorption study was conducted by adding the same volume of diluents adjusted to the system with constant of electrolyte concentration (0.001 M NaCl) and solution pH of 7.0±0.5 as the same volume of supernatant was removed. Thus the solid to liquid ratio remained constant as the washing step was achieved through sequential washing. Then the vials were shaken for 48-hours for desorption process as the same as the equilibrium time in adsorption study. Several of washing steps of surfactant desorption solutions with alumina fine particles in 40 mL vial were achieved. The surfactant concentration in each vials were then analyzed to determine the amount of surfactant concentration, desorbed from the surface by IC. The zetapotential of alumina particle was measured by zeta potential meter (Model) and zetapotential measurement

6.2.2.3 Analytical Method

All surfactants were analyzed using ion chromatography, IC (ICS-2500, Dionex) with a reverse phase column NS1 (Dionex) and electro conductivity detector (ECD) (Doan et al., 2003; Fuangswasdi et al., 2006a and b). The zeta potential meter was used to measure the electrostatic interaction onto alumina particles in surfactant solution.

6.2.3 Result and Discussion

Desorption of Surfactant Adsorption

The surfactant desorption study was conducted to evaluate the surfactant losses from the alumina surface. The concentration of extended surfactant after the first-wash cannot be detected by the analytical technique (ICS-2500) that was used in adsorption study due to the detection limit of the instrument. It can be implied that the amount of surfactant desorbed is very low.

To confirm this result, an indirect method to evaluate the surfactant desorption was conducted by zeta-potential measurement. This method was applied to measure the concentration of charge (mV) on the modified alumina surface. The desorption potential was indicated by charge reversal (charge goes from positive to negative). The zeta potential values (mV) for alumina surface at electrolyte solution 0.001 M NaCl and solution pH 7.0 ±0.5 (PZC of alumina is 9.1) without surfactant had a positively charged (+26 mV). After negatively charged anionic surfactant adsorbs as a bilayer onto oppositely charge positively charged alumina surface, zeta-potential value changes from positive to negative values as surfactant concentration reached maximum bilayer coverage. The zeta potential values for all surfactant systems (before washing steps) illustrate in Figure 6-9. The results show that the zeta potential values of extended surfactant system with C14,15 series with 3, 5 and 8 PO numbers have higher negative values (range from - 109 mV to - 61 mV) comparing to C12,13 series (range from - 52 mV to - 43 mV). Furthermore, these values are higher than linker-based system, SDS and dodecanol (- 29 mV), and conventional surfactant, SDS alone (- 26 mV). It was indicated that all extended surfactants in this study formed the bilayer coverage onto aluminum oxide surface and surfactant molecules orient in a denser packing than linker-based and conventional surfactant systems. The number of the PO group in extended surfactant affected the orientation and packing density of surfactant admicelles as PO numbers increased with decreased the zeta-potential to lower values (desorption).

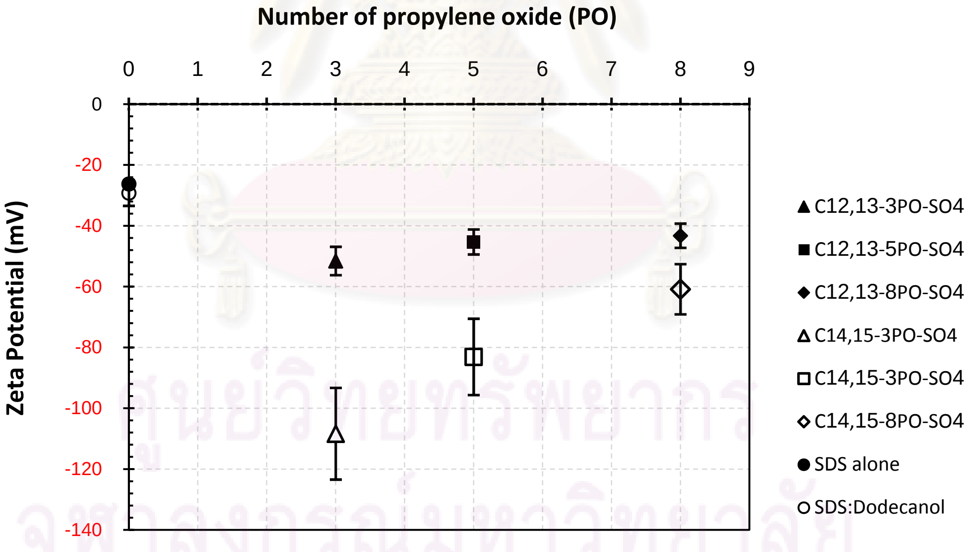


Figure 6-9 Relationship between the zeta-potential of extended-surfactant system and linker-based surfactant system at 0.001M NaCl and solution pH of 7.0±0.5

The evidences of surfactant desorption are shown in Figure 6-10. Figure 6-10 shows the desorption potential all surfactant system in this study plotted between zeta-potential versus number of washing step. Desorption potential was implied from the charge reversal of alumina through the zeta potential measurements. As number of washing steps increased, the zeta potential decreased from negative (> - 30 mV for all surfactants) to more positive values and remains constant after five-time sequential washing. The result indicated that extended surfactant systems retained their anionic zeta potential (positive charge) after sequential washing much better than linker-based and conventional surfactant systems, SDS with dodecanol and SDS alone, respectively. After four washes, the zeta potential of extended surfactant system remained negatively charged. This indicated that the surfactant bilayer coverage is still present. However, linker-based and conventional surfactant system had a positively charged after the second-wash indicating the completed desorption after the third-wash. This finding could be due to the characteristic of extended surfactant providing strong tighter packing. This could be reduced the surfactant desorption from un-equilibrium system. However, desorption of surfactant adsolubilization could yet been done because the equilibrium concentration of surfactant after desorption process is very low than the instrument detection limits.

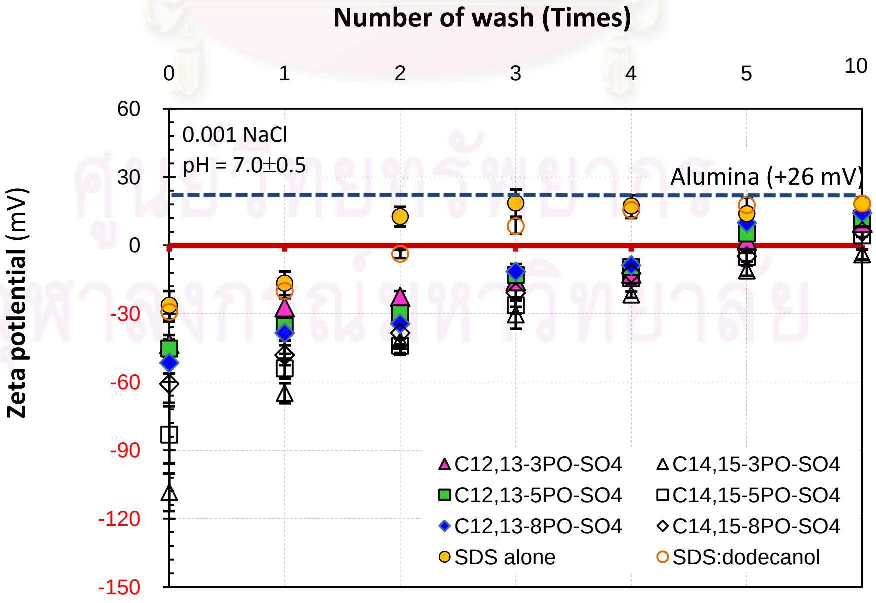


Figure 6-10 Desorption capacity of extended surfactant-based system and linker-based systems

6.3 SURFACE CHARACTERIZATION

6.3.1 Introduction

The surfactant adsorption at the liquid-solid interface has been studied for various applications. However, an understanding of the structure of adsorbed aggregates at a molecular level is largely unknown to date, partly due to experimental difficulties involved in detecting structure in nanometer scale of adsorbed surfactant aggregates in a liquid environment. Recently, adsorbed surfactant properties have been investigated extensively using techniques such as small angle neutron scattering (SANS), fluorescence spectroscopy and atomic force microscopy. The SANS technique provided the scattering spectra of solid and aggregates. Besides, this technique is used to determine the stability of colloid/surfactant suspension and used to study the effects of concentration and structure of surfactant monomer. A few interesting observations have been noted using this technique including the pattern of the scattering was changed as a function of hydrophobic chain length. Fluorescence spectroscopy using fluorescence emission explores the solution behavior of surfactant. Zhang and Somasundaran (2006) developed this technique to investigate the surfactant structure on the adsorbent and obtain information on the aggregation number, polarity, and viscosity of the interior of the surfactant layer. They studied the adsorption of sodium dodecyl sulfate (SDS) on alumina using the ratio of relative intensities of the unknown peak to the first peak, I_3/I_1 through pyrene emission spectrum. They confirm that the abrupt change occurs in a region that is well below the CMC and approximately coincides with the transition in adsorption isotherm from regions I to II. For plateau region (IV), the ratio I_3/I_1 coincided with maximum I_3/I_1 value for SDS solution, indicating that the complete bilayer adsorption of the surfactant aggregates. Other techniques have been used recently to obtain information on the structure of adsorbed surfactant aggregates onto solid surface through spectroscopy technique such as fluorescence, electron-spinning resonance, excite-state resonance Raman, but the size, shape and lateral organization of aggregates has been proven difficult to quantify.

Recently, atomic force microscopy (AFM), capable of direct imaging at the nanometer resolution, has been developed to clarify the structure of adsorbed surfactant aggregates onto solid surface. This technique operated in the repulsive force region between the absorbed surfactant layer on the tip and sample. The formation of adsorbed surfactant aggregates at solid-liquid interface is much like surfactant micelle in liquid-liquid interface and thus they have been term admicelle. Admicelle provides three regions, i.e., surfactant head, palisade and core regions where the solute can be partition depending upon the physicochemical compatibility between each region and the solubilizate. Different types of surfactant layer on solids were described depending on the conditions of formation:

- Planar aggregates: monolayer or bilayers,
- Spherical aggregates: micelles, hemimicelles
- Cylindrical aggregates: long, parallel-aligned full or hemi-(half) cylinders, or short rod-like aggregates of periodic structure

For AFM studies (Hwa See and O'Haver, 2004; Saphanuchart et al., 2007), the most important results was that the surfactant aggregate, mainly using cetyltriethylammonium bromide (CTAB), do not form continuous monolayers or bilayers at the solid-liquid interface but that they form discrete aggregates of different shape and size depending on different factors: ionic strength, surfactant structure, surfactant chain length and head group, surfactant concentration related to the CMC and solid phase. The solid surfaces have been investigated including hydrophobic surfaces, e.g. graphite, the surfactant adsorbed as a half-spherical, half cylinder or monolayer-hemimicelle, while on hydrophilic surfaces, e.g., silica and mica, surfactant adsorbed as full-spherical, full-cylindrical and bilayer-admicelle. This study aims to elucidate the characteristic of adsorbed extended surfactant admicelles and effect of the number of PO groups in extended surfactant onto alumina surface.

6.3.2 Result and Discussion

6.3.2.1 Atomic Force Microscopy (AFM) Study

In this study, we tried to image the anionic extended surfactant admicelles ($C_{12,13}$-8PO-SO_4 and $C_{14,15}$-8PO-SO_4) onto mica surface through the AFM using the contract or friction mode in a solid cell. Unfortunately, we found that we cannot get the correctly image through solid cell. We learnt that sample preparation for AFM instrument had to be specifically prepared such as fluid cell, AFM-tip, solid disc (mica). From our expectation, we would like to see the behavior of adsorbed anionic surfactant admicelles onto alumina surface. Due to instrument limitation, AFM was not applicable for this study. For SEMs technique, it is impossible to get the result on the lateral distribution of adsorbed surfactant aggregates in micrometer or nanometer ranges, so we did not include the SEMs in our investigation on adsorbed surfactant layer.

6.3.2.2 Fourier Transform Infrared Spectroscopic (FTIR) Study

Alumina surfaces was modified by extended surfactant C14,15 with 3 PO and 8PO numbers through adsorption process, then the adsorbent was dried out at room temperature (25±2^{o}C). The dried adsorbents were used to evaluate the molecular-level of adsorbed surfactant structure. The FTIR spectra of the extended surfactants are shown in Figure 6-11. Figure 6-11, two significant bands around 2930 and 2860 were assigned to stretching vibration of C-CH_2 and C-CH_3 in hydrocarbon tail. This is consistent with the FTIR spectra of cetyltrimethylammonium bromide (CTAB) onto silica surface (Kung and Hayes, 1993). Unfortunately, we cannot see the intense band of the propylene oxide chain or the PO group through the FTIR study.

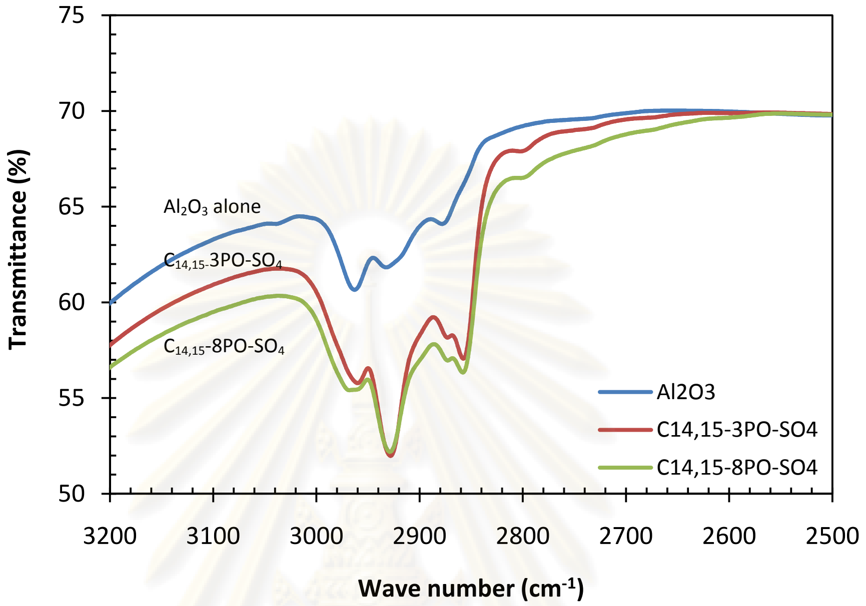


Figure 6-11 FTIR spectra of extended surfactant absorbed on alumina

CHAPTER VII

SUMMARIES, CONCLUSIONS AND ENGINEERING SIGNIFICANCE

7.1 SUMMARIES

Surfactant adsorption and adsolubilization has been applied in many environmental applications such as soil and ground water remediation, wastewater treatment, admicellar enhanced chromatography (AEC) and solid phase extraction (SPE), for treating various organic solutes. In this study, laboratory batch experiments were conducted to study the surfactant adsorption, adsolubilization and solubilization of organic solutes by linker-based surfactant system and extended-surfactant-based systems onto positively charged aluminum oxide surface. The extended-surfactant which has propylene oxide (PO) groups of intermediate polarity inserted between hydrophobic and lipophilic moieties in the surfactant molecule were selected with varying number of alkyl chain length (C12,13 and C14,15 series) and number of the PO group (3, 5, and 8 POs). Three organic solutes with different degrees of polarity from polar to nonpolar, phenylethanol, styrene and ethylcyclohexane, were used.

The critical micelle concentration (CMC) of the surfactant systems was examined through measurement of surface tension of the surfactant at liquid-air interface. The extended surfactant-based systems showed one to two order magnitudes lower in CMC than those of the linker-based system. The increasing number of propylene oxide groups (PO) in extended surfactants, both the C12,13 series and C14,15 series, showed decreasing CMC values.

The impact of linker-based surfactant system and extended-surfactant-based systems on surfactant adsorption and admicelle formation were evaluated through adsorption studies on aluminum oxide. While linker-based systems achieved a higher maximum adsorption than extended surfactants, the extended surfactants reached maximum adsorption at a lower aqueous surfactant concentration.

The attempt to enhance the adsolubilization of organic solute is accomplished by increasing interaction between the hydrophobic core of adsorbed admicelle and the organic solute. Adsolubilization reaches its maximum when surfactant adsorbed onto the solid-liquid interface achieves completed bilayer or maximum adsorption. Results of solubilization and adsolubilization studies are summarized by the extent of solute solubilization into micelle and admicelle, as captured through micellar partition coefficient (K_{mic}) and admicellar partition coefficient (K_{adm}). The results showed that the extended surfactant-based systems have higher solubilization and adsolubilization capacity than the conventional surfactant, SDS and SDS with linker systems. For the solute with high polarity (phenylethanol), the presence of propylene oxide group (PO) has a greater effect than the number of PO groups or the tail length, while for the weak polar solute (ethylcyclohexane) as the number of POs groups and the tail length increased, the adsolubilization capacity also increased. It could be noted that the PO group in extended surfactant would tend to “squeeze out” the cavities in the palisade layer where the polar solute would segregate and increased the hydrophobic moieties of the surfactant where increase the partition of weaker degree of the weak polar solute. From our results, the coiling effect seems to dominate the polarity effect

The comparison of the micellar and admicellar partition coefficients (log K_{mic} and log K_{adm}) shows that the admicellar systems (log K_{adm}) are less efficient at solubilizing organic solutes than the micellar system (log K_{mic}). This could be due to the fact that the coiling of

PO groups in extended surfactants packs more efficiently into three dimensional micelles than into the more planar, two dimensional admicelles. The results of locus of the solute partition in admicelles was observed that the partition of organic solutes into extended surfactant micelles and admicelles depends on degree of organic solute polarity and the number of PO groups inserted in the extended surfactant.

The evidence of surfactant desorption was found through zeta-potential measurement. However, the extended surfactant based system had lower desorption potential compared to linker-based system and conventional surfactant due to the tighter packing density of adsorbed surfactant aggregates. The surface characterization by AFM, directed imaging technique, was not proper with the investigation of adsorbed anionic surfactant aggregates onto positively charged alumina surface. However, the FTIR technique found the evidence of the intense spectra of adsorbed surfactant aggregates onto alumina particle but the indication of the PO group in extend surfactants still undetected.

As a result, the extended-surfactant-based admicelles showed adsolubilization enhancement while requiring lower amount of surfactants to form admicelles. These results thus provide insights into external and internal linker-based and extended-surfactant-based admicellar systems and highlight the differences observed from admicelles based on conventional surfactant systems.

7.2 CONCLUSIONS

The specific conclusions are made based on the results of this research:

1) The CMCs of extended surfactants are lower than the external linker system (SDS/dodecanol) and PO number increases with CMCs decreases for extended surfactant with equal number of carbon in their chain length of 12-13 and 14-15 carbons. When the carbon chain length increases from C12,13 to C4,15, CMC decreases.
2) The surfactant adsorption, linker-based system shows higher maximum adsorption capacity but the extended surfactants require lower equilibrium concentration to reach the maximum adsorption. The number of PO group and number of carbon chain length effect to the adsorption capacity by increase space between adsorbed surfactant molecules.
3) Extended surfactant-based micellar (K_{mic}) and admicellar (K_{adm}) systems exhibit the enhancement for all solutes comparing to linker-based (SDS:dodecanol) and conventional surfactant (SDS) system. The solubilization and adsolubilization capacity increases with PO numbers decrease for solute with high polarity (phenylethanol) and increase for solute with weak polarity (ethylcyclohexane).
4) Capacities of extended surfactants of solute with high polarity decreases with increasing PO numbers, due to the "squeezing out effect". For solute with weak polarity, solubilization and adsolubilization increases with increasing PO numbers as hydrophobicity increases.
5) Relative to the effect of carbon chain length in extended surfactant based system, the longer chain length (C14,15 series) shows solubilization and adsolubilization

enhancement versus C12,13 series for solute with weak polarity due to increased hydrophobicity of the core but this enhancement is not observed for solutes with high polarity, which prefer the palisade region.

6) Adsolubilization capacity (K_{adm}) was lower than solubilization capacity (K_{mic}) due to the tighter packing density observed in the surface admicelles may have squeezed out the area where enhanced solubilization was experienced in micelles.
7) The extended surfactant systems showed lower desorption potential due tighter packing density between hydrophilic cores of adsorbed admicelles.
8) The surface characterization by AFM technique was not able to study for the adsorption of anionic surfactant aggregates onto aluminum oxide surface.

7.3 ENGINEERING SIGNIFICANCE

The extended-based surfactant system demonstrated solubilization and adsolubilization enhancement and significantly lower desorption potential compared to the linker-based surfactant and conventional surfactant system. Therefore, the surface modification by extended surfactants shows particular promise for treatment of groundwater and wastewater contaminated with organic solutes, such as wastewater contamination with valuable organic solute at pharmaceutical industry. The unique characteristics of extended surfactant includes, the PO groups, carbon chain length and organic solute properties including structure, degree of polarity; all of the factors impact the efficiency of admicelle formation and adsolubilization enchantment. Selecting the appropriate surfactant for a specific solute is vital for enhancing the efficiency of adsolubilization processes. In analytical process, the applications which have been developed up to date involving admicellar enhanced chromatography (AEC) have been shown the slow elution of the surfactant from the support (i.e., alumina and silica), thus giving different retention performance with time. The modified adsorbent can be applied in solid phase extraction (SPE) technique which is an application of adsolubilization to concentrate organic solute in aqueous phase prior to liquid chromatography.

In field applications, the surfactant modified adsorbent could be used for organic solute removal in filter, packed-bed reactors. For in-situ application, passive permeable barrier by the modified adsorbent could be applied for mitigate groundwater contamination. Relative to bioremediation processes, surfactant enhanced bioavailability of slightly soluble organic contaminants could be enhancing by adsolubilization.

7.4 RECOMMENDATIONS AND FUTURE WORKS

The surfactant modified adsorbent by linker-based surfactant systems appeared to be effective adsorbents for removal organic contaminants dissolved in aqueous stream. Some aspects as should be carefully considered when applying admicelles to various environmental applications (i.e., permeable barrier and pack-bed adsorbent) and some precise area should be further investigated, including;

1) ***Surfactant desorption:*** Although the extended surfactant based system provided lower desorption potential comparing to external linker-based system (conventional surfactant/linker molecule) and conventional surfactant alone, one limiting factor of using surfactant modified adsorbent is losses of the adsorbed surfactant aggregates from surface to aqueous solution which lead to removal efficiency of the adsorbents
2) ***Multi-component system:*** Wastewater stream usually contain more than single organic solute. The selectivity of the admicellar-based modified adsorbent is important. From our study, admicellar partition coefficient (K_{adm}) is recommend in term of surfactant selectivity. However, the K_{adm} is a function of mole fraction of organic solute in admicelles (X_{adm}) over mole fraction of organic solute in aqueous phase (X_{aq}) – which relate to property of solute. The organic solute in this study (phenylethanol, styrene and ethylcyclohexane) has similar molecular structure but different aqueous solubility and degree of polarity. Thus, the competition and the corresponding mechanism should be involved by controlling the pre-adsolubilized solutes while adsolubilizing other solute with higher hydrophobicity.

3) ***Surface characterization:*** In addition, adsolubilization enhancement depends on a combination of surfactant structure and solute properties. To understand the admicelle formation and adsolubilization mechanism of extended surfactant (i.e., coiling effect from longer propoxy group, PO) onto solid oxide surface in the more detail, characterization of adsorbed surfactant aggregates in nanometer size are necessary. By addition, atomic force microscopy (AFM) is promising technique to obtain direct image of admicelles morphology at solid-liquid interface. Base on this study, AFM with contact-mode and solid sample does not allow capturing the image of the adsorbed aggregates. Furthermore, the smoothness of the surface and the scanning parameter are the important factors to obtain the image from AFM.

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APPENDICES

APPENDIX I

Calculation: Effective area per head surfactant (Rosen et al.,1989)

Salt : swamping amount of electrolyte (high salt concentration

$$\Gamma = -\frac{1}{2.303RT}\left(\frac{\partial \gamma}{\partial \log C_1}\right)_T$$

No Salt : absence of any other solute

$$\Gamma = -\frac{1}{4.606\,RT}\left(\frac{\partial \gamma}{\partial \log C_1}\right)_T$$

where

g = Interfacial tension (N/m)
R = 8.314 J mol^{-1} K^{-1}
G = in unit mol/1000m^2
<u>K@25 =</u> 298 K

The area per molecule at the interface

$$a_1^s = \frac{10^{16}}{NT_1}$$

N = Avogado's number (= 6.023 x 10^{23})
Γ = in unit mol/cm^2

γ = Interfacial tension (N/m)

When G is in mol/1000m^2, in square angstroms, equals 10^{23}/NT

γ = N/m then

Γ = mol/1000m^2

APPENDIX II

EXPERIMENTAL RAW DATA

Table A - 1 Surface tension measurement C12,13-3PO-SO4

Tube AF43	**Conc** (M)	**ISF** mN/m
1	1.0E-7	65.8080
2	3.0E-7	70.7690
3	5.0E-7	67.2250
4	1.0E-6	65.4560
5	3.0E-6	60.2020
6	5.0E-6	58.8330
7	1.0E-5	51.3050
8	3.0E-5	43.5190
9	5.0E-5	40.9680
10	7.0E-5	37.5800
11	1.0E-4	35.5420
12	3.0E-4	30.7400
13	5.0E-4	30.6364
14	7.0E-4	31.5500
15	1.0E-3	31.3450

Table A - 2 Surface tension measurement C12,13-5PO-SO4

Tube AF45	**Conc** (M)	**ISF** mN/m
1	1.0E-7	70.4530
2	3.0E-7	69.7690
3	5.0E-7	67.9130
4	1.0E-6	63.7840
5	3.0E-6	57.0240
6	5.0E-6	53.7230
7	1.0E-5	48.0490
8	3.0E-5	40.8180
9	5.0E-5	36.7900
10	7.0E-5	36.3290
11	1.0E-4	34.5750
12	3.0E-4	32.8010
13	5.0E-4	33.2750
14	7.0E-4	32.9730
15	1.0E-3	31.3450

Table A - 3 Surface tension measurement C12,13-8PO-SO4

Tube AF48	Conc (M)	ISF mN/m	ISF#2 mN/m	AV mN/m
1	1.0E-7	70.785	70.185	70.485
2	3.0E-7		70.126	70.126
3	5.0E-7		69.468	69.468
4	7.0E-7		67.143	67.143
5	1.0E-6	61.254	60.094	60.674
6	3.0E-6		48.104	48.104
7	5.0E-6		45.590	45.590
8	7.0E-6		43.185	43.185
9	9.0E-6		41.428	41.428
10	1.0E-5		40.999	40.999
11	2.0E-5	35.451	35.022	35.236
12	3.0E-5	33.212	33.252	33.232
13	5.0E-5	32.214	32.215	32.215
14	1.0E-4	32.211	32.719	32.465
15	3.0E-4	32.854	33.706	33.280
16	5.0E-4	32.215	33.563	32.889
17	1.0E-3	33.146	33.101	33.124
18	5.0E-3	33.954	33.591	33.773

Table A - 4 Surface tension measurement C14,15-3PO-SO4

Tube AF53	Conc (M)	ISF mN/m	ISF2 mN/m	Average
1	1.0E-7		71.609	71.609
2	3.0E-7	67.260	70.744	69.002
3	5.0E-7	70.660		70.660
4	7.0E-7	70.326	71.116	70.721
2	1.0E-6		69.235	69.235
6	3.0E-6	62.768	63.174	62.971
7	5.0E-6	56.086	55.235	55.661
8	7.0E-6	49.398	48.055	48.727
9	9.0E-6	46.943		46.943
3	1.0E-5	40.971	43.722	42.347
11	2.0E-5	35.022		35.022
4	3.0E-5	34.606	34.190	34.398
5	5.0E-5	33.705		33.705
	7.0E-5		33.442	33.442
5	9.0E-5	33.705		33.705
6	1.0E-4	32.217	33.472	32.845
7	3.0E-4	31.927	31.456	31.692
8	5.0E-4	32.960	32.366	32.663
9	1.0E-3	32.121	32.751	32.436
10	5.0E-3	31.351	31.785	31.568

Table A - 5 Surface tension measurement C14,15-5PO-SO4

Tube AF55	**Conc** (M)	**ISF** mN/m	**ISF(2)** mN/m	**Average**
1	1.0E-7		71.493	71.4930
2	3.0E-7		70.566	70.5660
3	7.0E-7		70.075	70.0750
4	1.0E-6		64.322	64.3220
5	3.0E-6	54.737	57.027	55.8820
6	5.0E-6	47.071		47.0710
7	7.0E-6	43.623	45.665	44.6440
8	9.0E-6	42.679	42.679	42.6790
9	1.0E-5	39.6030	42.222	40.9125
10	3.0E-5	34.8180	34.504	34.6610
11	5.0E-5	32.6490		32.6490
12	7.0E-5		32.908	32.9080
13	9.0E-5		32.649	32.6490
14	1.0E-4	32.6930	32.742	32.7175
15	3.0E-4	32.8120	32.711	32.7615
16	5.0E-4	32.8090	32.809	32.8090
17	1.0E-3	32.4650	32.764	32.6145
18	5.0E-3	32.7480	32.748	32.7480

Table A - 6 Surface tension measurement C14,15-8PO-SO4

Tube AF58	**Conc** (M)	**ISF** mN/m	**ISF#2** mN/m	**Average**
1	1.0E-7	70.1256	70.02.551	70.1256
2	3.0E-7	62.124	59.145	60.6347
3	5.0E-7	56.9750		56.9750
4	7.0E-7		52.991	52.9910
6	3.0E-6	48.737	48.246	48.4915
7	5.0E-6	45.232		45.2320
8	7.0E-6	43.623		43.6230
9	9.0E-6	42.679	40.263	41.4710
10	1.0E-5	38.1770	37.7100	37.9435
12	3.0E-5	33.6680	33.6520	33.6600
13	5.0E-5	33.8440	33.8440	33.8440
14	7.0E-5		33.5570	33.5570
15	9.0E-5		33.6670	33.6670
16	1.0E-4	32.4420	33.4380	32.9400
17	3.0E-4	33.1260	33.7570	33.4415
18	5.0E-4	33.4450	33.4450	33.4450
19	1.0E-3	33.2190	33.3930	33.3060
20	5.0E-3	33.4210		33.4210

Table A - 7 surface tension measurement of SDS : dodecanol 10:1 molar ratio

Tube SDS:doc	**Conc** (M)	**ISF** mN/m
	1.0E-5	49.2360
1	1.0E-4	40.2120
2	3.0E-4	33.8140
3	5.0E-4	31.9440
4	1.0E-3	28.0010
5	3.0E-3	23.7570
6	5.0E-3	23.5070
7	1.0E-2	22.1460
8	3.0E-2	25.6560
9	5.0E-2	25.4700

Table A - 8 surface tension measurement of SDS alone

Tube SDS:doc	**Conc** (M)	**ISF** mN/m
1	1.0E-5	71.3950
2	3.0E-5	70.8830
3	5.0E-5	70.2030
4	7.0E-5	68.4860
5	1.0E-4	64.5270
6	3.0E-4	56.2610
7	5.0E-4	49.7650
8	7.0E-4	44.5520
9	9.0E-4	41.2120
10	1.0E-3	39.3920
11	3.0E-3	33.4800
12	5.0E-3	27.2650
13	7.0E-3	25.9830
14	1.0E-2	23.7880
15	3.0E-2	28.3320
16	5.0E-2	27.3320
17	7.0E-2	25.2650
18	9.0E-2	27.2340
19	1.0E-1	25.1200

Table A - 9 HLB calculations

SO4Na	38.7
CH2	-0.475
PO	-0.15

HLB = 7 + Σ(Hydrophilic group number) + Σ(Lipophilic group number)

	Hydrophilic	**Hydrophobic**	**PON**	**HLB**
SDS	1	12	0	40.00
SDS:dodecanol	1	12	0	40.00
C12,13-3PO-SO4	1	12	3	39.55
C12,13-5PO-SO4	1	12	5	39.25
C12,13-8PO-SO4	1	12	8	38.80
C14,15-3PO-SO4	1	14	3	38.60
C14,15-5PO-SO4	1	14	5	38.30
C14,15-8PO-SO4	1	14	8	37.85

Table A – 10 Adsorption of C12,13 -3PO-SO4 at 0.001 M NaCl, pH 7.0 ± 0.5 and temperature 25±2 ^{o}C

Sample	AF43	Solution	AF_ini		AF_eq		Cs	Alumina	q	[q]	pH
AF43	(M)	(ml)	Area (us*min)	(M)	Area (us*min)	(M)	(M)	(g)	mole/g	molecule/nm^2	final
1	1.00E-04	20	2.4020	8.83E-5	1.5280	5.61E-05	3.21E-05	0.0030	2.14E-04	0.8319	6.65
1a	1.00E-04	20	2.4020	8.83E-5	1.4950	5.49E-05	3.33E-05	0.0034	1.96E-04	0.7617	6.63
1b	1.00E-04	20	2.4020	8.83E-5	1.7240	6.33E-05	2.49E-05	0.0028	1.78E-04	0.6914	6.85
2	2.00E-04	20	4.8679	1.79E-4	3.3784	1.24E-04	5.47E-05	0.0055	1.99E-04	0.7733	6.63
2a	2.00E-04	20	4.8679	1.79E-4	3.4400	1.26E-04	5.25E-05	0.0052	2.02E-04	0.7841	6.82
3	3.00E-04	20	7.9430	2.92E-4	4.9932	1.83E-04	1.08E-04	0.0103	2.10E-04	0.8177	7.09
3a	3.00E-04	20	7.9430	2.92E-4	4.6602	1.71E-04	1.21E-04	0.0113	2.13E-04	0.8295	7.04
4	4.00E-04	20	10.2520	3.77E-4	6.4602	2.37E-04	1.39E-04	0.0124	2.25E-04	0.8731	7.05
5	5.00E-04	20	12.9690	4.76E-4	9.5628	3.51E-04	1.25E-04	0.0102	2.45E-04	0.9535	6.89
5a	5.00E-04	20	12.9690	4.76E-4	8.9611	3.29E-04	1.47E-04	0.0122	2.41E-04	0.9380	7.12
6	6.00E-04	20	15.8459	5.82E-4	11.7418	4.31E-04	1.51E-04	0.0110	2.74E-04	1.0653	6.87
7	7.00E-04	20	18.6844	6.86E-4	14.8570	5.46E-04	1.41E-04	0.0105	2.68E-04	1.0408	6.92
8	8.00E-04	20	21.2329	7.80E-4	16.7576	6.16E-04	1.64E-04	0.0120	2.74E-04	1.0649	6.93
9	9.00E-04	20	24.4150	8.97E-4	20.1815	7.41E-04	1.56E-04	0.0104	2.99E-04	1.1623	7.62
10	1.00E-03	20	27.3079	1.00E-3	21.2179	7.80E-04	2.24E-04	0.0126	3.55E-04	1.3801	7.05
10a	1.00E-03	20	27.3079	1.00E-3	20.2640	7.45E-04	2.59E-04	0.0151	3.43E-04	1.3320	6.65
10b	1.00E-03	20	27.3079	1.00E-3	22.4298	8.24E-04	1.79E-04	0.0101	3.55E-04	1.3791	7.22
12	2.00E-03	20	53.4229	1.96E-3	47.9753	1.76E-03	2.00E-04	0.0115	3.48E-04	1.3526	6.78
13	2.50E-03	20	68.1478	2.50E-3	63.5884	2.34E-03	1.68E-04	0.0106	3.16E-04	1.2282	6.91
12	3.00E-03	20	83.3382	3.06E-3	77.6802	2.85E-03	2.08E-04	0.0128	3.25E-04	1.2621	7.05
13a	3.00E-03	20	83.3382	3.06E-3	78.8422	2.90E-03	1.65E-04	0.0108	3.06E-04	1.1887	6.75
14	3.50E-03	20	93.3657	3.43E-3	87.6308	3.22E-03	2.11E-04	0.0121	3.48E-04	1.3533	7.05
15	4.00E-03	20	110.2495	4.05E-3	104.5663	3.84E-03	2.09E-04	0.0121	3.45E-04	1.3411	6.80
16	4.50E-03	20	121.4044	4.46E-3	114.7378	4.22E-03	2.45E-04	0.0145	3.38E-04	1.3128	6.82

Table A – 11 Summarizes: adsorption of C12,13 -3PO-SO4 with standard deviation

Sample **AF43**	**Cini** (M)	**Ceq**	**q** mole/g	**q** stDEV	**[q]** molecule/nm^2	**[q]** stDEV
1b	1.00E-04	5.81E-05	1.96E-04	1.81E-05	0.7616	7.02E-02
2	2.00E-04	1.25E-04	2.00E-04	1.96E-06	0.7787	7.63E-03
3	3.00E-04	2.04E-04	2.19E-04	7.94E-06	0.8513	3.08E-02
4	4.00E-04	2.37E-04	2.25E-04		0.8731	
5	5.00E-04	3.40E-04	2.43E-04	2.82E-06	0.9458	1.10E-02
6	6.00E-04	4.31E-04	2.74E-04		1.0653	
7	7.00E-04	5.46E-04	2.68E-04		1.0408	
8	8.00E-04	6.16E-04	2.74E-04		1.0649	
9	9.00E-04	7.41E-04	2.99E-04		1.1623	
10b	1.00E-03	7.83E-04	3.51E-04	7.07E-06	1.3637	2.75E-02
12	2.00E-03	1.76E-03	3.48E-04		1.3526	
13	2.50E-03	2.34E-03	3.16E-04		1.2282	
12	3.00E-03	2.88E-03	3.15E-04	1.34E-05	1.2254	5.20E-02
14	3.50E-03	3.22E-03	3.48E-04		1.3533	
15	4.00E-03	3.84E-03	3.45E-04		1.3411	
16	4.50E-03	4.22E-03	3.38E-04		1.3128	

Table A – 12 Adsorption of C12,13-5PO-SO4 at 0.001 M NaCl, pH 7.0 ± 0.5 and temperature 25±2 ^{o}C

Sample	AF45	Solution	AF_ini		AF_eq		Cs	Alumina	q	[q]	pH
AF45	(M)	(ml)	Area (us*min)	(M)	Area (us*min)	(M)	(M)	(g)	mole/g	molecule/nm^2	final
1	1.00E-04	20	1.7906	7.36E-5	1.2391	5.09E-05	2.27E-05	0.0032	1.42E-04	0.5507	6.42
1	1.00E-04	20	1.7906	7.36E-5	1.1122	4.57E-05	2.79E-05	0.0035	1.59E-04	0.6194	6.54
1	1.00E-04	20	1.7906	7.36E-5	1.0229	4.21E-05	3.16E-05	0.0036	1.75E-04	0.6815	6.89
2	2.00E-04	20	4.1859	1.72E-4	2.5723	1.06E-04	6.63E-05	0.0070	1.90E-04	0.7366	7.02
2	2.00E-04	20	4.1859	1.72E-4	2.4612	1.01E-04	7.09E-05	0.0075	1.89E-04	0.7349	7.12
3	3.00E-04	20	6.1627	2.53E-4	3.4941	1.44E-04	1.10E-04	0.0105	2.09E-04	0.8122	7.15
4	4.00E-04	20	8.9329	3.67E-4	5.1420	2.11E-04	1.56E-04	0.0109	2.86E-04	1.1114	7.22
5	5.00E-04	20	11.1630	4.59E-4	7.1517	2.94E-04	1.65E-04	0.0107	3.08E-04	1.1980	6.76
5	5.00E-04	20	11.1630	4.59E-4	6.8781	2.83E-04	1.76E-04	0.0107	3.29E-04	1.2797	6.76
6	6.00E-04	20	13.4888	5.55E-4	8.6745	3.57E-04	1.98E-04	0.0102	3.88E-04	1.5083	7.31
7	7.00E-04	20	15.4040	6.33E-4	11.2302	4.62E-04	1.72E-04	0.0105	3.27E-04	1.2703	6.87
8	8.00E-04	20	18.1411	7.46E-4	13.5474	5.57E-04	1.89E-04	0.0107	3.53E-04	1.3719	6.65
9	9.00E-04	20	20.5955	8.47E-4	16.5114	6.79E-04	1.68E-04	0.0103	3.26E-04	1.2671	6.79
10	1.00E-03	20	23.9074	9.83E-4	19.7016	8.10E-04	1.73E-04	0.0105	3.29E-04	1.2800	7.18
10	1.00E-03	20	23.9074	9.83E-4	19.3467	7.96E-04	1.88E-04	0.0099	3.79E-04	1.4721	7.25
12	2.00E-03	20	49.3378	2.03E-3	44.3234	1.82E-03	2.06E-04	0.0108	3.82E-04	1.4837	7.11
13	2.50E-03	20	61.6529	2.54E-3	57.2277	2.35E-03	1.82E-04	0.0102	3.57E-04	1.3864	7.35
14	3.00E-03	20	72.0400	2.96E-3	68.0907	2.80E-03	1.62E-04	0.0095	3.42E-04	1.3284	6.56
16	5.00E-03	20	121.9419	5.01E-3	117.7246	4.84E-03	1.73E-04	0.0107	3.24E-04	1.2595	7.23
17	7.00E-03	20	170.8899	7.03E-3	166.1162	6.83E-03	1.96E-04	0.0103	3.81E-04	1.4810	7.09

Table A – 13 Summarizes: adsorption of C12,13 -3PO-SO4 with standard deviation

Sample **AF45**	**Cini** (M)	**Ceq** (M)	**q** mole/g	**q** stDEV	**[q]** molecule/nm2	**[q]** stDEV
1	1.00E-04	7.36E-05	1.59E-04	1.68E-05	0.6172	6.54E-02
2	2.00E-04	1.72E-04	1.89E-04	3.22E-07	0.7357	1.25E-03
3	3.00E-04	2.53E-04	2.09E-04		0.8122	
4	4.00E-04	3.67E-04	2.86E-04		1.1114	
5	5.00E-04	4.59E-04	3.19E-04	1.49E-05	1.2388	5.78E-02
7	6.00E-04	5.55E-04	3.88E-04		1.5083	
8	7.00E-04	6.33E-04	3.27E-04		1.2703	
8	8.00E-04	7.46E-04	3.53E-04		1.3719	
9	9.00E-04	8.47E-04	3.26E-04		1.2671	
10	1.00E-03	9.83E-04	3.54E-04	3.50E-05	1.3761	1.36E-01
11	2.00E-03	2.03E-03	3.82E-04		1.4837	
12	2.50E-03	2.54E-03	3.57E-04		1.3864	
13	3.00E-03	2.96E-03	3.42E-04		1.3284	
14	5.00E-03	5.01E-03	3.24E-04		1.2595	
15	7.00E-03	7.03E-03	3.81E-04		1.4810	

