NOVEL ANIONIC EXTENDED SURFACTANT AND CATIONIC SURFACTANT MIXTURES FOR MAXIMIZING SYNERGISM (SOLUBILIZATION AND ADSOLUBILIZATION) AND MINIMIZING PRECIPITATION

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สารผสมระหว่างสารลดแรงตึงผิวประจุลบที่มีส่วนขยายและประจุบวกเพื่อเพิ่มประสิทธิภาพในการโซลูบิไลเซชัน และแอดโซลูบิไลเซชัน และลดการตกตะกอน

นางดนยภรณ์ พรรณสวัสดิ์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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ดนยภรณ์ พรรณสวัสดิ์ : สารผสมระหว่างสารลดแรงตึงผิวประจุลบที่มีส่วนขยายและประจุบวกเพื่อเพิ่มประสิทธิภาพในการโซลูบีไลเซชันและแอดโซลูบีไลเซชัน และลดการตกตะกอน. (NOVEL ANIONIC EXTENDED SURFACTANT AND CATIONIC SURFACTANT MIXTURES FOR MAXIMIZING SYNEGISM (SOLUBILIZATION AND ADSOLUBILIZATION) AND MINIMIZING PRECIPITATION) อ. ที่ปรึกษาวิทยานิพนธ์หลัก: รศ.ดร.สุธา ขาวเธียร, อ. ที่ปรึกษาวิทยานิพนธ์ร่วม : PROF. DAVID A. SABATINI, Ph.D., 143 หน้า.

โดยทั่วไปแล้วสารผสมระหว่างสารลดแรงตึงผิวประจุลบ และสารลดแรงตึงผิวประจุบวกมีคุณสมบัติหลายอย่างเป็นที่น่าสนใจ แต่สารผสมนี้มีข้อจำกัดในการใช้ เนื่องจากเมื่อผสมกันแล้วมีแนวโน้ม ที่จะเกิดการตกตะกอน ผลึก ในงานวิจัยนี้ได้ศึกษาคุณสมบัติต่างๆ ของสารผสม ทั้งสอง ได้แก่ การตกตะกอนผลึก แรงตึงผิว การดูดซับ การนำสารดูดซับไปดูดน้ำมัน การดูดซึมน้ำมัน การหลุดออก และลักษณะของพื้นผิวตัวดูดซับ ผลการศึกษาพบว่า สารผสมระหว่างสารลดแรงตึงผิวประจุลบที่มีส่วนขยาย และสารลดแรงตึงผิวประจุบวก มีขอบเขตการเกิด ตกตะกอน ผลึกน้อย กว่าสารผสมระหว่างสารลดแรงตึงผิวประจุลบ และสารลดแรงตึงผิวประจุบวกทั่วไป และยังสามารถคงประสิทธิภาพด้านอื่นๆ ได้ แม้จะมีประสิทธิภาพในการลดแรงตึงผิวน้อยลงเล็กน้อยเมื่อเทียบกับสารลดแรงตึงผิวประจุลบ และสารลดแรงตึงผิวประจุบวกทั่วไป ผลการศึกษาการดูดซับพบว่า สารผสมระหว่างสารลดแรงตึงผิวประจุลบที่มีส่วนขยาย และสารลดแรงตึงผิวประจุบวก ใช้ความเข้มข้นของสารลดแรงตึงผิวต่ำกว่า เพื่อให้ได้ค่าการดูดซับที่ระดับปริมาณการดูดซับสูงสุด ถึงแม้ว่าระดับการดูดซับสูงสุดจะน้อยกว่าการดูดซับที่ใช้สารลดแรงตึงผิวประจุบวกเพียงอย่างเดียว นอกจากนี้ สารดูดซับด้วยสารผสมนี้ ยังมีความเสถียรของการดูดซับน้อยกว่าสารดูดซับที่ใช้สารลดแรงตึงผิวเพียงชนิดเดียว อย่างไรก็ตาม สารผสมระหว่างสารลดแรงตึงผิว 2 ชนิดนี้ ยังมีความสามารถในการดูดซึมน้ำมัน และการนำสารดูดซับไปดูดซึมน้ำมัน มากกว่าการใช้สารลดแรงตึงผิวชนิดเดียว ผลการศึกษานี้แสดงให้เห็นว่า สารผสมระหว่างสารลดแรงตึงผิวประจุลบที่มีส่วนขยาย และสารลดแรงตึงผิวประจุบวกสามารถนำไปใช้ในงานด้านสิ่งแวดล้อมได้ เช่น การเพิ่มประสิทธิภาพการสกัดสารปนเปื้อนในน้ำใต้ดิน และการกำจัดสารอินทรีย์ในระบบบำบัดน้ำเสีย

สาขาวิชาการ จัดการสิ่งแวดล้อม ลายมือชื่อนิสิต...
ปีการศึกษา 2554 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก......................
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5187844220: MAJOR ENVIRONMENTAL MANAGEMENT
KEYWORDS: EXTENDED SURFACTANT / MIXED SURFACTANT / PRECIPITATION / ADSOLUBILIZATION / SOLUBILIZATION

DONYAPORN PANSWAD: NOVEL ANIONIC EXTENDED SURFACTANT AND CATIONIC SURFACTANT MIXTURES FOR MAXIMIZING SYNERGISM (SOLUBILIZATION AND ADSOLUBILIZATION) AND MINIMIZING PRECIPITATION. ADVISOR: ASSOC. PROF. SUTHA KHAODHIAR, Ph.D., CO-ADVISOR : PROF. DAVID A. SABATINI, Ph.D., 143 pp.

Generally, anionic and cationic surfactant mixtures exhibit desirable properties, but are limited by their tendency to form precipitates. In this research, mixture of anionic extended surfactants and a cationic surfactant have been evaluated for precipitation phase boundaries, surface tension, adsorption, adsolubilization, solubilization, desorption, and surface characterization. The results showed that anionic extended surfactant and cationic surfactant mixtures can greatly increase formulation space (reduce precipitation region) while maintaining synergism, although slightly reduced from conventional anionic-cationic mixtures reported previously. For adsorption study, mixed anionic extended surfactant and cationic surfactant systems can reach plateau adsorption region at lower surfactant concentration than that of the CPC alone, although the maximum adsorption capacity of CPC is not enhanced in our mixed surfactant systems. Moreover, stabilities of these mixed surfactant systems are slightly lower than have the individual surfactant system. However, solubilization and adsolubilization capacities of these mixed surfactant systems are higher than that of the individual surfactant system. From these results, these mixed surfactant systems can be employed in many environmental applications including enhanced contaminant extraction from subsurface water, and removing organic pollutants from wastewater.

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Student's Signature ....
Advisor's Signature ....
Co-Advisor's Signature ....

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ABBREVIATIONS

AEC	Admicellar - enhanced chromatography
AFM	Atomic force microscopy
C167-42	Alkyl propoxylated ethoxylated carboxylate with carbon chain length of 16 and 17, 4 moles of PO group, and 2 moles of EO group
C168-42	Alkyl propoxylated ethoxylated carboxylate with carbon chain length of 16 and 18, 4 moles of PO group, and 2 moles of EO group
C167-45	Alkyl propoxylated ethoxylated carboxylate with carbon chain length of 16 and 17, 4 moles of PO group, and 5 moles of EO group
C168-45	Alkyl propoxylated ethoxylated carboxylate with carbon chain length of 16 and 18, 4 moles of PO group, and 5 moles of EO group
$C_2H_3O_2NH_4$	Ammonium acetate
C_2H_3N	Acetonitrile
CMC	Critical micelle concentration
CPC	Cetylpyridinium chloride
DAD	Diode array detector
DPC	Dodecylpyridinium chloride
ELSD	Evaporative light scattering detector
EO	Ethylene oxide
FID	Flame ionization detector
GC	Gas chromatography
HCl	Hydrochloric acid
HPLC	High performance liquid chromatography
M	Mole/L
MSR	Molar solubilization ratio

NaCl	Sodium chloride
NaOH	Sodium hydroxide
NAPLs	Non-aqueous phase liquids
PO	Propylene oxide
rpm	Round per minute
SDS	Sodium dodecyl sulfate
SiO_2	Silica
SPE	Solid phase extraction

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Surfactant-based remediation techniques have been widely used for the remediation of contaminated groundwater since treatment of aquifers contaminated by non-aqueous phase liquids (NAPLs) by traditional pump and treat systems has proven impracticable in many instances (West and Harwell, 1992). Surfactants are especially attractive for several reasons including their low toxicity and their efficiency at very low concentration (Harwell et al., 1999). However, the main problem of using this method is the losses of surfactant due to precipitation, sorption, and other phenomena (Sabatini et al., 2000). Adsorbed surfactant aggregates or admicelles at the solid/liquid interface provides hydrophobic region in which organic solutes can solubilize. This phenomenon, called adsolubilization, has been widely used in a variety of applications including admicellar-enhanced chromatography (AEC), admicellar polymerization, adsolubilization of solid phase extraction (SPE) for pharmaceutical products, wastewater treatment, soil remediation, landfill liner or subsurface barrier to mitigate contaminant transport, and nanotechnology (Harwell and O'Rear, 1989; Asvapathanagul et al., 2005; Charoensaeng et al., 2008).