Table A – 14 Adsorption of C12,13-8PO-SO4 at 0.001 M NaCl, pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	AF48	Solution	AF_ini		AF_eq		Cs	Alumina	q	[q]	pH
AF48	(M)	(ml)	Area (us*min)	(M)	Area (us*min)	(M)	(M)	(g)	mole/g	molecule/nm^2	final
x1	1.00E-04	20	1.9096	7.11E-5	0.7536	2.80E-05	4.30E-05	0.0055	1.56E-04	0.6079	7.18
x2	1.00E-04	20	1.9096	7.11E-5	0.7794	2.90E-05	4.21E-05	0.0049	1.72E-04	0.6671	7.42
x3	1.00E-04	20	1.9096	7.11E-5	1.2665	4.71E-05	2.39E-05	0.0030	1.60E-04	0.6200	7.33
x4	1.00E-04	20	1.9096	7.11E-5	1.2805	4.77E-05	2.34E-05	0.0025	1.87E-04	0.7278	7.20
1	1.00E-04	20	1.4443	5.38E-5	0.0086	3.20E-07	5.34E-05	0.0100	1.07E-04	0.4153	6.69
2	2.00E-04	20	3.8851	1.45E-4	1.4262	5.31E-05	9.15E-05	0.0102	1.79E-04	0.6972	6.63
3	3.00E-04	20	6.3493	2.36E-4	3.2306	1.20E-04	1.16E-04	0.0104	2.23E-04	0.8674	6.69
4	4.00E-04	20	9.2407	3.44E-4	5.8330	2.17E-04	1.27E-04	0.0104	2.44E-04	0.9477	6.83
5	5.00E-04	20	12.0530	4.49E-4	7.9725	2.97E-04	1.52E-04	0.0104	2.92E-04	1.1349	6.85
6	6.00E-04	20	14.2654	5.31E-4	10.5415	3.92E-04	1.39E-04	0.0105	2.64E-04	1.0258	6.97
7	7.00E-04	20	17.6594	6.57E-4	13.3406	4.97E-04	1.61E-04	0.0102	3.15E-04	1.2247	6.73
8	8.00E-04	20	20.1499	7.50E-4	16.4128	6.11E-04	1.39E-04	0.0099	2.81E-04	1.0919	6.95
9	9.00E-04	20	22.9646	8.55E-4	18.2810	6.80E-04	1.74E-04	0.0104	3.35E-04	1.3026	7.00
10	1.00E-03	20	25.8301	9.61E-4	20.9227	7.79E-04	1.83E-04	0.0100	3.65E-04	1.4194	6.82
11	2.00E-03	20	52.7377	1.96E-3	49.5088	1.84E-03	1.20E-04	0.0098			6.90
12	3.00E-03	20	81.4389	3.03E-3	75.7533	2.82E-03	2.12E-04	0.0105	4.03E-04	1.5662	6.96
13	4.00E-03	20	107.8488	4.01E-3	102.6768	3.82E-03	1.92E-04	0.0101	3.81E-04	1.4811	6.85
14	5.00E-03	20	135.8185	5.05E-3	130.6857	4.86E-03	1.91E-04	0.0101	3.78E-04	1.4699	6.94

Table A – 15 Adsorption of C14,15-3PO-SO4 at 0.001 M NaCl, pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	**AF53**	**Solution**	**AF_ini**		**AF_eq**		**Cs**	**Alumina**	**q**	**[q]**	**pH**
AF53	(M)	(ml)	Area (us*min)	(M)	Area (us*min)	(M)	(M)	(g)	mole/g	molecule/nm^2	final
1	1.00E-04	20	2.6096	8.55E-5	0.6968	2.28E-05	6.27E-05	0.0054	2.32E-04	0.9023	7.31
1	1.00E-04	20	2.6096	8.55E-5	0.8275	2.71E-05	5.84E-05	0.0052	2.25E-04	0.8730	7.42
1	1.00E-04	20	2.6096	8.55E-5	1.3870	4.55E-05	4.01E-05	0.0032	2.50E-04	0.9732	7.44
1	1.00E-04	20	2.6096	8.55E-5	1.8521	6.07E-05	2.48E-05	0.0020	2.48E-04	0.9648	7.22
1	1.00E-04	20	1.5128	4.96E-5	0.0087	2.84E-07	4.93E-05	0.0103	9.57E-05	0.3720	7.01
2	2.00E-04	20	5.0022	1.64E-4	1.2046	3.95E-05	1.24E-04	0.0101	2.46E-04	0.9578	7.07
3	3.00E-04	20	8.0626	2.64E-4	3.4813	1.14E-04	1.50E-04	0.0105	2.86E-04	1.1114	6.87
4	4.00E-04	20	11.2079	3.67E-4	6.0185	1.97E-04	1.70E-04	0.0109	3.12E-04	1.2128	6.91
5	5.00E-04	20	14.4790	4.75E-4	9.4469	3.10E-04	1.65E-04	0.0107	3.08E-04	1.1980	6.83
6	6.00E-04	20	17.5230	5.74E-4	12.5192	4.10E-04	1.64E-04	0.0102	3.22E-04	1.2496	6.80
7	7.00E-04	20	20.5317	6.73E-4	15.8949	5.21E-04	1.52E-04	0.0101	3.01E-04	1.1694	6.75
8	8.00E-04	20	23.4902	7.70E-4	18.1908	5.96E-04	1.74E-04	0.0100	3.47E-04	1.3499	7.01
9	*9.00E-04*	*20*	*25.2648*	*8.28E-4*	*18.1655*	*5.95E-04*	*2.33E-04*	*0.0100*	*4.65E-04*	*1.8084*	*7.01*
10	1.00E-03	20	29.9370	9.81E-4	24.4204	8.00E-04	1.81E-04	0.0099	3.65E-04	1.4194	6.81
11	2.00E-03	20	61.4482	2.01E-3	55.2057	1.81E-03	2.05E-04	0.0110	3.72E-04	1.4456	6.54
12	3.00E-03	20	91.2755	2.99E-3	85.9675	2.82E-03	1.74E-04	0.0100	3.48E-04	1.3521	6.83
13	4.00E-03	20	121.8629	3.99E-3	116.5152	3.82E-03	1.75E-04	0.0099	3.54E-04	1.3760	6.66
14	5.00E-03	20	153.5556	5.03E-3	147.4016	4.83E-03	2.02E-04	0.0110	3.67E-04	1.4251	6.56

Table A – 16 Adsorption of C14,15-5PO-SO4 at 0.001 M NaCl, pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	**AF55**	**Solution**	**AF_ini**		**AF_eq**		**Cs**	**Alumina**	**q**	**[q]**	**pH**
AF55	(M)	(ml)	Area (us*min)	(M)	Area (us*min)	(M)	(M)	(g)	mole/g	molecule/nm^2	final
x1	1.00E-04	20	2.0965	7.80E-5	0.6512	2.42E-05	5.38E-05	0.0052	2.07E-04	0.8039	7.32
x2	1.00E-04	20	2.0965	7.80E-5	0.4981	1.85E-05	5.95E-05	0.0054	2.20E-04	0.8561	7.44
x3	1.00E-04	20	2.0965	7.80E-5	0.9932	3.70E-05	4.11E-05	0.0032	2.57E-04	0.9972	6.68
x4	1.00E-04	20	2.0965	7.80E-5	1.2037	4.48E-05	3.32E-05	0.0024	2.77E-04	1.0760	7.12
1	1.00E-04	20	2.0071	7.47E-5	0.0822	3.06E-06	7.16E-05	0.0103	1.39E-04	0.5406	7.51
2	2.00E-04	20	4.8122	1.79E-4	1.0860	4.04E-05	1.39E-04	0.0101	2.75E-04	1.0671	6.85
3	3.00E-04	20	7.5548	2.81E-4	3.0987	1.15E-04	1.66E-04	0.0105	3.16E-04	1.2275	7.25
4	4.00E-04	20	10.3699	3.86E-4	6.2724	2.33E-04	1.52E-04	0.0100	3.05E-04	1.1852	7.45
5	5.00E-04	20	13.2438	4.93E-4	8.5009	3.16E-04	1.77E-04	0.0107	3.30E-04	1.2821	6.69
6	6.00E-04	20	15.5937	5.80E-4	11.3480	4.22E-04	1.58E-04	0.0100	3.16E-04	1.2280	6.87
7	7.00E-04	20	19.0715	7.10E-4	14.3759	5.35E-04	1.75E-04	0.0105	3.33E-04	1.2935	6.98
8	8.00E-04	20	22.0000	8.19E-4	17.7843	6.62E-04	1.57E-04	0.0104	3.02E-04	1.1724	7.44
9	9.00E-04	20	24.7550	9.21E-4	19.8934	7.40E-04	1.81E-04	0.0105	3.45E-04	1.3392	7.21
10	1.00E-04	20	27.4761	1.02E-3	23.5424	8.76E-04	1.46E-04	0.0099	2.96E-04	1.1493	7.27
11	2.00E-03	20	56.1019	2.09E-3	51.0459	1.90E-03	1.88E-04	0.0102	3.69E-04	1.4338	7.18
12	3.00E-03	20	85.6047	3.19E-3	80.7549	3.01E-03	1.80E-04	0.0107	3.37E-04	1.3110	6.74
13	4.00E-03	20	113.9214	4.24E-3	109.0403	4.06E-03	1.82E-04	0.0105	3.46E-04	1.3446	6.58
14	5.00E-03	20	142.6787	5.31E-3	137.8171	5.13E-03	1.81E-04	0.0104	3.48E-04	1.3521	6.75

Table A – 17 Adsorption of C14,15-8PO-SO4 at 0.001 M NaCl, pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	**AF58**	**Solution**	**AF_ini**		**AF_eq**		**Cs**	**Alumina**	**q**	**[q]**	**pH**
AF58	(M)	(ml)	Area (us*min)	(M)	Area (us*min)	(M)	(M)	(g)	mole/g	molecule/nm^2	final
x1	1.00E-04	20	1.3473	5.49E-5	0.2464	1.00E-05	4.49E-05	0.0050	1.79E-04	0.6972	7.31
x2	1.00E-04	20	1.3473	5.49E-5	0.2659	1.08E-05	4.41E-05	0.0052	1.69E-04	0.6586	7.31
x3	1.00E-04	20	1.3473	5.49E-5	0.7620	3.10E-05	2.39E-05	0.0034	1.40E-04	0.5452	7.23
x4	1.00E-04	20	1.3473	5.49E-5	0.9077	3.70E-05	1.79E-05	0.0022	1.63E-04	0.6328	7.43
1	1.00E-04	20	1.3385	5.45E-5	0.0616	2.51E-06	5.20E-05	0.0103	1.01E-04	0.3926	7.01
2	2.00E-04	20	3.0418	1.24E-4	1.0237	4.17E-05	8.22E-05	0.0101	1.63E-04	0.6328	6.89
3	3.00E-04	20	5.4193	2.21E-4	2.9479	1.20E-04	1.01E-04	0.0105	1.92E-04	0.7454	6.78
4	4.00E-04	20	7.8601	3.20E-4	5.1676	2.11E-04	1.10E-04	0.0109	2.01E-04	0.7823	6.72
5	5.00E-04	20	11.0008	4.48E-4	7.8200	3.19E-04	1.30E-04	0.0107	2.42E-04	0.9414	6.94
6	6.00E-04	20	12.8265	5.23E-4	9.7059	3.96E-04	1.27E-04	0.0100	2.54E-04	0.9883	6.95
7	7.00E-04	20	15.2425	6.21E-4	12.0992	4.93E-04	1.28E-04	0.0105	2.44E-04	0.9481	6.77
8	8.00E-04	20	18.0735	7.36E-4	13.9242	5.67E-04	1.69E-04	0.0110	3.07E-04	1.1946	6.55
9	9.00E-04	20	21.1695	8.63E-4	17.1195	6.98E-04	1.65E-04	0.0105	3.14E-04	1.2215	6.65
10	1.00E-03	20	23.3922	9.53E-4	19.6378	8.00E-04	1.53E-04	0.0099	3.09E-04	1.2010	6.88
11	2.00E-03	20	48.7018	1.98E-3	44.6217	1.82E-03	1.66E-04	0.0109	3.05E-04	1.1854	7.08
12	3.00E-03	20	74.5743	3.04E-3	70.1792	2.86E-03	1.79E-04	0.0107	3.35E-04	1.3008	6.96
13	4.00E-03	20	98.7355	4.02E-3	94.8105	3.86E-03	1.60E-04	0.0105	3.05E-04	1.1838	6.82
14	5.00E-03	20	123.4267	5.03E-3	119.2350	4.86E-03	1.71E-04	0.0104	3.28E-04	1.2764	6.56

Table A – 18 Adsorption of SDS/dodecanol, 10:1 molar ratio at 0.001 M NaCl, pH 7.0 ± 0.5 and temperature 25±2 °C

Tube	**SDS:D**	**Solution**	**AF_ini**		**AF_eq**		**Cs**	**Alumina**	**q**	**[q]**	**pH**
SDS:D	(M)	(ml)	Area (us*min)	(M)	Area (us*min)	(M)	(M)	(g)	mole/g	molecule/nm^2	final
1	1.00E-04	20	3.8784	9.09E-5	2.9819	6.99E-05	2.10E-05	0.1010	4.16E-06	0.0162	7.22
2	2.00E-04	20	7.3475	1.72E-4	5.3466	1.25E-04	4.69E-05	0.0105	8.93E-05	0.3470	7.08
3	3.00E-04	20	12.4110	2.91E-4	9.6242	2.25E-04	6.53E-05	0.0104	1.26E-04	0.4879	7.30
5	5.00E-04	20	21.2579	4.98E-4	17.0717	4.00E-04	9.81E-05	0.0100	1.96E-04	0.7623	7.30
7	7.00E-04	20	29.9551	7.02E-4	23.0792	5.41E-04	1.61E-04	0.0107	3.01E-04	1.1701	7.19
8	8.00E-04	20	34.3928	8.06E-4	27.4006	6.42E-04	1.64E-04	0.0102	3.21E-04	1.2483	7.12
9	9.00E-04	20	38.0648	8.92E-4	30.4551	7.14E-04	1.78E-04	0.0110	3.24E-04	1.2597	7.16
10	1.00E-03	20	42.4890	9.96E-4	32.8930	7.71E-04	2.25E-04	0.0110	4.09E-04	1.5885	7.06
11	2.00E-03	20	85.0692	1.99E-3	75.2765	1.76E-03	2.29E-04	0.0100	4.59E-04	1.7832	6.72
12	3.00E-03	20	128.2615	3.01E-3	115.9459	2.72E-03	2.89E-04	0.0107	5.39E-04	2.0958	6.51
13	4.00E-03	20	170.0561	3.98E-3	157.8631	3.70E-03	2.86E-04	0.0105	5.44E-04	2.1145	6.75
14	5.00E-03	20	214.1779	5.02E-3	202.9845	4.76E-03	2.62E-04	0.0100	5.25E-04	2.0382	6.45
15	7.00E-03	20	340.8707	7.99E-3	327.6302	7.68E-03	3.10E-04	0.0115	5.40E-04	2.0965	6.63
16	9.00E-03	20	383.4716	8.98E-3	371.4516	8.70E-03	2.82E-04	0.0105	5.36E-04	2.0845	6.89
18	3.00E-02	20	865.8429	2.03E-2	852.6715	2.00E-02	3.09E-04	0.0110	5.61E-04	2.1803	6.54

Table A – 19 Adsorption of SDS alone at 0.001 M NaCl, pH 7.0 ± 0.5 and temperature 25±2 °C

Tube	**SDS**	**Solution**	**AF_ini**		**AF_eq**		**Cs**	**Alumina**	**q**	**[q]**	**pH**
SDS	(M)	(ml)	Area (us*min)	(M)	Area (us*min)	(M)	(M)	(g)	mole/g	molecule/nm^2	final
1	1.00E-04	20	3.6213	9.49E-5	0.7286	1.91E-05	7.58E-05	0.1050	1.44E-05	0.0561	7.12
2	2.00E-04	20	7.5837	1.99E-4	4.5620	1.20E-04	7.92E-05	0.0105	1.51E-04	0.5864	7.15.
3	3.00E-04	20	11.3087	2.96E-4	6.7571	1.77E-04	1.19E-04	0.0104	2.29E-04	0.8918	7.22
	4.00E-04	20	15.0914	3.96E-4	10.4100	2.73E-04	1.23E-04	0.0104	2.36E-04	0.9172	7.30
5	5.00E-04	20	19.4166	5.09E-4	14.6294	3.84E-04	1.26E-04	0.0100	2.51E-04	0.9754	7.01
6	6.00E-04	20	23.5619	6.18E-4	17.8885	4.69E-04	1.49E-04	0.0104	2.86E-04	1.1116	6.89
7	7.00E-04	20	27.0720	7.10E-4	22.4113	5.88E-04	1.22E-04	0.0098	2.49E-04	0.9690	6.85
8	8.00E-04	20	31.2224	8.19E-4	25.0702	6.57E-04	1.61E-04	0.0102	3.16E-04	1.2290	7.12
9	9.00E-04	20	34.7962	9.12E-4	28.8172	7.56E-04	1.57E-04	0.0098	3.20E-04	1.2431	7.15
10	1.00E-03	20	38.1102	9.99E-4	32.2484	8.46E-04	1.54E-04	0.0105	2.93E-04	1.1375	7.11
11	2.00E-03	20	78.1704	2.05E-3	71.0968	1.86E-03	1.85E-04	0.0100	3.71E-04	1.4413	7.08
12	3.00E-03	20	119.2034	3.13E-3	111.2100	2.92E-03	2.10E-04	0.0107	3.92E-04	1.5222	7.44
13	4.00E-03	20	156.8902	4.11E-3	149.4914	3.92E-03	1.94E-04	0.0105	3.69E-04	1.4358	7.15
14	5.00E-03	20	198.9492	5.22E-3	192.0860	5.04E-03	1.80E-04	0.0100	3.60E-04	1.3984	6.99
15	7.00E-03	20	276.8440	7.26E-3	269.0598	7.05E-03	2.04E-04	0.0107	3.81E-04	1.4823	6.78
16	1.00E-02	20	366.6820	9.61E-3	358.8742	9.41E-03	2.05E-04	0.0104	3.94E-04	1.5297	7.21

Table A – 20 Styrene solubilization of C12,13-3PO-SO4 at 0.001 M NaCl, temperature 25±2 °C

Tube AF43	Conc surf.			Styrene Initial		Absorbance				Styrene Final			
	Molar (M)	mM	uM	Amount(ul)	Conc(mg/l)	1	2	3	av	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-5	0.01	10	15	336.35	453.0	465.2		459.1	11.57	259.49	2.48E-03	2.48
2	1.0E-5	0.01	10	15	336.35	457.6	471.5		464.6	11.71	262.57	2.51E-03	2.51
3	3.0E-5	0.03	30	15	336.35	461.8	481.3		471.5	11.89	266.52	2.55E-03	2.55
4	3.0E-5	0.03	30	15	336.35	354.8	344.2		349.5				
5	1.0E-4	0.10	100	16	358.78	484.9	450.2		467.5	11.78	264.25	2.53E-03	2.53
6	1.0E-4	0.10	100	16	358.78	445.9	462.8		454.3	11.45	256.78	2.46E-03	2.46
7	3.0E-4	0.30	300	16	358.78	466.9	452.9		459.9	11.59	259.94	2.49E-03	2.49
8	3.0E-4	0.30	300	16	358.78	471.1	488.6		479.8	12.09	271.20	2.60E-03	2.60
9	1.0E-3	1.00	1000	17	381.20	442.1	462.2		452.2	11.40	255.57	2.45E-03	2.45
10	1.0E-3	1.00	1000	17	381.20	477.9	490.2		484.1	12.20	273.59	2.62E-03	2.62
10	1.5E-3	1.50	1500	17	381.20	493.2	480.9		487.0	12.28	275.27	2.63E-03	2.63
10	1.5E-3	1.50	1500	17	381.20	450.2	435.7		443.0	11.17	250.36	2.40E-03	2.40
11	2.0E-3	2.00	2000	18	403.62	528.4	530.1		529.3	13.34	299.13	2.86E-03	2.86
12	2.0E-3	2.00	2000	18	403.62	525.1	533.7		529.4	13.34	299.21	2.86E-03	2.86
13	3.0E-3	3.00	3000	20	448.47	601.4	613.1		607.3	15.31	343.21	3.28E-03	3.28
14	3.0E-3	3.00	3000	20	448.47	611.1	627.5		619.3	15.61	350.02	3.35E-03	3.35
15	4.0E-3	4.00	4000	25	560.59	648.2	659.4		653.8	16.48	369.52	3.54E-03	3.54
16	4.0E-3	4.00	4000	25	560.59	653.5	675.4		664.5	16.75	375.54	3.59E-03	3.59
17	5.0E-3	5.00	5000	30	672.71	718.5	702.6		710.6	17.91	401.60	3.84E-03	3.84
18	5.0E-3	5.00	5000	30	672.71	703.8	711.4		707.6	17.84	399.93	3.83E-03	3.83
19	6.0E-3	6.00	6000	40	896.94	803.3	780.4		791.8	19.96	447.53	4.28E-03	4.28
20	6.0E-3	6.00	6000	40	896.94	768.1	799.2		783.7	19.75	442.93	4.24E-03	4.24
21	7.0E-3	7.00	7000	45	1009.06	965.2	986.6		975.9	24.60	551.59	5.28E-03	5.28

Table A – 21 Styrene solubilization of C12,13-5PO-SO4 at 0.001 M NaCl, temperature 25±2 °C

Tube	Conc surf.			Styrene Initial		Absorbance				Styrene Final			
45	Molar (M)	mM	uM	Amount(ul)	Conc(mg/l)	1	2	3	av	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-5	0.01	10	15	336.35	453.3	285.6		369.5	9.31	208.82	2.00E-03	2.00
2	1.0E-5	0.01	10	15	336.35	405.0	380.2		392.6	9.90	221.90	2.12E-03	2.12
3	3.0E-5	0.03	30	15	336.35	401.8	412.2		407.0	10.26	230.03	2.20E-03	2.20
4	3.0E-5	0.03	30	15	336.35	447.6	365.2		406.4	10.24	229.71	2.20E-03	2.20
5	1.0E-4	0.10	100	15	336.35	379.9	354.6		367.2	9.26	207.55	1.99E-03	1.99
6	1.0E-4	0.10	100	15	336.35	479.8	340.3		410.0	10.33	231.74	2.22E-03	2.22
7	3.0E-4	0.30	300	15	336.35	427.7	441.9		434.8	10.96	245.75	2.35E-03	2.35
8	3.0E-4	0.30	300	15	336.35	511.2	395.2		453.2	11.42	256.15	2.45E-03	2.45
9	1.0E-3	1.00	1000	15	336.35	577.7	455.3		516.5	13.02	291.93	2.79E-03	2.79
10	1.0E-3	1.00	1000	16	358.78	532.7	458.3		495.5	12.49	280.05	2.68E-03	2.68
10	1.5E-3	1.50	1500	16	358.78	605.7	458.3		532.0	13.41	300.68	2.88E-03	2.88
10	1.5E-3	1.50	1500	16	358.78	619.4	458.3		538.8	13.58	304.55	2.91E-03	2.91
11	2.0E-3	2.00	2000	18	403.62	581.2	457.0		519.1	13.08	293.39	2.81E-03	2.81
12	2.0E-3	2.00	2000	18	403.62	593.7	466.5		530.1	13.36	299.60	2.87E-03	2.87
13	3.0E-3	3.00	3000	20	448.47	635.1	660.5		647.8	16.33	366.15	3.50E-03	3.50
14	3.0E-3	3.00	3000	20	448.47	660.9	673.4		667.2	16.82	377.07	3.61E-03	3.61
15	4.0E-3	4.00	4000	25	560.59	688.7	699.4		694.0	17.49	392.26	3.75E-03	3.75
16	4.0E-3	4.00	4000	25	560.59	695.3	687.8		691.5	17.43	390.85	3.74E-03	3.74
17	5.0E-3	5.00	5000	30	672.71	751.3	754.6		753.0	18.98	425.58	4.07E-03	4.07
17	5.0E-3	5.00	5000	30	672.71	877.6	838.4		858.0	21.63	484.94	4.64E-03	4.64
20	6.0E-3	6.00	6000	30	672.71	1013.3	995.7		1004.5	25.32	567.73	5.43E-03	5.43
21	7.0E-3	7.00	7000	35	784.82	1236.0	1195.8		1215.9	30.65	687.22	6.58E-03	6.58

Table A – 22 Styrene solubilization of C12,13-8PO-SO4 at 0.001 M NaCl, temperature 25±2 °C

Tube	**Conc surf.**			**Styrene Initial**		**Absorbance**				**Styrene Final**			
48	Molar (M)	mM	uM	**Amount(ul)**	**Conc(mg/l)**	**1**	**2**	**3**	**av**	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
0	DI water			20	448.47	2075.3	2030.3	1972.4	2026.0	11.43	256.35	2.45E-03	2.45
1	1.0E-6	1.0E-3	1	15	336.35	1704.5	1667.3	1605.3	1659.0	9.36	209.92	2.01E-03	2.01
2	3.0E-6	3.0E-3	3	15	336.35	1635.3	1626.0		1630.7	9.20	206.32	1.97E-03	1.97
3	1.0E-5	1.0E-2	10	15	336.35	1616.3	1608.7	1616.3	1613.8	9.11	204.19	1.95E-03	1.95
4	3.0E-5	3.0E-2	30	15	336.35	1982.4	1977.3	1964.3	1974.7	11.14	249.85	2.39E-03	2.39
5	1.0E-4	1.0E-1	100	15	336.35	1802.3	1767.4	1772.3	1780.7	10.05	225.31	2.16E-03	2.16
6	3.0E-4	3.0E-1	300	15	336.35	2124.7	2044.3	2035.5	2068.2	11.67	261.68	2.50E-03	2.50
6.1	3.0E-4	3.0E-1	300										
7	5.0E-4	5.0E-1	500	16	358.78	2279.6	2290.9		2285.3	12.89	289.15	2.77E-03	2.77
8	7.0E-4	7.0E-1	700	20	448.47	2429.0	2455.0	2433.1	2439.0	13.76	308.61	2.95E-03	2.95
8.1	7.0E-4	7.0E-1	700	16	358.78	2650.6	2665.6		2658.1	15.00	336.33	3.22E-03	3.22
9	1.0E-3	1.0E+0	1000	15	336.35	2274.4	2266.1	2262.6	2267.7	12.80	286.93	2.75E-03	
10	3.0E-3	3.0E+0	3000	40	896.94	5026.7	5008.1	4996.1	5010.3	28.27	633.95	6.07E-03	6.07
11	5.0E-3	5.0E+0	5000	40	896.94	6215.0	6231.1		6223.1	35.11	787.40	7.53E-03	7.53
12	7.0E-3	7.0E+0	7000	100	2242.35	7984.0	7984.0		7984.0	45.05	1010.21	9.67E-03	9.67

Table A – 23 Styrene solubilization of C14,15-3PO-SO4 at 0.001 M NaCl, temperature 25±2 °C

Tube 53	Conc surf.			Styrene Initial		Absorbance				Styrene Final			
	Molar (M)	mM	uM	Amount(ul)	Conc(mg/l)	1	2	3	av	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
0	DI water			20	448.47	2075.3	2030.3	1972.4	2026.00	11.43	256.35	2.45E-03	2.45
1	1.00E-06	1.0E-3	1	12	269.08	1887.2	1900.1		1893.65	10.69	239.60	2.29E-03	2.29
3	1.00E-05	1.0E-2	10	13	291.51	2158.9	2285.9		2222.40	12.54	281.20	2.69E-03	2.69
4	3.00E-05	3.0E-2	30	16	358.78	2089.1	2080.0		2084.55	11.76	263.76	2.52E-03	2.52
6	3.00E-04	3.0E-1	300	15	336.35	2306.9	2313.0		2309.95	13.03	292.28	2.80E-03	2.80
7	5.00E-04	5.0E-1	500	15	336.35	2285.6	2246.3		2265.95	12.79	286.71	2.74E-03	2.74
8	7.00E-04	7.0E-1	700	15	336.35	2468.0	2410.0		2439.00	13.76	308.60	2.95E-03	2.95
8.1	7.00E-04	7.0E-1	700	15	336.35	2427.7	2410.0		2418.85	13.65	306.06	2.93E-03	2.93
9	1.00E-03	1.0E+0	1000	15	336.35	2402.0	2470.3		2436.15	13.75	308.24	2.95E-03	
9.1	1.00E-03	1.0E+0	1000	16	358.78	2741.1	2744.3		2742.70	15.48	347.03	3.32E-03	3.32
10	3.00E-03	3.0E+0	3000	16	358.78	3882.6	3823.8		3853.20	21.74	487.54	4.67E-03	4.67
10.1	3.00E-03	3.0E+0	3000	50	1121.18	4523.0	4498.2		4510.60	25.45	570.72	5.46E-03	5.46
11	5.00E-03	5.0E+0	5000	30	672.71	4712.6	4789.1		4750.85	26.81	601.12	5.75E-03	5.75
12	7.00E-03	7.0E+0	7000	32	717.55	5070.0	5091.0		5080.50	28.67	642.83	6.15E-03	6.15
12.1	7.00E-03	7.0E+0	7000	50	1121.18	5453.7	5443.2		5448.45	30.74	689.39	6.60E-03	6.60

Table A – 24 Styrene solubilization of C14,15-5PO-SO4 at 0.001 M NaCl, temperature 25±2 °C

Tube 55	Conc surf.			Styrene Initial		Absorbance				Styrene Final			
	Molar (M)	mM	uM	**Amount(ul)**	**Conc(mg/l)**	**1**	**2**	**3**	**av**	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
0	DI water			20	448.47	2075.3	2030.3	1972.4	2026.0	11.43	256.35	2.45E-03	2.45
1	1.00E-06	1.0E-3	1	13	291.51	1778.9	1778.9		1778.9	10.04	225.08	2.15E-03	2.15
2	3.00E-06	3.0E-3	3	13	291.51	1762.2	1780.5		1771.4	10.00	224.13	2.14E-03	2.14
3	1.00E-05	1.0E-2	10	13	291.51	1952.0	1935.0		1943.5	10.97	245.91	2.35E-03	2.35
4	3.00E-05	3.0E-2	30	13	291.51	1802.0	1977.8		1889.9	10.66	239.13	2.29E-03	2.29
5	1.00E-04	1.0E-1	100	15	336.35	2267.5	2236.6		2252.1	12.71	284.95	2.73E-03	2.73
6	3.00E-04	3.0E-1	300	20	448.47	2551.4	2551.7		2551.6	14.40	322.85	3.09E-03	
6.1	3.00E-04	3.0E-1	300	20	0.00	2036.5	2162.8		2099.7	11.85	265.67	2.54E-03	2.54
7	5.00E-04	5.0E-1	500	20	448.47	2210.6	2230.1		2220.4	12.53	280.94	2.69E-03	2.69
8	7.00E-04	7.0E-1	700	20	448.47	2360.6	2373.1		2366.9	13.36	299.48	2.87E-03	2.87
8.7	7.00E-04	7.0E-1	700	15	336.35	2307.9	2298.6		2303.3	13.00	291.43	2.79E-03	2.79
11	5.00E-03	5.0E+0	5000	40	896.94	5005.9	4980.9		4993.4	28.18	631.81	6.05E-03	6.05
12	7.00E-03	7.0E+0	7000	70		5936.4	5921.6		5929.0	33.46	750.19	7.18E-03	7.18
12.1	7.00E-03	7.0E+0	7000	70	1569.65	5928.6	5703.3		5816.0	32.82	735.89	7.04E-03	7.04

Table A – 25 Styrene solubilization of C14,15-8PO-SO4 at 0.001 M NaCl, temperature 25±2 °C

Tube	Conc surf.			Styrene Initial		Absorbance				Styrene Final			
58	Molar (M)	mM	uM	Amount(ul)	Conc(mg/l)	1	2	3	av	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
0	DI water			20	448.47	2075.3	2030.3	1972.4	2026.0	11.43	256.35	2.45E-03	2.45
1	1.00E-06	1.0E-3	1	13	291.51	2065.8	2081.9		2073.9	11.70	262.40	2.51E-03	2.51
2	3.00E-06	3.0E-3	3	13	291.51	2176.0	2174.6		2175.3	12.27	275.24	2.63E-03	2.63
4	3.00E-05	3.0E-2	30	15	336.35	2072.0	2040.0		2056.0	11.60	260.14	2.49E-03	2.49
5	1.00E-04	1.0E-1	100	20	448.47	2469.0	2457.0		2463.0	13.90	311.64	2.98E-03	2.98
6	3.00E-04	3.0E-1	300	25	560.59	2849.0	2806.5		2827.8	15.96	357.79	3.42E-03	3.42
7	5.00E-04	5.0E-1	500	20	448.47	2931.0	2941.0		2936.0	16.57	371.49	3.55E-03	3.55
8	7.00E-04	7.0E-1	700	30	672.71	4408.4	4368.5						
8.1	7.00E-04	7.0E-1	700	28	627.86	3245.0	3288.0		3266.5	18.43	413.31	3.96E-03	3.96
9	1.00E-03	1.0E+0	1000	20	448.47	4408.4	4368.5						
9.1	1.00E-03	1.0E+0	1000	20	448.47	3563.0	3511.0		3537.0	19.96	447.53	4.28E-03	4.28
10	2.00E-03	2.0E+0	2000	32	717.55	4044.0	4044.0		4044.0	22.82	511.68	4.90E-03	4.90
11	3.00E-03	3.0E+0	3000	32	717.55	4527.0	4582.0		4554.5	25.70	576.28	5.51E-03	5.51
11.1	3.00E-03	3.0E+0	3000	35	784.82	5249.0	5225.8						
12	5.00E-03	5.0E+0	5000	40	896.94	5964.3	5964.3		5964.3	33.65	754.66	7.22E-03	7.22
13	7.00E-03	7.0E+0	7000	100	2242.35	7206.4	7236.6		7221.5	40.75	913.73	8.74E-03	8.74
13.1	7.00E-03	7.0E+0	7000	100	2242.35	7206.4	7469.4		7337.9	41.41	928.46	8.88E-03	8.88

Table A – 26 Styrene solubilization of SDS:D, 10:10 molar ratio at 0.001 M NaCl, temperature 25±2 °C

Tube SDS:D	Conc surf.			Styrene Initial		Absorbance				Styrene Final			
	Molar (M)	mM	uM	Amount(ul)	Conc(mg/l)	1	2	3	av	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	7.00E-03	7	7000	30	672.71	770.0	729.0		775.5	19.55	438.29	4.19E-03	4.19
2	7.00E-03	7	7000	25	560.59	740.0	746.1		743.1	18.73	419.98	4.02E-03	4.02
3	8.00E-03	8	8000	30	672.71	891.9	854.9		873.4	22.01	493.64	4.72E-03	4.72
4	8.00E-03	8	8000	30	672.71	744.0	858.7		801.3	20.20	452.92	4.33E-03	4.33
5	1.00E-02	10	10000	50	1121.18	1202.2	1169.5		1185.8	29.89	670.23	6.41E-03	6.41
6	1.00E-02	10	10000	40	896.94	1098.8	1085.1		1091.9	27.52	617.15	5.91E-03	5.91
7	1.50E-02	15	15000	50	1121.18	1630.9	1700.6		1665.7	41.99	941.47	9.01E-03	9.01
8	1.50E-02	15	15000	50	1121.18	1681.2	1705.4		1693.3	42.68	957.03	9.16E-03	9.16
9	2.00E-02	20	20000	60	1345.41	1876.2	1945.9		1911.1	48.17	1080.13	1.03E-02	10.34
10	2.00E-02	20	20000	60	1345.41	1886.8	2106.5		1996.7	50.33	1128.51	1.08E-02	10.80
11	3.00E-02	30	30000	120	2690.82	3326.7	3241.3		3284.0	82.77	1856.10	1.78E-02	17.76
12	3.00E-02	30	30000	120	2690.82	3449.6	3296.2		3372.9	85.02	1906.34	1.82E-02	18.24
13	4.00E-02	40	40000	160	3587.76	3306.2	3827.3		3566.7	89.90	2015.90	1.93E-02	19.29
14	4.00E-02	40	40000	160	3587.76	3835.3	3556.7		3554.9	89.60	2009.18	1.92E-02	19.23

Table A – 27 Styrene solubilization of SDS 0.001 M NaCl, temperature 25±2 °C

Tube	Conc surf.			Styrene Initial		Absorbance				Styrene Final			
SDS	Molar (M)	mM	uM	Amount(ul)	Conc(mg/l)	1	2	3	av	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
0	DI water			20	448.47	2075.3	2030.3	1972.4	2026.0	11.43	256.35	2.45E-03	2.45
1	1.00E-04	1.0E-1	100	13	291.51	1786.0	1805.5		1795.8	10.13	227.21	2.17E-03	2.17
2	3.00E-04	3.0E-1	300	13	291.51	1806.0	1802.6		1804.3	10.18	228.30	2.18E-03	2.18
3	7.00E-04	7.0E-1	700	13	291.51	2002.0	2010.2		2006.1	11.32	253.83	2.43E-03	2.43
4	9.00E-04	9.0E-1	900	15	336.35	2221.3	2242.6		2232.0	12.59	282.41	2.70E-03	2.70
5	1.00E-03	1.0E+0	1000	20	448.47	2242.6	2241.0		2241.8	12.65	283.65	2.71E-03	2.71
6	2.00E-03	2.0E+0	2000	25	560.59	2345.9	2330.0		2338.0	13.19	295.82	2.83E-03	2.83
7	3.00E-03	3.0E+0	3000	20	448.47	2198.3	2177.3		2187.8	12.35	276.82	2.65E-03	2.65
8	5.00E-03	5.0E+0	5000	30	672.71	2291.1	2253.0		2272.1	12.82	287.48	2.75E-03	2.75
9	7.00E-03	7.0E+0	7000	28	627.86	2594.1	2585.1		2589.6	14.61	327.66	3.14E-03	3.14
10	1.00E-02	1.0E+1	10000	20	448.47	3371.6	3386.1		3378.9	19.07	427.52	4.09E-03	4.09

Table A-28 Molar solubilization ratio (MSR) and micellar partition coefficient (K_{mic}) of styrene

$X_{aq}=C_{eq}/(C_{eq}+55.55)$ = 5.36E-05

MSR=Slope

$K_{mic}=X_{mic}/X_{aq}$

Surfactant, STYRENE, 0.01M NaCl	**MSR**	**r^2**	**X_{mic}**	K_{mic}	$\log K_{mic}$
SDS	0.31	0.96	0.23	4382.88	3.64
SDS/dodecanol	0.50	0.97	0.33	6242.04	3.80
C12,13-3PO-SO4	0.40	0.94	0.28	5314.46	3.73
C12,13-5PO-SO4	0.56	0.90	0.36	6666.83	3.82
C12,13-8PO-SO4	0.67	0.93	0.40	7471.87	3.87
C14,15-3PO-SO4	0.70	0.96	0.41	7675.48	3.89
C14,15-5PO-SO4	1.22	0.96	0.55	10262.47	4.01
C14,15-8PO-SO4	1.94	0.94	0.66	12313.11	4.09

Table A -29 Styrene adsolubilization of C12,13-3PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

y_af43 = 26893 y_sty 96.264

Sample	**Styrene**	**Solution**	**Surf_in**		**Surf_eq**		**Sty_ini**				**Sty_eq**						
AF43	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	2	40	18.7114	6.96E-04	13.6165	5.06E-04	3	67.27	6.44E-04	643.74	273.80	281.10	277.45	2.88	64.63	6.18E-04	618.45
2	3	40	18.7114	6.96E-04	12.9675	4.82E-04	5	112.12	1.07E-03	1072.89	460.00		460.00	4.78	107.15	1.03E-03	1025.37
3	5	40	18.7114	6.96E-04	12.6177	4.69E-04	7	156.96	1.50E-03	1502.05	633.90	643.90	638.90	6.64	148.82	1.42E-03	1424.15
3	5	40	18.7114	6.96E-04	12.8274	4.77E-04	7	156.96	1.50E-03	1502.05	630.20	638.20	634.20	6.59	147.73	1.41E-03	1413.67
4	6	40	18.7114	6.96E-04	12.6715	4.71E-04	9	201.81	1.93E-03	1931.21	814.90	809.20	812.05	8.44	189.16	1.81E-03	1810.11
5	7	40	18.7114	6.96E-04	12.1456	4.52E-04	10	224.24	2.15E-03	2145.79	898.40	896.20	897.30	9.32	209.01	2.00E-03	2000.14
5	7	40	18.7114	6.96E-04	12.7523	4.74E-04	10	224.24	2.15E-03	2145.79	906.90	890.20	898.55	9.33	209.31	2.00E-03	2002.93
7	10	40	18.7114	6.96E-04	13.3951	4.98E-04	10	224.24	2.15E-03	2145.79	907.20	899.80	903.50	9.39	210.46	2.01E-03	2013.96
7	10	40	18.7114	6.96E-04	12.4454	4.63E-04	12	269.08	2.57E-03	2574.95	1079.70	1046.60	1063.15	11.04	247.65	2.37E-03	2369.83
8	12	40	18.7114	6.96E-04	12.8729	4.79E-04	13	291.51	2.79E-03	2789.53	1146.10	1165.90	1156.00	12.01	269.28	2.58E-03	2576.80
9	13	40	18.7114	6.96E-04	13.1280	4.88E-04	13	291.51	2.79E-03	2789.53	1143.00	1137.40	1140.20	11.84	265.60	2.54E-03	2541.58
10	15	40	18.7114	6.96E-04	12.7659	4.75E-04	14	313.93	3.00E-03	3004.11	1207.90	1224.30	1216.10	12.63	283.28	2.71E-03	2710.77
11	15	40	18.7114	6.96E-04	12.4599	4.63E-04	15	336.35	3.22E-03	3218.68	1277.80	1286.60	1282.20	13.32	298.67	2.86E-03	2858.11
12	17	40	18.7114	6.96E-04	12.8954	4.80E-04	15	336.35	3.22E-03	3218.68	1266.10	1244.00	1255.05	13.04	292.35	2.80E-03	2797.59
13	20	40	18.7114	6.96E-04	12.5646	4.67E-04	17	381.20	3.65E-03	3647.84	1409.00	1349.00	1379.00	14.33	321.22	3.07E-03	3073.88
14	22	40	18.7114	6.96E-04	12.8967	4.80E-04	20	448.47	4.29E-03	4291.58	1571.80		1571.80	16.33	366.13	3.50E-03	3503.65
15	22	40	18.7114	6.96E-04	12.7867	4.75E-04	22	493.32	4.72E-03	4720.74	1637.70		1637.70	17.01	381.48	3.65E-03	3650.54