Mixtures of anionic and cationic surfactants have been widely used in detergency and fabric softening, analytical chemistry, enhanced oil recovery, and pharmaceutical applications (Stellner et al., 1988; Mehreteab, 1999; Doan et al., 2003; Fuangswasdi et al., 2006a; Fuangswasdi et al., 2006b; Upadhyaya et al., 2006; Upadhyaya et al., 2007; Kume et al., 2008). Generally, anionic and cationic surfactants are incompatible because their mixtures form insoluble complexes (Mehreteab, 1999).

However, several studies have shown that not only it is possible to combine cationic and anionic surfactants but mixed anionic and cationic surfactant systems can exhibit great synergism as evidenced by ultra low critical micelle concentrations (CMC), increased surface activity, and improved detergency performance (Fuangswasdi et al., 2006a; Fuangswasdi et al., 2006b; Upadhyaya et al., 2006; Upadhyaya et al., 2007; Kume et al., 2008). Moreover, many studies have shown that at an appropriate ratio of anionic and cationic surfactant mixtures, adsorption, solubilization, and adsolubilization capacity of mixed surfactant micelles and admicelles can increase (Fuangswasdi et al., 2006a; Fuangswasdi et al., 2006b; Upadhyaya et al., 2006; Upadhyaya et al., 2007). Hence, it is expected that the remediation of subsurface by this surfactant system can be enhanced.

Extended surfactants are a novel class of surfactants that have groups of intermediate polarity such as polypropylene oxides (PO) or ethylene oxides (EO) inserted between the hydrocarbon tail and hydrophilic head group. As a result of their unique molecular structure, many researchers have demonstrated the advantages of using these extended surfactants to enhance oil solubilization since they can offer a smoother transition between the hydrophilic and hydrophobic phases resulting in more suitable environment for solubilizing both hydrophilic and lipophilic solutes (Fernández et al., 2005b; Fernández et al., 2005a; Witthayapanyanon et al., 2006; Charoensaeng et al., 2008; Charoensaeng et al., 2009; Arpornpong et al., 2010).

This research aims to investigate the synergism properties of the novel surfactant mixtures system since the anionic and cationic surfactant system have successfully shown the capabilities to enhance the solubilization and adsolubilization capacity of organic solutes. Therefore, it is expected that this novel surfactant system can exhibit greater synergism than the conventional anionic and cationic surfactant mixtures system.

1.2 OBJECTIVES

The overall objectives of this study are to investigate the synergism of surfactant adsorption onto solid surfaces by mixtures of carboxylated-based anionic extended surfactant and pyridinium-based cationic surfactant, and to determine properties of these mixed surfactant systems. The specific objectives of this study are:

1. To evaluate the precipitation phase boundary of carboxylated-based anionic extended surfactant and pyridinium-based cationic surfactant mixtures to define the isotropic concentration regimes in which to conduct the adsorption studies.

2. To evaluate the solubilization and adsolubilization capacity of micelles and admicelles formed by the mixtures of carboxylated-based anionic extended surfactant and pyridinium-based cationic surfactant.

3. To characterize the adsorbed mineral oxide surface by Atomic Force Microscopy (AFM).

1.3 SCOPES OF THE STUDY

This research aims to investigate the synergism properties of anionic extended surfactant and cationic surfactant mixture systems. The precipitation study is conducted in order to find the appropriate ratio in which to conduct the adsorption studies. The surfactant adsorption, solubilization and adsolubilization isotherm of the organic solutes is used to evaluate the impact of the mixture of anionic and cationic surfactant onto negatively charged surface (silica). All experiments are conducted in batch experiment under constant solution pH of 9 ± 0.5, electrolyte concentration of 0.001 M NaCl and room temperature (25 ± 2 °C). Dipole moment of the organic solutes used to conduct the solubilization and adsolubilization are varied from polar to nonpolar. The solubilization and adsolubilization capacity of organic solutes are evaluated through micellar and admicellar partition coefficient (K_{mic} and K_{adm}), respectively. The adsorbed surfactants onto solid oxide surface are characterized by Atomic Force Microscopy (AFM).

1.4 HYPOTHESES

To our knowledge this is the first time that carboxylated-based anionic extended surfactants are mixed with pyridinium-based cationic surfactants. The structure of anionic extended surfactant contains an internal linker, propylene oxide (PO) group, ethylene oxide (EO) group, and then carboxylated, while the pyridinium-based cationic surfactant is a cationic quaternary ammonium compound. The specific hypotheses of this research are:

1. Mixed surfactant systems can enhance the synergistic adsorptive behavior since it can reach the adsorption plateau at lower surfactant concentration when compared with the single surfactant systems.

2. This novel mixed surfactant system can exhibit greater synergism than the conventional mixed surfactant system because of their lower precipitation region. Therefore, this system can enhance the solubilization and adsolubilization capacity of micelles and admicelles.

CHAPTER II

THEORETICAL BACKGROUNDS AND LITERATURE REVIEWS

2.1 SURFACTANT PHENOMENA

Surfactants (surface active agents) have an amphipathic molecular structure which consists of hydrophilic head group and hydrophobic tail group (Figure 2-1) which allows them to alter the surface or interface of the system. Surfactants are classified into 4 types based on the charge of their hydrophilic head group which are anionic (negatively charge), cationic (positively charge), nonionic (no ionic charge) and zwitterionic (both positive and negative charge) surfactants (Rosen, 2004). At low surfactants concentration, surfactants monomers will act independently in the solution phase and accumulate at the surface of the system. As surfactants concentration increase to a certain level, these monomers will form into aggregates called micelles. The concentration where the first micelle is formed is called the critical micelle concentration (CMC).

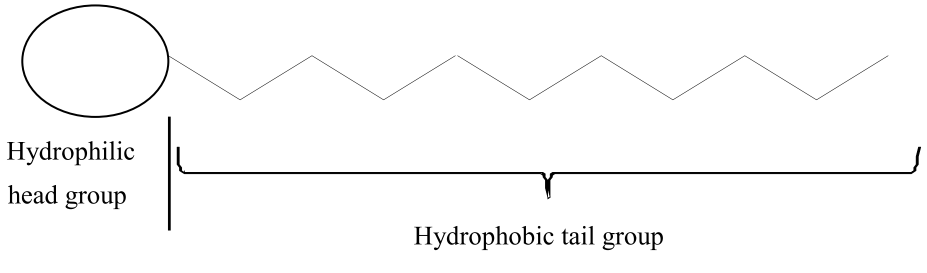


Figure 2-1 Surfactant molecule

When a solid phase is added to the surfactant solution, surfactant will first adsorb at the solid-liquid interface. At low surfactant concentrations, the surfactant begins to adsorb and form micelle-like structure called hemimicelles or admicelles, depending on whether the aggregates are monolayer or bilayer (Figure 2-2). Once the CMC is reached, additional surfactant does not increase the amount of adsorbed surfactant, but rather increase the concentration of micelles in aqueous solution (West and Harwell, 1992).

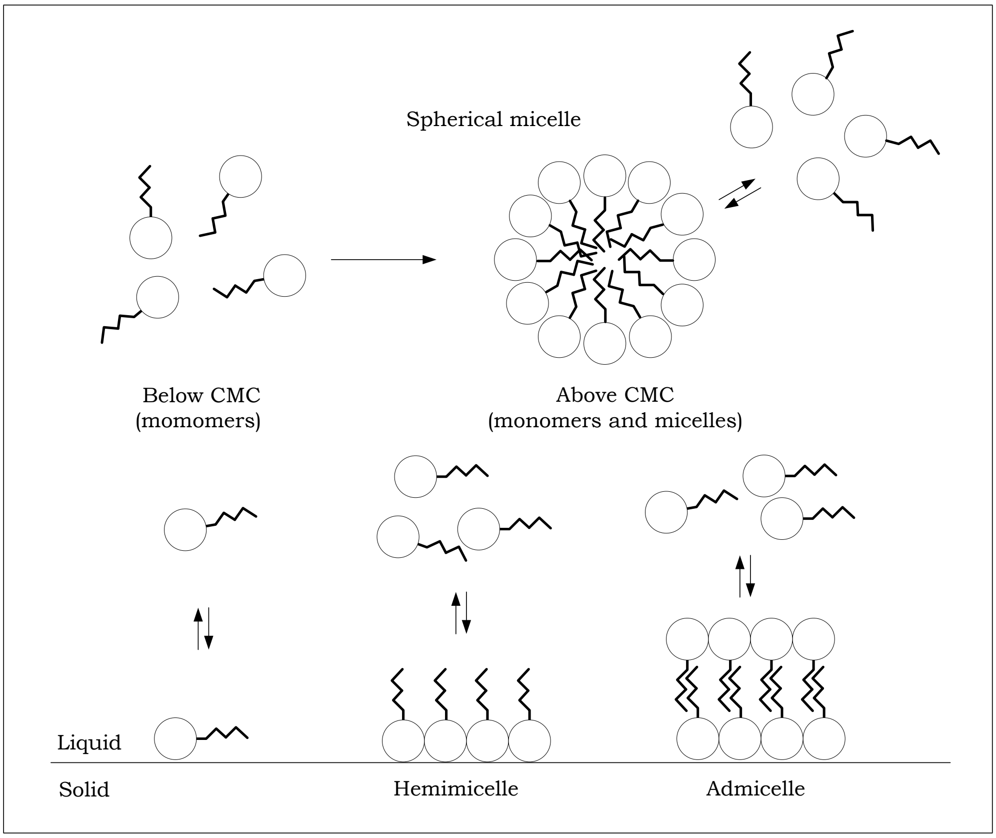


Figure 2-2 Schematic diagram of surfactant micellization (West and Harwell, 1992)

2.2 MIXED ANIONIC AND CATIONIC SURFACTANTS

Mixtures of anionic and cationic surfactants have been widely used in detergency and fabric softening, analytical chemistry, enhanced oil recovery, and pharmaceutical applications (Stellner et al., 1988; Mehreteab, 1999; Doan et al., 2003; Fuangswasdi et al., 2006a; Fuangswasdi et al., 2006b; Upadhyaya et al., 2006; Upadhyaya et al., 2007; Kume et al., 2008). Mixtures of anionic and cationic surfactants are known to exhibit greater synergism than other mixed systems (anionic-anionic, cationic-cationic, ionic-nonionic, and nonionic-nonionic): they have the potential for much lower critical micelle concentration (CMC) than either of the anionic and cationic surfactant component (Mehreteab, 1999; Doan et al., 2003; Fuangswasdi et al., 2006b; Upadhyaya et al., 2006; Upadhyaya et al., 2007; Kume et al., 2008); they are usually more surface active (low interfacial tension, IFT) than individual surfactants (Doan et al., 2003; Upadhyaya et al., 2006); and they can also produce microstructures not formed by pure components such as vesicles and rod-like micelles (Kume et al., 2008).

2.3 PRECIPITATION OF MIXED ANIONIC AND CATIONIC SURFACTANTS

Generally, it is commonly known that anionic and cationic surfactants cannot be present in the same formulation since their mixtures tend to form insoluble complexes (Stellner et al., 1988; Mehreteab, 1999; Rodriguez et al., 2001; Rodriguez and Scamehorn, 2001; Doan et al., 2003; Fuangswasdi et al., 2006b; Upadhyaya et al., 2006; Upadhyaya et al., 2007; Kume et al., 2008). When small amounts of either anionic or cationic surfactants are added to an aqueous solution, the surfactants exist as dissociated surfactant monomers in solution. As the surfactant concentration increases and reaches the CMC, micelles begin to form. If the concentration of both anionic and cationic monomers exceeds the solubility limit, precipitation will occur (Kume et al., 2008). Below the CMC, all of the surfactant is present as monomers. As the concentration of one of the surfactants increases, a lower concentration of the oppositely charged surfactant is needed to cause precipitation. In mixed surfactant system, surfactants can be present in 3 different forms which are monomers, mixed micelles and precipitate (Stellner et al., 1988; Kume et al., 2008). The schematic diagram of basic equilibrium in anionic-cationic surfactant system is shown in Figure 2-3.

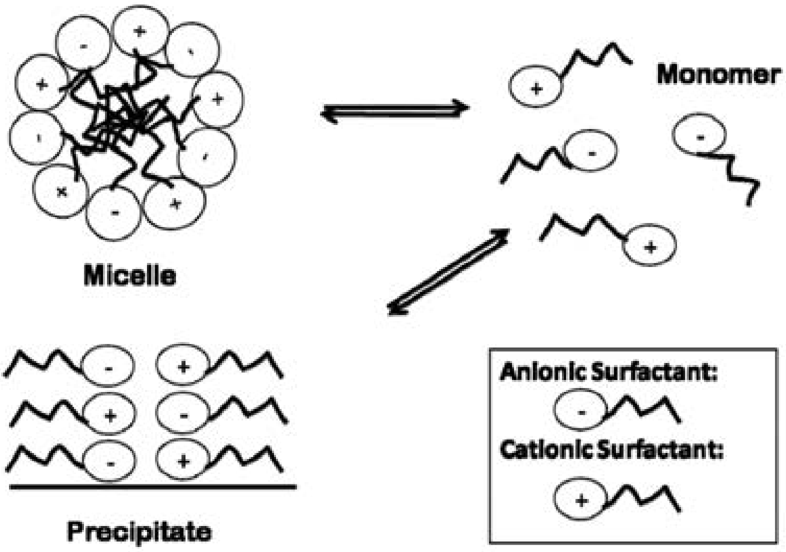


Figure 2-3 The schematic diagram of the basic equilibrium in an anionic-cationic surfactant system (Adapted from Stellner et al., 1988)

The formation of precipitate can be represented by Equation 2-1 (Stellner et al., 1988):

$$A^{-}(aq) + C^{+}(aq) \Longleftrightarrow AC(s) \quad (2\text{-}1)$$

where A^- is the concentration of the anionic surfactant monomer, C^+ is the concentration of the cationic surfactant monomer, and AC is the concentration of the precipitate.

The activity based solubility product for this precipitation reaction can be expressed by the solubility product as shown in Equation 2-2 (Scamehorn, 1986; Stellner et al., 1988; Fuangswasdi et al., 2006b):

$$K_{sp} = [A^-]_{mon}\,[C^+]_{mon}\,f_{\pm}^{2} \qquad (2\text{-}2)$$

where K_{sp} is the solubility product of the precipitate, $[A^-]_{mon}$ and $[C^+]_{mon}$ are the anionic and cationic surfactant monomer concentration, respectively, and $f_{\pm}$ is the activity coefficient in solution.

2.4 MOLECULAR INTERACTIONS AND SYNERGISM

It is well known that mixed anionic and cationic surfactant systems exhibit synergism as demonstrated by a lower CMC in the mixtures than in that of individual surfactant systems. The molecular interaction between oppositely charged surfactants at the interface is generally explained by the molecular interaction parameter (β) which indicates the nature and strength of those interactions in a mixed monolayer at an interface and in a mixed micelle in aqueous solution (Rosen, 1998; Vora et al., 1999; Rosen, 2004). If β is positive, the interaction is repulsive (antagonism), and if β is negative, the interaction is attractive (synergism). The interaction parameter for mixed monolayer formation can be calculated by Equation 2-3 and 2-4 (Rosen, 2004):

$$\left(\frac{X_1^2 \ln(\alpha C_{12} / X_1 C_1^0}{(1-X_1)^2 \ln\left[(1-\alpha)C_{12} /(1-X_1)C_2^0\right]}\right)=1 \tag{2-3}$$

$$\beta^{\sigma} = \frac{\ln(\alpha C_{12} / X_1 C_1^0)}{(1-X_1)^2} \tag{2-4}$$

where α is the mole fraction of surfactant 1 in the total surfactant in the solution phase; X_1 is the mole fraction of surfactant 1 in the total surfactant in the mixed monolayer; C_1^0, C_2^0, and C_{12} are the solution phase molar concentrations of surfactant 1, 2, and their mixture, respectively, that are required to produce the same surface tension; and β^{σ} is the molecular interaction parameter for mixed monolayer formations at the aqueous solution-air interface.

The molecular interaction parameter for mixed micelle formation proposed by can be calculated by Equation 2-5 and 2-6 (Rubingh, 1979):

$$\left(\frac{(X_1^M)^2 \ln(\alpha C_{12}^M / X_1^M C_1^M}{(1-X_1^M)^2 \ln\left[(1-\alpha)C_{12}^M /(1-X_1^M)C_2^M\right]}\right)=1 \tag{2-5}$$

$$\beta^{M} = \frac{\ln(\alpha C_{12}^M / X_1^M C_1^M)}{(1-X_1^M)^2} \tag{2-6}$$

where X_1^M is the mole fraction of surfactant 1 in the total surfactant in the mixed micelle; C_1^M, C_2^M, *and* C_{12}^M are the critical micelle concentrations of surfactant 1, 2, and their mixture at a given value of α, respectively; and β^{M} is the molecular interaction parameter for mixed micelle formations.