Table A -29a Styrene adsolubilization of C12,13-3PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample **AF43**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**Sty(in-f)** (mg/l)	**Sty(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	**Xadm**	**X_{aq}**	**X_{aq} x 10^5**	**Kadm**
1	1.89E-04	0.0305	2.48E-04	0.97	2.64	2.53E-05	33.16	0.04	0.12	1.11E-05	1.11	0.11
2	2.14E-04	0.0305	2.80E-04	1.09	4.97	4.75E-05	62.33	0.04	0.18	1.85E-05	1.85	0.10
3	2.27E-04	0.0312	2.91E-04	1.13	8.14	7.79E-05	99.87	0.05	0.26	2.56E-05	2.56	0.10
3	2.19E-04	0.0310	2.82E-04	1.10	9.24	8.84E-05	114.04	0.06	0.29	2.54E-05	2.54	0.11
4	2.25E-04	0.0300	2.99E-04	1.16	12.65	1.21E-04	161.46	0.06	0.35	3.26E-05	3.26	0.11
5	2.44E-04	0.0315	3.10E-04	1.20	15.22	1.46E-04	184.95	0.07	0.37	3.60E-05	3.60	0.10
5	2.22E-04	0.0312	2.84E-04	1.10	14.93	1.43E-04	183.16	0.07	0.39	3.61E-05	3.61	0.11
7	1.98E-04	0.0318	2.49E-04	0.97	13.78	1.32E-04	165.82	0.06	0.40	3.63E-05	3.63	0.11
7	2.33E-04	0.0307	3.04E-04	1.18	21.43	2.05E-04	267.25	0.08	0.47	4.27E-05	4.27	0.11
8	2.17E-04	0.0302	2.88E-04	1.12	22.23	2.13E-04	281.75	0.08	0.49	4.64E-05	4.64	0.11
9	2.08E-04	0.0314	2.64E-04	1.03	25.91	2.48E-04	315.85	0.09	0.54	4.58E-05	4.58	0.12
10	2.21E-04	0.0314	2.82E-04	1.09	30.65	2.93E-04	373.68	0.10	0.57	4.88E-05	4.88	0.12
11	2.32E-04	0.0308	3.02E-04	1.17	37.68	3.61E-04	468.28	0.11	0.61	5.14E-05	5.14	0.12
12	2.16E-04	0.0310	2.79E-04	1.08	44.00	4.21E-04	543.35	0.13	0.66	5.04E-05	5.04	0.13
13	2.29E-04	0.0305	3.00E-04	1.16	59.98	5.74E-04	752.73	0.16	0.72	5.53E-05	5.53	0.13
14	2.16E-04	0.0304	2.84E-04	1.11	82.34	7.88E-04	1036.75	0.18	0.78	6.31E-05	6.31	0.12
15	2.20E-04	0.0312	2.82E-04	1.10	111.84	1.07E-03	1372.04	0.23	0.83	6.57E-05	6.57	0.13

Table A -30 Styrene adsolubilization of C12,13-5PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 ^{o}C

Sample	**Styrene**	**Solution**	**Surf_in**		**Surf_eq**		**Sty_ini**				**Sty_eq**						
AF45	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	2	40	8.7013	6.00E-04	6.8296	4.71E-04	2	44.85	4.29E-04	429.16	166.60	164.40	165.50	1.72	38.55	3.69E-04	368.91
2	3	40	8.7013	6.00E-04	5.4320	3.75E-04	3	67.27	6.44E-04	643.74	251.20	246.80	246.40	2.56	57.40	5.49E-04	549.24
3	5	40	8.7013	6.00E-04	4.7303	3.26E-04	4	89.69	8.58E-04	858.32	307.50	307.50	312.80	3.25	72.86	6.97E-04	697.25
4	6	40	8.7013	6.00E-04	5.6990	3.93E-04	6	134.54	1.29E-03	1287.47	505.70		505.70	5.25	117.80	1.13E-03	1127.24
5	7	40	8.7013	6.00E-04	5.6990	3.93E-04	7	156.96	1.50E-03	1502.05	570.12	550.74	560.43	5.82	130.55	1.25E-03	1249.24
6	9	40	8.7013	6.00E-04	6.2235	4.29E-04	9	201.81	1.93E-03	1931.21							
7	10	40	8.7013	6.00E-04	4.1374	2.85E-04	10	224.24	2.15E-03	2145.79	790.40		790.40	8.21	184.11	1.76E-03	1761.85
8	12	40	8.7013	6.00E-04	5.0041	3.45E-04	12	269.08	2.57E-03	2574.95	981.50		981.50	10.20	228.63	2.19E-03	2187.83
9	13	40	8.7013	6.00E-04	5.5512	3.83E-04	13	291.51	2.79E-03	2789.53	1037.60		1037.60	10.78	241.70	2.31E-03	2312.88
10	15	40	8.7013	6.00E-04	5.9707	4.12E-04	15	336.35	3.22E-03	3218.68	1124.10	1311.80	1217.95	12.65	283.71	2.71E-03	2714.89
11	15	40	8.7013	6.00E-04	5.9707	4.12E-04	15	336.35	3.22E-03	3218.68	1155.21	1212.04	1183.63	12.30	275.71	2.64E-03	2638.38
12	17	40	8.7013	6.00E-04	5.9707	4.12E-04	17	381.20	3.65E-03	3647.84	1304.80	1311.80	1308.30	13.59	304.75	2.92E-03	2916.29
13	20	40	8.7013	6.00E-04	5.9707	4.12E-04	20	448.47	4.29E-03	4291.58	1571.80	1579.40	1575.60	16.37	367.02	3.51E-03	3512.12
14	22	40	8.7013	6.00E-04	4.9707	3.43E-04	22	493.32	4.72E-03	4720.74	1713.03	1682.37	1697.70	17.64	395.46	3.78E-03	3784.28

Table A -30a Styrene adsolubilization of C12,13-5PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample **AF45**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**Sty(in-f)** (mg/l)	**Sty(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	**Xadm**	**X$_{aq}$**	**X$_{aq}$ x 10^5**	Kadm
1	1.29E-04	0.0300	1.72E-04	0.67	6.30	6.02E-05	80.33	0.14	0.32	6.64E-06	0.66	0.48
2	2.25E-04	0.0300	3.01E-04	1.17	9.87	9.45E-05	125.99	0.15	0.30	9.89E-06	0.99	0.30
3	2.74E-04	0.0300	3.65E-04	1.42	16.83	1.61E-04	214.75	0.19	0.37	1.26E-05	1.26	0.30
4	2.07E-04	0.0300	2.76E-04	1.07	16.74	1.60E-04	213.65	0.12	0.44	2.03E-05	2.03	0.22
5	2.07E-04	0.0300	2.76E-04	1.07	26.42	2.53E-04	337.08	0.17	0.55	2.25E-05	2.25	0.24
7	3.15E-04	0.0300	4.20E-04	1.63	40.12	3.84E-04	511.91	0.18	0.55	3.17E-05	3.17	0.17
8	2.55E-04	0.0300	3.40E-04	1.32	40.45	3.87E-04	516.16	0.15	0.60	3.94E-05	3.94	0.15
9	2.17E-04	0.0300	2.90E-04	1.13	49.81	4.77E-04	635.53	0.17	0.69	4.16E-05	4.16	0.17
10	1.88E-04	0.0300	2.51E-04	0.98	52.65	5.04E-04	671.72	0.16	0.73	4.89E-05	4.89	0.15
11	1.88E-04	0.0300	2.51E-04	0.98	60.64	5.80E-04	773.73	0.18	0.76	4.75E-05	4.75	0.16
12	1.88E-04	0.0300	2.51E-04	0.98	76.45	7.32E-04	975.40	0.20	0.80	5.25E-05	5.25	0.15
13	1.88E-04	0.0300	2.51E-04	0.98	81.45	7.79E-04	1039.28	0.18	0.81	6.32E-05	6.32	0.13
14	2.57E-04	0.0300	3.43E-04	1.33	97.86	9.36E-04	1248.61	0.20	0.78	6.81E-05	6.81	0.12

Table A -31 Styrene adsolubilization of C12,13-8PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	**Styrene**	**Solution**	**Surf_in**		**Surf_eq**		**Sty_ini**				**Sty_eq**						
AF48	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	1	2	**av**	ul	mg/l	**Molar**	**uMolar**
1	3	40	12.5891	6.86E-04	8.2764	4.51E-04	3	67.27	6.44E-04	643.74	256.90	257.40	257.15	2.67	59.90	5.23E-04	523.16
1	3	40	12.5891	6.86E-04	8.6764	4.73E-04	3	67.27	6.44E-04	643.74	272.80	265.60	269.20	2.80	62.71	5.48E-04	547.68
2	5	40	12.5891	6.86E-04	8.3764	4.56E-04	5	112.12	1.07E-03	1072.89	428.40	430.40	429.40	4.46	100.03	8.74E-04	873.60
3	7	40	12.5891	6.86E-04	8.5897	4.68E-04	7	156.96	1.50E-03	1502.05	616.50	608.70	612.60	6.36	142.70	1.25E-03	1246.32
4	10	40	12.5891	6.86E-04	8.1274	4.43E-04	10	224.24	2.15E-03	2145.79	886.30	828.60	857.45	8.91	199.74	1.74E-03	1744.46
5	12	40	12.5891	6.86E-04	8.4638	4.61E-04	12	269.08	2.57E-03	2574.95	992.50		992.50	10.31	231.20	2.02E-03	2019.22
6	13	40	12.5891	6.86E-04	8.4985	4.63E-04	13	291.51	2.79E-03	2789.53	1092.70	1034.80	1063.75	11.05	247.80	2.16E-03	2164.17
7	14	40	12.5891	6.86E-04	8.4251	4.59E-04	14	313.93	3.00E-03	3004.11	1120.60		1120.60	11.64	261.04	2.28E-03	2279.83
8	15	40	12.5891	6.86E-04	8.4210	4.59E-04	15	336.35	3.22E-03	3218.68	1181.90		1181.90	12.28	275.32	2.40E-03	2404.54
9	15	40	12.5891	6.86E-04	8.7542	4.77E-04	15	336.35	3.22E-03	3218.68	1219.00		1219.00	12.66	283.96	2.48E-03	2480.02
10	17	40	12.5891	6.86E-04	8.6615	4.72E-04	17	381.20	3.65E-03	3647.84	1328.70		1328.70	13.80	309.52	2.70E-03	2703.21
11	20	40	12.5891	6.86E-04	8.5311	4.65E-04	20	448.47	4.29E-03	4291.58	1432.30		1432.30	14.88	333.65	2.91E-03	2913.98
12	22	40	12.5891	6.86E-04	8.2146	4.48E-04	22	493.32	4.72E-03	4720.74	1571.00		1571.00	16.32	365.96	3.20E-03	3196.16

Table A -31a Styrene adsolubilization of C12,13-8PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample **AF48**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**Sty(in-f)** (mg/l)	**Sty(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	**Xadm**	X_{aq}	X_{aq} **x 10**^{5}	Kadm
1	2.35E-04	0.0299	3.14E-04	1.22	7.37	6.44E-05	86.09	0.10	0.21	9.42E-06	0.94	0.23
1	2.13E-04	0.0299	2.85E-04	1.11	4.56	3.98E-05	53.29	0.06	0.16	9.86E-06	0.99	0.16
2	2.30E-04	0.0302	3.04E-04	1.18	12.09	1.06E-04	139.85	0.10	0.32	1.57E-05	1.57	0.20
3	2.18E-04	0.0305	2.86E-04	1.11	14.26	1.25E-04	163.34	0.08	0.36	2.24E-05	2.24	0.16
4	2.43E-04	0.0310	3.14E-04	1.22	24.49	2.14E-04	276.03	0.10	0.47	3.14E-05	3.14	0.15
5	2.25E-04	0.0298	3.02E-04	1.17	37.88	3.31E-04	444.09	0.13	0.60	3.63E-05	3.63	0.16
6	2.23E-04	0.0299	2.98E-04	1.16	43.71	3.82E-04	510.67	0.14	0.63	3.90E-05	3.90	0.16
7	2.27E-04	0.0305	2.98E-04	1.16	52.89	4.62E-04	605.78	0.15	0.67	4.10E-05	4.10	0.16
8	2.27E-04	0.0304	2.99E-04	1.16	61.03	5.33E-04	701.36	0.17	0.70	4.33E-05	4.33	0.16
9	2.09E-04	0.0293	2.85E-04	1.11	52.39	4.58E-04	624.65	0.14	0.69	4.46E-05	4.46	0.15
10	2.14E-04	0.0302	2.83E-04	1.10	71.68	6.26E-04	829.20	0.17	0.75	4.87E-05	4.87	0.15
11	2.21E-04	0.0307	2.88E-04	1.12	114.82	1.00E-03	1306.57	0.23	0.82	5.25E-05	5.25	0.16
12	2.38E-04	0.0306	3.12E-04	1.21	127.36	1.11E-03	1453.97	0.24	0.82	5.75E-05	5.75	0.14

Table A -32 Styrene adsolubilization of C14,15-3PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

y_53 26909 y_sty 96.264

Sample	Styrene	Solution	Surf_in		Surf_eq		Sty_ini				Sty_eq						
AF53	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	1	2	**av**	ul	mg/l	**Molar**	**uMolar**
1	3	40	16.5122	6.14E-04	8.4479	3.14E-04	3	67.27	6.44E-04	643.74	252.60		252.60	2.62	58.84	5.14E-04	513.89
2	3	40	16.5122	6.14E-04	8.4479	3.14E-04	3	67.27	6.44E-04	643.74	254.70	252.95	253.82	2.64	59.12	5.16E-04	516.37
3	4	40	16.5122	6.14E-04	8.2055	3.05E-04	4	89.69	8.58E-04	858.32	325.60	341.01	333.30	3.46	77.64	6.78E-04	678.07
4	5	40	16.5122	6.14E-04	8.1670	3.04E-04	5	112.12	1.07E-03	1072.89	421.80	431.88	426.84	4.43	99.43	8.68E-04	868.36
5	7	40	16.5122	6.14E-04	8.4553	3.14E-04	7	156.96	1.50E-03	1502.05	592.70		592.70	6.16	138.06	1.21E-03	1205.78
6	8	40	16.5122	6.14E-04	8.4553	3.14E-04	8	179.39	1.72E-03	1716.63	657.60	678.50	668.05	6.94	155.61	1.36E-03	1359.07
7	9	40	16.5122	6.14E-04	8.1543	3.03E-04	9	201.81	1.93E-03	1931.21	752.20	754.95	753.57	7.83	175.54	1.53E-03	1533.06
8	10	40	16.5122	6.14E-04	8.4978	3.16E-04	10	224.24	2.15E-03	2145.79	840.68		840.68	8.73	195.83	1.71E-03	1710.26
9	11	40	16.5122	6.14E-04	8.5546	3.18E-04	11	246.66	2.36E-03	2360.37	900.81		900.81	9.36	209.83	1.83E-03	1832.59
10	12	40	16.5122	6.14E-04	8.7245	3.24E-04	12	269.08	2.57E-03	2574.95	947.78		947.78	9.85	220.77	1.93E-03	1928.15
11	13	40	16.5122	6.14E-04	8.1622	3.03E-04	13	291.51	2.79E-03	2789.53	1013.39	1101.46	1057.42	10.98	246.31	2.15E-03	2151.21
12	14	40	16.5122	6.14E-04	8.1422	3.03E-04	14	313.93	3.00E-03	3004.11	1176.90		1176.90	12.23	274.14	2.39E-03	2394.27
13	15	40	16.5122	6.14E-04	8.5474	3.18E-04	15	336.35	3.22E-03	3218.68	1291.35		1291.35	13.41	300.80	2.63E-03	2627.10
14	15	40	16.5122	6.14E-04	8.3254	3.09E-04	15	336.35	3.22E-03	3218.68	1207.48		1207.48	12.54	281.27	2.46E-03	2456.48

Table A -32a Styrene adsolubilization of C14,15-3PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	**Cs**	**Alumina**	**q**	**[q]**	**Sty(in-f)**	**Sty(in-f)**	**Adsbilized**					
AF53	(M)	(g)	mole/g	molecule/nm^2	(mg/l)	Molar	**umole/g(alumina)**	**Degree of adsl**	**Xadm**	**X_{aq}**	**X_{aq} x 10^5**	**Kadm**
1	3.00E-04	0.0312	3.84E-04	1.49	8.43	7.36E-05	94.40	0.11	0.20	9.25E-06	0.93	0.21
2	3.00E-04	0.0304	3.94E-04	1.53	8.15	7.11E-05	93.61	0.11	0.19	9.30E-06	0.93	0.21
3	3.09E-04	0.0303	4.08E-04	1.58	12.05	1.05E-04	138.99	0.12	0.25	1.22E-05	1.22	0.21
4	3.10E-04	0.0303	4.09E-04	1.59	12.69	1.11E-04	146.32	0.10	0.26	1.56E-05	1.56	0.17
5	2.99E-04	0.0304	3.94E-04	1.53	18.90	1.65E-04	217.22	0.11	0.36	2.17E-05	2.17	0.16
6	2.99E-04	0.0320	3.74E-04	1.45	23.77	2.08E-04	259.54	0.12	0.41	2.45E-05	2.45	0.17
7	3.11E-04	0.0307	4.05E-04	1.57	26.28	2.29E-04	299.00	0.12	0.42	2.76E-05	2.76	0.15
8	2.98E-04	0.0300	3.97E-04	1.54	28.41	2.48E-04	330.83	0.12	0.45	3.08E-05	3.08	0.15
9	2.96E-04	0.0307	3.85E-04	1.50	36.83	3.22E-04	419.06	0.14	0.52	3.30E-05	3.30	0.16
10	2.89E-04	0.0311	3.72E-04	1.45	48.31	4.22E-04	542.65	0.16	0.59	3.47E-05	3.47	0.17
11	3.10E-04	0.0298	4.17E-04	1.62	45.19	3.95E-04	529.79	0.14	0.56	3.87E-05	3.87	0.14
12	3.11E-04	0.0306	4.07E-04	1.58	39.79	3.47E-04	454.21	0.12	0.53	4.31E-05	4.31	0.12
13	2.96E-04	0.0307	3.86E-04	1.50	35.55	3.10E-04	404.53	0.10	0.51	4.73E-05	4.73	0.11
14	3.04E-04	0.0294	4.14E-04	1.61	55.09	4.81E-04	654.55	0.15	0.61	4.42E-05	4.42	0.14

Table A -33 Styrene adsolubilization of C14,15-5PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

y_55 18874 y_sty 96.26

Sample	**Styrene**	**Solution**	**Surf_in**		**Surf_eq**		**Sty_ini**				**Sty_eq**						
AF55	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	1	2	**av**	ul	mg/l	**Molar**	**uMolar**
1	3	40	11.7824	6.24E-04	5.9373	3.15E-04	3	67.27	6.44E-04	643.74	217.81	223.23	220.52	2.29	51.37	4.92E-04	491.57
2	5	40	11.7824	6.24E-04	5.7858	3.07E-04	5	112.12	1.07E-03	1072.89	375.89	388.87	382.38	3.97	89.07	8.52E-04	852.39
3	7	40	11.7824	6.24E-04	5.6398	2.99E-04	7	156.96	1.50E-03	1502.05	537.60	542.98	540.29	5.61	125.86	1.20E-03	1204.39
4	9	40	11.7824	6.24E-04	5.7397	3.04E-04	9	201.81	1.93E-03	1931.21	697.45		697.45	7.25	162.47	1.55E-03	1554.73
5	10	40	11.7824	6.24E-04	5.6398	2.99E-04	10	224.24	2.15E-03	2145.79	781.10	800.10	790.60	8.21	184.17	1.76E-03	1762.37
6	12	40	11.7824	6.24E-04	5.6088	2.97E-04	12	269.08	2.57E-03	2574.95	903.40	914.50	908.95	9.44	211.74	2.03E-03	2026.20
7	13	40	11.7824	6.24E-04	5.5350	2.93E-04	13	291.51	2.79E-03	2789.53	1013.40		1013.40	10.53	236.07	2.26E-03	2259.03
8	14	40	11.7824	6.24E-04	5.8270	3.09E-04	14	313.93	3.00E-03	3004.11	1051.70		1051.70	10.93	244.99	2.34E-03	2344.41
9	15	40	11.7824	6.24E-04	6.1526	3.26E-04	15	336.35	3.22E-03	3218.68	1158.30		1158.30	12.03	269.82	2.58E-03	2582.04
10	17	40	11.7824	6.24E-04	5.9501	3.15E-04	17	381.20	3.65E-03	3647.84	1275.10		1275.10	13.25	297.03	2.84E-03	2842.40
11	20	40	11.7824	6.24E-04	5.8342	3.09E-04	20	448.47	4.29E-03	4291.58	1490.20	1535.20	1512.70	15.71	352.38	3.37E-03	3372.05
12	22	40	11.7824	6.24E-04	5.8036	3.07E-04	22	493.32	4.72E-03	4720.74	1644.70		1644.70	17.09	383.13	3.67E-03	3666.30

Table A -33a Styrene adsolubilization of C14,15-5PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample **AF55**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**Sty(in-f)** (mg/l)	**Sty(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	**Xadm**	**X$_{aq}$**	**X$_{aq}$ x 10^5**	Kadm
1	3.10E-04	0.0304	4.07E-04	1.58	15.90	1.52E-04	200.22	0.24	0.33	8.85E-06	0.88	0.37
2	3.18E-04	0.0295	4.31E-04	1.67	23.04	2.21E-04	298.99	0.21	0.41	1.53E-05	1.53	0.27
3	3.25E-04	0.0310	4.20E-04	1.63	31.11	2.98E-04	384.08	0.20	0.48	2.17E-05	2.17	0.22
4	3.20E-04	0.0298	4.30E-04	1.67	39.34	3.76E-04	505.35	0.19	0.54	2.80E-05	2.80	0.19
5	3.25E-04	0.0304	4.28E-04	1.66	40.07	3.83E-04	504.49	0.18	0.54	3.17E-05	3.17	0.17
6	3.27E-04	0.0304	4.30E-04	1.67	57.34	5.49E-04	722.04	0.21	0.63	3.65E-05	3.65	0.17
7	3.31E-04	0.0303	4.37E-04	1.70	55.44	5.30E-04	700.32	0.19	0.62	4.07E-05	4.07	0.15
8	3.16E-04	0.0309	4.08E-04	1.59	68.94	6.60E-04	853.98	0.22	0.68	4.22E-05	4.22	0.16
9	2.98E-04	0.0307	3.89E-04	1.51	66.53	6.37E-04	829.51	0.20	0.68	4.65E-05	4.65	0.15
10	3.09E-04	0.0306	4.04E-04	1.57	84.17	8.05E-04	1052.86	0.22	0.72	5.12E-05	5.12	0.14
11	3.15E-04	0.0307	4.11E-04	1.60	96.09	9.20E-04	1198.08	0.21	0.74	6.07E-05	6.07	0.12
12	3.17E-04	0.0308	4.11E-04	1.60	110.19	1.05E-03	1369.40	0.22	0.77	6.60E-05	6.60	0.12

Table A -34 Styrene adsolubilization of C14,15-8PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

y_58 = 14504   y_sty 96.264

Sample	Styrene	Solution	Surf_in		Surf_eq		Sty_ini				Sty_eq						
AF58	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	Molar	uMolar	1	2	av	ul	mg/l	Molar	uMolar
1	2	40	8.7013	6.00E-04	5.8296	4.02E-04	2	44.85	4.29E-04	429.16	166.60	164.40	165.50	1.72	38.55	3.69E-04	368.91
2	3	40	8.7013	6.00E-04	5.4320	3.75E-04	3	67.27	6.44E-04	643.74	251.20	246.80	249.00	2.59	58.00	5.55E-04	555.04
3	5	40	8.7013	6.00E-04	4.8303	3.33E-04	4	89.69	8.58E-04	858.32	317.50	312.50	315.00	3.27	73.38	7.02E-04	702.16
3	5	40	8.7013	6.00E-04	4.9303	3.40E-04	5	112.12	1.07E-03	1072.89	387.00	394.00	390.50	4.06	90.96	8.70E-04	870.45
4	6	40	8.7013	6.00E-04	5.6990	3.93E-04	6	134.54	1.29E-03	1287.47	505.70		505.70	5.25	117.80	1.13E-03	1127.24
5	7	40	8.7013	6.00E-04	5.3990	3.72E-04	7	156.96	1.50E-03	1502.05	579.00	550.74	564.87	5.87	131.58	1.26E-03	1259.14
6	9	40	8.7013	6.00E-04	5.2235	3.60E-04	9	201.81	1.93E-03	1931.21	732.40	752.30	742.35	7.71	172.92	1.65E-03	1654.75
7	10	40	8.7013	6.00E-04	5.1374	3.54E-04	10	224.24	2.15E-03	2145.79	790.40	799.70	795.05	8.26	185.20	1.77E-03	1772.22
8	12	40	8.7013	6.00E-04	5.4041	3.73E-04	12	269.08	2.57E-03	2574.95	981.50		981.50	10.20	228.63	2.19E-03	2187.83
9	13	40	8.7013	6.00E-04	5.5512	3.83E-04	13	291.51	2.79E-03	2789.53	1037.60		1037.60	10.78	241.70	2.31E-03	2312.88
10	15	40	8.7013	6.00E-04	5.6707	3.91E-04	15	336.35	3.22E-03	3218.68	1124.10	1211.80	1167.95	12.13	272.06	2.60E-03	2603.44
11	15	40	8.7013	6.00E-04	5.9807	4.12E-04	15	336.35	3.22E-03	3218.68	1155.21	1212.04	1183.63	12.30	275.71	2.64E-03	2638.38
12	17	40	8.7013	6.00E-04	5.7707	3.98E-04	17	381.20	3.65E-03	3647.84	1304.80	1311.80	1308.30	13.59	304.75	2.92E-03	2916.29
13	20	40	8.7013	6.00E-04	5.9432	4.10E-04	20	448.47	4.29E-03	4291.58	1571.80	1579.40	1575.60	16.37	367.02	3.51E-03	3512.12
14	22	40	8.7013	6.00E-04	5.5707	3.84E-04	22	493.32	4.72E-03	4720.74	1713.03	1682.37	1697.70	17.64	395.46	3.78E-03	3784.28

Table A -34a Styrene adsolubilization of C14,15-8PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample **AF58**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**Sty(in-f)** (mg/l)	**Sty(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	**Xadm**	**X_{aq}**	**X_{aq} x 10^5**	Kadm
1	1.98E-04	0.0300	2.64E-04	1.03	6.30	6.02E-05	80.33	0.14	0.23	6.64E-06	0.66	0.35
2	2.25E-04	0.0300	3.01E-04	1.17	9.27	8.87E-05	118.27	0.14	0.28	9.99E-06	1.00	0.28
3	2.67E-04	0.0300	3.56E-04	1.38	16.32	1.56E-04	208.21	0.18	0.37	1.26E-05	1.26	0.29
3	2.60E-04	0.0300	3.47E-04	1.35	21.16	2.02E-04	269.93	0.19	0.44	1.57E-05	1.57	0.28
4	2.07E-04	0.0300	2.76E-04	1.07	16.74	1.60E-04	213.65	0.12	0.44	2.03E-05	2.03	0.22
5	2.28E-04	0.0300	3.04E-04	1.18	25.38	2.43E-04	323.89	0.16	0.52	2.27E-05	2.27	0.23
6	2.40E-04	0.0300	3.20E-04	1.24	28.89	2.76E-04	368.62	0.14	0.54	2.98E-05	2.98	0.18
7	2.46E-04	0.0300	3.28E-04	1.27	39.04	3.74E-04	498.09	0.17	0.60	3.19E-05	3.19	0.19
8	2.27E-04	0.0300	3.03E-04	1.18	40.45	3.87E-04	516.16	0.15	0.63	3.94E-05	3.94	0.16
9	2.17E-04	0.0300	2.90E-04	1.13	49.81	4.77E-04	635.53	0.17	0.69	4.16E-05	4.16	0.17
10	2.09E-04	0.0300	2.79E-04	1.08	64.29	6.15E-04	820.33	0.19	0.75	4.69E-05	4.69	0.16
11	1.88E-04	0.0300	2.50E-04	0.97	60.64	5.80E-04	773.73	0.18	0.76	4.75E-05	4.75	0.16
12	2.02E-04	0.0300	2.69E-04	1.05	76.45	7.32E-04	975.40	0.20	0.78	5.25E-05	5.25	0.15
13	1.90E-04	0.0300	2.54E-04	0.99	81.45	7.79E-04	1039.28	0.18	0.80	6.32E-05	6.32	0.13
14	2.16E-04	0.0300	2.88E-04	1.12	97.86	9.36E-04	1248.61	0.20	0.81	6.81E-05	6.81	0.12

Table A -35 Styrene adsolubilization of SDS/dodecanol 10:1 molar ratio at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 ^{o}C

y_sdd 14626 y_sty 96.26

Sample	**Styrene**	**Solution**	**Surf_in**		**Surf_eq**		**Sty_ini**				**Sty_eq**						
SDS:D	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	Molar	uMolar	1	2	**av**	ul	mg/l	**Molar**	**uMolar**
2a	2	40	43.9011	3.00E-03	39.4125	2.69E-03	2	44.85	4.29E-04	429.16	159.70	151.60	155.65	1.62	36.26	3.47E-04	346.97
2b	2	40	43.9011	3.00E-03	39.5053	2.70E-03	3	67.27	6.44E-04	643.74	227.10	225.80	226.45	2.35	52.75	5.05E-04	504.79
2c	2	40	43.9011	3.00E-03	39.0675	2.67E-03	3	67.27	6.44E-04	643.74	248.80	242.90	245.85	2.55	57.27	5.48E-04	548.04
3	3	40	43.9011	3.00E-03	39.3350	2.69E-03	5	112.12	1.07E-03	1072.89	410.40	394.30	402.35	4.18	93.73	8.97E-04	896.90
4	5	40	43.9011	3.00E-03	39.2435	2.68E-03	7	156.96	1.50E-03	1502.05	552.90	537.70	545.30	5.66	127.03	1.22E-03	1215.56
5	6	40	43.9011	3.00E-03	39.5654	2.71E-03	8	179.39	1.72E-03	1716.63	634.90	655.90	645.40	6.70	150.34	1.44E-03	1438.70
6	7	40	43.9011	3.00E-03	39.6660	2.71E-03	9	201.81	1.93E-03	1931.21	697.00	710.06	703.53	7.31	163.89	1.57E-03	1568.28
9	13	40	43.9011	3.00E-03	38.9296	2.66E-03	12	269.08	2.57E-03	2574.95	902.00	894.10	898.05	9.33	209.20	2.00E-03	2001.90
10a	15	40	43.9011	3.00E-03	38.8585	2.66E-03	14	313.93	3.00E-03	3004.11	1007.10	1007.10	1007.10	10.46	234.60	2.24E-03	2244.99
10b	15	40	43.9011	3.00E-03	39.8585	2.73E-03	15	336.35	3.22E-03	3218.68	1002.50	1017.50	1010.00	10.49	235.28	2.25E-03	2251.45
10c	15	40	43.9011	3.00E-03	40.0748	2.74E-03	16	358.78	3.43E-03	3433.26	1084.80	1025.30	1055.05	10.96	245.77	2.35E-03	2351.88
10d	15	40	43.9011	3.00E-03	39.9978	2.73E-03	17	381.20	3.65E-03	3647.84	1190.10	1122.10	1156.10	12.01	269.31	2.58E-03	2577.13

Table A -35a Styrene adsolubilization of SDS/dodecanol 10:1 molar ratio at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample SDS:D	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**Sty(in-f)** (mg/l)	**Sty(in-f)** Molar	**Adsbilized** umole/g(alumina)	**Degree of adsl**	**Xadm**	**X_{aq}**	**X_{aq} x 10^5**	Kadm
2a	3.07E-04	0.0309	3.97E-04	1.54	8.59	8.22E-05	106.39	0.19	0.21	6.25E-06	0.62	0.34
2b	3.01E-04	0.0306	3.93E-04	1.53	14.52	1.39E-04	181.63	0.22	0.32	9.09E-06	0.91	0.35
2c	3.30E-04	0.0308	4.29E-04	1.67	10.00	9.57E-05	124.28	0.15	0.22	9.87E-06	0.99	0.23
3	3.12E-04	0.0312	4.00E-04	1.56	18.39	1.76E-04	225.63	0.16	0.36	1.61E-05	1.61	0.22
4	3.18E-04	0.0311	4.10E-04	1.59	29.94	2.86E-04	368.48	0.19	0.47	2.19E-05	2.19	0.22
5	2.96E-04	0.0306	3.88E-04	1.51	29.04	2.78E-04	363.31	0.16	0.48	2.59E-05	2.59	0.19
6	2.90E-04	0.0298	3.89E-04	1.51	37.93	3.63E-04	487.15	0.19	0.56	2.82E-05	2.82	0.20
9	3.40E-04	0.0306	4.44E-04	1.73	59.88	5.73E-04	749.09	0.22	0.63	3.60E-05	3.60	0.17
10a	3.45E-04	0.0304	4.54E-04	1.76	79.33	7.59E-04	998.84	0.25	0.69	4.04E-05	4.04	0.17
10b	2.76E-04	0.0304	3.64E-04	1.41	101.08	9.67E-04	1272.67	0.30	0.78	4.05E-05	4.05	0.19
10c	2.62E-04	0.0309	3.39E-04	1.32	113.01	1.08E-03	1399.85	0.31	0.81	4.23E-05	4.23	0.19
10d	2.67E-04	0.0311	3.43E-04	1.33	111.89	1.07E-03	1377.12	0.29	0.80	4.64E-05	4.64	0.17

Table A -36 Styrene adsolubilization of SDS at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 ^{o}C

y_sdd 14626 y_sty 96.26

Sample	**Styrene**	**Solution**	**Surf_in**		**Surf_eq**		**Sty_ini**				**Sty_eq**						
SDS	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	Molar	uMolar	1	2	**av**	ul	mg/l	**Molar**	**uMolar**
1	2	40	43.9011	3.00E-03	39.4125	2.69E-03	3	67.27	6.44E-04	643.74	246.00	242.00	244.00	2.53	56.84	5.44E-04	543.92
2	2	40	43.9011	3.00E-03	39.5053	2.70E-03	3	67.27	6.44E-04	643.74	258.00	241.00	249.50	2.59	58.12	5.56E-04	556.18
3	2	40	43.9011	3.00E-03	39.0675	2.67E-03	5	112.12	1.07E-03	1072.89	384.00		384.00	3.99	89.45	8.56E-04	856.00
4	3	40	43.9011	3.00E-03	39.3350	2.69E-03	7	156.96	1.50E-03	1502.05	561.00		561.00	5.83	130.68	1.25E-03	1250.56
5	5	40	43.9011	3.00E-03	39.2435	2.68E-03	7	156.96	1.50E-03	1502.05	562.20		562.20	5.84	130.96	1.25E-03	1253.23
6	6	40	43.9011	3.00E-03	39.5654	2.71E-03	8	179.39	1.72E-03	1716.63	641.00		641.00	6.66	149.32	1.43E-03	1428.89
7	7	40	43.9011	3.00E-03	39.6660	2.71E-03	10	224.24	2.15E-03	2145.79	786.00		786.00	8.17	183.10	1.75E-03	1752.12
8	13	40	43.9011	3.00E-03	38.9296	2.66E-03	12	269.08	2.57E-03	2574.95	869.00		869.00	9.03	202.43	1.94E-03	1937.14
9	15	40	43.9011	3.00E-03	38.8585	2.66E-03	13	291.51	2.79E-03	2789.53	896.50		896.50	9.31	208.84	2.00E-03	1998.44
10	15	40	43.9011	3.00E-03	39.8585	2.73E-03	14	313.93	3.00E-03	3004.11	1197.60	1017.50	1107.55	11.51	258.00	2.47E-03	2468.91
11	15	40	43.9011	3.00E-03	40.0748	2.74E-03	15	336.35	3.22E-03	3218.68	1084.80	1025.30	1055.05	10.96	245.77	2.35E-03	2351.88
12	15	40	43.9011	3.00E-03	39.9978	2.73E-03	16	358.78	3.43E-03	3433.26	1049.00	1122.10	1085.55	11.28	252.88	2.42E-03	2419.86

Table A -36a Styrene adsolubilization of SDS at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample SDS	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**Sty(in-f)** (mg/l)	**Sty(in-f)** Molar	**Adsbilized umole/g(alumina)**	**Degree of adsl**	**Xadm**	**X_{aq}**	**$X_{aq} \times 10^5$**	Kadm
1	3.07E-04	0.0309	3.97E-04	1.54	10.43	9.98E-05	129.22	0.16	0.25	9.79E-06	0.98	0.25
2	3.01E-04	0.0306	3.93E-04	1.53	9.15	8.76E-05	114.46	0.14	0.23	1.00E-05	1.00	0.23
3	3.30E-04	0.0308	4.29E-04	1.67	22.67	2.17E-04	281.68	0.20	0.40	1.54E-05	1.54	0.26
4	3.12E-04	0.0312	4.00E-04	1.56	26.28	2.51E-04	322.43	0.17	0.45	2.25E-05	2.25	0.20
5	3.18E-04	0.0311	4.10E-04	1.59	26.00	2.49E-04	320.02	0.17	0.44	2.26E-05	2.26	0.19
6	2.96E-04	0.0306	3.88E-04	1.51	30.07	2.88E-04	376.13	0.17	0.49	2.57E-05	2.57	0.19
7	2.90E-04	0.0298	3.89E-04	1.51	41.14	3.94E-04	528.42	0.18	0.58	3.15E-05	3.15	0.18
8	3.40E-04	0.0306	4.44E-04	1.73	66.65	6.38E-04	833.74	0.25	0.65	3.49E-05	3.49	0.19
9	3.45E-04	0.0304	4.54E-04	1.76	82.67	7.91E-04	1040.90	0.28	0.70	3.60E-05	3.60	0.19
10	2.76E-04	0.0304	3.64E-04	1.41	55.93	5.35E-04	704.21	0.18	0.66	4.44E-05	4.44	0.15
11	2.62E-04	0.0309	3.39E-04	1.32	90.58	8.67E-04	1122.08	0.27	0.77	4.23E-05	4.23	0.18
12	2.67E-04	0.0311	3.43E-04	1.33	105.90	1.01E-03	1303.41	0.30	0.79	4.36E-05	4.36	0.18

Table A -37 Phenyl ethanol solubilization of C12,13-3PO-SO4 at 1.0 mM , and temperature 25±2 °C

y = 0.00083x + 0.04575 for ul y_pth_ul 0.00083

AF43: $C_{12,13}$-3PO-SO_4 y = 0.00003x + 0.04575 for mg/l y_pth_mgl 0.00003

Tube	**Conc surf.**			**pth Initial**		**Absorbance**				**pth Final**		
43	Molar (M)	mM	uM	**Amount(ul)**	**Conc(mg/l)**	**1**	**2**	**av**	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	0.10	100	625	15654.38	0.5265	0.5518	0.5392	594.46	14889.39	0.1219	121.87
2	1.0E-04	0.10	100	625	15654.38	0.5203	0.5576	0.5390	594.22	14883.35	0.1218	121.82
3	3.0E-04	0.30	300	625	15654.38	0.5353	0.5324	0.5339	588.07	14729.45	0.1206	120.57
4	3.0E-04	0.30	300	625	15654.38	0.5477	0.5448	0.5463	603.01	15103.64	0.1236	123.63
5	7.0E-04	0.70	700	625	15654.38	0.5484	0.5455	0.5470	603.86	15124.77	0.1238	123.80
6	7.0E-04	0.70	700	625	15654.38	0.5345	0.5417	0.5381	593.19	14857.70	0.1216	121.61
7	9.0E-04	0.90	900	625	15654.38	0.5484	0.5340	0.5412	596.93	14951.25	0.1224	122.38
8	9.0E-04	0.90	900	625	15654.38	0.5345	0.5347	0.5346	588.98	14752.08	0.1208	120.75
9	1.0E-03	1.00	1,000	650	16280.55	0.5369	0.5600	0.5485	605.66	15170.03	0.1242	124.17
10	1.0E-03	1.00	1,000	650	16280.55	0.5374	0.5754	0.5564	615.24	15409.94	0.1261	126.14
11	1.5E-03	1.50	1,500	650	16280.55	0.5673	0.5641	0.5657	626.45	15690.59	0.1284	128.43
12	1.5E-03	1.50	1,500	650	16280.55	0.5672	0.5637	0.5655	626.14	15683.04	0.1284	128.37
13	2.0E-03	2.00	2,000	650	16280.55	0.5761	0.5818	0.5790	642.41	16090.43	0.1317	131.71
14	2.0E-03	2.00	2,000	650	16280.55	0.5784	0.5637	0.5763	639.22	16010.46	0.1311	131.05
15	2.5E-03	2.50	2,500	650	16280.55	0.5872	0.5818	0.5845	649.10	16257.92	0.1331	133.08
16	2.5E-03	2.50	2,500	650	16280.55	0.5763	0.5732	0.5748	637.35	15963.69	0.1307	130.67
17	3.0E-03	3.00	3,000	700	17532.90	0.6107	0.6012	0.6060	674.94	16905.22	0.1384	138.37
18	3.5E-03	3.50	3,500	700	17532.90	0.6239	0.6201	0.6220	694.28	17389.56	0.1423	142.34
19	2.5E-03	2.50	2,500	675	16906.73	0.5910		0.5910	656.93	16454.07	0.1347	134.68
20	4.0E-03	4.00	4,000	725	18159.08	0.6518		0.6518	730.18	18288.84	0.1497	149.70