2.4.1 Synergism in Surface Tension Reduction Efficiency

The efficiency of surface tension reduction by a surfactant has been defined as the solution phase surfactant concentration required to produce a given surface tension. Efficiency in surface tension reduction exists when a given surface tension can be attained at a total mixed surfactant concentration less than that required of either surfactant by itself (Rosen, 2004). The conditions to evaluate the existence of synergism in surface tension reduction efficiency are:

1. β^{σ} must be negative.
2. $| \beta^{\sigma} | > |\ln (C_1^0/C_2^0)$.

2.4.2 Synergism in Mixed Micelle Formation in Aqueous Medium

Synergism in mixed micelle formation exists when the CMC of the mixture of two surfactants is smaller than the CMC of either individual surfactant (Rosen, 2004). The conditions for the existence of synergism in mixed micelle formation are:

1. β^{M} must be negative.
2. $| \beta^{M} | > |\ln (C_1^M/C_2^M)|$.

2.4.3 Synergism in Surface Tension Reduction Effectiveness

Synergism in surface tension reduction effectiveness is presented when the CMC of the mixture of two surfactants reaches a lower surface tension than that obtained from either individual surfactant (Rosen, 2004). The conditions for this type of synergism are:

1. $\beta^{\sigma} - \beta^{M}$ must be negative.
2. $| \beta^{\sigma} - \beta^{M} | > \ln \frac{\left|C_1^{0,CMC} C_2^M\right|}{\left|C_2^{0,CMC} C_1^M\right|}$.

where $\mathbf{C_1^{0,CMC}}$ and $\mathbf{C_2^{0,CMC}}$ are the molar concentration of individual surfactants 1 and 2, respectively, that required to yield a surface tension value equal to that of mixture of the two surfactants at its CMC.

2.5 ADSORPTION OF IONIC SURFACTANTS ONTO METAL OXIDE SURFACES

Surfactant adsorption is a complex process that transfers the surfactant molecules from bulk solution phase to the surface/ interface. The adsorption of surfactant at the solid-liquid interface play an important role in many technological and industrial applications, such as detergency, mineral floatation, foaming, emulsification, corrosion inhibition and oil recovery. This process can occur by various mechanisms which are ion exchange, ion pairing, acid-base interaction, hydrophobic bonding, adsorption by polarization of π electrons and adsorption by dispersion force (Paria and Khilar, 2004). An adsorption isotherm relates the amount of surfactant adsorbed and the activity of the adsorbate (aqueous concentration) at a constant temperature. It is a common method of describing adsorption at the liquid-solid interface (Somasundaran and Krishnakumar, 1997; Rosen, 2004). The isotherm is usually divided into 4 regions as shown in Figure 2-4.

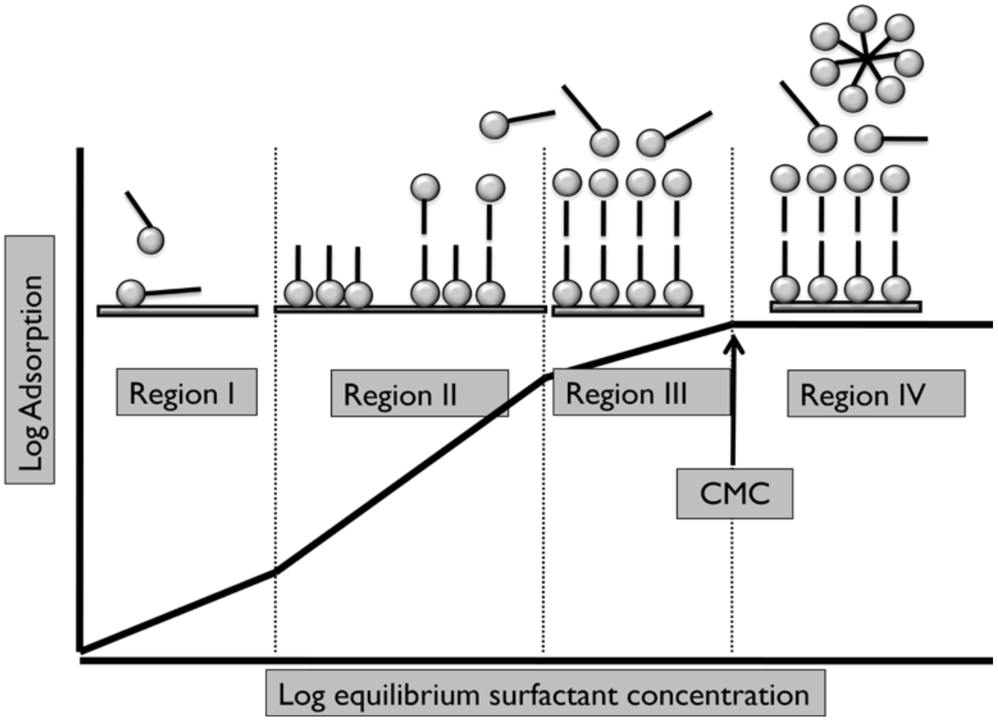


Figure 2-4 Schematic diagram of adsorption isotherm of a surfactant onto a solid surface (Rosen, 2004)

Region I or Henry's Law region occurs at very low surfactant concentration. In this region, the surfactant adsorbs in a linear manner mainly by ion exchange. Adsorbed surfactants in this region are proportional to surfactant concentration and adsorb without forming any surfactant aggregates.

Region II is characterized by a sharp change in the isotherm slope between region I and region II. This marked increase in adsorption resulting from interaction of hydrophobic chains of oncoming surfactant ions with those of previously adsorbed surfactant. This aggregation of the hydrophobic groups which occurs at concentrations well below the critical micelle concentration (CMC) of the surfactant is known as hemimicelle or admicelle, depending on whether the aggregates are monolayer or bilayer.

Region III is indicated by the decreasing of isotherm slope since adsorption now must overcome electrostatic repulsion between the oncoming ions and the similarly charged solid and the beginning of admicelle formation on lower energy surface patches.

Region IV is the plateau adsorption region. In this region, the critical micelle concentration (CMC) is reached and the first micelle is formed. The adsorption in this region is constant with increasing surfactant concentration because of the maximum bilayer coverage of ionic surfactant adsorbed onto oppositely charged surfaces or the completed adsorption on hydrophobic surfaces.

The amount of surfactant adsorbed onto solid oxide surface is obtained from Equation 2-7 (Rosen, 2004). In this equation, it is assumed that the adsorption of water or salt is neglected and the adsorption of the surfactant does not have effect on solution density.

$$\Gamma_i = \frac{(C_i - C_f)V}{W_g} \qquad (2\text{-}7)$$

where Γ_i is the adsorption density of surfactant i (mole/g), V is the volume of sample (liter), C_i is the initial concentration of surfactant (mole/liter), C_f is the equilibrium concentration of surfactant (mole/liter), and W_g is the mass of the adsorbent (g)

2.6 ADSOLUBILIZATION AND SOLUBILIZATION OF ORGANIC SOLUTES

When ionic surfactant solutions are contacted with solid surfaces of opposite charge, the surfactant will adsorb on the solid surface and form “adsorbed micelles” or admicelles. Similar to micelles, admicelles have a hydrophobic interior in which organic solutes are capable to solubilize, a process called adsolubilization. This process has been utilized in a variety of applications including admicellar chromatography, surface engineering and wastewater treatment (Nayyar et al., 1994; O'Haver et al., 1995; Kitiyanan et al., 1996; Talbot et al., 2003; Adak et al., 2005; Asvapathanagul et al., 2005; Fuangswasdi et al., 2006a; Li et al., 2007). The phenomenon of adsolubilization is illustrated in Figure 2-5.

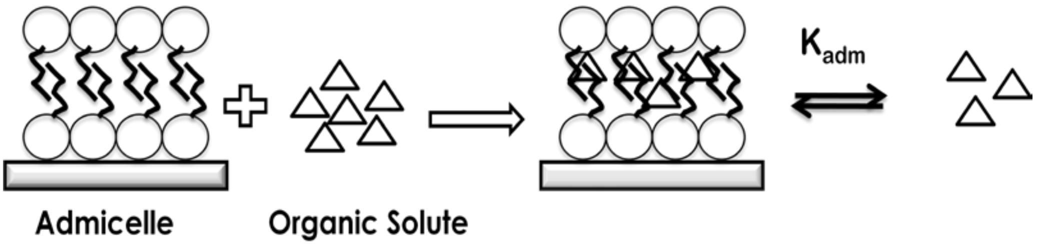


Figure 2-5 The phenomenon of adsolubilization

When a surfactant concentration has reached the critical micelle concentration (CMC), surfactant aggregates or micelles are formed. When an oil phase is in contact with an aqueous micellar solution, oil molecules will partition into the hydrophobic core of these micelles. This process is known as solubilization (Rosen, 2004) as shown in Figure 2-6.

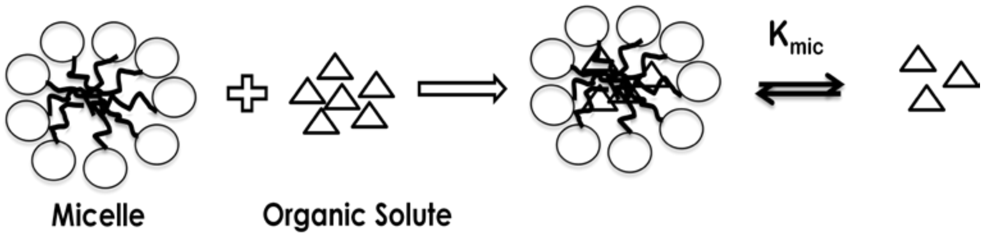


Figure 2-6 The phenomenon of solubilization

The structure of the micelles and admicelles can be divided into three regions which are outer region, inner region, and palisade region. The outer region consists of the surfactant head groups which consequently make it the most polar region. The inner region or the core region is nonpolar region since it is consisted of the hydrocarbon chain of surfactant tail groups. The palisade region is the region between the surfactant head groups and the core region, thus this region exhibits an intermediate polar region. Studies have indicated that the locus of solubilization in micelles and admicelles impacts the nature of solubilization and adsolubilization. Many researchers have been evaluated the locus of solubilization in the surfactant micelle and admicelle and it was found that organic solutes tend to partition into the region that has the similar polarity to the solute. Nonpolar organic solutes tend to partition into the core region, while polar organic solutes partition into the palisade region of the micelle and admicelle (Nayyar et al., 1994; Dickson and O'Haver, 2002; Fuangswasdi et al., 2006a; Charoensaeng et al., 2008; Charoensaeng et al., 2009; Arpornpong et al., 2010; Asnachinda et al., 2010a). Moreover, many researchers have investigated the nature of adsolubilization and of organic solutes into admicelles and micelles which mostly focused on the effect of various parameters to maximize adsolubilization capacity of organic solutes including the effect of surfactant structure, solution pH, structure of organic solutes, electrolyte concentration and temperature (Kitiyanan et al., 1996; Esumi, 2001; Dickson and O'Haver, 2002; Esumi, 2004; Tan and O'Haver, 2004; Asvapathanagul et al., 2005;

Fuangswasdi et al., 2006a; Li et al., 2007; Saphanuchart et al., 2007; Charoensaeng et al., 2008; Saphanuchart et al., 2008; Charoensaeng et al., 2009; Arpornpong et al., 2010; Asnachinda et al., 2010a).

The partition of various organic solutes into the micelle can be calculated by the micellar partition coefficient (K_{mic}) which is shown in Equation 2-8 (Rosen, 2004):

$$K_{mic} = \frac{X_{mic}}{X_{aq}} \tag{2-8}$$

where, X_{mic} is the mole fraction of the organic solutes in the micelle pseudophase and X_{aq} is the mole fraction of organic solute in the aqueous phase. X_{mic} and X_{aq} are calculated by Equation 2-9 and Equation 2-10 (Rosen, 2004), respectively

$$X_{mic} = \frac{MSR}{1+MSR} \tag{2-9}$$

where the molar solubilization ration (MSR) is the moles of the solute solubilized per mole of surfactant in micelles and is obtained from the slope of the graph of the surfactant concentration versus organic solutes concentration in mole/L.

$$X_{aq} = \frac{C_{eq}}{C_{eq} + 55.55} \tag{2-10}$$

where C_{eq} is the equilibrium concentration of organic solute at aqueous solubility and 55.55 is the inverse molar volume of water.

Similar to solubilization, admicellar partition coefficient (K_{adm}) can be used to quantify the adsolubilization capacity. The mole fraction of the organic solutes in admicelles (X_{adm}) can be calculated by Equation 2-11 (Nayyar et al., 1994):

$$X_{adm} = \frac{(S_i - S_f)}{(S_i - S_f) + (A_i - A_f) + (C_i - C_f)} \tag{2-11}$$

where X_{adm} is mole fraction of organic solutes in admicelles, S_i is the initial concentration of organic solutes (Molar), S_f is the equilibrium concentration of organic solutes (Molar), A_i is the initial concentration of anionic surfactant (Molar), A_f is the equilibrium concentration of anionic surfactant (Molar), C_i is the initial concentration of cationic surfactant (Molar), and C_f is the equilibrium concentration of cationic surfactant (Molar)

The admicellar partition coefficient (K_{adm}) is calculated similar to the micellar partition coefficient as shown in Equation 2-12 (Nayyar et al., 1994).

$$K_{adm} = \frac{X_{adm}}{X_{aq}} \tag{2-12}$$

where X_{adm} is the mole fraction of organic solutes in admicelles and X_{aq} is the mole fraction of organic solutes in the aqueous phase

2.7 EXTENDED SURFACTANT

Extended surfactants are a novel class of surfactants that have groups of intermediate polarity such as polypropylene oxides (PO) or ethylene oxides (EO) inserted between the hydrocarbon tail and the hydrophilic head group. As a result of their unique molecular structure, many researchers have demonstrated advantages of using these extended surfactants to enhance oil solubilization since they can offer a smoother transition between the hydrophilic and hydrophobic phases resulting in a more suitable environment for solubilizing both hydrophilic and lipophilic solutes (Fernández et al., 2005b; Fernández et al., 2005a; Witthayapanyanon et al., 2006; Charoensaeng et al., 2008; Charoensaeng et al., 2009; Arpornpong et al., 2010; Witthayapanyanon et al., 2010). However, the main disadvantage of extended surfactant is their tendency to form gels at moderate concentration (Sabatini et al., 2003; Witthayapanyanon et al., 2006).

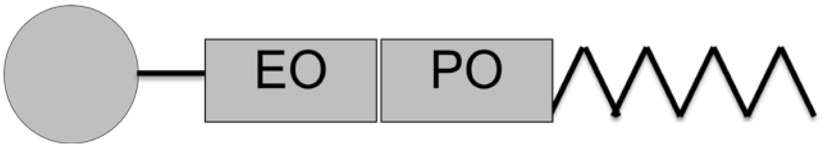


Figure 2-7 Extended surfactant structure

Carboxylate-based anionic surfactant has many advantages including their ready biodegradability and their low toxicity. By introducing the ethoxylated groups into the anionic surfactant can increase water solubility and enhance chemical stability (Tadros, 2005). Many researchers have been investigated the properties extended surfactant and it was found that the extended surfactant can lower the critical micelle concentration (CMC) and the interfacial tension (IFT) of the surfactant systems (Miñana-Perez et al., 1995; Witthayapanyanon et al., 2006; Charoensaeng et al., 2008;

Arpornpong et al., 2010; Witthayapanyanon et al., 2010). Moreover, many researchers have been evaluated the ability of extended surfactants to enhance the oil solubilization showing that the extended surfactant can enhance the oil solubilization capacity while using lower concentration of the extended surfactant (Miñana-Perez et al., 1995; Charoensaeng et al., 2008; Charoensaeng et al., 2009; Lewlomphaisan, 2009; Arpornpong et al., 2010).

2.8 ATOMIC FORCE MICROSCOPY

Surfactant adsorption at the solid-liquid interface plays an important role in many industrial processes such as surface modification, detergency, mineral flotation, corrosion inhibition, dispersion of solids, oil recovery and deinking (Scamehorn et al., 1982; Nayyar et al., 1994; Koopal et al., 1995; Esumi et al., 1996; Lee and Koopal, 1996; Goloub and Koopal, 1997; Somasundaran and Huang, 2000; Esumi, 2001; Schulz and Warr, 2002; Atkin et al., 2003; Paria and Khilar, 2004; Fuangswasdi et al., 2006b; Kume et al., 2008; Asnachinda et al., 2010b). Generally, adsorption isotherms have been used to quantify the amount of adsorbed surfactant and infer an adsorbed layer structure (Schulz and Warr, 2002). However, the structure of adsorbed aggregates at a solid oxide surface is not clearly understandable due to the equipment detection scale. Many techniques have been used to evaluate the morphology of surfactant modified surface including small angle neutron scattering (SANS), fluorescence spectroscopy and atomic force microscopy (AFM). Recently, the atomic force microscopy (AFM) is a promising technique to directly image the classical view of the adsorbed layer. This technique uses a mechanism namely a pre-contact repulsive force between the adsorbed surfactant layers on the tip and sample (Manne, 1997). Surfactant aggregates are fragile, so hard contact measurements will destroy the adsorbed morphology. Thus, the non-contact mode, the repulsive electrical double layer force associated with the adsorbed species is used to generate the morphology of the adsorbed layer (Paria and Khilar, 2004). A number of mineral oxide surfaces including alumina, silica, titanium dioxide and quartz have been extensively investigated (Manne, 1997; Schulz and Warr, 2000; Schulz and Warr, 2002; Asnachinda et al., 2010b). Major advantages of AFM are that it has a combination of high resolution in three dimensions and the sample does not have to be conductive. The technique for imaging interfacial aggregates is schematically illustrated in Figure 2-8.