Table A -38 Summarizes phenyl ethanol solubilization of C12,13-3PO-SO4 at 1.0 mM , and temperature 25±2 °C

tube	Surfactant concentration			Phenylethanol Final (average)							
				Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
43	Molar	mMolar			Stdev		Stdev		Stdev		Stdev
1	1.0E-4	0.10		594.34	0.17	14886.37	4.27	0.1218	0.0000	121.8496	0.0349
2	3.0E-4	0.30		595.54	10.56	14916.54	264.60	0.1221	0.0022	122.0966	2.1658
3	7.0E-4	0.70		598.52	7.54	14991.23	188.85	0.1227	0.0015	122.7080	1.5458
4	9.0E-4	0.90		592.95	5.62	14851.66	140.83	0.1216	0.0012	121.5656	1.1528
5	1.0E-3	1.00		610.45	6.77	15289.99	169.64	0.1252	0.0014	125.1534	1.3886
6	1.5E-3	1.50		626.30	0.21	15686.82	5.33	0.1284	0.0000	128.4015	0.0437
7	2.0E-3	2.00		640.81	2.26	16050.45	56.55	0.1314	0.0005	131.3780	0.4629
8	2.5E-3	2.50		647.79	9.85	16225.23	246.82	0.1328	0.0020	132.8086	2.0203
9	3.0E-3	3.00		674.94		16905.22		0.1384		138.3745	
10	3.5E-3	3.50		694.28		17389.56		0.1423		142.3390	
11	4.0E-3	4.00		730.18		18288.84		0.1497		149.6999	

Table A - 39 Phenyl ethanol solubilization of C12,13-5PO-SO4 at 1.0 mM , and temperature 25±2 °C

y = 0.00083x + 0.04575 for ul y_pth_ul 0.00083

AF45: $C_{12,13}$-5PO-SO_4 y = 0.00003x + 0.04575 for mg/l y_pth_mgl 0.00003

Tube 45	**Conc surf.**			**pth Initial**		**Absorbance**				**pth Final**		
	Molar (M)	mM	uM	**Amount(ul)**	**Conc(mg/l)**	**1**	**2**	**av**	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	0.10	100	625	15654.38	0.5572	0.5412	0.5492	606.57	15192.67	0.1244	124.36
2	1.0E-04	0.10	100	625	15654.38	0.5557	0.5414	0.5486	605.78	15173.05	0.1242	124.20
3	3.0E-04	0.30	300	625	15654.38	0.5669	0.5627	0.5648	625.36	15663.43	0.1282	128.21
4	3.0E-04	0.30	300	625	15654.38	0.5702	0.5745	0.5724	634.46	15891.27	0.1301	130.08
5	7.0E-04	0.70	700	625	15654.38	0.5635	0.5647	0.5641	624.52	15642.30	0.1280	128.04
6	7.0E-04	0.70	700	625	15654.38	0.5670	0.5710	0.5690	630.42	15790.17	0.1292	129.25
7	9.0E-04	0.90	900	625	15654.38	0.5756	0.5758	0.5757	638.49	15992.36	0.1309	130.90
8	9.0E-04	0.90	900	625	15654.38	0.5720	0.5749	0.5735	635.78	15924.46	0.1303	130.35
9	1.0E-03	1.00	1,000	650	16280.55	0.5742	0.5710	0.5726	634.76	15898.81	0.1301	130.14
10	1.0E-03	1.00	1,000	650	16280.55	0.5774	0.5803	0.5789	642.29	16087.42	0.1317	131.68
11	1.5E-03	1.50	1,500	650	16280.55	0.5758	0.5745	0.5752	637.83	15975.76	0.1308	130.77
12	1.5E-03	1.50	1,500	650	16280.55	0.5857	0.5875	0.5866	651.63	16321.29	0.1336	133.59
13	2.0E-03	2.00	2,000	650	16280.55	0.5904	0.5894	0.5899	655.60	16420.87	0.1344	134.41
14	2.0E-03	2.00	2,000	650	16280.55	0.5880	0.5841	0.5861	650.96	16304.69	0.1335	133.46
15	2.5E-03	2.50	2,500	675	16906.73	0.5964	0.5974	0.5969	664.04	16632.11	0.1361	136.14
16	2.5E-03	2.50	2,500	675	16906.73	0.5986	0.5983	0.5985	665.90	16678.89	0.1365	136.52
17	3.0E-03	3.00	3,000	700	17532.90	0.6019	0.6104	0.6062	675.18	16911.25	0.1384	138.42
18	3.5E-03	3.50	3,500	700	17532.90	0.6107	0.6198	0.6153	686.14	17185.86	0.1407	140.67
19	2.5E-03	2.50	2,500	650	16280.55	0.5874	0.5907	0.5891	654.58	16395.22	0.1342	134.20
20	4.0E-03	4.00	4,000	725	18159.08	0.6276	0.6341	0.6309	704.94	17656.63	0.1445	144.53

Table A -40 Summarizes phenyl ethanol solubilization of C12,13-5PO-SO4 at 1.0 mM , and temperature 25±2 °C

tube	Surfactant concentration			Phenylethanol Final (average)							
				Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
45	Molar	mMolar			Stdev		Stdev		Stdev		Stdev
1	1.0E-4	0.10		606.17	0.55	15182.86	13.87	0.1243	0.0001	124.2765	0.1135
2	3.0E-4	0.30		629.91	6.43	15777.35	161.11	0.1291	0.0013	129.1426	1.3187
3	7.0E-4	0.70		627.47	4.17	15716.24	104.56	0.1286	0.0009	128.6424	0.8558
4	9.0E-4	0.90		637.14	1.92	15958.41	48.01	0.1306	0.0004	130.6246	0.3930
5	1.0E-3	1.00		638.52	5.32	15993.11	133.37	0.1309	0.0011	130.9087	1.0916
6	1.5E-3	1.50		644.73	9.75	16148.53	244.33	0.1322	0.0020	132.1808	1.9999
7	2.0E-3	2.00		653.28	3.28	16362.78	82.15	0.1339	0.0007	133.9345	0.6724
8	2.5E-3	2.50		661.51	6.07	16568.74	152.08	0.1356	0.0012	135.6204	1.2448
9	3.0E-3	3.00		675.18		16911.25		0.1384		138.4239	
10	3.5E-3	3.50		0.6239		17185.86		0.1407		140.6717	
11	4.0E-3	4.00		704.94		17656.63		0.1445		144.5251	

Table A -41 Phenyl ethanol solubilization of C12,13-8PO-SO4 at 1.0 mM , and temperature 25±2 °C

y = 0.00083x + 0.04575	for ul	y_pth_ul	0.00083
y = 0.00003x + 0.04575	for mg/l	y_pth_mgl	0.00003

AF48: $C_{12,13}$-8PO-SO_4

Tube	**Conc surf.**			**pth Initial**		**Absorbance**				**pth Final**		
48	Molar (M)	mM	uM	**Amount(ul)**	**Conc(mg/l)**	**1**	**2**	**av**	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	0.10	100	625	15654.38	0.5426	0.5412	0.5419	597.77	14972.37	0.1226	122.55
2	1.0E-04	0.10	100	625	15654.38	0.5326	0.5411	0.5369	591.69	14819.98	0.1213	121.31
3	3.0E-04	0.30	300	625	15654.38	0.5381	0.5485	0.5433	599.46	15014.62	0.1229	122.90
4	3.0E-04	0.30	300	625	15654.38	0.5395	0.5495	0.5445	600.92	15051.29	0.1232	123.20
5	7.0E-04	0.70	700	625	15654.38	0.5408	0.5421	0.5415	597.23	14958.79	0.1224	122.44
6	7.0E-04	0.70	700	625	15654.38	0.5368	0.5458	0.5413	597.05	14954.27	0.1224	122.41
7	9.0E-04	0.90	900	625	15654.38	0.5432	0.5485	0.5459	602.55	15092.18	0.1235	123.53
8	9.0E-04	0.90	900	625	15654.38	0.5501	0.5489	0.5495	606.93	15201.72	0.1244	124.43
9	1.0E-03	1.00	1,000	650	16280.55	0.5463	0.5574	0.5519	609.76	15272.63	0.1250	125.01
10	1.0E-03	1.00	1,000	650	16280.55	0.5508	0.5610	0.5559	614.64	15394.85	0.1260	126.01
11	1.5E-03	1.50	1,500	650	16280.55	0.5511	0.5574	0.5543	612.65	15345.06	0.1256	125.60
12	1.5E-03	1.50	1,500	650	16280.55	0.5600	0.5645	0.5623	622.29	15586.48	0.1276	127.58
13	2.0E-03	2.00	2,000	650	16280.55	0.5677	0.5681	0.5679	629.10	15756.98	0.1290	128.98
14	2.0E-03	2.00	2,000	650	16280.55	0.5689	0.5706	0.5698	631.33	15812.80	0.1294	129.43
15	2.5E-03	2.50	2,500	675	16906.73	0.5725	0.5741	0.5733	635.60	15919.93	0.1303	130.31
16	2.5E-03	2.50	2,500	675	16906.73	0.5699	0.5722	0.5711	632.89	15852.04	0.1298	129.75
17	3.0E-03	3.00	3,000	725	18159.08	0.5769	0.5789	0.5779	641.14	16058.75	0.1314	131.45
18	3.5E-03	3.50	3,500	725	18159.08	0.5930	0.5845	0.5888	654.22	16386.32	0.1341	134.13
19	2.5E-03	2.50	2,500	650	16280.55	0.5699	0.5745	0.5722	634.28	15886.74	0.1300	130.04
20	4.0E-03	4.00	4,000	750	18785.25	0.6047	0.5978	0.6013	669.28	16763.38	0.1372	137.21

Table A -42 Summarizes phenyl ethanol solubilization of C12,13-8PO-SO4 at 1.0 mM , and temperature 25±2 °C

tube 48	Surfactant concentration			Phenylethanol Final (average)							
				Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
	Molar	mMolar			Stdev		Stdev		Stdev		Stdev
1	1.0E-4	0.10		594.73	4.30	14896.18	107.76	0.1219	0.0009	121.9299	0.8820
2	3.0E-4	0.30		600.19	1.04	15032.95	25.93	0.1230	0.0002	123.0495	0.2122
3	7.0E-4	0.70		597.14	0.13	14956.53	3.20	0.1224	0.0000	122.4239	0.0262
4	9.0E-4	0.90		604.74	3.09	15146.95	77.46	0.1240	0.0006	123.9825	0.6340
5	1.0E-3	1.00		612.20	3.45	15333.74	86.42	0.1255	0.0007	125.5115	0.7074
6	1.5E-3	1.50		617.47	6.82	15465.77	170.71	0.1266	0.0014	126.5922	1.3973
7	2.0E-3	2.00		630.21	1.58	15784.89	39.48	0.1292	0.0003	129.2043	0.3231
8	2.5E-3	2.50		634.26	1.36	15886.24	33.95	0.1300	0.0003	130.0339	0.2779
9	3.0E-3	3.00		641.14		16058.75		0.1314		131.4459	
10	3.5E-3	3.50		0.6239		16386.32		0.1341		134.1272	
11	4.0E-3	4.00		669.28		16763.38		0.1372		137.2136	

Table A -43 Phenyl ethanol solubilization of C14,15-3PO-SO4 at 1.0 mM , and temperature 25±2 °C

y = 0.00083x + 0.04575 for ul y_pth_ul 0.00083

AF53: $C_{14,15}$-3PO-SO_4 y = 0.00003x + 0.04575 for mg/l y_pth_mgl 0.00003

Tube 53	**Conc surf.**			**pth Initial**		**Absorbance**				**pth Final**		
	Molar (M)	mM	uM	**Amount(ul)**	**Conc(mg/l)**	**1**	**2**	**av**	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	0.10	100	625	15654.38	0.5359		0.5359	590.54	14791.31	0.1211	121.07
2	1.0E-04	0.10	100	625	15654.38	0.5465		0.5465	603.31	15111.19	0.1237	123.69
3	3.0E-04	0.30	300	625	15654.38	0.5471		0.5471	604.04	15129.29	0.1238	123.84
4	3.0E-04	0.30	300	625	15654.38	0.5397		0.5397	595.12	14905.98	0.1220	122.01
5	7.0E-04	0.70	700	625	15654.38	0.5449		0.5449	601.39	15062.90	0.1233	123.29
6	7.0E-04	0.70	700	625	15654.38	0.5436		0.5436	599.82	15023.67	0.1230	122.97
7	9.0E-04	0.90	900	625	15654.38	0.5514		0.5514	609.22	15259.05	0.1249	124.90
8	9.0E-04	0.90	900	625	15654.38	0.5549		0.5549	613.43	15364.67	0.1258	125.76
9	1.0E-03	1.00	1,000	650	16280.55	0.5601		0.5601	619.70	15521.60	0.1270	127.05
10	1.0E-03	1.00	1,000	650	16280.55	0.5696		0.5696	631.14	15808.28	0.1294	129.40
11	1.5E-03	1.50	1,500	650	16280.55	0.5641		0.5641	624.52	15642.30	0.1280	128.04
12	1.5E-03	1.50	1,500	650	16280.55	0.5812		0.5812	645.12	16158.33	0.1323	132.26
13	2.0E-03	2.00	2,000	650	16280.55	0.5830		0.5830	647.29	16212.65	0.1327	132.71
14	2.0E-03	2.00	2,000	650	16280.55	0.5804		0.5804	644.16	16134.19	0.1321	132.06
15	2.5E-03	2.50	2,500	675	16906.73	0.5919		0.5919	658.01	16481.23	0.1349	134.90
16	2.5E-03	2.50	2,500	675	16906.73	0.5934		0.5934	659.82	16526.49	0.1353	135.27
17	3.0E-03	3.00	3,000	700	17532.90	0.5905		0.5905	656.33	16438.98	0.1346	134.56
18	3.0E-03	3.00	3,000	700	17532.90	0.5995		0.5995	667.17	16710.57	0.1368	136.78
19	2.5E-03	2.50	2,500	650	16280.55	0.5895		0.5895	655.12	16408.80	0.1343	134.31
20	4.0E-03	4.00	4,000	725	18159.08	0.6102		0.6102	680.06	17033.47	0.1394	139.42

Table A -44 Summarizes phenyl ethanol solubilization of C14,15-3PO-SO4 at 1.0 mM , and temperature 25±2 °C

tube	**Surfactant concentration**			**Phenylethanol Final (average)**							
				Amount(ul)		**Conc(mg/l)**		**Conc(M)**		**Conc(mM)**	
53	**Molar**	**mMolar**			**Stdev**		**Stdev**		**Stdev**		**Stdev**
1	1.0E-4	0.10		596.93	9.03	14951.25	226.19	0.1224	0.0019	122.3807	1.8514
2	3.0E-4	0.30		599.58	6.30	15017.64	157.90	0.1229	0.0013	122.9241	1.2925
3	7.0E-4	0.70		600.60	1.11	15043.29	27.74	0.1231	0.0002	123.1341	0.2271
4	9.0E-4	0.90		611.33	2.98	15311.86	74.68	0.1253	0.0006	125.3324	0.6113
5	1.0E-3	1.00		625.42	8.09	15664.94	202.72	0.1282	0.0017	128.2225	1.6593
6	1.5E-3	1.50		634.82	14.57	15900.32	364.89	0.1301	0.0030	130.1491	2.9867
7	2.0E-3	2.00		645.72	2.22	16173.42	55.48	0.1324	0.0005	132.3846	0.4541
8	2.5E-3	2.50		657.65	2.37	16472.17	59.37	0.1348	0.0005	134.8299	0.4859
9	3.0E-3	3.00		661.75	7.67	16574.78	192.05	0.1357	0.0016	135.6698	1.5720
11	4.0E-3	4.00		680.06		17033.47		0.1394		139.4243	

Table A -45 Phenyl ethanol solubilization of C14,15-5PO-SO4 at 1.0 mM , and temperature 25±2 °C

y = 0.00083x + 0.04575 for ul y_pth_ul 0.00083

AF55: $C_{14,15}$-5PO-SO_4 y = 0.00003x + 0.04575 for mg/l y_pth_mgl 0.00003

Tube	Conc surf.			pth Initial		Absorbance				pth Final		
	Molar (M)	mM	uM	Amount(ul)	Conc(mg/l)	1	2	av	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	0.10	100	625	15654.38	0.5495	0.5452	0.5474	604.34	15136.84	0.1239	123.90
2	1.0E-04	0.10	100	625	15654.38	0.5461	0.5482	0.5472	604.10	15130.80	0.1239	123.85
3	3.0E-04	0.30	300	625	15654.38	0.5495	0.5510	0.5503	607.83	15224.35	0.1246	124.62
4	3.0E-04	0.30	300	625	15654.38	0.5481	0.5589	0.5535	611.75	15322.43	0.1254	125.42
5	7.0E-04	0.70	700	625	15654.38	0.5482	0.5603	0.5543	612.65	15345.06	0.1256	125.60
6	7.0E-04	0.70	700	625	15654.38	0.5409	0.5426	0.5418	597.59	14967.85	0.1225	122.52
7	9.0E-04	0.90	900	625	15654.38	0.5484	0.5436	0.5460	602.71	15096.10	0.1236	123.57
8	9.0E-04	0.90	900	625	15654.38	0.5598	0.5549	0.5574	616.39	15438.61	0.1264	126.37
9	1.0E-03	1.00	1,000	650	16280.55	0.5510	0.5519	0.5515	609.28	15260.56	0.1249	124.91
10	1.0E-03	1.00	1,000	650	16280.55	0.5489	0.5549	0.5519	609.82	15274.14	0.1250	125.02
11	1.5E-03	1.50	1,500	650	16280.55	0.5602	0.5659	0.5631	623.25	15610.62	0.1278	127.78
12	1.5E-03	1.50	1,500	650	16280.55	0.5682	0.5681	0.5682	629.40	15764.52	0.1290	129.04
13	2.0E-03	2.00	2,000	650	16280.55	0.5645	0.5761	0.5703	631.99	15829.40	0.1296	129.57
14	2.0E-03	2.00	2,000	650	16280.55	0.5688	0.5712	0.5700	631.63	15820.35	0.1295	129.49
15	2.5E-03	2.50	2,500	675	16906.73	0.5710	0.5738	0.5724	634.52	15892.77	0.1301	130.09
16	2.5E-03	2.50	2,500	675	16906.73	0.5706	0.5769	0.5738	636.14	15933.51	0.1304	130.42
17	3.0E-03	3.00	3,000	700	17532.90	0.5745	0.5880	0.5813	645.18	16159.84	0.1323	132.27
18	3.0E-03	3.00	3,000	700	17532.90	0.5862	0.5925	0.5894	654.94	16404.28	0.1343	134.27
19	2.5E-03	2.50	2,500	650	16280.55	0.5745	0.5817	0.5781	641.39	16064.78	0.1315	131.50
20	4.0E-03	4.00	4,000	725	18159.08	0.6085	0.6006	0.6046	673.25	16862.97	0.1380	138.03

Table A -46 Summarizes phenyl ethanol solubilization of C14,15-5PO-SO4 at 1.0 mM , and temperature 25±2 °C

tube	Surfactant concentration			Phenylethanol Final (average)							
				Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
55	Molar	mMolar			Stdev		Stdev		Stdev		Stdev
1	1.0E-4	0.10		604.22	0.17	15133.82	4.27	0.1239	0.0000	123.8751	0.0349
2	3.0E-4	0.30		609.79	2.77	15273.39	69.35	0.1250	0.0006	125.0175	0.5677
3	7.0E-4	0.70		605.12	10.65	15156.45	266.73	0.1241	0.0022	124.0603	2.1833
4	9.0E-4	0.90		609.55	9.67	15267.35	242.19	0.1250	0.0020	124.9681	1.9824
5	1.0E-3	1.00		609.55	0.38	15267.35	9.60	0.1250	0.0001	124.9681	0.0786
6	1.5E-3	1.50		626.33	4.34	15687.57	108.83	0.1284	0.0009	128.4077	0.8908
7	2.0E-3	2.00		631.81	0.26	15824.88	6.40	0.1295	0.0001	129.5316	0.0524
8	2.5E-3	2.50		637.35	3.59	15963.69	89.89	0.1307	0.0007	130.6678	0.7358
9	3.0E-3	3.00		650.06	6.90	16282.06	172.84	0.1333	0.0014	133.2738	1.4148
11	4.0E-3	4.00		673.25		16862.97		0.1380		138.0287	

Table A -47 Phenyl ethanol solubilization of C14,15-8PO-SO4 at 1.0 mM , and temperature 25±2 °C

AF58: $C_{14,15}$-8PO-SO_4	$y = 0.00083x + 0.04575$	for ul	y_pth_ul 0.00083
	$y = 0.00003x + 0.04575$	for mg/l	y_pth_mgl 0.00003

Tube 58	Conc surf.			pth Initial		Absorbance				pth Final		
	Molar (M)	mM	uM	Amount(ul)	Conc(mg/l)	1	2	av	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	0.10	100	625	15654.38	0.5121	0.5183	0.5152	565.63	14167.25	0.1160	115.96
2	1.0E-04	0.10	100	625	15654.38	0.5214	0.5267	0.5241	576.28	14434.01	0.1181	118.15
3	3.0E-04	0.30	300	625	15654.38	0.5102	0.5104	0.5103	559.71	14019.08	0.1148	114.75
4	3.0E-04	0.30	300	625	15654.38	0.5199	0.5266	0.5232	575.29	14409.27	0.1179	117.94
5	7.0E-04	0.70	700	625	15654.38	0.5125	0.5124	0.5124	562.28	14083.35	0.1153	115.28
6	7.0E-04	0.70	700	625	15654.38	0.5097	0.5191	0.5144	564.66	14143.11	0.1158	115.77
7	9.0E-04	0.90	900	625	15654.38	0.5215	0.5337	0.5276	580.52	14540.39	0.1190	119.02
8	9.0E-04	0.90	900	625	15654.38	0.5332	0.5422	0.5377	592.73	14846.23	0.1215	121.52
9	1.0E-03	1.00	1,000	650	16280.55	0.5549	0.5515	0.5532	611.38	15313.22	0.1253	125.34
10	1.0E-03	1.00	1,000	650	16280.55	0.5384	0.5483	0.5434	599.52	15016.13	0.1229	122.91
11	1.5E-03	1.50	1,500	650	16280.55	0.5425	0.5594	0.5509	608.64	15244.72	0.1248	124.78
12	1.5E-03	1.50	1,500	650	16280.55	0.5412	0.5596	0.5504	608.04	15229.48	0.1247	124.66
13	2.0E-03	2.00	2,000	650	16280.55	0.5533	0.5667	0.5600	619.55	15517.82	0.1270	127.02
14	2.0E-03	2.00	2,000	650	16280.55	0.5655	0.5704	0.5680	629.16	15758.49	0.1290	128.99
15	2.5E-03	2.50	2,500	675	16906.73	0.5712	0.5735	0.5724	634.48	15891.87	0.1301	130.08
16	2.5E-03	2.50	2,500	675	16906.73	0.5640	0.5704	0.5672	628.26	15736.00	0.1288	128.80
17	3.0E-03	3.00	3,000	700	17532.90	0.5650	0.5741	0.5696	631.09	15806.92	0.1294	129.38
18	3.0E-03	3.00	3,000	700	17532.90	0.5716	0.5804	0.5760	638.86	16001.41	0.1310	130.98
19	2.5E-03	2.50	2,500	650	16280.55	0.5648	0.5648	0.5648	625.36	15663.43	0.1282	128.21
20	4.0E-03	4.00	4,000	750	18785.25	0.5801	0.5903	0.5852	649.96	16279.49	0.1333	133.25

Table A -48 Summarizes phenyl ethanol solubilization of C12,13-8PO-SO4 at 1.0 mM , and temperature 25±2 °C

tube	Surfactant concentration			Phenylethanol Final (average)							
				Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
58	Molar	mMolar			Stdev		Stdev		Stdev		Stdev
1	1.0E-4	0.10		570.95	7.53	14300.63	188.63	0.1171	0.0015	117.0552	1.5440
2	3.0E-4	0.30		567.50	11.02	14214.17	275.91	0.1163	0.0023	116.3475	2.2584
3	7.0E-4	0.70		563.47	1.69	14113.23	42.25	0.1155	0.0003	115.5212	0.3458
4	9.0E-4	0.90		586.63	8.63	14693.31	216.27	0.1203	0.0018	120.2694	1.7702
5	1.0E-3	1.00		605.45	8.39	15164.68	210.08	0.1241	0.0017	124.1277	1.7195
6	1.5E-3	1.50		608.34	0.43	15237.10	10.78	0.1247	0.0001	124.7205	0.0882
7	2.0E-3	2.00		624.35	6.79	15638.15	170.17	0.1280	0.0014	128.0032	1.3929
8	2.5E-3	2.50		629.37	4.66	15763.77	116.72	0.1290	0.0010	129.0314	0.9554
9	3.0E-3	3.00		634.97	5.49	15904.17	137.53	0.1302	0.0011	130.1806	1.1257
11	4.0E-3	4.00		649.96		16279.49		0.1333		133.2528	0.0000

Table A -49 Phenyl ethanol solubilization of SDS: dodecanol 10:1 molar ratio at 1.0 mM , and temperature 25±2 °C

y = 0.00083x + 0.04575 for ul y_pth_ul 0.00083

SDS:D y = 0.00003x + 0.04575 for mg/l y_pth_mgl 0.00003

Tube SDS:D	Conc surf.			pth Initial		Absorbance				pth Final		
	Molar (M)	mM	uM	Amount(ul)	Conc(mg/l)	1	2	av	Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-03	1.00	1,000	625	15654.38	0.5924	0.5914	0.5919	658.01	16481.23	0.1349	134.90
2	1.0E-03	1.00	1,000	625	15654.38	0.5922	0.5932	0.5927	658.98	16505.37	0.1351	135.10
3	3.0E-03	3.00	3,000	625	15654.38	0.5901	0.5921	0.5911	657.05	16457.09	0.1347	134.71
4	3.0E-03	3.00	3,000	625	15654.38	0.5912	0.5894	0.5903	656.08	16432.94	0.1345	134.51
5	7.0E-03	7.00	7,000	625	15654.38	0.5927	0.5897	0.5912	657.17	16460.10	0.1347	134.73
6	7.0E-03	7.00	7,000	625	15654.38	0.5914	0.5901	0.5908	656.63	16446.52	0.1346	134.62
7	9.0E-03	9.00	9,000	625	15654.38	0.5926	0.5974	0.5950	661.75	16574.78	0.1357	135.67
8	9.0E-03	9.00	9,000	625	15654.38	0.5936	0.5940	0.5938	660.30	16538.56	0.1354	135.37
9	1.0E-02	10.00	10,000	650	16280.55	0.5942	0.5937	0.5940	660.48	16543.09	0.1354	135.41
10	1.0E-02	10.00	10,000	650	16280.55	0.5948	0.5941	0.5945	661.08	16558.18	0.1355	135.53
11	1.5E-02	15.00	15,000	650	16280.55	0.5974	0.5954	0.5964	663.43	16617.02	0.1360	136.02
12	1.5E-03	1.50	1,500	650	16280.55	0.5932	0.5944	0.5938	660.30	16538.56	0.1354	135.37
13	2.0E-02	20.00	20,000	650	16280.55	0.5973	0.5981	0.5977	665.00	16656.26	0.1363	136.34
14	2.0E-02	20.00	20,000	650	16280.55	0.6497	0.6012	0.6255	698.43	17493.67	0.1432	143.19
15	2.5E-02	25.00	25,000	650	16280.55	0.6017	0.6174	0.6096	679.28	17013.85	0.1393	139.26
16	2.5E-02	25.00	25,000	650	16280.55	0.6287	0.6358	0.6323	706.63	17698.87	0.1449	144.87
17	3.0E-02	30.00	30,000	700	17532.90	0.6422	0.6245	0.6334	707.95	17732.07	0.1451	145.14
18	3.5E-02	35.00	35,000	700	17532.90	0.6654	0.6784	0.6719	754.40	18895.40	0.1547	154.66
19	4.0E-02	40.00	40,000	675	16906.73	0.7235	0.7054	0.7145	805.66	20179.43	0.1652	165.18
20	4.5E-02	45.00	45,000	725	18159.08	0.7424	0.7347	0.7386	834.70	20906.70	0.1711	171.13

Table A -50 Summarizes phenyl ethanol solubilization of SDS/dodecanol, 10:1 molar ratio at 1.0 mM , and temperature 25±2 °C

tube	Surfactant concentration			**Phenylethanol Final (average)**							
				Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
SDS:D	Molar	mMolar			Stdev		Stdev		Stdev		Stdev
1	1.0E-3	1.00		658.49	0.68	16493.30	17.07	0.1350	0.0001	135.0029	0.1397
2	3.0E-3	3.00		656.57	0.68	16445.02	17.07	0.1346	0.0001	134.6076	0.1397
3	7.0E-3	7.00		656.90	0.38	16453.31	9.60	0.1347	0.0001	134.6756	0.0786
4	9.0E-3	9.00		661.02	1.02	16556.67	25.61	0.1355	0.0002	135.5216	0.2096
5	1.0E-2	10.00		660.78	0.43	16550.64	10.67	0.1355	0.0001	135.4722	0.0873
6	1.5E-2	15.00		661.87	2.22	16577.79	55.48	0.1357	0.0005	135.6945	0.4541
7	2.0E-2	20.00		681.72	23.64	17074.96	592.14	0.1398	0.0048	139.7640	4.8469
8	2.5E-2	25.00		730.52	19.34	18297.39	1665.50	0.1498	0.0136	149.7699	13.6326

Table A -51 Summarizes phenyl ethanol solubilization of SDS at 1.0 mM , and temperature 25±2 °C

y = 0.00083x + 0.04575 for ul y_pth_ul 0.00083

SDS y = 0.00003x + 0.04575 for mg/l y_pth_mgl 0.00003

Tube SDS	**Conc surf.**			**pth Initial**		**Absorbance**				**pth Final**		
	Molar (M)	**mM**	**uM**	**Amount(ul)**	**Conc(mg/l)**	**1**	**2**	**av**	**Amount(ul)**	**Conc(mg/l)**	**Conc(M)**	**Conc(mM)**
1	1.0E-03	1.00	1,000	625	15654.38	0.5744	0.5745	0.5745	636.99	15954.64	0.1306	130.59
2	1.0E-03	1.00	1,000	625	15654.38	0.5723	0.5714	0.5719	633.86	15876.18	0.1300	129.95
3	3.0E-03	3.00	3,000	625	15654.38	0.5822	0.5830	0.5826	646.81	16200.58	0.1326	132.61
4	3.0E-03	3.00	3,000	625	15654.38	0.5845	0.5824	0.5835	647.83	16226.23	0.1328	132.82
5	7.0E-03	7.00	7,000	625	15654.38	0.5835	0.5842	0.5839	648.31	16238.30	0.1329	132.92
6	7.0E-03	7.00	7,000	625	15654.38	0.5821	0.5947	0.5884	653.80	16375.61	0.1340	134.04
7	9.0E-03	9.00	9,000	625	15654.38	0.5832	0.5811	0.5822	646.27	16187.00	0.1325	132.50
8	9.0E-03	9.00	9,000	625	15654.38	0.5872	0.5818	0.5845	649.10	16257.92	0.1331	133.08
9	1.0E-02	10.00	10,000	650	16280.55	0.5845	0.5819	0.5832	647.53	16218.69	0.1328	132.76
10	1.0E-02	10.00	10,000	650	16280.55	0.5936	0.5826	0.5881	653.43	16366.55	0.1340	133.97
11	1.5E-02	15.00	15,000	650	16280.55	0.5848	0.5855	0.5852	649.88	16277.53	0.1332	133.24
12	1.5E-02	15.00	15,000	650	16280.55	0.5961	0.5823	0.5892	654.76	16399.75	0.1342	134.24
13	2.0E-02	20.00	20,000	650	16280.55	0.5862	0.5955	0.5909	656.75	16449.54	0.1346	134.64
14	2.0E-02	20.00	20,000	650	16280.55	0.5917	0.5903	0.5910	656.93	16454.07	0.1347	134.68
15	2.5E-02	25.00	25,000	650	16280.55	0.6016	0.6123	0.6070	676.14	16935.39	0.1386	138.62
16	2.5E-02	25.00	25,000	650	16280.55	0.6212	0.6475	0.6344	709.16	17762.25	0.1454	145.39
17	3.0E-02	30.00	30,000	700	17532.90	0.6414	0.6513	0.6464	723.61	18124.37	0.1484	148.35
18	3.5E-02	35.00	35,000	700	17532.90	0.6612	0.6745	0.6679	749.54	18773.63	0.1537	153.67
19	4.0E-02	40.00	40,000	675	16906.73	0.6899	0.6925	0.6912	777.65	19477.81	0.1594	159.43
20	4.5E-02	45.00	45,000	725	18159.08	0.7118	0.7112	0.7115	802.11	20090.41	0.1644	164.45

Table A -52 Summarizes phenyl ethanol solubilization of SDS at 1.0 mM , and temperature 25±2 °C

				Phenylethanol Final (average)							
tube	Surfactant concentration			Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
SDS	Molar	mMolar			Stdev		Stdev		Stdev		Stdev
1	1.0E-3	1.00		635.42	2.22	15915.41	55.48	0.1303	0.0005	130.2726	0.4541
2	3.0E-3	3.00		647.32	0.72	16213.41	18.14	0.1327	0.0001	132.7118	0.1485
3	7.0E-3	7.00		651.05	3.88	16306.95	97.09	0.1335	0.0008	133.4776	0.7947
4	9.0E-3	9.00		647.68	2.00	16222.46	50.15	0.1328	0.0004	132.7859	0.4105
5	1.0E-2	10.00		650.48	4.17	16292.62	104.56	0.1334	0.0009	133.3602	0.8558
6	1.5E-2	15.00		652.32	3.45	16338.64	86.42	0.1337	0.0007	133.7369	0.7074
7	2.0E-2	20.00		656.84	0.13	16451.81	3.20	0.1347	0.0000	134.6632	0.0262
8	2.5E-2	25.00		720.98	23.34	18058.48	1296.84	0.1478	0.0106	147.8144	10.6150

Table A -53 Summarizes molar solubilization ratio (MSR) and K_{mic} of phenyl ethanol

Phenylethanol MSR=Slope $K_{mic}=X_{mic}/X_{aq}$

Surfactant	**MSR**	**r^2**	**X_{mic}**	K_{mic}	$logK_{mic}$
C12,13-3PO-SO4	7.45	0.95	0.88	3072.12	3.49
C12,13-5PO-SO4	4.45	0.95	0.82	2845.11	3.45
C12,13-8PO-SO4	3.74	0.95	0.79	2749.85	3.44
C14,15-3PO-SO4	4.78	0.95	0.83	2881.81	3.46
C14,15-5PO-SO4	4.09	0.98	0.80	2799.93	3.45
C14,15-8PO-SO4	3.13	0.96	0.76	2641.07	3.42
SDS	1.08	0.96	0.52	1809.17	3.26
SDS:D	1.25	0.96	0.56	1935.05	3.29

Table A -54 Phenylethanol adsolubilization of C12,13-3PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	**Phe**	**Solution**	**Surf_in**		**Surf_eq**		**Phe_ini**				**Phe_eq**						
AF43	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	100	40	17.4717	6.42E-04	12.1000	4.45E-04	100	2479.40	2.03E-02	20296.33	0.2556		0.26	97.01	2405.32	1.97E-02	19689.91
2	110	40	18.4717	6.79E-04	12.1500	4.47E-04	110	2727.34	2.23E-02	22325.97	0.2754		0.28	105.62	2618.67	2.14E-02	21436.40
3	120	40	19.4717	7.16E-04	12.4650	4.58E-04	120	2975.28	2.44E-02	24355.60	0.2954		0.30	114.31	2834.18	2.32E-02	23200.53
4	125	40	20.4717	7.52E-04	12.8065	4.71E-04	125	3099.25	2.54E-02	25370.42	0.3052		0.31	118.57	2939.78	2.41E-02	24064.96
5	130	40	21.4717	7.89E-04	12.2540	4.50E-04	130	3223.22	2.64E-02	26385.23	0.3102		0.31	120.74	2993.65	2.45E-02	24505.99
6	140	40	22.4717	8.26E-04	11.9852	4.40E-04	140	3471.16	2.84E-02	28414.87	0.3303		0.33	129.48	3210.24	2.63E-02	26278.94
7	150	40	23.4717	8.63E-04	12.4334	4.57E-04	150	3719.10	3.04E-02	30444.50	0.3483		0.35	137.30	3404.19	2.79E-02	27866.66
8	175	40	24.4717	8.99E-04	11.7704	4.33E-04	175	4338.95	3.55E-02	35518.58	0.3743		0.37	148.60	3684.35	3.02E-02	30160.03
9	180	40	25.4717	9.36E-04	11.6585	4.28E-04	180	4462.92	3.65E-02	36533.40	0.3854		0.39	153.42	3803.96	3.11E-02	31139.13
10	200	40	26.4717	9.73E-04	12.3373	4.53E-04	200	4958.80	4.06E-02	40592.67	0.4095		0.41	163.90	4063.64	3.33E-02	33264.90
11	210	40	27.4717	1.01E-03	12.2585	4.51E-04	210	5206.74	4.26E-02	42622.30	0.4302		0.43	172.89	4286.69	3.51E-02	35090.78
12	225	40	28.4717	1.05E-03	12.3940	4.56E-04	225	5578.65	4.57E-02	45666.75	0.4522		0.45	182.45	4523.75	3.70E-02	37031.32
13	240	40	29.4717	1.08E-03	12.0125	4.41E-04	240	5950.56	4.87E-02	48711.20	0.4652		0.47	188.10	4663.83	3.82E-02	38178.01
14	250	40	30.4717	1.12E-03	12.0950	4.45E-04	250	6198.50	5.07E-02	50740.83	0.4988		0.50	202.71	5025.88	4.11E-02	41141.75
15	260	40	31.4717	1.16E-03	12.9850	4.77E-04	260	6446.44	5.28E-02	52770.46	0.5022		0.50	204.18	5062.51	4.14E-02	41441.65
16	275	40	17.4717	6.42E-04	12.3917	4.55E-04	275	6818.35	5.58E-02	55814.91	0.5373		0.54	219.44	5440.73	4.45E-02	44537.70
17	300	40	17.4717	6.42E-04	12.0980	4.45E-04	300	7438.20	6.09E-02	60889.00	0.5843	0.5759	0.58	238.04	5901.91	4.83E-02	48312.95
18	325	40	17.4717	6.42E-04	12.3917	4.55E-04	325	8058.05	6.60E-02	65963.08	0.6235		0.62	256.90	6369.56	5.21E-02	52141.11
19	350	40	17.4717	6.42E-04	12.7567	4.69E-04	350	8677.90	7.10E-02	71037.16	0.6785	0.6655	0.67	277.98	6892.16	5.64E-02	56419.13
20	375	40	17.4717	6.42E-04	12.7306	4.68E-04	375	9297.75	7.61E-02	76111.25	0.7163	0.6911	0.70	291.97	7239.13	5.93E-02	59259.38
21	400	40	17.4717	6.42E-04	14.4309	5.30E-04	400	9917.60	8.12E-02	81185.33	0.7423		0.74	308.53	7649.67	6.26E-02	62620.05
22	425	40	17.4717	6.42E-04	14.0453	5.16E-04	425	10537.45	8.63E-02	86259.41	0.7812		0.78	325.43	8068.83	6.61E-02	66051.29
23	450	40	17.4717	6.42E-04	13.8039	5.07E-04	450	11157.30	9.13E-02	91333.50	0.8144		0.81	339.86	8426.57	6.90E-02	68979.75
24	500	40	17.4717	6.42E-04	14.3930	5.29E-04	500	12397.00	1.01E-01	101481.66	0.8475	0.8371	0.84	351.99	8727.20	7.14E-02	71440.71

Table A -54a Phenylethanol adsolubilization of C12,13-3PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 ^{o}C

Sample **AF43**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**pH** final	**Phe(in-f)** (mg/l)	**Phel(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	**Xadm**	**X_{aq}**	**X_{aq} x 10^5**	**Kadm**
1	1.97E-04	0.0312	2.53E-04	0.98	7.14	74.08	6.60E-04	846.78	0.03	0.77	3.54E-04	35.43	0.0217
2	2.32E-04	0.0312	2.98E-04	1.16	8.14	108.67	9.69E-04	1242.15	0.04	0.81	3.86E-04	38.57	0.0209
3	2.58E-04	0.0312	3.30E-04	1.28	9.14	141.10	1.26E-03	1612.88	0.05	0.83	4.17E-04	41.75	0.0199
4	2.82E-04	0.0312	3.61E-04	1.40	10.14	159.47	1.42E-03	1822.88	0.06	0.83	4.33E-04	43.30	0.0193
5	3.39E-04	0.0312	4.34E-04	1.69	11.14	229.57	2.05E-03	2624.09	0.08	0.86	4.41E-04	44.10	0.0195
6	3.85E-04	0.0312	4.94E-04	1.92	12.14	260.92	2.33E-03	2982.51	0.08	0.86	4.73E-04	47.28	0.0181
7	4.06E-04	0.0312	5.20E-04	2.02	13.14	314.91	2.81E-03	3599.58	0.09	0.87	5.01E-04	50.14	0.0174
8	4.67E-04	0.0312	5.98E-04	2.33	14.14	654.60	5.84E-03	7482.45	0.16	0.93	5.43E-04	54.26	0.0171
9	5.08E-04	0.0312	6.51E-04	2.53	15.14	658.96	5.88E-03	7532.33	0.16	0.92	5.60E-04	56.02	0.0164
10	5.19E-04	0.0312	6.66E-04	2.59	16.14	895.16	7.98E-03	10232.17	0.20	0.94	5.98E-04	59.85	0.0157
11	5.59E-04	0.0312	7.17E-04	2.79	17.14	920.05	8.20E-03	10516.69	0.19	0.94	6.31E-04	63.13	0.0148
12	5.91E-04	0.0312	7.58E-04	2.94	18.14	1054.90	9.41E-03	12058.13	0.21	0.94	6.66E-04	66.62	0.0141
13	6.42E-04	0.0312	8.23E-04	3.20	19.14	1286.73	1.15E-02	14708.09	0.24	0.95	6.87E-04	68.68	0.0138
14	6.75E-04	0.0312	8.66E-04	3.36	20.14	1172.62	1.05E-02	13403.74	0.21	0.94	7.40E-04	74.01	0.0127
15	6.79E-04	0.0312	8.71E-04	3.38	21.14	1383.93	1.23E-02	15819.06	0.23	0.95	7.45E-04	74.55	0.0127
16	1.87E-04	0.0312	2.39E-04	0.93	6.98	1377.62	1.23E-02	15747.01	0.22	0.99	8.01E-04	80.11	0.0123
17	1.97E-04	0.0318	2.48E-04	0.97	6.95	1536.29	1.37E-02	17229.32	0.22	0.99	8.69E-04	86.90	0.0113
18	1.87E-04	0.0307	2.43E-04	0.95	7.32	1688.49	1.51E-02	19614.74	0.23	0.99	9.38E-04	93.78	0.0105
19	1.73E-04	0.0330	2.10E-04	0.82	6.98	1785.74	1.59E-02	19298.61	0.22	0.99	1.01E-03	101.46	0.0097
20	1.74E-04	0.0314	2.22E-04	0.86	7.13	2058.62	1.84E-02	23381.34	0.24	0.99	1.07E-03	106.56	0.0093
21	1.12E-04	0.0314	1.42E-04	0.55	7.36	2267.93	2.02E-02	25758.63	0.25	0.99	1.13E-03	112.60	0.0088
22	1.26E-04	0.0314	1.60E-04	0.62	7.36	2468.62	2.20E-02	28038.02	0.26	0.99	1.19E-03	118.76	0.0084
23	1.35E-04	0.0310	1.74E-04	0.68	7.18	2730.73	2.43E-02	31415.19	0.27	0.99	1.24E-03	124.02	0.0080
24	1.13E-04	0.0305	1.48E-04	0.58	6.98	3669.80	3.27E-02	42910.63	0.32	1.00	1.28E-03	128.44	0.0078