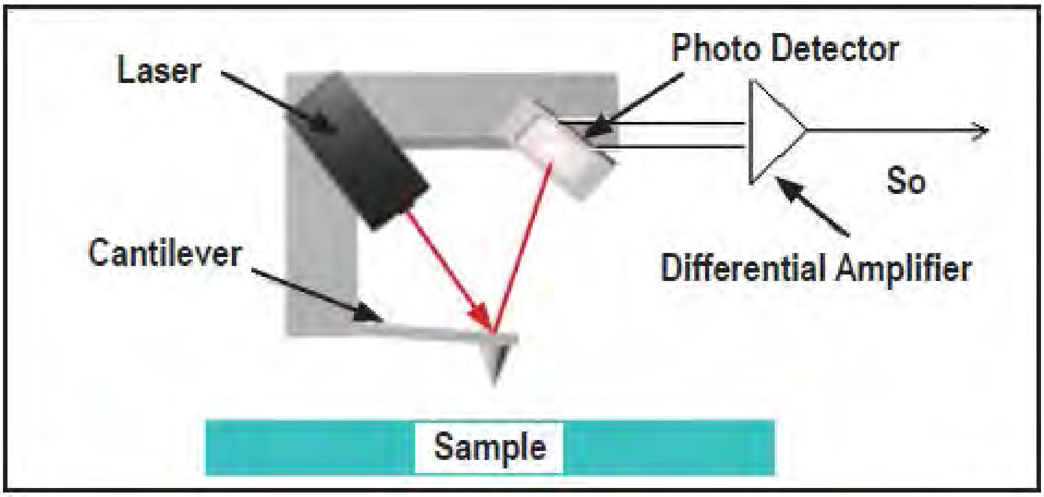


Figure 2-8 Schematic of the technique for imaging surface aggregates by AFM (Starostina and West, 2006)

The roughness and the charge density of the mineral oxide surface are of great concerned. Thus, mica is used since it is regarded as a model for both clays and other metal oxide surface and it is extensively used in the surface forces apparatus (Pashley and Israelachvili, 1981; Schulz and Warr, 2000; Schulz and Warr, 2002). Since mica has a higher number of adsorption sites than other mineral oxide surface, thus the AFM images of adsorbed cationic surfactants on mica have been recently evaluated (Pashley and Israelachvili, 1981; Nishimura et al., 1992; Schulz and Warr, 2002).

CHAPTER III

METHODOLOGY

3.1 MATERIALS

3.1.1 Surfactants

Surfactants used in this research are anionic carboxylated extended surfactants and a pyridinium-based cationic surfactant.

Anionic extended surfactant: Alkyl propoxylated ethoxylated carboxylates with different carbon chain lengths (16 and 17 or 16 and 18) with 4 mol of a propylene oxide (PO) group and a different number of an moles of ethylene oxide (EO) group (2 and 5 mol) were donated by Sasol North America Inc. (LA, USA).

Cationic surfactant: Cetylpyridinium chloride (CPC, 98% purity) with a C16 alkyl chain length was purchased from Fluka Chemical Company Ltd. (Buchs, Germany). All the surfactants were of research grade and were used as received. The properties of the studied surfactants are shown in Table 3-1.

Table 3-1 Surfactant properties

Surfactant	Formula	MW	Moles PO[a]	Moles EO[b]	Carbon	HLB[c] number
Anionic extended surfactants						
Alkyl propoxylated ethoxylated carboxylate, $C_{16\text{-}17}$ (C167-42)	$C_{16,17}(PO)_4(EO)_2COONa$	624	4	2	16-17	18.3
Alkyl propoxylated ethoxylated carboxylate, $C_{16\text{-}18}$ (C168-42)	$C_{16,18}(PO)_4(EO)_2COONa$	630	4	2	16-18	18.1
Alkyl propoxylated ethoxylated carboxylate, $C_{16\text{-}17}$ (C167-45)	$C_{16,17}(PO)_4(EO)_5COONa$	756	4	5	16-17	19.3
Alkyl propoxylated ethoxylated carboxylate, $C_{16\text{-}18}$ (C168-45)	$C_{16,18}(PO)_4(EO)_5COONa$	763	4	5	16-18	19.1
Cationic surfactant						
Cetylpyridinium Chloride (CPC)	$C_{21}H_{38}ClN$	358	-	-	16	26

[a] PO: Propylene oxide (C_3H_6O)

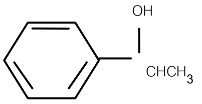
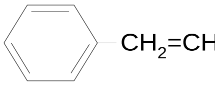
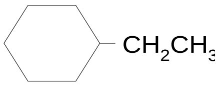
[b] EO: Ethylene oxide (C_2H_4O)

[c] HLB is hydrophilic—lipophilic balance (Rosen et al. 2004)

3.1.2 Organic Solutes

Three organic solutes with different dipole moment and hydrophobicity properties were selected in this study. Ethylcyclohexane (99% purity) was purchased from Arcos chemical company. Styrene (99% purity) and phenylethanol (98% purity) were purchased from Fluka chemical company Ltd. (Buchs, Germany). Properties of the organic solutes are shown in Table 3- 2.

Table 3-2 Properties of the organic solutes

Organic solute	MW	Molecular		Water Solubility (mg/L)	Density 25 °C (g/mL)	log K_{ow}	Dipole moment
		Formula	Structure				
Phenylethanol	122.16	$C_6H_5CH(OH)CH_3$		1950	1.01	1.42[a]	1.65
Styrene	104.15	$C_6H_5CH=CH_2$		310	0.909	2.95[b]	0.13
Ethylcyclohexane	112.21	$C_6H_{11}C_2H_5$		2.92	0.788	3.13[c]	0.00

[a] http://faculty.uscupstate.edu/labmanager/MSDS%20files/2760%20-%20sec-Phenethyl%20Alcohol.pdf

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

[c] EPA. (2003). Toxicological Review of Cyclohexane. Available from: http://www.epa.gov/IRIS/toxreviews/1005-tr.pdf (2009, June 10).

3.1.3 Solid Oxide Surface

The adsorbent used in this research, silica (SiO_2), was purchased from Sigma Aldrich Pte Ltd. and used without further purification. Silica dioxide has a measured specific surface area of 334 m^2/g (measured by N_2/BET adsorption method) and the reported point of zero charge is 2-4 (Okamoto et al., 2004).

The electrolyte concentration was controlled using sodium chloride (NaCl) purchased from VWR International Ltd. (Poole, England). The solution pH was adjusted using sodium hydroxide (NaOH) and hydrochloric acid (HCl) purchased from Merck (Darmstadt, Germany). All chemicals were analytical reagent grade and were used as received. All solutions in this research were prepared with deionized water having a resistance of 18.2 MΩ cm^{-1}. Plastic and glassware were rinsed well with deionized water three times prior to use.

3.2 EXPERIMENTAL METHOD

All experiments were conducted under constant room temperature (25 ± 2°C). The electrolyte concentration was controlled at 0.001 M (non swamping electrolyte concentration system) and 0.01 M (swamping electrolyte concentration system) by using sodium chloride (NaCl). The solution pH was controlled at 9 ± 0.5 by using sodium hydroxide (NaOH) and hydrochloric acid (HCl).

3.2.1 Precipitation Study

A series of samples was prepared by mixing stock solutions of surfactant in 15-mL vials with Teflon-lined caps (Fisher Scientific, Denver, CO). All solutions contained 0.001 M and 0.01 M NaCl as an electrolyte. The solution pH was adjusted to 9.0 ± 0.5 using NaOH and HCl. This pH value was chosen to achieve water solubility for all of the extended surfactants. Samples were forced to precipitate at 0 °C for 2 days to avoid supersaturation effects. These samples were kept at room temperature (25 ± 2 °C) and shaken periodically for one week. The presence of precipitate in solution was determined by visual inspection using a high intensity light.

3.2.2 CMC Measurements

Surface tension measurements were conducted at room temperature (25 ± 2 ºC) using a solution pH of 9.0 ± 0.5 and Wilhelmy plate tensiometer (DCAT 11, DataPhysics, Filderstadt, Germany) with a platinum plate. In this experiment, 0.001 M and 0.01 M of NaCl was used as a background electrolyte concentration to minimize change in the ionic strength of the solution.

3.2.3 Adsorption Study

Surfactant adsorption isotherms onto negatively charge surface, silica (SiO_2), were conducted at a constant room temperature (25 ± 2 °C), at an electrolyte concentration of 0.001 M NaCl and at a solution pH of 9.0 ± 0.5. The adsorption studies were conducted in 40 mL vials with Teflon-lined caps using a constant volume of mixed anionic extended surfactant and cationic surfactant at a mixing ratio that is not in the precipitation region. The amount of silica added was sufficient to significantly decrease the initial concentration while ensuring that the final surfactant concentrations were detectable. The solution was equilibrated by shaking at 150 rpm for at least 48 hours. The pH of the solution was checked after 12 hours of shaking and adjusted to be in the range of 8.5-9.5 using NaOH and/or HCl. After equilibration, the solution was centrifuged to remove silica and the concentration of anionic extended surfactant and cationic surfactant in the supernatant were analyzed by high performance liquid chromatography, HPLC (LC 1100, Agilent).

3.2.4 Adsolubilization Study

Adsolubilization studies were conducted at room temperature (25 ± 2 °C) with an electrolyte concentration of 0.001 M NaCl and a solution pH of 9.0 ± 0.5. Known concentrations of the mixed surfactants were added to solution containing a known mass of silica with various organic solute (ethylcyclohexane, styrene, and phenylethanol) concentrations less than the solubilization capacity. The equilibrium aqueous surfactant concentration was selected at 95% of the CMC to ensure that no micelles are presented in aqueous solution at equilibrium. These solutions were shaken for 48 hours to achieve equilibrium. The pH of the solution was checked and adjusted to be in the range of 8.5-9.5. The samples were centrifuged to remove silica and the concentration of anionic surfactant, cationic surfactant and organic solute were analyzed by high performance liquid chromatography, HPLC (LC 1100, Agilent) and gas chromatography, GC (6890N, Agilent).

3.2.5 Solubilization Study

Solubilization studies were conducted in 40 mL vials with Teflon-lined caps (Fisher Scientific, Denver, CO) at room temperature (25±2°C), electrolyte concentration of 0.001 M NaCl and a solution pH of 9±0.5 with the maximum solubilization. The surfactant concentration was varied from below to above the CMC. The solution was equilibrated by shaking at 150 rpm for 48 hours. The organic solutes were allowed to phase separate, and then the solution was analyzed by high performance liquid chromatography, HPLC (LC 1100, Agilent) and gas chromatography, GC (6890N, Agilent).

3.2.6 Desorption Study

Desorption studies were conducted by using silica that had achieved equilibrium adsorption with a surfactant concentration at 95% of CMC to ensure that the maximum adsorption had occurred at equilibrium concentration. The surfactant modified silica was washed with deionized water and shaken for 48 hours. The zeta potential values of the surfactant modified silica in the solution before and after being washed were measured to determine the change in surface charge of silica by using an electrophoretic apparatus (Zeta-Meter System 3.0, Zeta-Meter Inc.). The number of washing were varied to determine the desorption potential.

3.2.7 Atomic Force Microscopy Study

To characterized the surface of the surfactant adsorbed onto the solid oxide surface, 9 mm mica discs and 12 mm AFM specimen discs were purchased from Ted Pella Inc. (Reddings, CA). The surfactant modified mica disc samples were prepared at 95% of the CMC of each system to avoid aqueous micelle and surface admicelle interaction which occur above the CMC. The electrolyte concentration was controlled at 0.001 M NaCl. The surfactant modified mica surface morphologies images were capture by using the multimode Nanoscape IV AFM (Veeco/Digital Instruments Inc., Santa Barbara, CA).

3.3 ANALYTICAL METHODS

The concentration of anionic and cationic surfactants, styrene and phenylethanol were measured by high performance liquid chromatography, HPLC (LC 1100, Agilent) with a reverse phase column (Acclaim Surfactant Column, Dionex). The mobile phase was a mixture of 0.1 M ammonium acetate ($C_2H_3O_2NH_4$) at pH 5.4 and acetonitrile (C_2H_3N) with the ratio of 60:40. Evaporative light scattering detector (ELSD) was used to detect the concentration of the anionic surfactants. Diode array detector (DAD) at 247 nm was used to detect the concentration of cationic surfactant and styrene while phenylethanol was detected at 260 nm. Ethylcyclohexane was analyzed using gas chromatography, GC (6890N, Agilent) with HP-5 column (Agilent) at temperature of 200 °C and detected by flame ionization detector (FID).

CHAPTER IV

RESULTS AND DISCUSSION

4.1 PRECIPITATION PHASE BOUNDARIES

Precipitation studies were conducted to evaluate the precipitation potential of these mixtures as well as to ensure that the surface tension studies were conducted in regions without precipitate or liquid crystals. Figure 4-1 shows the precipitation phase boundaries of the anionic extended surfactants and CPC mixtures (C167-42/CPC, C168-42/CPC, C167-45/CPC and C168-45/CPC) in the presence of 0.01 M NaCl.

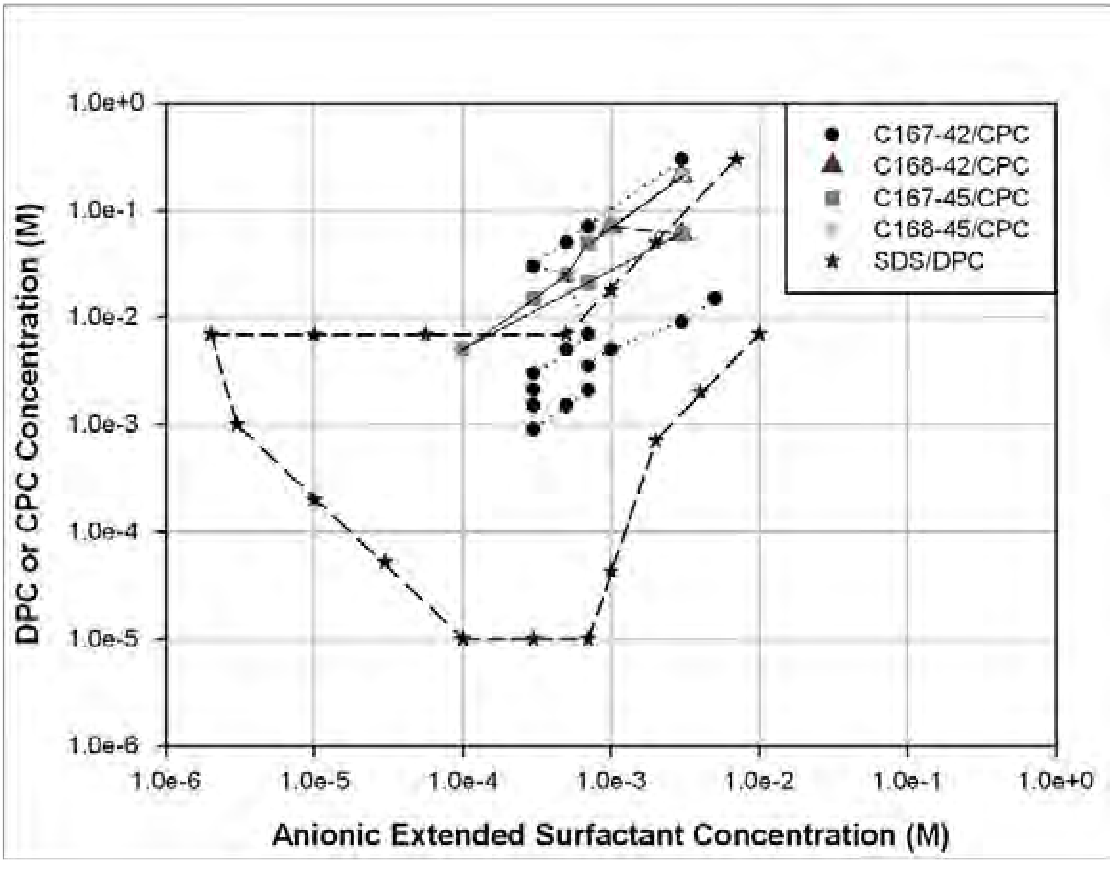


Figure 4-1 Precipitation phase boundaries of SDS/DPC, C167-42/CPC, C168-42/CPC, C167-45/CPC and C168-45/CPC at 25 °C, and in the presence of 0.01 M NaCl. * Data from Stellner et al., 1988, and under the same conditions

Mixed surfactant systems in this study have the same linear hydrophobic groups (12 carbons for SDS/DPC and 16 carbons for anionic extended surfactant/CPC) and these systems are referred to as symmetric-linear. The precipitation phase boundary of a conventional mixed surfactant system (SDS/DPC) is included from previous work (Stellner et al., 1988) for comparison with the anionic extended surfactants and cationic surfactant (CPC).