Table A -55 Phenylethanol adsolubilization of C12,13-5PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	**Phe**	**Solution**	**Surf_in**		**Surf_eq**		**Phe_ini**				**Phe_eq**						
AF45	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	100	40	15.584	6.99E-04	10.2641	4.60E-04	100	2479.40	2.03E-02	20296.33	0.2320		0.23	96.67	2396.75	1.96E-02	19619.79
2	110	40	15.584	6.99E-04	10.4732	4.70E-04	110	2727.34	2.23E-02	22325.97	0.2561		0.26	106.71	2645.73	2.17E-02	21657.88
3	120	40	15.584	6.99E-04	9.9263	4.45E-04	120	2975.28	2.44E-02	24355.60	0.2778		0.28	115.75	2869.91	2.35E-02	23493.01
4	125	40	15.584	6.99E-04	10.1597	4.56E-04	125	3099.25	2.54E-02	25370.42	0.2907		0.29	121.13	3003.17	2.46E-02	24583.93
5	130	40	15.584	6.99E-04	10.2196	4.58E-04	130	3223.22	2.64E-02	26385.23	0.3004		0.30	125.15	3102.97	2.54E-02	25400.86
6	140	40	15.584	6.99E-04	10.3365	4.64E-04	140	3471.16	2.84E-02	28414.87	0.3198		0.32	133.25	3303.80	2.70E-02	27044.86
7	150	40	15.584	6.99E-04	9.2534	4.15E-04	150	3719.10	3.04E-02	30444.50	0.3369		0.34	140.38	3480.46	2.85E-02	28490.98
8	170	40	15.584	6.99E-04	9.4584	4.24E-04	170	4214.98	3.45E-02	34503.77	0.3695		0.37	153.96	3817.24	3.12E-02	31247.90
9	180	40	15.584	6.99E-04	10.2167	4.58E-04	180	4462.92	3.65E-02	36533.40	0.3928		0.39	163.67	4057.95	3.32E-02	33218.33
10	200	40	15.584	6.99E-04	9.6299	4.32E-04	200	4958.80	4.06E-02	40592.67	0.4317		0.43	179.88	4459.82	3.65E-02	36508.03
11	210	40	15.584	6.99E-04	10.2232	4.59E-04	210	5206.74	4.26E-02	42622.30	0.4401		0.44	183.38	4546.60	3.72E-02	37218.40
12	225	40	15.584	6.99E-04	10.2120	4.58E-04	225	5578.65	4.57E-02	45666.75	0.4798		0.48	199.92	4956.73	4.06E-02	40575.75
13	240	40	15.584	6.99E-04	10.2641	4.60E-04	240	5950.56	4.87E-02	48711.20	0.5069		0.51	211.21	5236.70	4.29E-02	42867.55
14	250	40	15.584	6.99E-04	10.4732	4.70E-04	250	6198.50	5.07E-02	50740.83	0.5410		0.54	225.42	5588.98	4.58E-02	45751.32
15	260	40	15.584	6.99E-04	9.9263	4.45E-04	260	6446.44	5.28E-02	52770.46	0.5575		0.56	232.29	5759.44	4.71E-02	47146.69
16	250	40	15.584	6.99E-04	10.2641	4.60E-04	250	6198.50	5.07E-02	50740.83	0.5410		0.54	225.42	5588.98	4.58E-02	45751.32
17	275	40	15.584	6.99E-04	10.2641	4.60E-04	275	6818.35	5.58E-02	55814.91	0.5798		0.58	241.58	5989.82	4.90E-02	49032.56
18	280	40	15.584	6.99E-04	10.2641	4.60E-04	280	6942.32	5.68E-02	56829.73	0.6099		0.61	254.13	6300.78	5.16E-02	51578.06
19	300	40	15.584	6.99E-04	10.2196	4.58E-04	300	7438.20	6.09E-02	60889.00	0.6330		0.63	263.75	6539.42	5.35E-02	53531.58
20	300	40	15.584	6.99E-04	10.2641	4.60E-04	300	7438.20	6.09E-02	60889.00	0.6330		0.63	263.75	6539.42	5.35E-02	53531.58
21	325	40	15.584	6.99E-04	10.2641	4.60E-04	325	8058.05	6.60E-02	65963.08	0.6616		0.66	275.67	6834.88	5.60E-02	55950.22

Table A -55a Phenylethanol adsolubilization of C12,13-5PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample **AF45**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**pH** final	**Phe(in-f)** (mg/l)	**Phe(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	**Xadm**	**X_{aq}**	**X_{aq} x 10^5**	**Kadm**
1	2.39E-04	0.0315	3.03E-04	1.18	7.05	82.65	7.37E-04	935.70	0.04	0.76	3.53E-04	35.31	0.0214
2	2.29E-04	0.0305	3.01E-04	1.17	8.05	81.61	7.28E-04	954.30	0.03	0.76	3.90E-04	38.97	0.0195
3	2.54E-04	0.0310	3.27E-04	1.27	9.05	105.37	9.40E-04	1212.26	0.04	0.79	4.23E-04	42.27	0.0186
4	2.43E-04	0.0305	3.19E-04	1.24	10.05	96.08	8.57E-04	1123.42	0.03	0.78	4.42E-04	44.24	0.0176
5	2.41E-04	0.0295	3.26E-04	1.27	11.05	120.25	1.07E-03	1453.75	0.04	0.82	4.57E-04	45.71	0.0179
6	2.35E-04	0.0318	2.96E-04	1.15	12.05	167.36	1.49E-03	1876.92	0.05	0.86	4.87E-04	48.66	0.0178
7	2.84E-04	0.0355	3.20E-04	1.24	13.05	238.64	2.13E-03	2397.40	0.07	0.88	5.13E-04	51.26	0.0172
8	2.75E-04	0.0312	3.52E-04	1.37	14.05	397.74	3.55E-03	4546.36	0.10	0.93	5.62E-04	56.22	0.0165
9	2.41E-04	0.0309	3.12E-04	1.21	15.05	404.97	3.61E-03	4673.96	0.10	0.94	5.98E-04	59.76	0.0157
10	2.67E-04	0.0303	3.53E-04	1.37	16.05	498.98	4.45E-03	5873.02	0.11	0.94	6.57E-04	65.68	0.0144
11	2.40E-04	0.0295	3.26E-04	1.27	17.05	660.14	5.89E-03	7980.61	0.14	0.96	6.70E-04	66.95	0.0143
12	2.41E-04	0.0321	3.00E-04	1.17	18.05	621.92	5.54E-03	6909.53	0.12	0.96	7.30E-04	72.99	0.0131
13	2.39E-04	0.0309	3.09E-04	1.20	19.05	713.86	6.36E-03	8239.05	0.13	0.96	7.71E-04	77.11	0.0125
14	2.29E-04	0.0297	3.09E-04	1.20	20.05	609.52	5.43E-03	7319.02	0.11	0.96	8.23E-04	82.29	0.0117
15	2.54E-04	0.0321	3.16E-04	1.23	21.05	687.00	6.13E-03	7632.63	0.12	0.96	8.48E-04	84.80	0.0113
16	2.39E-04	0.0309	3.09E-04	1.20	22.05	609.52	5.43E-03	7034.79	0.11	0.96	8.23E-04	82.29	0.0116
17	2.39E-04	0.0303	3.15E-04	1.22	23.05	828.53	7.39E-03	9751.90	0.13	0.97	8.82E-04	88.19	0.0110
18	2.39E-04	0.0298	3.20E-04	1.24	24.05	641.54	5.72E-03	7677.73	0.10	0.96	9.28E-04	92.76	0.0103
19	2.41E-04	0.0321	3.00E-04	1.17	25.05	898.78	8.01E-03	9985.54	0.13	0.97	9.63E-04	96.27	0.0101
20	2.39E-04	0.0309	3.09E-04	1.20	26.05	898.78	8.01E-03	10373.33	0.13	0.97	9.63E-04	96.27	0.0101
21	2.39E-04	0.0297	3.21E-04	1.25	27.05	1223.17	1.09E-02	14687.66	0.17	0.98	1.01E-03	100.62	0.0097

Table A -56 Phenylethanol adsolubilization of C12,13-8PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	Phe	Solution	Surf_in		Surf_eq		Phe_ini				Phe_eq						
AF48	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	Molar	uMolar	1	2	av	ul	mg/l	Molar	uMolar
1	100	40	12.1515	7.67E-04	8.4309	5.32E-04	100	2479.40	2.03E-02	20296.33	0.2385		0.24	92.80	2300.92	1.88E-02	18835.31
2	110	40	12.1515	7.67E-04	8.2254	5.19E-04	110	2727.34	2.23E-02	22325.97	0.2624		0.26	102.10	2531.50	2.07E-02	20722.79
3	120	40	12.1515	7.67E-04	8.7545	5.53E-04	120	2975.28	2.44E-02	24355.60	0.2868		0.29	111.60	2766.89	2.26E-02	22649.76
4	125	40	12.1515	7.67E-04	8.4309	5.32E-04	125	3099.25	2.54E-02	25370.42	0.2965	0.30	0.30	116.25	2882.18	2.36E-02	23593.50
5	130	40	12.1515	7.67E-04	8.4573	5.34E-04	130	3223.22	2.64E-02	26385.23	0.3105		0.31	120.82	2995.54	2.45E-02	24521.44
6	140	40	12.1515	7.67E-04	8.3253	5.26E-04	140	3471.16	2.84E-02	28414.87	0.3294		0.33	128.17	3177.88	2.60E-02	26014.05
7	150	40	12.1515	7.67E-04	8.3372	5.26E-04	150	3719.10	3.04E-02	30444.50	0.3590	0.34	0.35	136.01	3372.27	2.76E-02	27605.38
8	170	40	12.1515	7.67E-04	8.1021	5.11E-04	170	4214.98	3.45E-02	34503.77	0.3894		0.39	151.52	3756.73	3.08E-02	30752.50
9	175	40	12.1515	7.67E-04	8.3372	5.26E-04	175	4338.95	3.55E-02	35518.58	0.3990		0.40	155.25	3849.34	3.15E-02	31510.65
10	180	40	12.1515	7.67E-04	8.0214	5.06E-04	180	4462.92	3.65E-02	36533.40	0.4111		0.41	159.96	3966.08	3.25E-02	32466.23
11	200	40	12.1515	7.67E-04	8.3498	5.27E-04	200	4958.80	4.06E-02	40592.67	0.4463	0.44	0.45	173.17	4293.61	3.51E-02	35147.40
12	210	40	12.1515	7.67E-04	8.0998	5.11E-04	210	5206.74	4.26E-02	42622.30	0.4754		0.48	184.98	4586.41	3.75E-02	37544.27
13	225	40	12.1515	7.67E-04	8.3498	5.27E-04	225	5578.65	4.57E-02	45666.75	0.4901		0.49	190.70	4728.23	3.87E-02	38705.19
14	240	40	12.1515	7.67E-04	8.2587	5.21E-04	240	5950.56	4.87E-02	48711.20	0.5212		0.52	202.80	5028.26	4.12E-02	41161.28
15	250	40	12.1515	7.67E-04	8.3420	5.27E-04	250	6198.50	5.07E-02	50740.83	0.5362	0.55	0.54	210.43	5217.35	4.27E-02	42709.17
16	260	40	12.1515	7.67E-04	8.3345	5.26E-04	260	6446.44	5.28E-02	52770.46	0.5599		0.56	217.86	5401.62	4.42E-02	44217.57
17	275	40	12.1515	7.67E-04	8.3420	5.27E-04	275	6818.35	5.58E-02	55814.91	0.5900		0.59	229.57	5692.01	4.66E-02	46594.69
18	280	40	12.1515	7.67E-04	8.4495	5.33E-04	280	6942.32	5.68E-02	56829.73	0.6012		0.60	233.93	5800.06	4.75E-02	47479.20
19	300	40	12.1515	7.67E-04	8.2520	5.21E-04	300	7438.20	6.09E-02	60889.00	0.6141	0.63	0.62	241.44	5986.26	4.90E-02	49003.40
20	325	40	12.1515	7.67E-04	8.2520	5.21E-04	325	8058.05	6.60E-02	65963.08	0.6616		0.66	257.43	6382.77	5.22E-02	52249.24
21	350	40	12.1515	7.67E-04	8.3942	5.30E-04	350	8677.90	7.10E-02	71037.16	0.6962	0.70	0.70	270.78	6713.67	5.50E-02	54958.05
22	375	40	12.1515	7.67E-04	8.3942	5.30E-04	375	9297.75	7.61E-02	76111.25	0.7211		0.72	280.58	6956.79	5.69E-02	56948.19
23	400	40	12.1515	7.67E-04	8.8021	5.56E-04	400	9917.60	8.12E-02	81185.33	0.7654		0.77	297.82	7384.17	6.04E-02	60446.74
24	425	40	12.1515	7.67E-04	8.8021	5.56E-04	425	10537.45	8.63E-02	86259.41	0.7814	0.78	0.78	303.33	7520.69	6.16E-02	61564.23
25	450	40	12.1515	7.67E-04	8.6137	5.44E-04	450	11157.30	9.13E-02	91333.50	0.8017		0.80	311.95	7734.38	6.33E-02	63313.50
26	500	40	12.1515	7.67E-04	8.4116	5.31E-04	500	12397.00	1.01E-01	101481.66	0.8772	0.88	0.88	341.23	8460.35	6.93E-02	69256.30
27	550	40	12.1515	7.67E-04	8.7448	5.52E-04	550	13636.70	1.12E-01	111629.83	0.9416		0.94	366.38	9084.06	7.44E-02	74361.97
29	650	40	12.1515	7.67E-04	8.5158	5.38E-04	650	16116.10	1.32E-01	131926.16	1.0640		1.06	414.01	10264.91	8.40E-02	84028.40
30	625	40	12.1515	7.67E-04	8.8455	5.58E-04	625	15496.25	1.27E-01	126852.08	1.0129		1.01	394.12	9771.92	8.00E-02	79992.82
31	675	40	12.1515	7.67E-04	8.8455	5.58E-04	675	16735.95	1.37E-01	137000.25	1.1052		1.11	430.04	10662.38	8.73E-02	87282.13
32	600	40	12.1515	7.67E-04	8.8455	5.58E-04	600	14876.40	1.22E-01	121778.00	0.9919		0.99	385.95	9569.33	7.83E-02	78334.37

Table A -56a Phenylethanol adsolubilization of C12,13-8PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 ^{o}C

Sample **AF48**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**pH** final	**Phe(in-f)** (mg/l)	**Phe(in-f)** Molar	**Adsbilized** **umole/g**	**Degree of** **adsl**	**Xadm**	**X_{aq}**	**X_{aq} x 10^5**	**Kadm**
1	2.35E-04	0.0300	3.13E-04	1.22	6.54	178.48	1.59E-03	2121.71	0.08	0.87	3.39E-04	33.90	0.0257
2	2.48E-04	0.0300	3.30E-04	1.28	7.54	195.84	1.75E-03	2328.15	0.08	0.88	3.73E-04	37.29	0.0235
3	2.14E-04	0.0300	2.86E-04	1.11	8.54	208.39	1.86E-03	2477.24	0.08	0.90	4.08E-04	40.76	0.0220
4	2.35E-04	0.0300	3.13E-04	1.22	9.54	217.07	1.94E-03	2580.46	0.08	0.89	4.25E-04	42.45	0.0210
5	2.33E-04	0.0300	3.11E-04	1.21	10.54	227.68	2.03E-03	2706.61	0.08	0.90	4.41E-04	44.12	0.0203
6	2.42E-04	0.0300	3.22E-04	1.25	11.54	293.28	2.61E-03	3486.48	0.09	0.92	4.68E-04	46.81	0.0196
7	2.41E-04	0.0320	3.01E-04	1.17	12.54	346.83	3.09E-03	3865.31	0.10	0.93	4.97E-04	49.67	0.0187
8	2.56E-04	0.0320	3.20E-04	1.24	13.54	458.25	4.09E-03	5107.16	0.12	0.94	5.53E-04	55.33	0.0170
9	2.41E-04	0.0320	3.01E-04	1.17	14.54	489.61	4.37E-03	5456.59	0.12	0.95	5.67E-04	56.69	0.0167
10	2.61E-04	0.0313	3.33E-04	1.29	15.54	496.84	4.43E-03	5661.07	0.12	0.94	5.84E-04	58.41	0.0162
11	2.40E-04	0.0300	3.20E-04	1.24	16.54	665.19	5.93E-03	7907.67	0.15	0.96	6.32E-04	63.23	0.0152
12	2.56E-04	0.0313	3.27E-04	1.27	17.54	620.33	5.53E-03	7068.09	0.13	0.96	6.75E-04	67.54	0.0142
13	2.40E-04	0.0300	3.20E-04	1.24	18.54	850.42	7.58E-03	10109.66	0.17	0.97	6.96E-04	69.63	0.0139
14	2.46E-04	0.0313	3.14E-04	1.22	19.54	922.30	8.22E-03	10508.70	0.17	0.97	7.40E-04	74.04	0.0131
15	2.40E-04	0.0313	3.07E-04	1.19	20.54	981.15	8.75E-03	11179.23	0.17	0.97	7.68E-04	76.83	0.0127
16	2.41E-04	0.0313	3.08E-04	1.20	21.54	1044.82	9.32E-03	11904.73	0.18	0.97	7.95E-04	79.54	0.0123
17	2.40E-04	0.0313	3.07E-04	1.19	22.54	1126.34	1.00E-02	12833.59	0.18	0.98	8.38E-04	83.81	0.0117
18	2.34E-04	0.0313	2.99E-04	1.16	23.54	1142.26	1.02E-02	13014.96	0.18	0.98	8.54E-04	85.40	0.0114
19	2.46E-04	0.0301	3.27E-04	1.27	6.88	1451.94	1.29E-02	17203.05	0.21	0.98	8.81E-04	88.14	0.0111
20	2.46E-04	0.0301	3.27E-04	1.27	7.12	1675.28	1.49E-02	19849.23	0.23	0.98	9.40E-04	93.97	0.0105
21	2.37E-04	0.0318	2.98E-04	1.16	7.15	1964.23	1.75E-02	22028.56	0.25	0.99	9.88E-04	98.84	0.0100
22	2.37E-04	0.0318	2.98E-04	1.16	7.31	2340.96	2.09E-02	26253.59	0.27	0.99	1.02E-03	102.41	0.0097
23	2.11E-04	0.0304	2.78E-04	1.08	7.45	2533.43	2.26E-02	29720.53	0.28	0.99	1.09E-03	108.70	0.0091
24	2.11E-04	0.0304	2.78E-04	1.08	7.11	3016.76	2.69E-02	35390.75	0.31	0.99	1.11E-03	110.70	0.0090
25	2.23E-04	0.0312	2.86E-04	1.11	7.23	3422.92	3.05E-02	39125.91	0.33	0.99	1.14E-03	113.85	0.0087
26	2.36E-04	0.0303	3.12E-04	1.21	6.84	3936.65	3.51E-02	46334.69	0.35	0.99	1.25E-03	124.52	0.0080
27	2.15E-04	0.0303	2.84E-04	1.10	6.75	4552.64	4.06E-02	53584.95	0.36	0.99	1.34E-03	133.69	0.0074
29	2.30E-04	0.0305	3.01E-04	1.17	6.87	5851.19	5.22E-02	68417.38	0.40	1.00	1.51E-03	151.04	0.0066
30	2.09E-04	0.0312	2.68E-04	1.04	7.14	5724.33	5.10E-02	65432.24	0.40	1.00	1.44E-03	143.79	0.0069
31	2.09E-04	0.0311	2.69E-04	1.04	7.28	6073.57	5.42E-02	69669.87	0.40	1.00	1.57E-03	156.88	0.0063
32	2.09E-04	0.0311	2.68E-04	1.04	7.31	5307.07	4.73E-02	60857.87	0.39	1.00			

Table A -57 Phenylethanol adsolubilization of C14,15-3PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	**Phe**	**Solution**	**Surf_in**		**Surf_eq**		**Phe_ini**				**Phe_eq**						
AF53	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	100	40	11.8541	5.99E-04	9.1600	4.63E-04	100	2479.40	2.03E-02	20296.33	0.2298		0.23	99.05	2455.89	2.01E-02	20103.87
2	125	40	11.8541	5.99E-04	9.1329	4.61E-04	125	3099.25	2.54E-02	25370.42	0.2874		0.29	123.88	3071.46	2.51E-02	25142.96
3	150	40	11.8541	5.99E-04	9.4459	4.77E-04	150	3719.10	3.04E-02	30444.50	0.3448		0.34	148.62	3684.90	3.02E-02	30164.55
4	175	40	11.8541	5.99E-04	9.2391	4.67E-04	175	4338.95	3.55E-02	35518.58	0.4020		0.40	173.28	4296.20	3.52E-02	35168.65
5	200	40	11.8541	5.99E-04	9.3986	4.75E-04	200	4958.80	4.06E-02	40592.67	0.4580		0.46	197.43	4895.00	4.01E-02	40070.38
6	225	40	11.8541	5.99E-04	8.4004	4.24E-04	225	5578.65	4.57E-02	45666.75	0.5006		0.50	215.76	5349.52	4.38E-02	43791.09
7	250	40	11.8541	5.99E-04	9.0142	4.55E-04	250	6198.50	5.07E-02	50740.83	0.5468		0.55	235.69	5843.69	4.78E-02	47836.36
8	275	40	11.8541	5.99E-04	9.6092	4.85E-04	275	6818.35	5.58E-02	55814.91	0.5779	0.59	0.59	252.67	6264.76	5.13E-02	51283.23
9	300	40	11.8541	5.99E-04	7.6520	3.87E-04	300	7438.20	6.09E-02	60889.00	0.6312		0.63	272.07	6745.68	5.52E-02	55220.02
10	325	40	11.8541	5.99E-04	7.3620	3.72E-04	325	8058.05	6.60E-02	65963.08	0.6591	0.68	0.67	289.14	7168.89	5.87E-02	58684.40
11	350	40	11.8541	5.99E-04	9.6202	4.86E-04	350	8677.90	7.10E-02	71037.16	0.7163		0.72	308.75	7655.15	6.27E-02	62664.93
12	375	40	11.8541	5.99E-04	9.4881	4.79E-04	375	9297.75	7.61E-02	76111.25	0.7561		0.76	325.91	8080.49	6.61E-02	66146.80
13	400	40	11.8541	5.99E-04	9.5339	4.82E-04	400	9917.60	8.12E-02	81185.33	0.7820		0.78	337.07	8357.29	6.84E-02	68412.64
14	425	40	11.8541	5.99E-04	9.5616	4.83E-04	425	10537.45	8.63E-02	86259.41	0.7940		0.79	342.24	8485.53	6.95E-02	69462.45
15	450	40	11.8541	5.99E-04	9.1112	4.60E-04	450	11157.30	9.13E-02	91333.50	0.8082		0.81	348.36	8637.29	7.07E-02	70704.72
16	500	40	11.8541	5.99E-04	9.3246	4.71E-04	500	12397.00	1.01E-01	101481.66	0.8694		0.87	374.74	9291.34	7.61E-02	76058.76
17	300	40	11.8541	5.99E-04	9.6589	4.88E-04	300	7438.20	6.09E-02	60889.00	0.6332		0.63	272.93	6767.05	5.54E-02	55394.99

Table A -57a Phenylethanol adsolubilization of C14,15-3PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample AF53	Cs (M)	Alumina (g)	q mole/g	[q] molecule/nm^2	pH final	Phe(in-f) (mg/l)	Phe(in-f) Molar	Adsbilized umole/g(alumina)	Degree of adsl	Xadm	X_{aq}	X_{aq} x 10^5	Kadm
1	1.36E-04	0.0305	1.78E-04	0.69	7.01	23.51	2.10E-04	274.92	0.01	0.61	3.62E-04	36.18	0.0168
2	1.37E-04	0.0305	1.80E-04	0.70	7.05	27.79	2.48E-04	324.90	0.01	0.64	4.52E-04	45.24	0.0142
3	1.22E-04	0.0305	1.60E-04	0.62	7.12	34.20	3.05E-04	399.88	0.01	0.71	5.43E-04	54.27	0.0132
4	1.32E-04	0.0312	1.69E-04	0.66	7.14	42.75	3.81E-04	488.64	0.01	0.74	6.33E-04	63.27	0.0117
5	1.24E-04	0.0310	1.60E-04	0.62	7.21	63.80	5.69E-04	734.00	0.01	0.82	7.21E-04	72.08	0.0114
6	1.74E-04	0.0300	2.33E-04	0.90	7.31	229.13	2.04E-03	2723.86	0.04	0.92	7.88E-04	78.77	0.0117
7	1.43E-04	0.0315	1.82E-04	0.71	7.28	354.81	3.16E-03	4017.06	0.06	0.96	8.60E-04	86.04	0.0111
8	1.13E-04	0.0312	1.45E-04	0.56	6.98	553.59	4.94E-03	6327.84	0.09	0.98	9.22E-04	92.23	0.0106
9	2.12E-04	0.0318	2.67E-04	1.04	6.95	692.52	6.17E-03	7766.56	0.10	0.97	9.93E-04	99.31	0.0097
10	2.27E-04	0.0307	2.96E-04	1.15	6.75	889.16	7.93E-03	10329.17	0.12	0.97	1.06E-03	105.53	0.0092
11	1.13E-04	0.0302	1.49E-04	0.58	6.98	1022.75	9.12E-03	12077.74	0.13	0.99	1.13E-03	112.68	0.0088
12	1.20E-04	0.0314	1.52E-04	0.59	7.13	1217.26	1.09E-02	13825.30	0.14	0.99	1.19E-03	118.93	0.0083
13	1.17E-04	0.0314	1.49E-04	0.58	7.36	1560.31	1.39E-02	17721.64	0.17	0.99	1.23E-03	123.00	0.0081
14	1.16E-04	0.0308	1.50E-04	0.58	6.87	2051.92	1.83E-02	23759.16	0.21	0.99	1.25E-03	124.89	0.0080
15	1.39E-04	0.0310	1.79E-04	0.69	7.18	2520.01	2.25E-02	28990.97	0.25	0.99	1.27E-03	127.12	0.0078
16	1.28E-04	0.0305	1.68E-04	0.65	6.98	3105.66	2.77E-02	36314.19	0.27	1.00	1.37E-03	136.73	0.0073
17	1.11E-04	0.0304	1.46E-04	0.57	7.25	671.15	5.98E-03	7873.48	0.10	0.98	9.96E-04	99.62	0.0099

Table A -58 Phenylethanol adsolubilization of C14,15-5PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 ^{o}C

Sample	**Phe**	**Solution**	**Surf_in**		**Surf_eq**		**Phe_ini**				**Phe_eq**						
AF55	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	100	40	15.584	8.26E-04	10.2641	5.44E-04	100	2479.40	2.03E-02	20296.33	0.2355		0.24	98.79	2449.47	2.01E-02	20051.36
2	125	40	15.584	8.26E-04	10.4732	5.55E-04	125	3099.25	2.54E-02	25370.42	0.2905		0.29	122.19	3029.51	2.48E-02	24799.55
3	150	40	15.584	8.26E-04	9.9263	5.26E-04	150	3719.10	3.04E-02	30444.50	0.3458		0.35	145.71	3612.71	2.96E-02	29573.63
4	175	40	15.584	8.26E-04	10.1597	5.38E-04	175	4338.95	3.55E-02	35518.58	0.4016		0.40	169.44	4201.19	3.44E-02	34390.88
5	200	40	15.584	8.26E-04	10.2196	5.41E-04	200	4958.80	4.06E-02	40592.67	0.4573		0.46	193.14	4788.61	3.92E-02	39199.50
6	225	40	15.584	8.26E-04	10.3365	5.48E-04	225	5578.65	4.57E-02	45666.75	0.4980		0.50	210.45	5217.84	4.27E-02	42713.15
7	250	40	15.584	8.26E-04	9.2534	4.90E-04	250	6198.50	5.07E-02	50740.83	0.5356		0.54	226.44	5614.37	4.60E-02	45959.18
8	275	40	15.584	8.26E-04	10.4080	5.51E-04	275	6818.35	5.58E-02	55814.91	0.5850		0.59	247.45	6135.35	5.02E-02	50223.92
9	300	40	15.584	8.26E-04	10.2167	5.41E-04	300	7438.20	6.09E-02	60889.00	0.6275		0.63	265.53	6583.57	5.39E-02	53892.97
10	325	40	15.584	8.26E-04	9.6299	5.10E-04	325	8058.05	6.60E-02	65963.08	0.6621		0.66	280.25	6948.46	5.69E-02	56880.01
11	350	40	15.584	8.26E-04	10.2232	5.42E-04	350	8677.90	7.10E-02	71037.16	0.6821		0.68	288.75	7159.39	5.86E-02	58606.62
12	375	40	15.584	8.26E-04	9.8797	5.23E-04	375	9297.75	7.61E-02	76111.25	0.7152		0.72	302.83	7508.46	6.15E-02	61464.17
13	400	40	15.584	8.26E-04	9.4454	5.00E-04	400	9917.60	8.12E-02	81185.33	0.7631		0.76	323.21	8013.62	6.56E-02	65599.40
14	425	40	15.584	8.26E-04	9.5288	5.05E-04	425	10537.45	8.63E-02	86259.41	0.7862		0.79	333.03	8257.24	6.76E-02	67593.64
15	450	40	15.584	8.26E-04	9.8075	5.20E-04	450	11157.30	9.13E-02	91333.50	0.8130		0.81	344.43	8539.88	6.99E-02	69907.30

Table A -58a Phenylethanol adsolubilization of C14,15-5PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 ^{o}C

Sample AF55	Cs (M)	Alumina (g)	q mole/g	[q] molecule/nm^2	pH final	Phe(in-f) (mg/l)	Phe(in-f) Molar	Adsbilized umole/g(alumina)	Degree of adsl	Xadm	X_{aq}	X_{aq} x 10^5	Kadm
1	2.82E-04	0.0297	3.80E-04	1.48	6.85	29.93	2.67E-04	359.34	0.0131	0.4863	3.61E-04	36.08	0.0135
2	2.71E-04	0.0297	3.65E-04	1.42	7.05	69.74	6.22E-04	837.40	0.0245	0.6966	4.46E-04	44.62	0.0156
3	3.00E-04	0.0308	3.89E-04	1.51	7.12	106.39	9.49E-04	1231.84	0.0312	0.7599	5.32E-04	53.21	0.0143
4	2.87E-04	0.0313	3.67E-04	1.43	7.14	137.76	1.23E-03	1569.64	0.0346	0.8104	6.19E-04	61.87	0.0131
5	2.84E-04	0.0320	3.55E-04	1.38	7.21	170.19	1.52E-03	1896.73	0.0374	0.8422	7.05E-04	70.52	0.0119
6	2.78E-04	0.0307	3.62E-04	1.41	7.31	360.81	3.22E-03	4191.44	0.0704	0.9204	7.68E-04	76.83	0.0120
7	3.35E-04	0.0301	4.46E-04	1.73	7.28	584.13	5.21E-03	6920.89	0.1026	0.9395	8.27E-04	82.67	0.0114
8	2.74E-04	0.0302	3.63E-04	1.41	6.98	683.00	6.09E-03	8065.54	0.1091	0.9569	9.03E-04	90.33	0.0106
9	2.84E-04	0.0323	3.52E-04	1.37	6.95	854.63	7.62E-03	9436.26	0.1251	0.9640	9.69E-04	96.92	0.0099
10	3.15E-04	0.0306	4.12E-04	1.60	6.75	1109.59	9.89E-03	12931.90	0.1500	0.9691	1.02E-03	102.29	0.0095
11	2.84E-04	0.0300	3.79E-04	1.47	6.98	1518.51	1.35E-02	18051.77	0.1906	0.9795	1.05E-03	105.39	0.0093
12	3.02E-04	0.0305	3.96E-04	1.54	7.13	1789.29	1.60E-02	20921.95	0.2096	0.9814	1.11E-03	110.52	0.0089
13	3.25E-04	0.0303	4.29E-04	1.67	7.36	1903.98	1.70E-02	22409.96	0.2091	0.9812	1.18E-03	117.95	0.0083
14	3.21E-04	0.0327	3.92E-04	1.52	6.87	2280.21	2.03E-02	24868.48	0.2357	0.9845	1.22E-03	121.53	0.0081
15	3.06E-04	0.0305	4.01E-04	1.56	7.18	2617.42	2.33E-02	30605.27	0.2555	0.9871	1.26E-03	125.69	0.0079

Table A -59 Phenylethanol adsolubilization of C14,15-8PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	Phe	Solution	Surf_in		Surf_eq		Phe_ini				Phe_eq						
AF58	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	Molar	uMolar	1	2	av	ul	mg/l	Molar	uMolar
1	100	40	10.2641	7.08E-04	5.2877	3.65E-04	100	2479.40	2.03E-02	20296.33							
2	125	40	10.2641	7.08E-04	5.3041	3.66E-04	125	3099.25	2.54E-02	25370.42	0.3011	0.31	0.31	116.91	2898.55	2.37E-02	23727.46
3	150	40	10.2641	7.08E-04	5.6129	3.87E-04	150	3719.10	3.04E-02	30444.50		0.36	0.36	140.12	3474.18	2.84E-02	28439.58
4	175	40	10.2641	7.08E-04	5.9169	4.08E-04	175	4338.95	3.55E-02	35518.58	0.4127		0.41	162.46	4028.10	3.30E-02	32973.95
5	200	40	10.2641	7.08E-04	6.1030	4.21E-04	200	4958.80	4.06E-02	40592.67	0.4520	0.47	0.46	183.86	4558.72	3.73E-02	37317.60
6	225	40	10.2641	7.08E-04	6.0970	4.20E-04	225	5578.65	4.57E-02	45666.75	0.4989	0.5108	0.50	201.83	5004.08	4.10E-02	40963.31
7	250	40	10.2641	7.08E-04	5.9770	4.12E-04	250	6198.50	5.07E-02	50740.83	0.5453	0.5595	0.55	222.14	5507.69	4.51E-02	45085.86
8	275	40	10.2641	7.08E-04	6.1200	4.22E-04	275	6818.35	5.58E-02	55814.91	0.5796	0.5878	0.58	235.51	5839.19	4.78E-02	47799.55
9	300	40	10.2641	7.08E-04	5.9630	4.11E-04	300	7438.20	6.09E-02	60889.00	0.6241	0.6367	0.63	255.46	6333.80	5.18E-02	51848.42
10	325	40	10.2641	7.08E-04	5.9430	4.10E-04	325	8058.05	6.60E-02	65963.08	0.6539	0.6537	0.65	265.45	6581.64	5.39E-02	53877.18
11	350	40	10.2641	7.08E-04	6.1900	4.27E-04	350	8677.90	7.10E-02	71037.16	0.6756	0.7077	0.69	281.62	6982.51	5.72E-02	57158.76
12	375	40	10.2641	7.08E-04	5.9970	4.13E-04	375	9297.75	7.61E-02	76111.25	0.7125	0.7497	0.73	298.47	7400.34	6.06E-02	60579.05
13	400	40	10.2641	7.08E-04	5.7370	3.96E-04	400	9917.60	8.12E-02	81185.33	0.7650		0.77	312.95	7759.38	6.35E-02	63518.16
14	425	40	10.2641	7.08E-04	6.4802	4.47E-04	425	10537.45	8.63E-02	86259.41	0.7872	0.7904	0.79	323.12	8011.45	6.56E-02	65581.60
15	450	40	10.2641	7.08E-04	6.4409	4.44E-04	450	11157.30	9.13E-02	91333.50	0.8245	0.8365	0.83	340.93	8453.10	6.92E-02	69196.97
16	500	40	10.2641	7.08E-04	6.3554	4.38E-04	475	11777.15	9.64E-02	96407.58	0.8470	0.8664	0.86	352.13	8730.59	7.15E-02	71468.49
17	300	40	10.2641	7.08E-04	6.3554	4.38E-04	500	12397.00	1.01E-01	101481.66	0.8941		0.89	368.10	9126.70	7.47E-02	74711.05

Table A -59a Phenylethanol adsolubilization of C14,15-8PO-SO4 at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample AF58	Cs (M)	Alumina (g)	q mole/g	[q] molecule/nm^2	pH final	Phe(in-f) (mg/l)	Phe(in-f) Molar	Adsbilized umole/g(alumina)	Degree of adsl	Xadm	X_{aq}	X_{aq} x 10^5	Kadm
2	3.42E-04	0.0307	4.46E-04	1.73	7.36	200.70	1.79E-03	2331.51	0.07	0.84	4.27E-04	42.70	0.0197
3	3.21E-04	0.0307	4.18E-04	1.62	6.45	244.92	2.18E-03	2845.19	0.07	0.87	5.12E-04	51.17	0.0170
4	3.00E-04	0.0307	3.91E-04	1.52	7,23	310.85	2.77E-03	3611.08	0.08	0.90	5.93E-04	59.32	0.0152
5	2.87E-04	0.0307	3.74E-04	1.45	7.31	400.08	3.57E-03	4647.65	0.09	0.93	6.71E-04	67.13	0.0138
6	2.87E-04	0.0307	3.74E-04	1.45	7.31	574.57	5.12E-03	6674.65	0.11	0.95	7.37E-04	73.69	0.0129
7	2.96E-04	0.0301	3.93E-04	1.53	7.54	690.81	6.16E-03	8184.93	0.12	0.95	8.11E-04	81.10	0.0118
8	2.86E-04	0.0302	3.78E-04	1.47	6.98	979.16	8.73E-03	11562.91	0.16	0.97	8.60E-04	85.97	0.0113
9	2.97E-04	0.0323	3.67E-04	1.43	6.65	1104.40	9.85E-03	12193.96	0.16	0.97	9.32E-04	93.25	0.0104
10	2.98E-04	0.0306	3.89E-04	1.51	6.67	1476.41	1.32E-02	17207.13	0.20	0.98	9.69E-04	96.89	0.0101
11	2.81E-04	0.0300	3.75E-04	1.46	6.98	1695.39	1.51E-02	20154.38	0.21	0.98	1.03E-03	102.79	0.0096
12	2.94E-04	0.0305	3.86E-04	1.50	7.13	1897.41	1.69E-02	22186.26	0.22	0.98	1.09E-03	108.93	0.0090
13	3.12E-04	0.0303	4.12E-04	1.60	7.36	2158.22	1.92E-02	25402.44	0.24	0.98	1.14E-03	114.21	0.0086
14	2.61E-04	0.0327	3.19E-04	1.24	6.69	2526.00	2.25E-02	27549.12	0.26	0.99	1.18E-03	117.92	0.0084
15	2.64E-04	0.0305	3.46E-04	1.34	7.07	2704.20	2.41E-02	31619.91	0.26	0.99	1.24E-03	124.41	0.0080
16	2.69E-04	0.0325	3.32E-04	1.29	6.80	3046.56	2.72E-02	33430.91	0.28	0.99	1.28E-03	128.49	0.0077
17	2.69E-04	0.0317	3.40E-04	1.32	7.34	3270.30	2.92E-02	36791.72	0.29	0.99	1.34E-03	134.31	0.0074

Table A -60 Phenylethanol adsolubilization of SDS/dodecanol, 10:1 molar ratio 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	**Phe**	**Solution**	**Surf_in**		**Surf_eq**		**Phe_ini**				**Phe_eq**						
SDS:D	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	100	40	78.1251	2.13E-03	64.3720	1.75E-03	100	2479.40	2.03E-02	20296.33	0.2313		0.23	91.31	2263.93	1.85E-02	18532.48
2	150	40	78.1251	2.13E-03	68.2922	1.86E-03	150	3719.10	3.04E-02	30444.50	0.3358		0.34	141.07	3497.73	2.86E-02	28632.33
3	200	40	78.1251	2.13E-03	66.4647	1.81E-03	200	4958.80	4.06E-02	40592.67	0.4365		0.44	189.02	4686.66	3.84E-02	38364.90
4	250	40	78.1251	2.13E-03	68.0876	1.85E-03	250	6198.50	5.07E-02	50740.83	0.5348		0.53	235.83	5847.25	4.79E-02	47865.52
5	300	40	78.1251	2.13E-03	68.8626	1.87E-03	300	7438.20	6.09E-02	60889.00	0.6197		0.62	276.26	6849.64	5.61E-02	56071.04
6	350	40	78.1251	2.13E-03	69.4781	1.89E-03	350	8677.90	7.10E-02	71037.16	0.6929		0.69	311.12	7713.89	6.31E-02	63145.76
7	400	40	78.1251	2.13E-03	69.0977	1.88E-03	400	9917.60	8.12E-02	81185.33	0.7432		0.74	335.07	8307.76	6.80E-02	68007.21
8	450	40	78.1251	2.13E-03	70.3740	1.92E-03	450	11157.30	9.13E-02	91333.50	0.8036		0.80	363.83	9020.88	7.38E-02	73844.82
9	500	40	78.1251	2.13E-03	69.9168	1.90E-03	500	12397.00	1.01E-01	101481.66	0.8797		0.88	400.07	9919.37	8.12E-02	81199.83
10	550	40	78.1251	2.13E-03	68.7403	1.87E-03	550	13636.70	1.12E-01	111629.83	0.9316		0.93	424.79	10532.14	8.62E-02	86215.92
11	600	40	78.1251	2.13E-03	71.0260	1.93E-03	600	14876.40	1.22E-01	121778.00	0.9946		0.99	454.79	11275.96	9.23E-02	92304.82
12	650	40	78.1251	2.13E-03	70.3737	1.92E-03	650	16116.10	1.32E-01	131926.16							
13	700	40	78.1251	2.13E-03	70.0569	1.91E-03	700	17355.80	1.42E-01	142074.33	1.0698		1.07	490.60	12163.82	9.96E-02	99572.84
14	750	40	78.1251	2.13E-03	70.2282	1.91E-03	750	18595.50	1.52E-01	152222.50	1.0890		1.09	499.74	12390.51	1.01E-01	101428.51
15	525	40	78.1251	2.13E-03	69.1468	1.88E-03	525	13016.85	1.07E-01	106555.75	0.8974		0.90	408.50	10128.35	8.29E-02	82910.52
16	575	40	78.1251	2.13E-03	69.9892	1.90E-03	575	14256.55	1.17E-01	116703.91							
17	625	40	78.1251	2.13E-03	69.3840	1.89E-03	625	15496.25	1.27E-01	126852.08	0.9746		0.97	445.26	11039.82	9.04E-02	90371.84

Table A -60a Phenylethanol adsolubilization of SDS/dodecanol, 10:1 molar ratio 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample SDS:D	Cs (M)	Alumina (g)	q mole/g	[q] molecule/nm^2	pH final	Phe(in-f) (mg/l)	Phe(in-f) Molar	Adsbilized umole/g(alumina)	Degree of adsl	Xadm	X_{aq}	X_{aq} x 10^5	Kadm
1	3.74E-04	0.0300	4.99E-04	1.94	7.31	215.47	1.92E-03	2561.48	0.09	0.84	3.34E-04	33.35	0.0251
2	2.68E-04	0.0300	3.57E-04	1.39	7.31	221.37	1.97E-03	2631.66	0.06	0.88	5.15E-04	51.52	0.0171
3	3.17E-04	0.0300	4.23E-04	1.64	7.31	272.14	2.43E-03	3235.18	0.06	0.88	6.90E-04	69.02	0.0128
4	2.73E-04	0.0300	3.64E-04	1.42	7.31	351.25	3.13E-03	4175.56	0.06	0.92	8.61E-04	86.09	0.0107
5	2.52E-04	0.0300	3.36E-04	1.31	7.31	588.56	5.25E-03	6996.70	0.09	0.95	1.01E-03	100.84	0.0095
6	2.35E-04	0.0300	3.14E-04	1.22	7.31	964.01	8.59E-03	11459.99	0.12	0.97	1.14E-03	113.54	0.0086
7	2.46E-04	0.0315	3.12E-04	1.21	7.28	1609.84	1.44E-02	18226.11	0.18	0.98	1.22E-03	122.28	0.0080
8	2.11E-04	0.0312	2.70E-04	1.05	6.98	2136.42	1.90E-02	24420.43	0.21	0.99	1.33E-03	132.76	0.0075
9	2.23E-04	0.0318	2.81E-04	1.09	6.95	2477.63	2.21E-02	27786.33	0.22	0.99	1.46E-03	145.96	0.0068
10	2.55E-04	0.0307	3.33E-04	1.29	6.75	3104.56	2.77E-02	36064.85	0.25	0.99	1.55E-03	154.96	0.0064
11	1.93E-04	0.0302	2.56E-04	0.99	6.98	3600.44	3.21E-02	42517.82	0.26	0.99	1.66E-03	165.89	0.0060
13	2.20E-04	0.0314	2.80E-04	1.09	7.36	5191.98	4.63E-02	58969.23	0.33	1.00	1.79E-03	178.93	0.0056
14	2.15E-04	0.0308	2.79E-04	1.08	6.87	6204.99	5.53E-02	71847.66	0.36	1.00	1.82E-03	182.26	0.0055
15	2.44E-04	0.0310	3.15E-04	1.23	7.18	2888.50	2.58E-02	33230.19	0.24	0.99	1.49E-03	149.03	0.0066
17	2.38E-04	0.0304	3.13E-04	1.22	7.25	4456.43	3.97E-02	52279.95	0.31	0.99	1.62E-03	162.42	0.0061

Table A -61 Phenylethanol adsolubilization of SDS at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample	Phe	Solution	Surf_in		Surf_eq		Phe_ini				Phe_eq						
SDS alone	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
4	250	40	88.7053	2.41E-03	77.7071	2.11E-03	250	6198.50	5.07E-02	50740.83	0.4742		0.47	230.31	5710.21	4.67E-02	46743.67
5	300	40	88.7053	2.41E-03	77.2879	2.10E-03	300	7438.20	6.09E-02	60889.00	0.5358		0.54	260.22	6451.98	5.28E-02	52815.81
6	350	40	88.7053	2.41E-03	77.3196	2.10E-03	350	8677.90	7.10E-02	71037.16	0.5928		0.59	287.91	7138.36	5.84E-02	58434.51
7	400	40	88.7053	2.41E-03	75.5522	2.06E-03	400	9917.60	8.12E-02	81185.33	0.6671		0.67	323.99	8033.06	6.58E-02	65758.54
8	450	40	88.7053	2.41E-03	73.8391	2.01E-03	450	11157.30	9.13E-02	91333.50	0.7179		0.72	348.66	8644.79	7.08E-02	70766.09
9	500	40	88.7053	2.41E-03	77.9711	2.12E-03	500	12397.00	1.01E-01	101481.66	0.7847		0.78	381.11	9449.18	7.74E-02	77350.81
10	550	40	88.7053	2.41E-03	76.9305	2.09E-03	550	13636.70	1.12E-01	111629.83	0.8351		0.84	405.59	10056.08	8.23E-02	82318.93
11	600	40	88.7053	2.41E-03	76.0175	2.07E-03	600	14876.40	1.22E-01	121778.00	0.8866		0.89	430.60	10676.23	8.74E-02	87395.48
12	650	40	88.7053	2.41E-03	76.6398	2.09E-03	650	16116.10	1.32E-01	131926.16	0.9328		0.93	453.04	11232.56	9.19E-02	91949.58
13	700	40	88.7053	2.41E-03	79.4755	2.16E-03	700	17355.80	1.42E-01	142074.33	0.9899		0.99	480.77	11920.15	9.76E-02	97578.14
14	750	40	88.7053	2.41E-03	79.4399	2.16E-03	750	18595.50	1.52E-01	152222.50	1.0578		1.06	513.74	12737.78	1.04E-01	104271.30
15	525	40	88.7053	2.41E-03	74.9957	2.04E-03	525	13016.85	1.07E-01	106555.75	0.8081		0.81	392.47	9730.95	7.97E-02	79657.44
16	575	40	88.7053	2.41E-03	77.7008	2.11E-03	575	14256.55	1.17E-01	116703.91	0.8705		0.87	422.78	10482.36	8.58E-02	85808.44
17	625	40	88.7053	2.41E-03	76.8995	2.09E-03	625	15496.25	1.27E-01	126852.08	0.9127		0.91	443.27	10990.52	9.00E-02	89968.25
18	675	40	88.7053	2.41E-03	76.2999	2.08E-03	675	16735.95	1.37E-01	137000.25	0.9658		0.97	469.06	11629.94	9.52E-02	95202.52
20	600	40	88.7053	2.41E-03	78.8245	2.15E-03	600	14876.40	1.22E-01	121778.00	0.8973		0.90	435.79	10805.08	8.85E-02	88450.22

Table A -61a Phenylethanol adsolubilization of SDS at 0.001 M NaCl , pH 7.0 ± 0.5 and temperature 25±2 °C

Sample SDS alone	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**pH** final	**Phe(in-f)** (mg/l)	**Phe(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	**Xadm**	**X_{aq}**	**X_{aq} x 10^5**	**Kadm**
4	2.99E-04	0.0312	3.84E-04	1.49	7.14	488.29	4.35E-03	5581.47	0.09	0.94	8.41E-04	84.08	0.0111
5	3.11E-04	0.0310	4.01E-04	1.56	7.21	986.22	8.79E-03	11345.78	0.14	0.97	9.50E-04	94.99	0.0102
6	3.10E-04	0.0300	4.13E-04	1.61	7.31	1539.54	1.37E-02	18301.71	0.19	0.98	1.05E-03	105.08	0.0093
7	3.58E-04	0.0315	4.55E-04	1.77	7.28	1884.54	1.68E-02	21336.15	0.21	0.98	1.18E-03	118.24	0.0083
8	4.05E-04	0.0312	5.19E-04	2.02	6.98	2512.51	2.24E-02	28719.44	0.25	0.98	1.27E-03	127.23	0.0077
9	2.92E-04	0.0318	3.67E-04	1.43	6.95	2947.82	2.63E-02	33059.52	0.26	0.99	1.39E-03	139.05	0.0071
10	3.20E-04	0.0307	4.18E-04	1.62	6.75	3580.62	3.19E-02	41595.07	0.29	0.99	1.48E-03	147.97	0.0067
11	3.45E-04	0.0302	4.57E-04	1.78	6.98	4200.17	3.74E-02	49600.01	0.31	0.99	1.57E-03	157.08	0.0063
12	3.28E-04	0.0314	4.18E-04	1.63	7.13	4883.54	4.35E-02	55466.02	0.33	0.99	1.65E-03	165.25	0.0060
13	2.51E-04	0.0314	3.20E-04	1.24	7.36	5435.65	4.85E-02	61736.80	0.34	0.99	1.75E-03	175.35	0.0057
14	2.52E-04	0.0308	3.27E-04	1.27	6.87	5857.72	5.22E-02	67826.55	0.34	1.00	1.87E-03	187.36	0.0053
15	3.73E-04	0.0310	4.81E-04	1.87	7.18	3285.90	2.93E-02	37801.96	0.27	0.99	1.43E-03	143.19	0.0069
16	2.99E-04	0.0305	3.93E-04	1.53	6.98	3774.19	3.37E-02	44131.23	0.29	0.99	1.54E-03	154.23	0.0064
17	3.21E-04	0.0304	4.23E-04	1.64	7.25	4505.73	4.02E-02	52858.33	0.32	0.99	1.62E-03	161.70	0.0061
18	3.38E-04	0.0312	4.33E-04	1.68	7.37	5106.01	4.55E-02	58364.55	0.33	0.99	1.71E-03	171.09	0.0058
20	2.69E-04	0.0312	3.45E-04	1.34	6.78	4071.32	3.63E-02	46537.48	0.30	0.99	1.59E-03	158.97	0.0062

Table A -62 Ethylcylclohexane solubilization of C12,13-3PO-SO4 at 0.001 M NaCl and temperature 25±2 °C

Tube	**Conc surf.**	**Ethylcyclohexane Initial**			**Ethylcyclohexane Final**			
43	Molar (M)	**Amount(ul)**	**Conc(mg/l)**		Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	8	156.02	8.25	5.21	101.54	9.05E-04	0.90
1	1.0E-04	8	156.02	8.33	5.21	101.63	9.06E-04	0.91
2	1.0E-04	8	156.02	8.13	5.20	101.38	9.04E-04	0.90
3	1.0E-04	8	156.02	7.33	5.15	100.40	8.95E-04	0.89
3	3.0E-04	8	156.02	8.45	5.22	101.79	9.07E-04	0.91
3	3.0E-04	8	156.02	8.52	5.22	101.87	9.08E-04	0.91
4	3.0E-04	8	156.02	9.63	5.29	103.23	9.20E-04	0.92
4	3.0E-04	8	156.02	9.46	5.28	103.02	9.18E-04	0.92
5	7.0E-04	9	175.53	12.63	5.48	106.92	9.53E-04	0.95
5	7.0E-04	9	175.53	14.26	5.58	108.91	9.71E-04	0.97
6	7.0E-04	9	175.53	11.83	5.43	105.93	9.44E-04	0.94
6	7.0E-04	9	175.53	12.16	5.45	106.34	9.48E-04	0.95
7	9.0E-04	11	214.53	18.85	5.87	114.56	1.02E-03	1.02
7	9.0E-04	11	214.53	17.63	5.80	113.05	1.01E-03	1.01
8	9.0E-04	12	234.04	19.36	5.90	115.18	1.03E-03	1.03
8	9.0E-04	12	234.04	20.85	6.00	117.01	1.04E-03	1.04
9	1.0E-03	12	234.04	21.52	6.04	117.84	1.05E-03	1.05
9	1.0E-03	12	234.04	21.93	6.07	118.34	1.05E-03	1.05
10	1.0E-03	12	234.04	22.54	6.11	119.10	1.06E-03	1.06
10	1.0E-03	12	234.04	21.68	6.05	118.04	1.05E-03	1.05
11	1.5E-03	11	214.53	62.57	8.62	168.26	1.50E-03	1.50
11	1.5E-03	11	214.53	63.86	8.71	169.85	1.51E-03	1.51
12	1.5E-03	11	214.53	65.25	8.79	171.57	1.53E-03	1.53
12	1.5E-03	11	214.53	59.33	8.42	164.28	1.46E-03	1.46
13	2.0E-03	12	234.04	102.23	11.12	216.98	1.93E-03	1.93
13	2.0E-03	12	234.04	107.23	11.43	223.13	1.99E-03	1.99
14	2.0E-03	12	234.04	100.25	11.00	214.56	1.91E-03	1.91
14	2.0E-03	12	234.04	101.37	11.07	215.93	1.92E-03	1.92
15	2.5E-03	15	292.55	142.26	13.64	266.16	2.37E-03	2.37
15	2.5E-03	15	292.55	140.67	13.54	264.21	2.35E-03	2.35

Tube	**Conc surf.**	**Ethylcyclohexane Initial**			**Ethylcyclohexane Final**			
43	Molar (M)	**Amount(ul)**	**Conc(mg/l)**		Amount(ul)	Conc(mg/l)	Conc(M)	Conc(mM)
16	2.5E-03	14	273.04	127.53	12.71	248.07	2.21E-03	2.21
16	2.5E-03	14	273.04	126.26	12.63	246.50	2.20E-03	2.20
17	3.0E-03	18	351.05	172.90	15.57	303.81	2.71E-03	2.71
17	3.0E-03	18	351.05	174.24	15.65	305.45	2.72E-03	2.72
18	3.0E-03	20	390.06	180.26	16.03	312.84	2.79E-03	2.79
18	3.0E-03	20	390.06	180.52	16.05	313.17	2.79E-03	2.79
19	4.0E-03	22	429.07	206.66	17.69	345.28	3.08E-03	3.08
19	4.0E-03	22	429.07	209.46	17.87	348.72	3.11E-03	3.11
20	1.5E-03	12	234.04	74.59	9.38	183.03	1.63E-03	1.63
20	1.5E-03	12	234.04	73.57	9.32	181.78	1.62E-03	1.62

Table A -63 Summarize ethylcylclohexane solubilization of C12,13-3PO-SO4 at 0.001 M NaCl and temperature 25±2 ^{o}C

Surfactant concentration, 43			**Ethylcyclohexane Final (average)**							
			Amount(ul)		**Conc(mg/l)**		**Conc(M)**		**Conc(mM)**	
Molar	**mMolar**	**uMolar**		**Stdev**		**Stdev**		**Stdev**		**Stdev**
1.0E-4	0.10	100	5.19	0.03	101.24	0.57	9.02E-4	5.06E-6	0.90	0.01
3.0E-4	0.30	300	5.25	0.04	102.47	0.75	9.13E-4	6.70E-6	0.91	0.01
7.0E-4	0.70	700	5.49	0.07	107.02	1.32	9.54E-4	1.18E-5	0.95	0.01
9.0E-4	0.90	900	5.89	0.08	114.95	1.64	1.02E-3	1.46E-5	1.02	0.01
1.0E-3	1.00	1000	6.07	0.03	118.33	0.55	1.05E-3	4.92E-6	1.05	0.00
1.5E-3	1.50	1500	8.87	0.39	173.13	7.59	1.54E-3	6.76E-5	1.54	0.07
2.0E-3	2.00	2000	11.15	0.19	217.65	3.78	1.94E-3	3.37E-5	1.94	0.03
2.5E-3	2.50	2500	13.13	0.53	256.23	10.38	2.28E-3	9.25E-5	2.28	0.09
3.0E-3	3.00	3000	15.82	0.25	308.82	4.89	2.75E-3	4.35E-5	2.75	0.04
4.0E-3	4.00	4000	17.78	0.12	347.00	2.43	3.09E-3	2.16E-5	3.09	0.02

Table A -64 Ethylcylclohexane solubilization of C12,13-5PO-SO4 at 0.001 M NaCl and temperature 25±2 °C

Tube	**Conc surf.**	**Ethylcyclohexane Initial**		**Ethylcyclohexane Final**				
45	Molar (M)	**Amount(ul)**	**Conc(mg/l)**	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	8	156.02	19.76	5.93	115.68	1.03E-03	1.03
2	1.0E-04	8	156.02	17.38	5.78	112.76	1.00E-03	1.00
3	1.0E-04	8	156.02	20.96	6.01	117.14	1.04E-03	1.04
4	1.0E-04	8	156.02	20.45	5.97	116.53	1.04E-03	1.04
5	3.0E-04	8	156.02	30.20	6.59	128.50	1.15E-03	1.15
6	3.0E-04	8	156.02	28.36	6.47	126.24	1.13E-03	1.13
7	3.0E-04	8	156.02	29.92	6.57	128.16	1.14E-03	1.14
8	3.0E-04	8	156.02	29.42	6.54	127.54	1.14E-03	1.14
9	7.0E-04	8	156.02	36.33	6.97	136.04	1.21E-03	1.21
10	7.0E-04	8	156.02	36.46	6.98	136.19	1.21E-03	1.21
11	7.0E-04	9	175.53	44.45	7.48	146.01	1.30E-03	1.30
12	7.0E-04	9	175.53	46.52	7.61	148.55	1.32E-03	1.32
13	9.0E-04	10	195.03	54.93	8.14	158.88	1.42E-03	1.42
14	9.0E-04	10	195.03	50.93	7.89	153.97	1.37E-03	1.37
15	9.0E-04	10	195.03	51.02	7.90	154.07	1.37E-03	1.37
16	9.0E-04	10	195.03	53.26	8.04	156.83	1.40E-03	1.40
17	1.0E-03	12	234.04	64.94	8.77	171.18	1.53E-03	1.53
18	1.0E-03	12	234.04	66.52	8.87	173.12	1.54E-03	1.54
19	1.0E-03	12	234.04	67.62	8.94	174.48	1.55E-03	1.55
20	1.0E-03	12	234.04	64.85	8.77	171.07	1.52E-03	1.52
21	1.5E-03	13	253.54	78.85	9.65	188.27	1.68E-03	1.68
22	1.5E-03	13	253.54	78.50	9.63	187.84	1.67E-03	1.67
23	1.5E-03	13	253.54	78.35	9.62	187.65	1.67E-03	1.67
24	1.5E-03	13	253.54					
25	1.5E-03	13	253.54					
26	2.0E-03	15	292.55	103.92	11.23	219.07	1.95E-03	1.95
27	2.0E-03	15	292.55	101.15	11.05	215.67	1.92E-03	1.92
28	2.0E-03	16	312.05	113.62	11.84	230.98	2.06E-03	2.06
29	2.0E-03	16	312.05	113.72	11.84	231.11	2.06E-03	2.06

Tube	Conc surf.	Ethylcyclohexane Initial		Ethylcyclohexane Final				
45	Molar (M)	Amount(ul)	Conc(mg/l)	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
30	2.5E-03	17	331.55	155.43	14.47	282.34	2.52E-03	2.52
31	2.5E-03	17	331.55	152.87	14.31	279.20	2.49E-03	2.49
32	2.5E-03	17	331.55	159.70	14.74	287.59	2.56E-03	2.56
33	2.5E-03	17	331.55	156.79	14.55	284.02	2.53E-03	2.53
34	3.0E-03	19	370.56	168.59	15.30	298.51	2.66E-03	2.66
35	3.0E-03	19	370.56	163.59	14.98	292.37	2.61E-03	2.61
36	3.0E-03	22	429.07	187.52	16.49	321.77	2.87E-03	2.87
37	4.0E-03	22	429.07	260.42	21.08	411.32	3.67E-03	3.67
37	4.0E-03	22	429.07	255.25	20.75	404.98	3.61E-03	3.61

Table A -65 Summarize ethylcylclohexane solubilization of C12,13-5PO-SO4 at 0.001 M NaCl and temperature 25±2 ^{o}C

Surfactant concentration,45			Ethylcyclohexane Final (average)							
			Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
Molar	**mMolar**	**uM**		**Stdev**		**Stdev**		**Stdev**		**Stdev**
1.0E-4	0.10	100	5.92	0.10	115.53	1.94	0.00	0.00	1.03	0.02
3.0E-4	0.30	300	6.54	0.05	127.61	1.00	0.00	0.00	1.14	0.01
7.0E-4	0.70	700	7.26	0.33	141.70	6.53	0.00	0.00	1.26	0.06
9.0E-4	0.90	900	7.99	0.12	155.94	2.37	0.00	0.00	1.39	0.02
1.0E-3	1.00	1,000	8.84	0.08	172.46	1.64	0.00	0.00	1.54	0.01
1.5E-3	1.50	1,500	9.63	0.02	187.92	0.32	0.00	0.00	1.67	0.00
2.0E-3	2.00	2,000	11.49	0.41	224.21	8.02	0.00	0.00	2.00	0.07
2.5E-3	2.50	2,500	14.52	0.18	283.29	3.50	0.00	0.00	2.52	0.03
3.0E-3	3.00	3,000	15.59	0.79	304.22	15.51	0.00	0.00	2.71	0.14
4.0E-3	4.00	4,000	20.91	0.23	408.15	4.49	0.00	0.00	3.64	0.04

Table A -66 Ethylcylclohexane solubilization of C12,13-8PO-SO4 at 0.001 M NaCl and temperature 25±2 °C

Tube,48	Conc surf.	Ethylcyclohexane Initial		Ethylcyclohexane Final				
	Molar (M)	Amount(ul)	Conc(mg/l)	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	8	156.02	8.33	5.21	101.63	9.06E-04	0.91
2	1.0E-04	8	156.02	8.25	5.21	101.54	9.05E-04	0.90
3	1.0E-04	8	156.02	8.56	5.23	101.92	9.08E-04	0.91
4	1.0E-04	8	156.02	8.37	5.21	101.68	9.06E-04	0.91
5	3.0E-04	8	156.02	15.52	5.66	110.47	9.84E-04	0.98
6	3.0E-04	8	156.02	15.25	5.65	110.14	9.82E-04	0.98
7	3.0E-04	8	156.02	15.25	5.65	110.14	9.82E-04	0.98
8	3.0E-04	8	156.02	16.00	5.69	111.06	9.90E-04	0.99
9	7.0E-04	8	156.02	17.36	5.78	112.72	1.00E-03	1.00
10	7.0E-04	8	156.02	16.85	5.75	112.09	9.99E-04	1.00
11	7.0E-04	9	175.53	15.20	5.64	110.07	9.81E-04	0.98
12	7.0E-04	9	175.53	15.25	5.65	110.14	9.82E-04	0.98
13	9.0E-04	10	195.03	47.70	7.69	150.00	1.34E-03	1.34
14	9.0E-04	10	195.03	50.41	7.86	153.33	1.37E-03	1.37
15	9.0E-04	10	195.03	51.53	7.93	154.70	1.38E-03	1.38
16	9.0E-04	10	195.03	53.65	8.06	157.31	1.40E-03	1.40
17	1.0E-03	12	234.04	56.38	8.23	160.66	1.43E-03	1.43
18	1.0E-03	12	234.04	58.63	8.38	163.42	1.46E-03	1.46
19	1.0E-03	12	234.04	67.62	8.94	174.48	1.55E-03	1.55
20	1.0E-03	12	234.04	65.24	8.79	171.55	1.53E-03	1.53
21	1.5E-03	13	253.54	89.42	10.31	201.25	1.79E-03	1.79
22	1.5E-03	13	253.54	93.54	10.57	206.32	1.84E-03	1.84
26	2.0E-03	15	292.55	113.91	11.86	231.34	2.06E-03	2.06
27	2.0E-03	15	292.55	109.25	11.56	225.62	2.01E-03	2.01
28	2.0E-03	15	292.55	115.45	11.95	233.24	2.08E-03	2.08
30	2.5E-03	17	331.55	168.57	15.29	298.48	2.66E-03	2.66
31	2.5E-03	17	331.55	165.25	15.09	294.40	2.62E-03	2.62
32	2.5E-03	17	331.55	166.82	15.19	296.34	2.64E-03	2.64
33	2.5E-03	17	331.55	162.55	14.92	291.09	2.59E-03	2.59
34	3.0E-03	20	390.06	186.51	16.42	320.52	2.86E-03	2.86

Tube,48	Conc surf.	Ethylcyclohexane Initial		Ethylcyclohexane Final				
	Molar (M)	Amount(ul)	Conc(mg/l)	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
35	3.0E-03	20	390.06	185.25	16.35	318.99	2.84E-03	2.84
36	3.0E-03	20	390.06	189.27	16.60	323.92	2.89E-03	2.89
37	3.0E-03	20	390.06	190.25	16.66	325.13	2.90E-03	2.90
38	3.5E-03	22	429.07	230.95	19.22	375.13	3.34E-03	3.34
39	3.5E-03	22	429.07	229.84	19.15	373.76	3.33E-03	3.33
40	4.0E-03	24	468.07	290.46	22.97	448.23	3.99E-03	3.99
41	4.0E-03	24	468.07	284.57	22.60	440.99	3.93E-03	3.93

Table A -67 Summarize ethylcylclohexane solubilization of C12,13-8PO-SO4 at 0.001 M NaCl and temperature 25±2

Surfactant concentration,48			Ethylcyclohexane Final (average)							
			Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
Molar	mMolar	uM		Stdev		Stdev		Stdev		Stdev
1.0E-4	0.10	100	5.21	0.01	101.69	0.16	9.06E-04	1.43E-06	0.91	0.00
3.0E-4	0.30	300	5.66	0.02	110.45	0.43	9.84E-04	3.86E-06	0.98	0.00
7.0E-4	0.70	700	5.70	0.07	111.26	1.35	9.92E-04	1.21E-05	0.99	0.01
9.0E-4	0.90	900	7.89	0.16	153.84	3.04	1.37E-03	2.71E-05	1.37	0.03
1.0E-3	1.00	1,000	8.59	0.34	167.53	6.54	1.49E-03	5.83E-05	1.49	0.06
1.5E-3	1.50	1,500	10.44	0.18	203.78	3.58	1.82E-03	3.19E-05	1.82	0.03
2.0E-3	2.00	2,000	11.79	0.20	230.06	3.97	2.05E-03	3.53E-05	2.05	0.04
2.5E-3	2.50	2,500	15.12	0.16	295.08	3.14	2.63E-03	2.80E-05	2.63	0.03
3.0E-3	3.00	3,000	16.51	0.15	322.14	2.87	2.87E-03	2.56E-05	2.87	0.03
3.5E-3	3.50	3,500	19.19	0.05	374.44	0.97	3.34E-03	8.62E-06	3.34	0.01
4.0E-3	4.00	4,000	22.78	0.26	444.61	5.12	3.96E-03	4.56E-05	3.96	0.05

Table A -68 Ethylcylclohexane solubilization of C14,15-3PO-SO4 at 0.001 M NaCl and temperature 25±2 °C

Tube 53	**Conc surf.**	**Ethylcyclohexane Initial**		**Ethylcyclohexane Final**				
	Molar (M)	**Amount(ul)**	**Conc(mg/l)**	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	8	156.02	9.61	5.29	103.21	9.20E-04	0.92
2	1.0E-04	8	156.02	11.10	5.39	105.04	9.36E-04	0.94
3	1.0E-04	8	156.02	9.44	5.28	103.00	9.18E-04	0.92
4	1.0E-04	8	156.02	9.80	5.30	103.44	9.22E-04	0.92
5	1.0E-04	8	156.02	8.70	5.23	102.09	9.10E-04	0.91
6	1.0E-04	8	156.02	12.07	5.45	106.23	9.47E-04	0.95
7	3.0E-04	9	175.53	21.45	6.04	117.75	1.05E-03	1.05
8	3.0E-04	9	175.53	21.10	6.01	117.32	1.05E-03	1.05
9	3.0E-04	9	175.53	20.08	5.95	116.07	1.03E-03	1.03
10	3.0E-04	9	175.53	17.16	5.77	112.48	1.00E-03	1.00
11	3.0E-04	9	175.53	17.86	5.81	113.34	1.01E-03	1.01
12	3.0E-04	9	175.53					
9	7.0E-04	8	156.02	29.10	6.52	127.15	1.13E-03	1.13
10	7.0E-04	8	156.02	24.71	6.24	121.76	1.09E-03	1.09
11	7.0E-04	9	175.53	27.10	6.39	124.69	1.11E-03	1.11
12	7.0E-04	9	175.53	26.17	6.33	123.55	1.10E-03	1.10
13	9.0E-04	10	195.03	36.90	7.01	136.73	1.22E-03	1.22
14	9.0E-04	10	195.03	36.10	6.96	135.75	1.21E-03	1.21
15	9.0E-04	10	195.03	36.60	6.99	136.36	1.22E-03	1.22
16	9.0E-04	10	195.03	35.75	6.94	135.32	1.21E-03	1.21
17	1.0E-03	12	234.04	40.21	7.22	140.80	1.25E-03	1.25
18	1.0E-03	12	234.04	41.25	7.28	142.08	1.27E-03	1.27
19	1.0E-03	12	234.04	39.67	7.18	140.14	1.25E-03	1.25
20	1.0E-03	12	234.04	39.88	7.20	140.39	1.25E-03	1.25
21	1.5E-03	13	253.54	49.52	7.80	152.24	1.36E-03	1.36
22	1.5E-03	13	253.54	48.25	7.72	150.68	1.34E-03	1.34
23	1.5E-03	13	253.54	46.70	7.63	148.77	1.33E-03	1.33
24	1.5E-03	13	253.54	47.40	7.67	149.63	1.33E-03	1.33
25	2.0E-03	15	292.55	73.50	9.31	181.70	1.62E-03	1.62

Tube	Conc surf.	Ethylcyclohexane Initial		Ethylcyclohexane Final				
53	Molar (M)	**Amount(ul)**	**Conc(mg/l)**	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
26	2.0E-03	15	292.55	77.30	9.55	186.36	1.66E-03	1.66
27	2.0E-03	15	292.55	76.25	9.49	185.07	1.65E-03	1.65
28	2.0E-03	15	292.55	73.25	9.30	181.39	1.62E-03	1.62
29	2.0E-03	15	292.55	73.70	9.32	181.94	1.62E-03	1.62
30	2.0E-03	15	292.55	77.85	9.59	187.04	1.67E-03	1.67
31	2.5E-03	20	390.06	115.30	11.94	233.05	2.08E-03	2.08
32	2.5E-03	20	390.06	113.80	11.85	231.20	2.06E-03	2.06
33	2.5E-03	20	390.06	113.50	11.83	230.84	2.06E-03	2.06
34	2.5E-03	20	390.06	102.10	11.11	216.83	1.93E-03	1.93
35	2.5E-03	20	390.06	98.90	10.91	212.90	1.90E-03	1.90
36	2.5E-03	20	390.06	98.80	10.90	212.78	1.90E-03	1.90
37	3.0E-03	23	448.57	150.20	14.14	275.92	2.46E-03	2.46
38	3.0E-03	23	448.57	147.20	13.95	272.24	2.43E-03	2.43
39	3.0E-03	23	448.57	143.90	13.74	268.18	2.39E-03	2.39
40	3.5E-03	24	468.07	195.90	17.02	332.06	2.96E-03	2.96
41	3.5E-03	24	468.07	197.70	17.13	334.28	2.98E-03	2.98
42	3.5E-03	24	468.07	194.90	16.95	330.84	2.95E-03	2.95
43	3.5E-03	24	468.07	203.70	17.51	341.65	3.04E-03	3.04
44	3.5E-03	24	468.07	205.20	17.60	343.49	3.06E-03	3.06
45	3.5E-03	24	468.07					
46	4.0E-03	25	487.58	232.40	19.31	376.90	3.36E-03	3.36
47	4.0E-03	25	487.58	235.60	19.51	380.84	3.39E-03	3.39
48	4.0E-03	25	487.58	234.90	19.47	379.98	3.39E-03	3.39

Table A -69 Summarize ethylcylclohexane solubilization of C14,15-3PO-SO4 at 0.001 M NaCl and temperature 25±2 °C

Surfactant concentration, 53			**Ethylcyclohexane Final (average)**							
			Amount(ul)		**Conc(mg/l)**		**Conc(M)**		**Conc(mM)**	
Molar	**mMolar**	**uM**		**Stdev**		**Stdev**		**Stdev**		**Stdev**
1.0E-4	0.10	100	5.32	0.08	103.83	1.52	9.25E-04	1.35E-05	0.93	0.01
3.0E-4	0.30	300	5.92	0.12	115.39	2.37	1.03E-03	2.11E-05	1.03	0.02
7.0E-4	0.70	700	6.37	0.12	124.29	2.26	1.11E-03	2.01E-05	1.11	0.02
9.0E-4	0.90	900	6.97	0.03	136.04	0.63	1.21E-03	5.61E-06	1.21	0.01
1.0E-3	1.00	1,000	7.22	0.04	140.85	0.86	1.26E-03	7.68E-06	1.26	0.01
1.5E-3	1.50	1,500	7.71	0.08	150.33	1.49	1.34E-03	1.33E-05	1.34	0.01
2.0E-3	2.00	2,000	9.43	0.13	183.92	2.54	1.64E-03	2.27E-05	1.64	0.02
2.5E-3	2.50	2,500	11.42	0.50	222.93	9.74	1.99E-03	8.68E-05	1.99	0.09
3.0E-3	3.00	3,000	13.94	0.20	272.11	3.87	2.43E-03	3.45E-05	2.43	0.03
3.5E-3	3.50	3,500	17.24	0.29	336.46	5.75	3.00E-03	5.12E-05	3.00	0.05
4.0E-3	4.00	4,000	19.43	0.11	379.24	2.07	3.38E-03	1.84E-05	3.38	0.02

Table A -70 Ethylcylclohexane solubilization of C14,15-5PO-SO4 at 0.001 M NaCl and temperature 25±2 °C

Tube	**Conc surf.**	**Ethylcyclohexane Initial**		**Ethylcyclohexane Final**				
55	Molar (M)	**Amount(ul)**	**Conc(mg/l)**	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	8	156.02	67.65	8.94	174.51	1.56E-03	1.56
2	1.0E-04	8	156.02	65.19	8.79	171.49	1.53E-03	1.53
3	1.0E-04	8	156.02	64.37	8.74	170.48	1.52E-03	1.52
4	1.0E-04	8	156.02	62.86	8.64	168.62	1.50E-03	1.50
5	3.0E-04	9	175.53	62.37	8.61	168.02	1.50E-03	1.50
6	3.0E-04	9	175.53	62.85	8.64	168.61	1.50E-03	1.50
7	3.0E-04	9	175.53	62.37	8.61	168.02	1.50E-03	1.50
8	3.0E-04	9	175.53	62.85	8.64	168.61	1.50E-03	1.50
9	7.0E-04	9	175.53	66.25	8.86	172.79	1.54E-03	1.54
10	7.0E-04	9	175.53	69.02	9.03	176.19	1.57E-03	1.57
11	7.0E-04	9	175.53	67.76	8.95	174.64	1.56E-03	1.56
12	7.0E-04	9	175.53	69.54	9.06	176.83	1.58E-03	1.58
13	9.0E-04	10	195.03	99.92	10.97	214.15	1.91E-03	1.91
14	9.0E-04	10	195.03	95.51	10.70	208.73	1.86E-03	1.86
15	9.0E-04	10	195.03	100.39	11.00	214.73	1.91E-03	1.91
16	9.0E-04	10	195.03	95.85	10.72	209.15	1.86E-03	1.86
17	1.0E-03	11	214.53	108.67	11.53	224.90	2.00E-03	2.00
18	1.0E-03	11	214.53	107.56	11.46	223.54	1.99E-03	1.99
19	1.0E-03	11	214.53	102.95	11.17	217.87	1.94E-03	1.94
20	1.0E-03	11	214.53	104.69	11.28	220.01	1.96E-03	1.96
21	1.5E-03	12	234.04	124.87	12.54	244.80	2.18E-03	2.18
22	1.5E-03	12	234.04	122.06	12.37	241.35	2.15E-03	2.15
23	1.5E-03	12	234.04	131.25	12.95	252.64	2.25E-03	2.25
24	1.5E-03	12	234.04	125.01	12.55	244.98	2.18E-03	2.18
25	2.0E-03	15	292.55	145.40	13.84	270.02	2.41E-03	2.41
26	2.0E-03	15	292.55	148.20	14.01	273.46	2.44E-03	2.44
27	2.0E-03	15	292.55	135.03	13.18	257.29	2.29E-03	2.29
28	2.0E-03	15	292.55	133.24	13.07	255.09	2.27E-03	2.27
29	2.5E-03	17	331.55	178.52	15.92	310.71	2.77E-03	2.77
30	2.5E-03	17	331.55	180.25	16.03	312.84	2.79E-03	2.79

Tube	Conc surf.	Ethylcyclohexane Initial		Ethylcyclohexane Final				
55	Molar (M)	Amount(ul)	Conc(mg/l)	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
31	2.5E-03	17	331.55	183.19	16.22	316.45	2.82E-03	2.82
32	2.5E-03	17	331.55	181.59	16.11	314.48	2.80E-03	2.80
33	2.5E-03	17	331.55	180.52	16.05	313.17	2.79E-03	2.79
34	2.5E-03	17	331.55	183.26	16.22	316.54	2.82E-03	2.82
35	3.0E-03	20	390.06	247.73	20.28	395.74	3.53E-03	3.53
36	3.0E-03	20	390.06	251.73	20.53	400.65	3.57E-03	3.57
37	3.0E-03	20	390.06	236.36	19.56	381.77	3.40E-03	3.40
38	3.0E-03	20	390.06	243.52	20.01	390.57	3.48E-03	3.48
39	4.0E-03	24	468.07	315.25	24.53	478.69	4.27E-03	4.27
40	4.0E-03	24	468.07	319.55	24.80	483.97	4.31E-03	4.31

Table A -71 Summarize ethylcylclohexane solubilization of C14,15-5PO-SO4 at 0.001 M NaCl and temperature 25±2 °C

Surfactant concentration,55			Ethylcyclohexane Final (average)							
			Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
Molar	mMolar	uM		Stdev		Stdev		Stdev		Stdev
1.0E-4	0.10	100	8.78	0.13	171.27	2.46	1.53E-03	2.19E-05	1.53	0.02
3.0E-4	0.30	300	8.63	0.02	168.32	0.34	1.50E-03	3.03E-06	1.50	0.00
7.0E-4	0.70	700	8.97	0.09	175.11	1.80	1.56E-03	1.61E-05	1.56	0.02
9.0E-4	0.90	900	10.85	0.16	211.69	3.19	1.89E-03	2.84E-05	1.89	0.03
1.0E-3	1.00	1,000	11.36	0.16	221.58	3.22	1.97E-03	2.87E-05	1.97	0.03
1.5E-3	1.50	1,500	12.60	0.24	245.94	4.77	2.19E-03	4.25E-05	2.19	0.04
2.0E-3	2.00	2,000	13.53	0.47	263.96	9.14	2.35E-03	8.14E-05	2.35	0.08
2.5E-3	2.50	2,500	16.09	0.12	314.03	2.26	2.80E-03	2.01E-05	2.80	0.02
3.0E-3	3.00	3,000	20.09	0.41	392.18	8.07	3.50E-03	7.19E-05	3.50	0.07
4.0E-3	4.00	4,000	24.66	0.19	481.33	3.74	4.29E-03	3.33E-05	4.29	0.03

Table A -72 Ethylcylclohexane solubilization of C14,15-8PO-SO4 at 0.001 M NaCl and temperature 25±2 °C

Tube	**Conc surf.**	**Ethylcyclohexane Initial**		**Ethylcyclohexane Final**				
58	Molar (M)	**Amount(ul)**	**Conc(mg/l)**	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	1.0E-04	8	156.02	15.85	5.68	110.88	9.88E-04	0.99
2	1.0E-04	8	156.02	16.18	5.70	111.27	9.92E-04	0.99
3	1.0E-04	8	156.02	17.86	5.81	113.34	1.01E-03	1.01
4	1.0E-04	8	156.02	18.95	5.88	114.69	1.02E-03	1.02
5	1.0E-04	8	156.02	19.25	5.90	115.04	1.03E-03	1.03
6	1.0E-04	8	156.02	16.18	5.70	111.28	9.92E-04	0.99
7	3.0E-04	9	175.53	23.28	6.15	120.01	1.07E-03	1.07
8	3.0E-04	9	175.53	24.45	6.23	121.44	1.08E-03	1.08
9	3.0E-04	9	175.53	21.89	6.06	118.29	1.05E-03	1.05
10	3.0E-04	9	175.53	21.25	6.02	117.51	1.05E-03	1.05
11	3.0E-04	9	175.53	22.45	6.10	118.98	1.06E-03	1.06
12	3.0E-04	9	175.53	21.25	6.02	117.51	1.05E-03	1.05
13	7.0E-04	9	175.53	28.55	6.48	126.47	1.13E-03	1.13
14	7.0E-04	9	175.53	25.99	6.32	123.32	1.10E-03	1.10
15	7.0E-04	9	175.53	27.89	6.44	125.66	1.12E-03	1.12
16	7.0E-04	9	175.53	25.99	6.32	123.32	1.10E-03	1.10
17	7.0E-04	9	175.53	27.89	6.44	125.66	1.12E-03	1.12
18	7.0E-04	9	175.53	28.54	6.48	126.47	1.13E-03	1.13
19	9.0E-04	10	195.03	63.54	8.69	169.46	1.51E-03	1.51
20	9.0E-04	10	195.03	70.27	9.11	177.72	1.58E-03	1.58
21	9.0E-04	10	195.03	62.04	8.59	167.61	1.49E-03	1.49
22	9.0E-04	10	195.03	72.64	9.26	180.63	1.61E-03	1.61
23	9.0E-04	10	195.03	69.59	9.07	176.89	1.58E-03	1.58
24	9.0E-04	10	195.03	70.51	9.12	178.03	1.59E-03	1.59
25	1.0E-03	11	214.53	104.05	11.23	219.23	1.95E-03	1.95
18	1.0E-03	11	214.53	97.30	10.81	210.93	1.88E-03	1.88
19	1.0E-03	11	214.53	100.74	11.03	215.15	1.92E-03	1.92
20	1.0E-03	11	214.53	106.30	11.38	221.99	1.98E-03	1.98
19	1.0E-03	11	214.53	105.96	11.35	221.57	1.97E-03	1.97

Tube	Conc surf.	Ethylcyclohexane Initial		Ethylcyclohexane Final				
58	Molar (M)	**Amount(ul)**	**Conc(mg/l)**	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
20	1.0E-03	11	214.53	104.82	11.28	220.17	1.96E-03	1.96
21	1.5E-03	12	234.04	116.10	11.99	234.03	2.09E-03	2.09
22	1.5E-03	12	234.04	114.80	11.91	232.43	2.07E-03	2.07
21	1.5E-03	12	234.04	126.30	12.63	246.56	2.20E-03	2.20
22	1.5E-03	12	234.04	111.34	11.69	228.19	2.03E-03	2.03
23	1.5E-03	12	234.04	118.63	12.15	237.14	2.11E-03	2.11
24	1.5E-03	12	234.04	107.54	11.45	223.52	1.99E-03	1.99
25	2.0E-03	15	292.55	113.75	11.85	231.15	2.06E-03	2.06
26	2.0E-03	15	292.55	134.52	13.15	256.66	2.29E-03	2.29
27	2.0E-03	15	292.55	130.95	12.93	252.28	2.25E-03	2.25
28	2.0E-03	15	292.55	144.46	13.78	268.87	2.40E-03	2.40
29	2.0E-03	15	292.55	146.20	13.89	271.01	2.42E-03	2.42
30	2.0E-03	15	292.55	144.70	13.79	269.17	2.40E-03	2.40
31	2.5E-03	18	351.05	184.52	16.30	318.08	2.83E-03	2.83
32	2.5E-03	18	351.05	166.52	15.17	295.97	2.64E-03	2.64
33	2.5E-03	18	351.05	173.63	15.61	304.70	2.72E-03	2.72
34	2.5E-03	18	351.05	185.61	16.37	319.43	2.85E-03	2.85
35	2.5E-03	18	351.05	187.50	16.49	321.75	2.87E-03	2.87
36	2.5E-03	18	351.05	184.25	16.28	317.76	2.83E-03	2.83
37	3.0E-03	20	390.06	242.70	19.96	389.56	3.47E-03	3.47
38	3.0E-03	20	390.06	250.21	20.43	398.78	3.55E-03	3.55
39	3.0E-03	20	390.06	251.93	20.54	400.89	3.57E-03	3.57
38	3.0E-03	20	390.06	238.75	19.71	384.71	3.43E-03	3.43
39	3.0E-03	20	390.06	240.85	19.84	387.28	3.45E-03	3.45
39	3.0E-03	20	390.06	247.11	20.24	394.98	3.52E-03	3.52
40	3.5E-03	22	429.07	306.10	23.95	467.44	4.17E-03	4.17
41	3.5E-03	22	429.07	304.20	23.83	465.11	4.15E-03	4.15
42	3.5E-03	22	429.07	324.50	25.11	490.05	4.37E-03	4.37
46	4.0E-03	24	468.07	369.66	27.95	545.52	4.86E-03	4.86
47	4.0E-03	24	468.07	365.28	27.67	540.15	4.81E-03	4.81
48	4.0E-03	24	468.07	341.21	26.16	510.58	4.55E-03	4.55
46	4.0E-03	24	468.07	401.1520	29.93	584.22	5.21E-03	5.21
47	4.0E-03	24	468.07	388.2552	29.12	568.37	5.07E-03	5.07
48	4.0E-03	24	468.07	398.7700	29.78	581.29	5.18E-03	5.18

Table A -73 Summarize ethylcylclohexane solubilization of C14,15-8PO-SO4 at 0.001 M NaCl and temperature 25±2 °C

Surfactant concentration,58			Ethylcyclohexane Final (average)							
			Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
Molar	mMolar	uM		Stdev		Stdev		Stdev		Stdev
1.0E-4	0.10	100	5.78	0.10	112.75	1.86	1.00E-03	1.65E-05	1.00	0.02
3.0E-4	0.30	300	6.10	0.08	118.96	1.54	1.06E-03	1.38E-05	1.06	0.01
7.0E-4	0.70	700	6.42	0.07	125.28	1.36	1.12E-03	1.21E-05	1.12	0.01
9.0E-4	0.90	900	8.97	0.29	175.79	5.67	1.57E-03	5.06E-05	1.57	0.05
1.0E-3	1.00	1,000	11.18	0.22	218.17	4.31	1.94E-03	3.84E-05	1.94	0.04
1.5E-3	1.50	1,500	11.97	0.52	233.85	10.18	2.08E-03	9.08E-05	2.08	0.09
2.0E-3	2.00	2,000	13.23	0.78	258.19	15.28	2.30E-03	1.36E-04	2.30	0.14
2.5E-3	2.50	2,500	16.04	0.52	312.95	10.25	2.79E-03	9.13E-05	2.79	0.09
3.0E-3	3.00	3,000	20.12	0.33	392.70	6.52	3.50E-03	5.81E-05	3.50	0.06
3.5E-3	3.50	3,500	24.30	0.71	474.20	13.77	4.23E-03	1.23E-04	4.23	0.12
4.0E-3	4.00	4,000	28.44	0.43	577.96	8.43	5.15E-03	7.51E-05	5.15	0.08

Table A -74 Ethylcylclohexane solubilization of SDS/dodecanol, 10:1 molar ratio at 0.001 M NaCl and temperature 25±2 °C

Tube SDS:D	**Conc surf.**	**Ethylcyclohexane Initial**		**Ethylcyclohexane Final**				
	Molar (M)	**Amount(ul)**	**Conc(mg/l)**	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	9.0E-4	8	156.02	9.14	5.26	102.63	9.15E-04	0.91
2	9.0E-4	8	156.02	9.45	5.28	103.01	9.18E-04	0.92
3	9.0E-4	8	156.02	9.89	5.31	103.55	9.23E-04	0.92
4	9.0E-4	8	156.02	12.12	5.45	106.29	9.47E-04	0.95
5	9.0E-4	8	156.02	12.65	5.48	106.94	9.53E-04	0.95
6	9.0E-4	8	156.02	12.26	5.46	106.46	9.49E-04	0.95
7	1.0E-3	9	175.53	10.22	5.33	103.96	9.26E-04	0.93
8	1.0E-3	9	175.53	12.22	5.46	106.41	9.48E-04	0.95
9	1.0E-3	9	175.53	11.45	5.41	105.47	9.40E-04	0.94
10	1.0E-3	9	175.53	11.29	5.40	105.27	9.38E-04	0.94
11	1.0E-3	9	175.53	14.59	5.60	109.32	9.74E-04	0.97
12	1.0E-3	9	175.53	12.33	5.46	106.55	9.50E-04	0.95
13	3.0E-3	10	195.03	10.94	5.38	104.84	9.34E-04	0.93
14	3.0E-3	10	195.03	10.61	5.35	104.43	9.31E-04	0.93
15	3.0E-3	10	195.03	13.88	5.56	108.45	9.67E-04	0.97
16	3.0E-3	10	195.03	14.25	5.58	108.91	9.71E-04	0.97
17	3.0E-3	10	195.03	13.21	5.52	107.63	9.59E-04	0.96
18	3.0E-3	10	195.03	14.21	5.58	108.86	9.70E-04	0.97
19	5.0E-3	11	214.53	14.01	5.57	108.61	9.68E-04	0.97
20	5.0E-3	11	214.53	13.98	5.57	108.57	9.68E-04	0.97
21	5.0E-3	11	214.53	14.04	5.57	108.65	9.68E-04	0.97
22	5.0E-3	11	214.53	15.99	5.69	111.04	9.90E-04	0.99
23	5.0E-3	11	214.53	14.45	5.60	109.15	9.73E-04	0.97
24	5.0E-3	11	214.53	13.98	5.57	108.57	9.68E-04	0.97
25	7.0E-3	13	253.54	17.56	5.79	112.97	1.01E-03	1.01
26	7.0E-3	13	253.54	16.45	5.72	111.61	9.95E-04	0.99
27	7.0E-3	13	253.54	16.01	5.69	111.07	9.90E-04	0.99
28	7.0E-3	13	253.54	17.25	5.77	112.59	1.00E-03	1.00
29	7.0E-3	13	253.54	16.96	5.75	112.23	1.00E-03	1.00

Tube	Conc surf.	Ethylcyclohexane Initial		Ethylcyclohexane Final				
SDS:D	Molar (M)	**Amount(ul)**	**Conc(mg/l)**	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
30	7.0E-3	13	253.54	17.02	5.76	112.31	1.00E-03	1.00
31	9.0E-3	15	292.55	18.26	5.84	113.83	1.01E-03	1.01
32	9.0E-3	15	292.55	17.25	5.77	112.59	1.00E-03	1.00
33	9.0E-3	15	292.55	16.85	5.75	112.10	9.99E-04	1.00
34	9.0E-3	15	292.55	16.41	5.72	111.56	9.94E-04	0.99
35	9.0E-3	15	292.55	17.25	5.77	112.59	1.00E-03	1.00
36	9.0E-3	15	292.55	17.58	5.79	113.00	1.01E-03	1.01
37	1.0E-2	17	331.55	52.45	7.99	155.84	1.39E-03	1.39
38	1.0E-2	17	331.55	55.45	8.18	159.52	1.42E-03	1.42
39	1.0E-2	17	331.55	53.95	8.08	157.68	1.41E-03	1.41
40	1.0E-2	17	331.55	57.56	8.31	162.11	1.44E-03	1.44
41	1.0E-2	17	331.55	58.25	8.35	162.97	1.45E-03	1.45
42	1.0E-2	17	331.55	57.24	8.29	161.72	1.44E-03	1.44
43	1.5E-2	15	292.55	142.45	13.65	266.40	2.37E-03	2.37
44	1.5E-2	15	292.55	147.23	13.95	272.27	2.43E-03	2.43
45	1.5E-2	15	292.55	149.12	14.07	274.59	2.45E-03	2.45
46	1.5E-2	15	292.55	148.45	14.03	273.78	2.44E-03	2.44
47	1.5E-2	15	292.55	140.95	13.56	264.56	2.36E-03	2.36
48	1.5E-2	15	292.55	140.02	13.50	263.42	2.35E-03	2.35
49	2.0E-2	17	331.55	172.03	15.51	302.73	2.70E-03	2.70
50	2.0E-2	17	331.55	179.26	15.97	311.62	2.78E-03	2.78
51	2.0E-2	17	331.55	188.23	16.53	322.64	2.88E-03	2.88
52	2.0E-2	17	331.55	181.75	16.12	314.68	2.80E-03	2.80
53	2.0E-2	17	331.55	185.35	16.35	319.10	2.84E-03	2.84
54	2.0E-2	17	331.55	198.78	17.20	335.60	2.99E-03	2.99
55	3.0E-2	20	390.06	310.26	24.21	472.55	4.21E-03	4.21
56	3.0E-2	20	390.06	301.25	23.65	461.49	4.11E-03	4.11
57	3.0E-2	20	390.06	307.25	24.02	468.86	4.18E-03	4.18
58	5.0E-2	24	468.07	443.90	32.62	636.73	5.67E-03	5.67
59	5.0E-2	24	468.07	461.47	33.73	658.32	5.87E-03	5.87
60	5.0E-2	24	468.07	461.06	33.70	657.81	5.86E-03	5.86

Table A -75 Summarize ethylcylclohexane solubilization of SDS/dodecanol, 10:1 molar ratio at 0.001 M NaCl and temperature 25±2 °C

Surf. Conc, SDS:D			Ethylcyclohexane Final (average)							
			Amount(ul)		**Conc(mg/l)**		**Conc(M)**		**Conc(mM)**	
Molar	**mMolar**	**uM**		**Stdev**		**Stdev**		**Stdev**		**Stdev**
9.0E-4	0.90	900	5.37	0.09	104.81	1.81	9.3E-04	1.6E-05	0.93	0.02
1.0E-3	1.00	1,000	5.44	0.09	106.16	1.81	9.5E-04	1.6E-05	0.95	0.02
3.0E-3	3.00	3,000	5.50	0.10	107.19	2.03	9.6E-04	1.8E-05	0.96	0.02
5.0E-3	5.00	5,000	5.59	0.05	109.10	0.98	9.7E-04	8.7E-06	0.97	0.01
7.0E-3	7.00	7,000	5.75	0.04	112.13	0.69	1.0E-03	6.1E-06	1.00	0.01
9.0E-3	9.00	9,000	5.77	0.04	112.54	0.84	1.0E-03	7.5E-06	1.00	0.01
1.0E-2	10.00	10,000	8.20	0.14	159.97	2.80	1.4E-03	2.5E-05	1.43	0.02
1.5E-2	15.00	15,000	13.79	0.25	269.17	4.95	2.4E-03	4.4E-05	2.40	0.04
2.0E-2	20.00	20,000	16.28	0.57	317.73	11.11	2.8E-03	9.9E-05	2.83	0.10
3.0E-2	30.00	30,000	23.96	0.29	467.63	5.63	4.2E-03	5.0E-05	4.17	0.05
5.0E-2	50.00	50,000	33.35	0.63	650.95	12.32	5.8E-03	1.1E-04	5.80	0.11

Table A -76 Ethylcylclohexane solubilization of SDS at 0.001 M NaCl and temperature 25±2 °C

Tube	**Conc surf.**	**Ethylcyclohexane Initial**		**Ethylcyclohexane Final**				
SDS	Molar (M)	**Amount(ul)**	**Conc(mg/l)**	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
1	9.0E-4	8	156.02	10.26	5.33	104.00	9.27E-04	0.93
2	9.0E-4	8	156.02	10.85	5.37	104.73	9.33E-04	0.93
3	9.0E-4	8	156.02	10.90	5.37	104.79	9.34E-04	0.93
4	9.0E-4	8	156.02	14.23	5.58	108.88	9.70E-04	0.97
5	9.0E-4	8	156.02	13.22	5.52	107.64	9.59E-04	0.96
6	9.0E-4	8	156.02	13.84	5.56	108.41	9.66E-04	0.97
7	1.0E-3	9	175.53	4.46	4.97	96.88	8.63E-04	0.86
8	1.0E-3	9	175.53	5.82	5.05	98.55	8.78E-04	0.88
9	1.0E-3	9	175.53	3.73	4.92	95.98	8.55E-04	0.86
10	1.0E-3	9	175.53	4.15	4.95	96.50	8.60E-04	0.86
11	1.0E-3	9	175.53	4.33	4.96	96.71	8.62E-04	0.86
12	1.0E-3	9	175.53	4.73	4.98	97.21	8.66E-04	0.87
13	3.0E-3	10	195.03	9.41	5.28	102.96	9.18E-04	0.92
14	3.0E-3	10	195.03	15.52	5.66	110.47	9.84E-04	0.98
15	3.0E-3	10	195.03	15.26	5.65	110.15	9.82E-04	0.98
16	3.0E-3	10	195.03	14.86	5.62	109.65	9.77E-04	0.98
17	3.0E-3	10	195.03	12.13	5.45	106.31	9.47E-04	0.95
18	3.0E-3	10	195.03	13.61	5.54	108.12	9.64E-04	0.96
19	5.0E-3	11	214.53	14.45	5.60	109.16	9.73E-04	0.97
20	5.0E-3	11	214.53	15.64	5.67	110.61	9.86E-04	0.99
21	5.0E-3	11	214.53	14.96	5.63	109.77	9.78E-04	0.98
22	5.0E-3	11	214.53	16.76	5.74	111.99	9.98E-04	1.00
23	5.0E-3	11	214.53	13.25	5.52	107.68	9.60E-04	0.96
24	5.0E-3	11	214.53	15.85	5.68	110.88	9.88E-04	0.99
25	7.0E-3	13	253.54	18.26	5.84	113.83	1.01E-03	1.01
26	7.0E-3	13	253.54	17.30	5.78	112.65	1.00E-03	1.00
27	7.0E-3	13	253.54	17.66	5.80	113.09	1.01E-03	1.01
28	7.0E-3	13	253.54	17.25	5.77	112.60	1.00E-03	1.00
29	7.0E-3	13	253.54	16.96	5.75	112.23	1.00E-03	1.00

Tube	Conc surf.	Ethylcyclohexane Initial		Ethylcyclohexane Final				
SDS	Molar (M)	**Amount(ul)**	**Conc(mg/l)**	Peak	Amount (ul)	Conc(mg/l)	Conc(M)	Conc(mM)
30	7.0E-3	13	253.54	18.56	5.85	114.20	1.02E-03	1.02
31	9.0E-3	15	292.55	25.96	6.32	123.29	1.10E-03	1.10
32	9.0E-3	15	292.55	31.21	6.65	129.75	1.16E-03	1.16
33	9.0E-3	15	292.55	28.66	6.49	126.60	1.13E-03	1.13
34	9.0E-3	15	292.55	36.26	6.97	135.94	1.21E-03	1.21
35	9.0E-3	15	292.55	27.24	6.40	124.86	1.11E-03	1.11
36	9.0E-3	15	292.55	35.21	6.90	134.66	1.20E-03	1.20
37	1.0E-2	17	331.55	67.99	8.97	174.92	1.56E-03	1.56
38	1.0E-2	17	331.55	68.27	8.98	175.27	1.56E-03	1.56
39	1.0E-2	17	331.55	64.37	8.74	170.47	1.52E-03	1.52
40	1.0E-2	17	331.55	64.25	8.73	170.34	1.52E-03	1.52
41	1.0E-2	17	331.55	65.53	8.81	171.90	1.53E-03	1.53
42	1.0E-2	17	331.55	66.41	8.87	172.99	1.54E-03	1.54
43	1.5E-2	15	292.55	109.33	11.57	225.71	2.01E-03	2.01
44	1.5E-2	15	292.55	113.26	11.81	230.54	2.05E-03	2.05
45	1.5E-2	15	292.55	111.25	11.69	228.07	2.03E-03	2.03
46	1.5E-2	15	292.55	112.24	11.75	229.28	2.04E-03	2.04
47	1.5E-2	15	292.55	116.13	11.99	234.06	2.09E-03	2.09
48	1.5E-2	15	292.55	110.26	11.63	226.85	2.02E-03	2.02
49	2.0E-2	17	331.55	123.54	12.46	243.17	2.17E-03	2.17
50	2.0E-2	17	331.55	126.54	12.65	246.86	2.20E-03	2.20
51	2.0E-2	17	331.55	130.63	12.91	251.87	2.24E-03	2.24
52	2.0E-2	17	331.55	125.50	12.58	245.58	2.19E-03	2.19
53	2.0E-2	17	331.55	127.65	12.72	248.22	2.21E-03	2.21
54	2.0E-2	17	331.55	122.25	12.38	241.58	2.15E-03	2.15
55	3.0E-2	20	390.06	235.70	19.52	380.96	3.40E-03	3.40
56	3.0E-2	20	390.06	243.84	20.03	390.96	3.48E-03	3.48
57	3.0E-2	20	390.06	293.25	23.14	451.66	4.03E-03	4.03
58	5.0E-2	24	468.07	443.90	32.62	636.73	5.67E-03	5.67
59	5.0E-2	24	468.07	391.47	29.32	572.32	5.10E-03	5.10
60	5.0E-2	24	468.07	441.06	32.44	633.24	5.64E-03	5.64

Table A -77 Summarize ethylcylclohexane solubilization of SDS at 0.001 M NaCl and temperature 25±2 °C

Surf. Conc, SDS			Ethylcyclohexane Final (average)									
			Amount(ul)		Conc(mg/l)		Conc(M)		Conc(mM)	
Molar	mMolar	uM		Stdev		Stdev		Stdev		Stdev
9.0E-4	0.90	900	5.46	0.24	106.41	4.77	9.5E-04	4.2E-05	0.95	0.04
1.0E-3	1.00	1,000	4.97	0.04	96.97	0.88	8.6E-04	7.8E-06	0.86	0.01
3.0E-3	3.00	3,000	5.53	0.15	107.94	2.89	9.6E-04	2.6E-05	0.96	0.03
5.0E-3	5.00	5,000	5.64	0.08	110.01	1.50	9.8E-04	1.3E-05	0.98	0.01
7.0E-3	7.00	7,000	5.80	0.04	113.10	0.77	1.0E-03	6.8E-06	1.01	0.01
9.0E-3	9.00	9,000	6.57	0.26	128.09	5.00	1.1E-03	4.5E-05	1.14	0.04
1.0E-2	10.00	10,000	8.85	0.11	172.65	2.13	1.5E-03	1.9E-05	1.54	0.02
1.5E-2	15.00	15,000	11.74	0.15	229.09	2.98	2.0E-03	2.7E-05	2.04	0.03
2.0E-2	20.00	20,000	12.62	0.19	246.21	3.68	2.2E-03	3.3E-05	2.19	0.03
3.0E-2	30.00	30,000	20.90	1.96	407.86	38.26	3.6E-03	3.4E-04	3.63	0.34
5.0E-2	50.00	50,000	31.46	1.86	614.10	36.22	5.5E-03	3.2E-04	5.47	0.32

Table A -78 Ethylcylclohexane adsolubilization of C12,13-3PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 °C

Sample	**Ethy**	**Solution**	**Surf_in 7e^{-4}**		**Surf_eq**		**Eth_ini**				**Eth_eq (base 16.7)**							
AF43	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**3**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
3	5	40	18.2441	6.7E-4	14.3567	5.3E-4	5	97.52	0.000869	869.04	4.7871	5.3458	4.7967	4.9765	1.9265	37.5731	3.35E-04	334.85
4	5	40	18.2441	6.7E-4	14.2541	5.2E-4	5	97.52	0.000869	869.04	4.9366	4.6994	5.0993	4.9118	1.9216	37.4778	3.34E-04	334.00
4	5	40	18.2441	6.7E-4	14.456	5.3E-4	5	97.52	0.000869	869.04	5.4972	5.0596	5.1966	5.2511	1.9473	37.9773	3.38E-04	338.45
5	6	40	18.2441	6.7E-4	14.5414	5.3E-4	6	117.02	0.001043	1042.85	12.4400	11.4500	11.6550	11.8483	2.4452	47.6879	4.25E-04	424.99
6	6	40	18.2441	6.7E-4	14.2445	5.2E-4	6	117.02	0.001043	1042.85	12.5510	12.8554	14.5821	13.3295	2.5569	49.8681	4.44E-04	444.42
6	6	40	18.2441	6.7E-4	14.4787	5.3E-4	6	117.02	0.001043	1042.85	12.2365	12.5840	12.2554	12.3586	2.4837	48.4390	4.32E-04	431.68
7	7	40	18.2441	6.7E-4	14.5414	5.3E-4	7	136.52	0.001217	1216.66	20.1445	24.2254	23.2554	22.5418	3.2522	63.4278	5.65E-04	565.26
8	7	40	18.2441	6.7E-4	14.754	5.4E-4	7	136.52	0.001217	1216.66	20.2550	21.1445	24.2250	21.8748	3.2019	62.4462	5.57E-04	556.51
9	7	40	18.2441	6.7E-4	14.544	5.3E-4	7	136.52	0.001217	1216.66	22.2544	24.2254	23.2554	23.2451	3.3053	64.4630	5.74E-04	574.49
10	8	40	18.2441	6.7E-4	14.954	5.5E-4	8	156.02	0.00139	1390.46	30.1440	30.1445	32.7787	31.0224	3.8923	75.9107	6.77E-04	676.51
11	8	40	18.2441	6.7E-4	14.6585	5.4E-4	8	156.02	0.00139	1390.46	32.2554	29.4453	29.8445	30.5151	3.8540	75.1639	6.70E-04	669.85
11	8	40	18.2441	6.7E-4	14.6585	5.4E-4	8	156.02	0.00139	1390.46	30.2544	32.5448	32.7787	31.8593	3.9554	77.1425	6.87E-04	687.48
12	8	40	18.2441	6.7E-4	14.4547	5.3E-4	9	175.53	0.001564	1564.27	38.7454	36.4588	37.1544	37.4529	4.3776	85.3758	7.61E-04	760.86
13	9	40	18.2441	6.7E-4	15.1025	5.6E-4	9	175.53	0.001564	1564.27	37.1155	36.2550	38.4541	37.2749	4.3641	85.1138	7.59E-04	758.52
14	9	40	18.2441	6.7E-4	15.1552	5.6E-4	9	175.53	0.001564	1564.27	38.4544	37.2544	36.4554	37.3881	4.3727	85.2805	7.60E-04	760.01
15	10	40	18.2441	6.7E-4	14.8789	5.5E-4	10	195.03	0.001738	1738.08	45.8544	48.5554	49.8440	48.0846	5.1800	101.0250	9.00E-04	900.32
16	10	40	18.2441	6.7E-4	15.5674	5.7E-4	10	195.03	0.001738	1738.08	45.8544	49.5850	48.9550	50.7445	5.3807	104.9401	9.35E-04	935.21
17	11	40	18.2441	6.7E-4	15.2544	5.6E-4	11	214.53	0.001912	1911.89	56.2880	56.8774	54.2544	55.8066	5.7628	112.3912	1.00E-03	1001.61
18	11	40	18.2441	6.7E-4	15.2545	5.6E-4	11	214.53	0.001912	1911.89	58.4400	56.8740	54.2880	56.5340	5.8177	113.4618	1.01E-03	1011.16
19	12	40	18.2441	6.7E-4	15.1025	5.6E-4	12	234.04	0.002086	2085.70	65.4400	65.2100	67.2500	65.9667	6.5296	127.3460	1.13E-03	1134.89
20	12	40	18.2441	6.7E-4	14.8211	5.4E-4	12	234.04	0.002086	2085.70	70.8440	72.6995	76.9440	73.4958	7.0978	138.4284	1.23E-03	1233.65
20	12	40	18.2441	6.7E-4	14.9954	5.5E-4	12	234.04	0.002086	2085.70	72.4400	70.9550	73.2554	72.2168	7.0013	136.5457	1.22E-03	1216.88

Table A -78a Ethylcylclohexane adsolubilization of C12,13-3PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 °C

Sample **AF43**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**pH** final	**Eth(in-f)** (mg/l)	**Eth(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	X_{adm}	X_{aq}	$X_{aq} \times 10^6$	**Kadm**
3	1.4E-4	0.0301	1.9E-4	0.74	6.89	59.9419	5.34E-04	709.89	0.61	0.79	6.03E-06	6.03	1.31E+05
4	1.5E-4	0.0301	1.9E-4	0.76	6.74	60.0372	5.35E-04	711.02	0.62	0.78	6.01E-06	6.01	1.31E+05
4	1.4E-4	0.0311	1.8E-4	0.70	6.74	59.5377	5.31E-04	682.43	0.61	0.79	6.09E-06	6.09	1.30E+05
5	1.4E-4	0.0323	1.7E-4	0.65	7.43	69.3301	6.18E-04	764.44	0.59	0.82	7.65E-06	7.65	1.07E+05
6	1.5E-4	0.0350	1.7E-4	0.65	7.22	67.1499	5.98E-04	683.92	0.57	0.80	8.00E-06	8.00	1.00E+05
6	1.4E-4	0.0350	1.6E-4	0.61	7.22	68.5790	6.11E-04	698.48	0.59	0.82	7.77E-06	7.77	1.05E+05
7	1.4E-4	0.0310	1.8E-4	0.68	7.14	73.0932	6.51E-04	840.51	0.54	0.83	1.02E-05	10.18	8.13E+04
8	1.3E-4	0.0318	1.6E-4	0.63	7.35	74.0748	6.60E-04	830.37	0.54	0.84	1.00E-05	10.02	8.36E+04
9	1.4E-4	0.0292	1.9E-4	0.72	7.22	72.0580	6.42E-04	879.69	0.53	0.83	1.03E-05	10.34	7.98E+04
10	1.2E-4	0.0317	1.5E-4	0.59	7.24	80.1133	7.14E-04	900.89	0.51	0.86	1.22E-05	12.18	7.02E+04
11	1.3E-4	0.0320	1.6E-4	0.64	6.98	80.8601	7.21E-04	900.77	0.52	0.85	1.21E-05	12.06	7.01E+04
11	1.3E-4	0.0320	1.6E-4	0.64	6.98	78.8815	7.03E-04	878.73	0.51	0.84	1.24E-05	12.38	6.80E+04
12	1.4E-4	0.0297	1.9E-4	0.73	6.87	90.1512	8.03E-04	1082.04	0.51	0.85	1.37E-05	13.70	6.22E+04
13	1.2E-4	0.0317	1.5E-4	0.57	7.22	90.4132	8.06E-04	1016.72	0.52	0.87	1.37E-05	13.65	6.41E+04
14	1.1E-4	0.0310	1.5E-4	0.57	7.54	90.2465	8.04E-04	1037.76	0.51	0.88	1.37E-05	13.68	6.41E+04
15	1.2E-4	0.0308	1.6E-4	0.62	6.58	94.0050	8.38E-04	1088.00	0.48	0.87	1.62E-05	16.21	5.38E+04
16	9.8E-5	0.0321	1.2E-4	0.48	6.97	90.0899	8.03E-04	1000.46	0.46	0.89	1.68E-05	16.84	5.29E+04
17	1.1E-4	0.0298	1.5E-4	0.57	6.67	102.1418	9.10E-04	1221.84	0.48	0.89	1.80E-05	18.03	4.95E+04
18	1.1E-4	0.0302	1.5E-4	0.57	7.12	101.0712	9.01E-04	1193.02	0.47	0.89	1.82E-05	18.20	4.90E+04
19	1.2E-4	0.0309	1.5E-4	0.58	7.18	106.6900	9.51E-04	1230.82	0.46	0.89	2.04E-05	20.43	4.36E+04
20	1.3E-4	0.0295	1.7E-4	0.66	7.22	95.6076	8.52E-04	1155.31	0.41	0.87	2.22E-05	22.21	3.92E+04
20	1.2E-4	0.0295	1.6E-4	0.63	7.22	97.4903	8.69E-04	1178.06	0.42	0.88	2.19E-05	21.91	4.01E+04

Table A -79 Ethylcylclohexane adsolubilization of C12,13-5PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 °C

y_45 22296

y_eth45 = 14.21 b_45 = 0

Sample	Ethy	Solution	Surf_in 7e^{-4}		Surf_eq		Eth_ini				Eth_eq (base 16.7)							
AF45	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**3**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	5	40	15.7125	7.0E-4	12.21	5.5E-4	5	97.52	0.000869	869.04	25.3156	26.5916	23.9580	25.2884	1.7796	34.7079	3.09E-04	309.31
2	5	40	15.7125	7.0E-4	12.212	5.5E-4	5	97.52	0.000869	869.04	24.8662	25.3120	26.5701	25.5828	1.8003	35.1120	3.13E-04	312.91
3	5	40	15.7125	7.0E-4	12.232	5.5E-4	5	97.52	0.000869	869.04	23.5177	26.6544	28.3030	26.1584	1.8408	35.9019	3.20E-04	319.95
4	6	40	15.7125	7.0E-4	12.221	5.5E-4	6	117.02	0.001043	1042.85	30.8825	29.5375	32.8540	31.0913	2.1880	42.6723	3.80E-04	380.29
5	6	40	15.7125	7.0E-4	12.335	5.5E-4	6	117.02	0.001043	1042.85	29.7671	32.6917	29.5537	30.6708	2.1584	42.0952	3.75E-04	375.15
6	6	40	15.7125	7.0E-4	12.255	5.5E-4	6	117.02	0.001043	1042.85	32.1617	29.1447	31.3869	30.8978	2.1744	42.4067	3.78E-04	377.92
7	7	40	15.7125	7.0E-4	12.021	5.4E-4	7	136.52	0.001217	1216.66	35.3023	34.7217	35.6221	35.2154	2.4782	48.3325	4.31E-04	430.73
8	7	40	15.7125	7.0E-4	12.258	5.5E-4	7	136.52	0.001217	1216.66	35.8702	33.8710		34.8706	2.4539	47.8593	4.27E-04	426.52
9	7	40	15.7125	7.0E-4	12.058	5.4E-4	7	136.52	0.001217	1216.66	36.4846	36.5484		36.5165	2.5698	50.1183	4.47E-04	446.65
10	8	40	15.7125	7.0E-4	12.012	5.4E-4	8	156.02	0.00139	1390.46	44.2651	44.6785	46.1805	45.0413	3.1697	61.8185	5.51E-04	550.92
11	8	40	15.7125	7.0E-4	12.122	5.4E-4	8	156.02	0.00139	1390.46	44.5420	46.4615	46.2023	45.7353	3.2185	62.7709	5.59E-04	559.41
12	8	40	15.7125	7.0E-4	12.35	5.5E-4	8	156.02	0.00139	1390.46	46.6545	42.8545	42.4440	43.9843	3.0953	60.3678	5.38E-04	537.99
13	8	40	15.7125	7.0E-4	11.87	5.3E-4	9	175.53	0.001564	1564.27	49.9851	47.4068	49.0150	48.8023	3.4344	66.9804	5.97E-04	596.92
14	9	40	15.7125	7.0E-4	11.94	5.4E-4	9	175.53	0.001564	1564.27	47.6964	47.4003	50.8448	48.6472	3.4234	66.7675	5.95E-04	595.02
15	9	40	15.7125	7.0E-4	11.878	5.3E-4	9	175.53	0.001564	1564.27	47.2605	47.4785	48.1804	47.6398	3.3526	65.3849	5.83E-04	582.70
16	10	40	15.7125	7.0E-4	11.95	5.4E-4	10	195.03	0.001738	1738.08	57.9455	54.7546	54.5441	55.7480	3.9232	76.5133	6.82E-04	681.88
17	10	40	15.7125	7.0E-4	11.988	5.4E-4	10	195.03	0.001738	1738.08	57.6555	57.2545	52.7545	55.8882	3.9330	76.7056	6.84E-04	683.59
18	11	40	15.7125	7.0E-4	11.998	5.4E-4	11	214.53	0.001912	1911.89	58.7695	56.6643	58.7291	58.0543	4.0855	79.6786	7.10E-04	710.08
19	11	40	15.7125	7.0E-4	11.94	5.4E-4	11	214.53	0.001912	1911.89	60.2377	60.7502	59.5911	60.1930	4.2360	82.6139	7.36E-04	736.24
20	12	40	15.7125	7.0E-4	11.98	5.4E-4	12	234.04	0.002086	2085.70	68.2077	65.1288	66.8412	66.7259	4.6957	91.5802	8.16E-04	816.15
21	12	40	15.7125	7.0E-4	12.048	5.4E-4	12	234.04	0.002086	2085.70	69.2544	65.2145	65.1455	66.5381	4.6825	91.3225	8.14E-04	813.85

Table A -79a Ethylcylclohexane adsolubilization of C12,13-5PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 ^{o}C

Sample **AF45**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**pH** final	**Eth(in-f)** (mg/l)	**Eth(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	X_{adm}	X_{aq}	X_{aq} **x 10^6**	**Kadm**
1	1.6E-4	0.0301	2.1E-4	0.81	6.89	62.8071	5.60E-04	743.82	0.64	0.78	5.57E-06	5.57	1.40E+05
2	1.6E-4	0.0306	2.1E-4	0.80	6.74	62.4030	5.56E-04	726.96	0.64	0.78	5.63E-06	5.63	1.38E+05
3	1.6E-4	0.0305	2.0E-4	0.80	6.74	61.6131	5.49E-04	720.11	0.63	0.78	5.76E-06	5.76	1.35E+05
4	1.6E-4	0.0302	2.1E-4	0.81	7.43	74.3457	6.63E-04	877.56	0.64	0.81	6.85E-06	6.85	1.18E+05
5	1.5E-4	0.0325	1.9E-4	0.72	7.22	74.9228	6.68E-04	821.79	0.64	0.82	6.75E-06	6.75	1.21E+05
6	1.6E-4	0.0303	2.0E-4	0.80	7.22	74.6113	6.65E-04	877.79	0.64	0.81	6.80E-06	6.80	1.19E+05
7	1.7E-4	0.0321	2.1E-4	0.80	7.14	88.1885	7.86E-04	979.34	0.65	0.83	7.75E-06	7.75	1.07E+05
8	1.5E-4	0.0328	1.9E-4	0.73	7.35	88.6617	7.90E-04	963.59	0.65	0.84	7.68E-06	7.68	1.09E+05
9	1.6E-4	0.0304	2.2E-4	0.84	7.22	86.4027	7.70E-04	1013.17	0.63	0.82	8.04E-06	8.04	1.03E+05
10	1.7E-4	0.0324	2.0E-4	0.80	7.24	94.2055	8.40E-04	1036.48	0.60	0.83	9.92E-06	9.92	8.42E+04
11	1.6E-4	0.0299	2.2E-4	0.84	6.98	93.2531	8.31E-04	1111.78	0.60	0.84	1.01E-05	10.07	8.32E+04
12	1.5E-4	0.0322	1.9E-4	0.73	6.98	95.6562	8.52E-04	1058.97	0.61	0.85	9.68E-06	9.68	8.77E+04
13	1.7E-4	0.0305	2.3E-4	0.88	6.87	108.5466	9.67E-04	1268.66	0.62	0.85	1.07E-05	10.75	7.90E+04
14	1.7E-4	0.0325	2.1E-4	0.81	7.22	108.7595	9.69E-04	1192.92	0.62	0.85	1.07E-05	10.71	7.95E+04
15	1.7E-4	0.0311	2.2E-4	0.86	7.54	110.1421	9.82E-04	1262.47	0.63	0.85	1.05E-05	10.49	8.11E+04
16	1.7E-4	0.0329	2.1E-4	0.80	6.58	118.5167	1.06E-03	1284.14	0.61	0.86	1.23E-05	12.27	7.02E+04
17	1.7E-4	0.0323	2.1E-4	0.80	6.97	118.3244	1.05E-03	1305.87	0.61	0.86	1.23E-05	12.31	7.02E+04
18	1.7E-4	0.0320	2.1E-4	0.81	6.67	134.8544	1.20E-03	1501.79	0.63	0.88	1.28E-05	12.78	6.87E+04
19	1.7E-4	0.0319	2.1E-4	0.82	7.12	131.9191	1.18E-03	1474.16	0.61	0.87	1.33E-05	13.25	6.60E+04
20	1.7E-4	0.0322	2.1E-4	0.81	7.18	142.4558	1.27E-03	1577.08	0.61	0.88	1.47E-05	14.69	6.01E+04
21	1.6E-4	0.0310	2.1E-4	0.82	7.22	142.7135	1.27E-03	1641.09	0.61	0.89	1.47E-05	14.65	6.04E+04

Table A -80 Ethylcylclohexane adsolubilization of C12,13-8PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 ^{o}C

y_48 20874

y_eth48 = 14.21 b48 = 13.21

Sample	Ethy	Solution	Surf_in 7e^{-4}		Surf_eq		Eth_ini				Eth_eq (base 16.7)							
AF48	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	Molar	uMolar	1	2	3	av	ul	mg/l	Molar	uMolar
1	5	5	15.2141	7.3E-4	11.4544	5.5E-4	5	97.52	0.000869	869.04	4.65	4.81	4.51	4.66	1.2573	24.5218	2.19E-04	218.53
2	5	5	15.2141	7.3E-4	11.2545	5.4E-4	5	97.52	0.000869	869.04	4.81	5.27	5.29	5.12	1.2900	25.1598	2.24E-04	224.22
3	6	6	15.2141	7.3E-4	11.8540	5.7E-4	6	117.02	0.001043	1042.85	12.23	12.75	11.83	12.27	1.7929	34.9678	3.12E-04	311.63
4	6	6	15.2141	7.3E-4	11.2844	5.4E-4	6	117.02	0.001043	1042.85	12.20	12.83		12.51	1.8101	35.3024	3.15E-04	314.61
17	6	6	15.2141	7.3E-4	11.5440	5.5E-4	6	117.02	0.001043	1042.85	11.50	12.30	15.42	13.07	1.8495	36.0709	3.21E-04	321.46
5	7	7	15.2141	7.3E-4	11.8524	5.7E-4	7	136.52	0.001217	1216.66	19.02	18.95		18.99	2.2657	44.1888	3.94E-04	393.80
6	7	7	15.2141	7.3E-4	11.1011	5.3E-4	7	136.52	0.001217	1216.66	19.72	19.92		19.82	2.3244	45.3332	4.04E-04	404.00
19	7	7	15.2141	7.3E-4	11.4551	5.5E-4	7	136.52	0.001217	1216.66	15.77			15.77	2.0397	39.7805	3.55E-04	354.52
18	8	8	15.2141	7.3E-4	11.7445	5.6E-4	8	156.02	0.00139	1390.46	29.76	33.45	29.25	30.82	3.0985	60.4306	5.39E-04	538.55
7	8	8	15.2141	7.3E-4	11.9542	5.7E-4	8	156.02	0.00139	1390.46	25.82	25.44		25.63	2.7331	53.3043	4.75E-04	475.04
8	8	8	15.2141	7.3E-4	11.5854	5.6E-4	8	156.02	0.00139	1390.46	27.52	25.92		26.72	2.8101	54.8046	4.88E-04	488.41
9	9	9	15.2141	7.3E-4	12.2541	5.9E-4	9	175.53	0.001564	1564.27	30.24	34.42		32.33	3.2047	62.5011	5.57E-04	557.00
10	9	9	15.2141	7.3E-4	11.8650	5.7E-4	9	175.53	0.001564	1564.27	32.59	34.25		33.42	3.2815	63.9990	5.70E-04	570.35
11	10	10	15.2141	7.3E-4	11.8440	5.7E-4	10	195.03	0.001738	1738.08	37.25	37.25	39.45	37.99	3.6028	70.2648	6.26E-04	626.19
12	10	10	15.2141	7.3E-4	12.1400	5.8E-4	10	195.03	0.001738	1738.08	39.55	38.21		38.88	3.6657	71.4927	6.37E-04	637.13
20	10	10	15.2141	7.3E-4	12.2100	5.8E-4	10	195.03	0.001738	1738.08	40.62	39.30		39.96	3.7416	72.9718	6.50E-04	650.31
13	11	11	15.2141	7.3E-4	11.8750	5.7E-4	11	214.53	0.001912	1911.89	42.99	42.50		42.75	3.9379	76.7999	6.84E-04	684.43
14	11	11	15.2141	7.3E-4	12.1000	5.8E-4	11	214.53	0.001912	1911.89	45.91	42.58		44.25	4.0434	78.8577	7.03E-04	702.77
15	12	12	15.2141	7.3E-4	12.1020	5.8E-4	12	234.04	0.002086	2085.70	52.64	53.24		52.94	4.6550	90.7862	8.09E-04	809.07
16	12	12	15.2141	7.3E-4	11.9854	5.7E-4	12	234.04	0.002086	2085.70	52.32	50.30		51.31	4.5408	88.5591	7.89E-04	789.23

Table A -80a Ethylcylclohexane adsolubilization of C12,13-8PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 ^{o}C

Sample **AF48**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^2	**pH** final	**Eth(in-f)** (mg/l)	**Eth(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	**X_{adm}**	**X_{aq}**	**X_{aq} x 10^6**	**Kadm**
1	1.8E-4	0.0321	2.8E-5	0.11	7.23	72.9932	6.51E-04	810.60	0.75	0.78	3.93E-06	3.93	1.99E+05
2	1.9E-4	0.0299	3.2E-5	0.12	6.89	72.3552	6.45E-04	862.64	0.74	0.77	4.04E-06	4.04	1.91E+05
3	1.6E-4	0.0305	3.2E-5	0.12	6.84	82.0502	7.31E-04	958.98	0.70	0.82	5.61E-06	5.61	1.46E+05
4	1.9E-4	0.0311	3.6E-5	0.14	6.94	81.7156	7.28E-04	936.64	0.70	0.79	5.66E-06	5.66	1.40E+05
17	1.8E-4	0.0303	3.5E-5	0.14	7.36	80.9471	7.21E-04	952.33	0.69	0.80	5.79E-06	5.79	1.39E+05
5	1.6E-4	0.0303	3.7E-5	0.14	7.23	92.3322	8.23E-04	1086.27	0.68	0.84	7.09E-06	7.09	1.18E+05
6	2.0E-4	0.0301	4.6E-5	0.18	7.25	91.1878	8.13E-04	1079.94	0.67	0.80	7.27E-06	7.27	1.11E+05
19	1.8E-4	0.0309	4.1E-5	0.16	6.78	96.7405	8.62E-04	1116.04	0.71	0.83	6.38E-06	6.38	1.30E+05
18	1.7E-4	0.0300	4.4E-5	0.17	7.25	95.5934	8.52E-04	1135.89	0.61	0.84	9.69E-06	9.69	8.63E+04
7	1.6E-4	0.0310	4.0E-5	0.16	7.14	102.7197	9.15E-04	1181.19	0.66	0.85	8.55E-06	8.55	9.99E+04
8	1.7E-4	0.0318	4.4E-5	0.17	7.35	101.2194	9.02E-04	1134.66	0.65	0.84	8.79E-06	8.79	9.54E+04
9	1.4E-4	0.0292	4.4E-5	0.17	7.22	113.0259	1.01E-03	1379.82	0.64	0.88	1.00E-05	10.03	8.74E+04
10	1.6E-4	0.0297	4.9E-5	0.19	6.84	111.5280	9.94E-04	1338.62	0.64	0.86	1.03E-05	10.27	8.39E+04
11	1.6E-4	0.0320	5.0E-5	0.20	6.98	124.7652	1.11E-03	1389.86	0.64	0.87	1.13E-05	11.27	7.75E+04
12	1.5E-4	0.0303	4.9E-5	0.19	6.75	123.5373	1.10E-03	1453.40	0.63	0.88	1.15E-05	11.47	7.69E+04
20	1.4E-4	0.0295	4.9E-5	0.19	6.98	122.0582	1.09E-03	1474.94	0.63	0.88	1.17E-05	11.71	7.54E+04
13	1.6E-4	0.0317	5.6E-5	0.22	7.12	137.7331	1.23E-03	1548.84	0.64	0.88	1.23E-05	12.32	7.18E+04
14	1.5E-4	0.0310	5.3E-5	0.21	7.33	135.6753	1.21E-03	1560.15	0.63	0.89	1.27E-05	12.65	7.04E+04
15	1.5E-4	0.0308	5.8E-5	0.23	7.1	143.2498	1.28E-03	1657.95	0.61	0.90	1.46E-05	14.56	6.15E+04
16	1.5E-4	0.0313	5.9E-5	0.23	7.14	145.4769	1.30E-03	1656.83	0.62	0.89	1.42E-05	14.21	6.29E+04

Table A -81 Ethylcylclohexane adsolubilization of C14,15-3PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 °C

y_53 19798

y_eth53 = 9.77 b_53 = 13.21

Sample	Ethy	Solution	Surf_in 7e^{-4}		Surf_eq		Eth_ini				Eth_eq (base 16.7)							
AF53	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**3**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	5	40	12.1253	6.1E-4	7.2581	3.7E-4	5	97.52	0.000869	869.04	10.50	9.40	10.00	9.97	2.3722	46.2656	4.12E-04	412.31
2	5	40	12.1253	6.1E-4	7.5657	3.8E-4	5	97.52	0.000869	869.04	8.40	9.60	9.30	9.10	2.2835	44.5355	3.97E-04	396.89
3	5	40	12.1253	6.1E-4	7.3426	3.7E-4	5	97.52	0.000869	869.04	10.50	9.80	8.60	9.63	2.3381	45.6002	4.06E-04	406.38
4	6	40	12.1253	6.1E-4	7.4533	3.8E-4	6	117.02	0.001043	1042.85	15.26	14.25	12.60	14.04	2.7888	54.3901	4.85E-04	484.72
5	6	40	12.1253	6.1E-4	7.2755	3.7E-4	6	117.02	0.001043	1042.85	16.50	16.90	15.60	16.33	3.0239	58.9748	5.26E-04	525.58
6	6	40	12.1253	6.1E-4	7.2753	3.7E-4	6	117.02	0.001043	1042.85	16.10	16.80	14.20	15.70	2.9591	57.7105	5.14E-04	514.31
7	7	40	12.1253	6.1E-4	7.1675	3.6E-4	7	136.52	0.001217	1216.66	15.90	17.50	15.60	16.33	3.0239	58.9748	5.26E-04	525.58
8	7	40	12.1253	6.1E-4	7.2347	3.7E-4	7	136.52	0.001217	1216.66	19.30	20.70	19.30	19.77	3.3753	65.8284	5.87E-04	586.65
9	7	40	12.1253	6.1E-4	7.0745	3.6E-4	7	136.52	0.001217	1216.66	20.30	23.40	22.40	22.03	3.6073	70.3532	6.27E-04	626.98
10	8	40	12.1253	6.1E-4	7.2554	3.7E-4	8	156.02	0.00139	1390.46	21.20	21.10	25.54	22.61	3.6667	71.5110	6.37E-04	637.30
11	8	40	12.1253	6.1E-4	7.0565	3.6E-4	8	156.02	0.00139	1390.46	23.50	23.80	22.14	23.15	3.7213	72.5756	6.47E-04	646.78
12	8	40	12.1253	6.1E-4	7.0656	3.6E-4	8	156.02	0.00139	1390.46	24.50	24.80	23.90	24.40	3.8495	75.0776	6.69E-04	669.08
13	9	40	12.1253	6.1E-4	7.5654	3.8E-4	9	175.53	0.001564	1564.27	28.80	27.50	30.90	29.07	4.3272	84.3932	7.52E-04	752.10
14	9	40	12.1253	6.1E-4	7.4322	3.8E-4	9	175.53	0.001564	1564.27	27.90	29.80	27.70	28.47	4.2658	83.1955	7.41E-04	741.43
15	10	40	12.1253	6.1E-4	7.2354	3.7E-4	10	195.03	0.001738	1738.08	30.50	32.60	30.50	31.20	4.5455	88.6518	7.90E-04	790.05
16	10	40	12.1253	6.1E-4	7.0765	3.6E-4	10	195.03	0.001738	1738.08	29.58	28.44	28.10	28.71	4.2903	83.6746	7.46E-04	745.70
17	11	40	12.1253	6.1E-4	7.5232	3.8E-4	11	214.53	0.001912	1911.89	35.75	32.98	33.84	34.19	4.8516	94.6205	8.43E-04	843.24
18	11	40	12.1253	6.1E-4	7.3354	3.7E-4	11	214.53	0.001912	1911.89	31.25	35.12	35.10	33.82	4.8141	93.8892	8.37E-04	836.73
19	12	40	12.1253	6.1E-4	7.6565	3.9E-4	12	234.04	0.002086	2085.70	48.10	48.25	46.10	47.48	6.2122	121.1568	1.08E-03	1079.73
20	12	40	12.1253	6.1E-4	7.2324	3.7E-4	12	234.04	0.002086	2085.70	48.40	50.90	50.20	49.83	6.4527	125.8479	1.12E-03	1121.54

Table A -81a Ethylcylclohexane adsolubilization of C14,15-3PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 ^{o}C

Sample **AF53**	**Cs** (M)	**Alumina** (g)	**q** mole/g	**[q]** molecule/nm^{2}	**pH** final	**Eth(in-f)** (mg/l)	**Eth(in-f)** Molar	**Adsbilized** **umole/g(alumina)**	**Degree of adsl**	**X_{adm}**	**X_{aq}**	**X_{aq} x 10^{6}**	**Kadm**
1	2.5E-4	0.0321	3.1E-4	1.19	7.23	51.2494	4.57E-04	569.13	0.53	0.65	7.42E-06	7.42	8.76E+04
2	2.3E-4	0.0299	3.1E-4	1.20	6.89	52.9795	4.72E-04	631.63	0.54	0.67	7.14E-06	7.14	9.41E+04
3	2.4E-4	0.0305	3.2E-4	1.23	6.84	51.9148	4.63E-04	606.76	0.53	0.66	7.32E-06	7.32	8.98E+04
4	2.4E-4	0.0311	3.0E-4	1.18	6.94	62.6279	5.58E-04	717.85	0.54	0.70	8.73E-06	8.73	8.05E+04
5	2.4E-4	0.0303	3.2E-4	1.26	7.23	58.0432	5.17E-04	682.87	0.50	0.68	9.46E-06	9.46	7.17E+04
6	2.4E-4	0.0301	3.3E-4	1.27	7.25	59.3075	5.29E-04	702.38	0.51	0.68	9.26E-06	9.26	7.38E+04
7	2.5E-4	0.0310	3.2E-4	1.26	7.14	77.5462	6.91E-04	891.72	0.57	0.73	9.46E-06	9.46	7.76E+04
8	2.5E-4	0.0318	3.1E-4	1.21	7.35	70.6926	6.30E-04	792.46	0.52	0.72	1.06E-05	10.56	6.80E+04
9	2.6E-4	0.0292	3.5E-4	1.36	7.22	66.1678	5.90E-04	807.78	0.48	0.70	1.13E-05	11.29	6.18E+04
10	2.5E-4	0.0297	3.3E-4	1.29	6.84	84.5130	7.53E-04	1014.37	0.54	0.75	1.15E-05	11.47	6.57E+04
11	2.6E-4	0.0320	3.2E-4	1.24	6.98	83.4484	7.44E-04	929.60	0.53	0.74	1.16E-05	11.64	6.39E+04
12	2.6E-4	0.0303	3.4E-4	1.31	6.75	80.9464	7.21E-04	952.32	0.52	0.74	1.20E-05	12.04	6.13E+04
13	2.3E-4	0.0317	2.9E-4	1.13	7.12	91.1338	8.12E-04	1024.82	0.52	0.78	1.35E-05	13.54	5.75E+04
14	2.4E-4	0.0310	3.1E-4	1.19	7.33	92.3315	8.23E-04	1061.74	0.53	0.78	1.33E-05	13.35	5.82E+04
15	2.5E-4	0.0308	3.2E-4	1.25	7.1	106.3782	9.48E-04	1231.20	0.55	0.79	1.42E-05	14.22	5.58E+04
16	2.6E-4	0.0313	3.3E-4	1.27	7.14	111.3554	9.92E-04	1268.22	0.57	0.80	1.34E-05	13.42	5.93E+04
17	2.3E-4	0.0303	3.1E-4	1.19	7.36	119.9125	1.07E-03	1410.75	0.56	0.82	1.52E-05	15.18	5.41E+04
18	2.4E-4	0.0300	3.2E-4	1.25	7.25	120.6438	1.08E-03	1433.55	0.56	0.82	1.51E-05	15.06	5.42E+04
19	2.3E-4	0.0309	2.9E-4	1.14	6.78	112.8792	1.01E-03	1302.22	0.48	0.82	1.94E-05	19.44	4.20E+04
20	2.5E-4	0.0295	3.4E-4	1.30	6.98	108.1881	9.64E-04	1307.33	0.46	0.80	2.02E-05	20.19	3.94E+04

Table A -82 Ethylcylclohexane adsolubilization of C14,15-5PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 °C

y_55 18874 y_eth_55 = 14.21 b_55 = 13.13

Sample	Ethy	Solution	Surf_in 7e^{-4}		Surf_eq		Eth_ini				Eth_eq (base 16.7)							
AF55	(ul)	(ml)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**3**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	6	40	14.2200	7.5E-4	8.5467	4.5E-4	6	117.02	0.001043	1042.85	23.40	24.50		23.95	2.6094	50.8917	4.54E-04	453.54
2	6	40	13.4355	7.1E-4	7.9860	4.2E-4	6	117.02	0.001043	1042.85	22.50	22.10		22.30	2.4933	48.6271	4.33E-04	433.36
3	7	40	13.4355	7.1E-4	8.4345	4.5E-4	7	136.52	0.001217	1216.66	32.80	31.10	31.30	31.73	3.1572	61.5742	5.49E-04	548.74
4	7	40	13.4355	7.1E-4	8.3440	4.4E-4	7	136.52	0.001217	1216.66	31.50	30.50	32.50	31.50	3.1407	61.2540	5.46E-04	545.89
5	8	40	13.4355	7.1E-4	8.2387	4.4E-4	8	156.02	0.00139	1390.46	36.14	35.21	35.14	35.50	3.4222	66.7435	5.95E-04	594.81
6	8	40	13.4355	7.1E-4	8.4109	4.5E-4	8	156.02	0.00139	1390.46	36.25	36.21	35.21	35.89	3.4500	67.2847	6.00E-04	599.63
7	9	40	13.4355	7.1E-4	8.2433	4.4E-4	9	175.53	0.001564	1564.27	38.20	37.70	35.60	37.17	3.5395	69.0314	6.15E-04	615.20
8	9	40	13.4355	7.1E-4	8.1376	4.3E-4	9	175.53	0.001564	1564.27	39.90	37.90		38.90	3.6615	71.4104	6.36E-04	636.40
9	10	40	13.4355	7.1E-4	8.4679	4.5E-4	10	195.03	0.001738	1738.08	43.90	44.88		44.39	4.0477	78.9419	7.04E-04	703.52
10	10	40	13.4355	7.1E-4	8.0163	4.2E-4	10	195.03	0.001738	1738.08	44.50	41.10		42.80	3.9360	76.7630	6.84E-04	684.10
11	11	40	13.4355	7.1E-4	8.0113	4.2E-4	11	214.53	0.001912	1911.89	47.90	45.60		46.75	4.2139	82.1844	7.32E-04	732.42
12	11	40	13.4355	7.1E-4	8.3671	4.4E-4	11	214.53	0.001912	1911.89	46.40	47.80		47.10	4.2386	82.6647	7.37E-04	736.70
13	12	40	13.4355	7.1E-4	8.2998	4.4E-4	12	234.04	0.002086	2085.70	51.70	50.60		51.15	4.5236	88.2233	7.86E-04	786.23
14	12	40	13.4355	7.1E-4	8.4513	4.5E-4	12	234.04	0.002086	2085.70	47.90	49.60		48.75	4.3547	84.9293	7.57E-04	756.88
15	12.5	40	13.4355	7.1E-4	8.1223	4.3E-4	12.5	243.79	0.002173	2172.60	52.70	52.45	51.80	52.32	4.6056	89.8227	8.00E-04	800.49
16	12.5	40	13.4355	7.1E-4	8.3433	4.4E-4	12.5	243.79	0.002173	2172.60	53.10	52.99		53.04	4.6568	90.8217	8.09E-04	809.39
17	13	40	13.4355	7.1E-4	8.2233	4.4E-4	13	253.54	0.00226	2259.50	59.32	59.25		59.29	5.0961	99.3884	8.86E-04	885.74
18	13	40	13.4355	7.1E-4	8.4198	4.5E-4	13	253.54	0.00226	2259.50	60.82	60.11		60.47	5.1791	101.0080	9.00E-04	900.17
19	14	40	13.4355	7.1E-4	8.4609	4.5E-4	14	273.04	0.002433	2433.31	72.20	78.30		75.25	6.2196	121.3002	1.08E-03	1081.01
20	14	40	13.4355	7.1E-4	8.0299	4.3E-4	14	273.04	0.002433	2433.31	72.20	78.30		75.25	6.2196	121.3002	1.08E-03	1081.01

Table A -82a Ethylcylclohexane adsolubilization of C14,15-5PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 ^{o}C

Sample	**Cs**	**Alumina**	**q**	**[q]**	**pH**	**Eth(in-f)**	**Eth(in-f)**	**Adsbilized**					
AF55	(M)	(g)	mole/g	molecule/nm^2	final	(mg/l)	Molar	**umole/g(alumina)**	**Degree of adsl**	**X_{adm}**	**X_{aq}**	**X_{aq} x 10^6**	**Kadm**
1	3.0E-4	0.0315	3.8E-4	1.48	6.25	66.1263	5.89E-04	748.33	0.57	0.66	8.16E-06	8.16	8.11E+04
2	2.9E-4	0.0300	3.8E-4	1.50	7.25	68.3909	6.09E-04	812.65	0.58	0.68	7.80E-06	7.80	8.70E+04
3	2.6E-4	0.0321	3.3E-4	1.28	7.23	74.9468	6.68E-04	832.29	0.55	0.72	9.88E-06	9.88	7.25E+04
4	2.7E-4	0.0299	3.6E-4	1.40	6.89	75.2670	6.71E-04	897.35	0.55	0.71	9.83E-06	9.83	7.26E+04
5	2.8E-4	0.0305	3.6E-4	1.40	6.84	89.2805	7.96E-04	1043.48	0.57	0.74	1.07E-05	10.71	6.94E+04
6	2.7E-4	0.0311	3.4E-4	1.33	6.94	88.7393	7.91E-04	1017.15	0.57	0.75	1.08E-05	10.79	6.93E+04
7	2.8E-4	0.0303	3.6E-4	1.41	7.23	106.4956	9.49E-04	1252.90	0.61	0.78	1.11E-05	11.07	7.00E+04
8	2.8E-4	0.0301	3.7E-4	1.45	7.25	104.1166	9.28E-04	1233.05	0.59	0.77	1.15E-05	11.46	6.70E+04
9	2.6E-4	0.0310	3.4E-4	1.32	7.14	116.0881	1.03E-03	1334.92	0.60	0.80	1.27E-05	12.66	6.29E+04
10	2.9E-4	0.0318	3.6E-4	1.40	7.35	118.2670	1.05E-03	1325.76	0.61	0.79	1.23E-05	12.31	6.38E+04
11	2.9E-4	0.0292	3.9E-4	1.53	7.22	132.3486	1.18E-03	1615.72	0.62	0.80	1.32E-05	13.18	6.10E+04
12	2.7E-4	0.0297	3.6E-4	1.41	6.84	131.8683	1.18E-03	1582.75	0.61	0.81	1.33E-05	13.26	6.14E+04
13	2.7E-4	0.0320	3.4E-4	1.32	6.98	145.8127	1.30E-03	1624.33	0.62	0.83	1.42E-05	14.15	5.84E+04
14	2.6E-4	0.0303	3.5E-4	1.35	6.75	149.1067	1.33E-03	1754.22	0.64	0.83	1.36E-05	13.62	6.12E+04
15	2.8E-4	0.0309	3.6E-4	1.42	6.78	153.9648	1.37E-03	1776.20	0.63	0.83	1.44E-05	14.41	5.76E+04
16	2.7E-4	0.0295	3.7E-4	1.42	6.98	152.9658	1.36E-03	1848.42	0.63	0.83	1.46E-05	14.57	5.73E+04
17	2.8E-4	0.0317	3.5E-4	1.35	7.12	154.1506	1.37E-03	1733.46	0.61	0.83	1.59E-05	15.94	5.22E+04
18	2.7E-4	0.0310	3.4E-4	1.33	7.33	152.5310	1.36E-03	1753.98	0.60	0.84	1.62E-05	16.20	5.16E+04
19	2.6E-4	0.0308	3.4E-4	1.33	7.1	151.7418	1.35E-03	1756.24	0.56	0.84	1.95E-05	19.46	4.30E+04
20	2.9E-4	0.0313	3.7E-4	1.42	7.14	151.7418	1.35E-03	1728.18	0.56	0.83	1.95E-05	19.46	4.24E+04

Table A -83 Ethylcylclohexane adsolubilization of C14,15-8PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 °C

y_58 14504 y_eth_58 = 15.9061 b_58 = 14.22

Sample	**Ethy**	**Surf_in 7e^{-4}**		**Surf_eq**		**Eth_ini**				**Eth_eq (base 16.7)**							
AF58	(ul)	ECD	conc (M)	ECD	conc (M)	ul	mg/l	**Molar**	**uMolar**	**1**	**2**	**3**	**av**	**ul**	**mg/l**	**Molar**	**uMolar**
1	5	9.1212	6.3E-4	5.7501	4.0E-4	5	97.52	0.000869	869.04	24.8662	25.3120	23.9580	24.7121	2.4476	47.7359	4.25E-04	425.42
2	5	9.1212	6.3E-4	5.8940	4.1E-4	5	97.52	0.000869	869.04	25.5660	24.9880	24.5896	25.0479	2.4687	48.1476	4.29E-04	429.09
3	5	9.1212	6.3E-4	5.6602	3.9E-4	5	97.52	0.000869	869.04	25.8825	25.5370	26.5770	25.9988	2.5285	49.3136	4.39E-04	439.48
4	6	9.1212	6.3E-4	5.5226	3.8E-4	6	117.02	0.001043	1042.85	29.2550	29.3566	30.2250	29.6122	2.7557	53.7441	4.79E-04	478.96
5	6	9.1212	6.3E-4	5.9831	4.1E-4	6	117.02	0.001043	1042.85	31.8702	29.6544	32.3033	31.2760	2.8603	55.7841	4.97E-04	497.14
6	6	9.1212	6.3E-4	5.9352	4.1E-4	6	117.02	0.001043	1042.85	30.1520	29.1447	33.3869	30.8945	2.8363	55.3164	4.93E-04	492.97
7	7	9.1212	6.3E-4	5.4525	3.8E-4	7	136.52	0.001217	1216.66	33.2651	34.6750	35.1841	34.3747	3.0551	59.5836	5.31E-04	531.00
8	7	9.1212	6.3E-4	5.9781	4.1E-4	7	136.52	0.001217	1216.66	33.3023	33.7217	35.7206	34.2482	3.0471	59.4285	5.30E-04	529.62
9	7	9.1212	6.3E-4	5.9146	4.1E-4	7	136.52	0.001217	1216.66	34.5177	33.8700	35.4407	34.6094	3.0699	59.8714	5.34E-04	533.57
10	8	9.1212	6.3E-4	5.4440	3.8E-4	8	156.02	0.00139	1390.46	40.6964	38.4052	39.1050	39.4022	3.3712	65.7480	5.86E-04	585.94
11	8	9.1212	6.3E-4	5.6402	3.9E-4	8	156.02	0.00139	1390.46	39.6640	37.4003	38.8448	38.6363	3.3230	64.8089	5.78E-04	577.57
12	8	9.1212	6.3E-4	5.6537	3.9E-4	8	156.02	0.00139	1390.46	38.5420	37.1784	38.9855	38.2353	3.2978	64.3172	5.73E-04	573.19
13	9	9.1212	6.3E-4	5.5221	3.8E-4	9	175.53	0.001564	1564.27	42.2377	42.7800	41.5411	42.1863	3.5462	69.1616	6.16E-04	616.36
14	9	9.1212	6.3E-4	5.4582	3.8E-4	9	175.53	0.001564	1564.27	40.7695	40.4260	41.7291	40.9749	3.4700	67.6763	6.03E-04	603.12
15	10	9.1212	6.3E-4	5.9580	4.1E-4	10	195.03	0.001738	1738.08	46.1000	45.1000	46.2020	45.8007	3.7734	73.5933	6.56E-04	655.85
16	10	9.1212	6.3E-4	5.7786	4.0E-4	10	195.03	0.001738	1738.08	46.2554	45.8000	46.2885	46.1146	3.7932	73.9783	6.59E-04	659.28
17	11	9.1212	6.3E-4	6.0126	4.1E-4	11	214.53	0.001912	1911.89	51.6780	51.2000	52.5770	51.8183	4.1518	80.9718	7.22E-04	721.61
18	11	9.1212	6.3E-4	5.9852	4.1E-4	11	214.53	0.001912	1911.89	54.2550	54.2220	53.2840	53.9203	4.2839	83.5491	7.45E-04	744.58
19	12	9.1212	6.3E-4	5.7257	3.9E-4	12	234.04	0.002086	2085.70	53.3000	58.6000	62.1900	58.0300	4.5423	88.5881	7.89E-04	789.49
20	12	9.1212	6.3E-4	5.7954	4.0E-4	12	234.04	0.002086	2085.70	64.8000	62.3000	60.0000	62.3667	4.8149	93.9055	8.37E-04	836.87
21	12	9.1212	6.3E-4	5.7257	3.9E-4	13	253.54	0.00226	2259.50	86.0000	86.5000	82.2000	84.9000	6.2316	121.5343	1.08E-03	1083.10
22	12	9.1212	6.3E-4	5.7954	4.0E-4	13	253.54	0.00226	2259.50	90.9600	90.8000	91.6000	91.1200	6.6226	129.1609	1.15E-03	1151.06
23	12	9.1212	6.3E-4	5.7257	3.9E-4	14	273.04	0.002433	2433.31	116.7000	116.9000		116.8000	8.2371	160.6480	1.43E-03	1431.67
24	12	9.1212	6.3E-4	5.7954	4.0E-4	14	273.04	0.002433	2433.31	126.7000	127.2000	124.2000	126.0333	8.8176	171.9693	1.53E-03	1532.57

Table A -83a Ethylcylclohexane adsolubilization of C14,15-8PO-SO4 at 0.001 M NaCl, pH 7.0±0.5 and temperature 25±2 °C

Sample	**Cs**	**Alumina**	**q**	**[q]**	**pH**	**Eth(in-f)**	**Eth(in-f)**	**Adsbilized**					
AF58	(M)	(g)	mole/g	molecule/nm^2	final	(mg/l)	Molar	**umole/g(alumina)**	**Degree of adsl**	**X_{adm}**	**X_{aq}**	**X_{aq} x 10^6**	**Kadm**
1	2.3E-4	0.0317	2.9E-4	1.14	6.85	49.7791	4.44E-04	559.78	0.51	0.66	7.66E-06	7.66	8.57E+04
2	2.2E-4	0.0326	2.7E-4	1.06	6.95	49.3674	4.40E-04	539.82	0.51	0.66	7.72E-06	7.72	8.60E+04
3	2.4E-4	0.0316	3.0E-4	1.17	6.84	48.2014	4.30E-04	543.75	0.49	0.64	7.91E-06	7.91	8.13E+04
4	2.5E-4	0.0311	3.2E-4	1.24	6.56	63.2739	5.64E-04	725.26	0.54	0.69	8.62E-06	8.62	8.05E+04
5	2.2E-4	0.0320	2.7E-4	1.05	7.21	61.2339	5.46E-04	682.14	0.52	0.72	8.95E-06	8.95	8.00E+04
6	2.2E-4	0.0307	2.9E-4	1.11	7.44	61.7016	5.50E-04	716.45	0.53	0.71	8.87E-06	8.87	8.05E+04
7	2.5E-4	0.0297	3.4E-4	1.32	7.35	76.9374	6.86E-04	923.44	0.56	0.73	9.56E-06	9.56	7.64E+04
8	2.2E-4	0.0323	2.7E-4	1.04	7.12	77.0925	6.87E-04	850.82	0.56	0.76	9.53E-06	9.53	7.97E+04
9	2.2E-4	0.0310	2.9E-4	1.11	6.87	76.6496	6.83E-04	881.41	0.56	0.76	9.61E-06	9.61	7.87E+04
10	2.5E-4	0.0317	3.2E-4	1.24	6.58	90.2760	8.05E-04	1015.18	0.58	0.76	1.05E-05	10.55	7.21E+04
11	2.4E-4	0.0307	3.1E-4	1.22	6.75	91.2151	8.13E-04	1059.15	0.58	0.77	1.04E-05	10.40	7.43E+04
12	2.4E-4	0.0325	2.9E-4	1.14	6.78	91.7068	8.17E-04	1005.88	0.59	0.77	1.03E-05	10.32	7.50E+04
13	2.5E-4	0.0310	3.2E-4	1.24	7.21	106.3654	9.48E-04	1223.11	0.61	0.79	1.11E-05	11.10	7.14E+04
14	2.5E-4	0.0314	3.2E-4	1.25	7.33	107.8507	9.61E-04	1224.40	0.61	0.79	1.09E-05	10.86	7.29E+04
15	2.2E-4	0.0304	2.9E-4	1.12	7.25	121.4367	1.08E-03	1423.98	0.62	0.83	1.18E-05	11.81	7.05E+04
16	2.3E-4	0.0315	2.9E-4	1.14	7.05	121.0517	1.08E-03	1369.90	0.62	0.82	1.19E-05	11.87	6.94E+04
17	2.1E-4	0.0303	2.8E-4	1.10	7.44	133.5612	1.19E-03	1569.77	0.62	0.85	1.30E-05	12.99	6.52E+04
18	2.2E-4	0.0319	2.7E-4	1.05	6.58	130.9839	1.17E-03	1463.71	0.61	0.84	1.34E-05	13.40	6.29E+04
19	2.3E-4	0.0301	3.1E-4	1.21	6.97	145.4479	1.30E-03	1722.54	0.62	0.85	1.42E-05	14.21	5.96E+04
20	2.3E-4	0.0309	3.0E-4	1.15	7.12	140.1305	1.25E-03	1616.60	0.60	0.84	1.51E-05	15.06	5.61E+04
21	2.3E-4	0.0301	3.1E-4	1.21	6.97	132.0047	1.18E-03	1563.33	0.52	0.83	1.95E-05	19.50	4.28E+04
22	2.3E-4	0.0309	3.0E-4	1.15	7.12	124.3781	1.11E-03	1434.87	0.49	0.83	2.07E-05	20.72	4.00E+04
23	2.3E-4	0.0301	3.1E-4	1.21	6.97	112.3940	1.00E-03	1331.08	0.41	0.81	2.58E-05	25.77	3.15E+04
24	2.3E-4	0.0309	3.0E-4	1.15	7.12	101.0727	9.01E-04	1166.01	0.37	0.80	2.76E-05	27.59	2.89E+04

Table A - 84 Zetapotential measurement

Al2O3	24.74	24.3	33.64	22.26	29.64	23.57	av	26.36			
48/w	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**average**	**std**
0	-45	-38.5	-44.8	-48.5	-35.7	-46.5	-43.17	-42.58	-44.97	-43.30	3.98
1	-23	-45	-27	-27	-16	-18.56	-26.09	-24.56	-37.56	-27.20	9.02
2	-26	-20	-20.8	-21.2	-22.8	-20.28	-21.85	-27.56	-23.1	-22.62	2.61
3	-12.6	-19.4	-10.4	-14.3	-18.3	-17.3	-15.38	-14.56	-19.74	-15.78	3.17
4	-12.6	-12.1	-13.9	-16.6	-10.9	-10.3	-12.73	-12.01	-10.56	-12.41	1.95
5	1.17	1.27	1.31	3.39	2.04	2.57	1.48	2.05	3.45	2.08	0.89
10	8.45	9.25	9.87	10.23	11.25	8.47	7.35	10.58	12.24	9.74	1.53
45/w	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**average**	**std**
0	-45	-43	-49	-53	-42	-40	-42.5	-48.50	-45.07	-45.34	4.11
1	-28	-27.58	-29	-33.47	-40.25	-38.27	-38.45	-45.6	-38.4	-35.45	6.27
2	-20.9	-25.5	-30.5	-35.4	-29.5	-27.5	-31.68	-35.54	-32.54	-29.90	4.73
3	-12.95	-18.56	-15.6	-17.25	-11.5	-12.54	-10.25	-8.6	-10.3	-13.06	3.40
4	-7.5	-7.7	-10.25	-12.36	-9.8	-10.54	-11.45	-8.75	-7.45	-9.53	1.79
5	5.14	4.75	3.25	5.4	7.65	8.25	3.74	5.5	3.25	5.21	1.78
10	10.25	13.25	12.11	10.95	14.25	10.88	11.84	12.25	10.9	11.85	1.28
43/w	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**average**	**std**
0	-47	-53	-52	-56	-47	-50	-45.4	-59.40	-54.55	-51.59	4.67
1	-31.2	-47.5	-22	-35.5	-43.6	-38.4	-36.40	-53.4	-38.4	-38.49	9.14
2	-18	-22.47	-46.3	-38	-37.4	-37.4	-30.20	-39.9	-40.28	-34.44	9.13
3	-13.9	-9.5	-11.3	-16	-14.9	-14.5	-8.30	-8.05	-7.3	-11.53	3.36
4	-8.4	-6.03	-13.3	-7.38	-8.5	-9.55	-10.25	-7.51	-8.55	-8.83	2.08
5	11.6	10.04	10.35	10.03	8.58	11.5	9.25	9.44	8.5	9.92	1.12
6	15.88	16.25	17.45	12.54	14.02	13.54	12.02	14.25	12.3	14.25	1.91
58/w	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**average**	**std**
0	-56	-61	-53	-50	-77	-64	-56	-67.00	-64	-60.89	8.25
1	-51.6	-50.1	-50	-44.8	-43.1	-48	-52.80	-52.8	-40.8	-48.22	4.37
2	-32.2	-35	-33.8	-33	-37.2	-39.4	-39.50	-47.7	-48.7	-38.50	6.09
3	-18.9	-21.4	-15.5	-12.3	-34.8	-20.5	-19.60	-23.3	-20.84	-20.79	6.21
4	-13.2	-13.8	-11.6	-12.5	-10.5	-13.5	-12.70	-9.84	-12.8	-12.27	1.36
5	-9.25	-1.25	-4.56	-6.36	-5.2	-4.2	-3.10	-4.4	-4.8	-4.79	2.19
6	3.25	7.45	7.55	8.58	4.58	2.68	4.84	6.5	8.5	5.99	2.23
55/w	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**average**	**std**
0	-66	-74	-75	-80	-100.5	-101.5	-93.5	-82.50	-75.4	-83.16	12.55
1	-55.4	-53.2	-45.5	-59.5	-57.1	-58.5	-50.20	-53.5	-53.5	-54.04	4.33
2	-40.5	-45.2	-47.5	-42.65	-42.56	-48.25	-47.58	-42.55	-40	-44.09	3.14
3	-25.7	-24.6	-20.3	-30.9	-30.4	-27.6	-26.80	-22.4	-28.5	-26.36	3.52
4	-15.8	-16.5	-17.6	-14.3	-10.9	-12.5	-14.80	-15.69	-12.33	-14.49	2.19
5	-2.6	-4.82	-8.6	-7.6	-5.3	-4.17	-3.35	-5.8	-4.8	-5.23	1.91
6	7.85	3.22	2.45	7.6	3.85	4.68	4.25	3.1	2.07	4.34	2.09
53/w	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**average**	**std**
0	-74.7	-114	-112	-129	-115	-100	-107	-106.00	-118	-108.41	15.08
1	-53.4	-57	-69.3	-65.3	-65.3	-67.2	-69.30	-70.35	-66.8	-64.88	5.83
2	-42.87	-52.46	-42.6	-42.35	-58.25	-27.76	-39.58	-23.24	-48.7	-41.98	11.07
3	-35.8	-40.8	-32.1	-14.8	-37	-29.2	-30.10	-23.2	-30.5	-30.39	7.75
4	-12.6	-25.4	-28.54	-23.2	-19.5	-16.28	-20.54	-22.54	-26.25	-21.65	5.03
5	-11.45	-10.95	-10.2	-9.25	-7.25	-10.51	-18.25	-12.57	-9.58	-11.11	3.06
6	-2.54	-3.58	-4.45	-3.06	-2.75	-5.84	-7.95	-3.05	-2.87	-4.01	1.81
SDS/w	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**average**	**std**
0	-19.7	-27.7	-23	-33	-30.1	-18.7	-19.3	-35.20	-29.9	-26.29	6.27
1	-20.5	-25.6	-20.5	-19.4	-15.3	-14.8	-10.40	-10.7	-12.5	-16.63	5.17
2	12.5	7.5	10.6	7.46	8.69	14.5	17.50	18.5	16.48	12.64	4.32
3	16.8	18.5	32.63	17.3	16	19.66	12.39	21.23	12.7	18.58	6.02
4	12.12	16.11	18.81	20.39	21.3	26.42	14.17	12.91	13.03	17.25	4.83
5	14.6	15.2	14.5	13.56	12.84	17.5	13.90	10.25	12.8	13.91	1.98
6	20.25	21.54	13.78	14.01	18.59	20.07	16.84	17.5	19.5	18.01	2.73
SDS:d/w	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**average**	**std**
0	-30.5	-25.9	-32.5	-34.2	-20.5	-32.4	-31.5	-27.95	-28	-29.27	4.22
1	-20.5	-14.25	-21.58	-18.45	-22.45	-25.45	-19.25	-20.22	-18.45	-20.07	3.10
2	-1.6	-2.7	-4.5	-5.65	-1.58	-2.7	-4.50	-3.3	-7	-3.73	1.84
3	3.8	4.2	5.5	7.9	8.75	9.9	12.50	12.7	10.7	8.44	3.36
4	12.55	14.51	19.58	10.55	17.8	18.8	17.50	10.8	17.5	15.51	3.48
5	14.58	17.4	12.85	17.96	14.12	18.5	20.88	22.6	19.5	17.60	3.24
6	19.08	18.58	19.05	14.25	13.25	19.25	20.56	22.85	17.8	18.30	2.96

Appendix III

Journal articles

1) Charoensaeng, A., Khoadhiar, S., Sabatini, D. A. (2008). "**Styrene Solubilization and Adsolubilization on an Aluminum Oxide Surface Using Linker Molecules and Extended Surfactants**". *Journal of surfactant and detergent*, 11 (1), p 61-71.
2) Charoensaeng, A., Khoadhiar, S., Sabatini, D. A. **"Solubilization and Adsolubilization of Polar and Nonpolar Organic Solutes by Linker Molecules and Extended Surfactants"** submitted (July, 2008) at Journal of surfactants and detergents.
3) Attaphong, C., Asnachinda, E., Charoensaeng, A.,Khoadhiar, S., Sabatini, D. A. "**Adsorption and Adsolubilization of Polymerizable Surfactants and Aluminum oxide Molecules and Extended Surfactants"** submitted (August, 2008) at Environmental Toxicology.

Proceeding:

1) Charoensaeng, A., Khoadhiar, S., Sabatini, D. A. "**Adsorption of Linker Molecule and Extended Surfactants onto Aluminum Oxide Surface**" Proceeding of International Conference of Hazardous Waste Management for a Sustainable a Future, January 10-12, 2006.

Conferences:

1) Charoensaeng A., Khaodhiar S., Sabatini D. A**. "Adsorption of Linker Molecule and Extended Surfactants onto Aluminum Oxide Surface"** Proceeding of International Conference of Hazardous Waste Management for a Sustainable a Future, January 10-12, 2006.

2) Charoensaeng A, Khaodhiar S., Sabatini D. A. “**Adsorption and Adsolubilization of Linker Molecule and Extended Surfactants of organic solutes onto Aluminum Oxide Surface”**. The 97th American Oil and Chemists’ Society (AOCS) Annual Meeting and Expo, St. Louis, Missouri, U.S.A., April 30 – 3 May, 2006.

3) Charoensaeng A. , Khaodhiar S., Sabatini D. A. “**Adsorption and Adsolubilization of Linker Molecule and Extended Surfactants of organic solutes onto Aluminum Oxide Surface**”. The 98th American Oil and Chemists’ Society (AOCS) Annual Meeting and Expo, St. Quebec city, Canada, May, 2007

4) Attaphong C., Asnachinda E., Charoensaeng A., Khaodhiar S., and Sabatini D. A. **“Adsorption and Adsolubilization Using Polymerizable Surfactants onto Aluminum Oxide Surface”.** The 98th American Oil and Chemists’ Society (AOCS) Annual Meeting and Expo, St. Quebec city, Canada, May, 2007

5) Charoensaeng A., Khaodhiar S., Sabatini D. A. **“Impact of Organic Solute Properties on Adsolubilization in Linker and Extended Surfactant Modified Alumina”** The 99th American Oil and Chemists’ Society (AOCS) Annual Meeting and Expo, Seattle, USA, May, 2008.

BIOGRAPHY

Miss Ampira Charoensaeng was born, on 21 March 1980 in Bangkok, Thailand. In year 2001, she graduated in Bachelor of Science, Department of General Science, Faculty of Science at Chulalongkorn University, Bangkok, Thailand. She received her Master's degree in the international postgraduate program in Environmental Management at the National Research Center for Environmental Management and Hazardous Waste Management (NRC-EHWM), Chulalongkorn University in 2004. She pursued her philosophy of Doctoral Degree studies in National Research Center for Environmental and Hazardous Water Management (NCE-EHWM), Chulalongkorn University in 2004. She finished her philosophy of Doctoral Degree in October, 2008