The results show that there is a significant reduction in the precipitation for the mixed anionic extended surfactant and cationic surfactant systems and a shift to the left (similar to observation in Fuangswasdi et al., 2006b). This reduction in precipitation region is also consistent with the system that has lower electrolyte concentration (0.001 M NaCl) as shown in Figure 4-2. When comparing the number of EO groups, it appears that the precipitation phase boundaries for systems that have higher number of EO groups are smaller than for lower number of EO groups. This observation should be systematically evaluated in future research. These results indicate that introducing intermediate polarity groups, ethylene oxide (EO) and propylene oxide (PO), into anionic surfactant structures can result in reduced precipitation (Mehreteab and Loprest, 1988; Li and Zhao, 1992; Cui and Canselier, 2001). This reduction in precipitation phase can be attributed to the coiling effect of the anionic extended surfactant that sterically hinders the interaction between oppositely charged head group and tail-tail interaction as depicted in Figure 4-3. Similar observations have been reported by Upadhyaya et al. (2006) who showed the steric effect of surfactant branching in reducing the head-head interaction and formation of precipitates. Based on the precipitation data in Figure 4-1 and Figure 4-2, all experiments in this study were conducted at ratio of 1:1 to avoid the presence of precipitates.

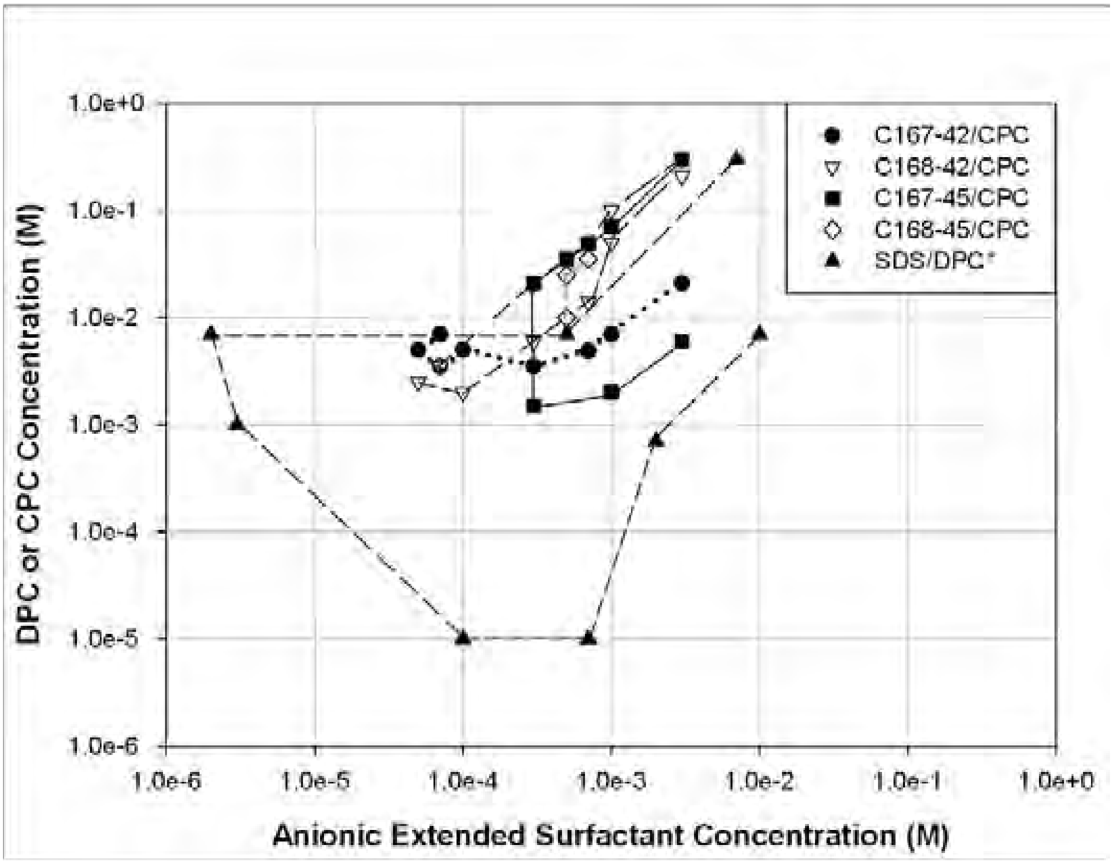


Figure 4-2 Precipitation phase boundaries of SDS/DPC, C167-42/CPC, C168-42/CPC, C167-45/CPC and C168-45/CPC at 25 °C, and in the presence of 0.001 M NaCl. *Data from Stellner et al., 1988, and under the same conditions

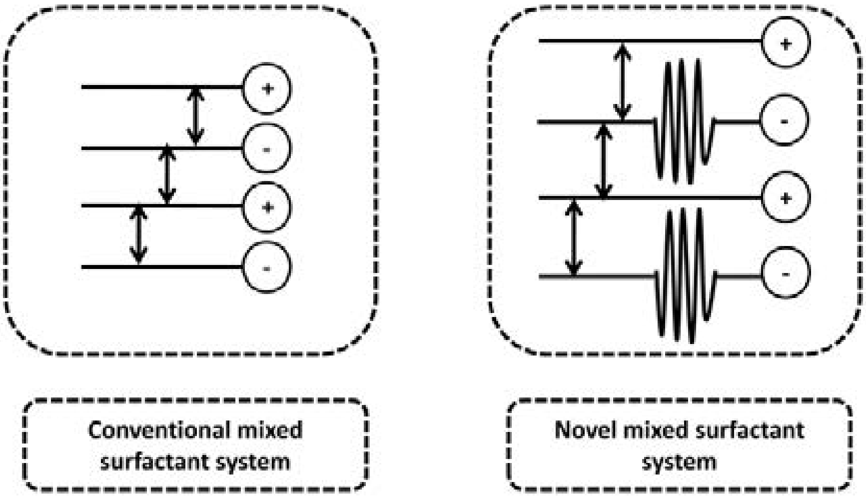


Figure 4-3 The coiling effect of anionic extended surfactant

4.2 CRITICAL MICELLE CONCENTRATION MEASUREMENT

The critical micelle concentrations (CMCs) of the individual and mixed micellar systems (C167-42/CPC, C168-42/CPC, C167-45/CPC and C168-45/CPC) were determined by the break point in the plot of the surface tension versus surfactant concentration (Figure 4-4 and Figure 4-5). Table 4-1 summarizes the CMC values of individual surfactant systems and mixed surfactant systems with 0.01 M and 0.001 M NaCl at room temperature (25 ± 2 °C) and solution pH of 9.0 ± 0.5. For individual surfactant systems, the CMCs of the anionic extended surfactants were one order of magnitude lower than that of the conventional cationic surfactant (CPC).

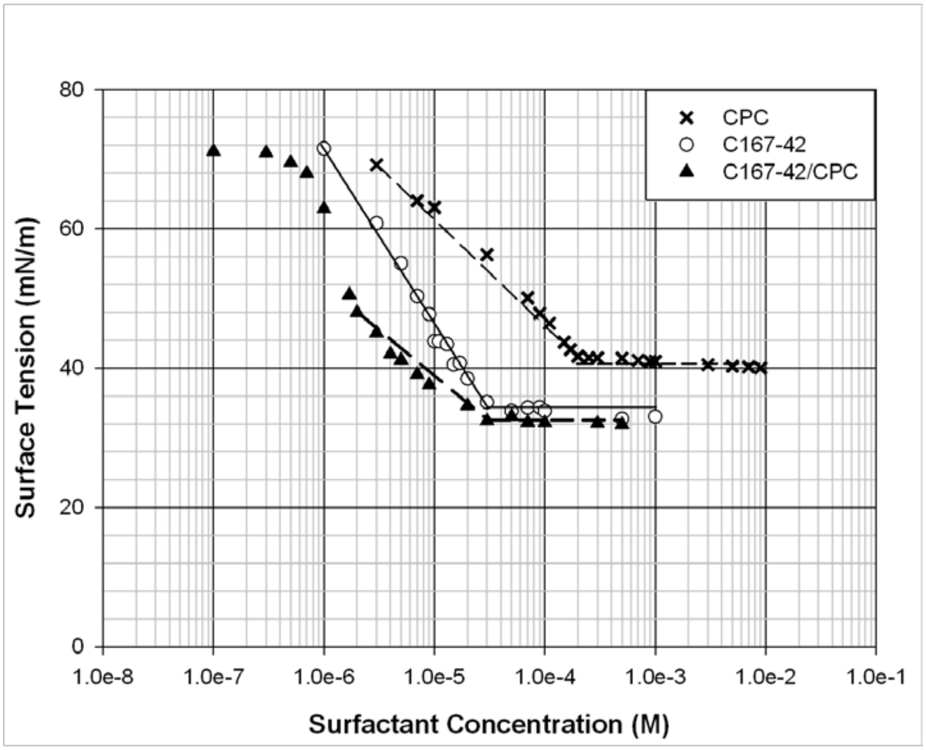


Figure 4-4 (a) The surface tension of CPC, C167-42 and C167-42/CPC at 0.01 M NaCl, solution pH 9 ± 0.5 and temperature 25 ± 2 °C

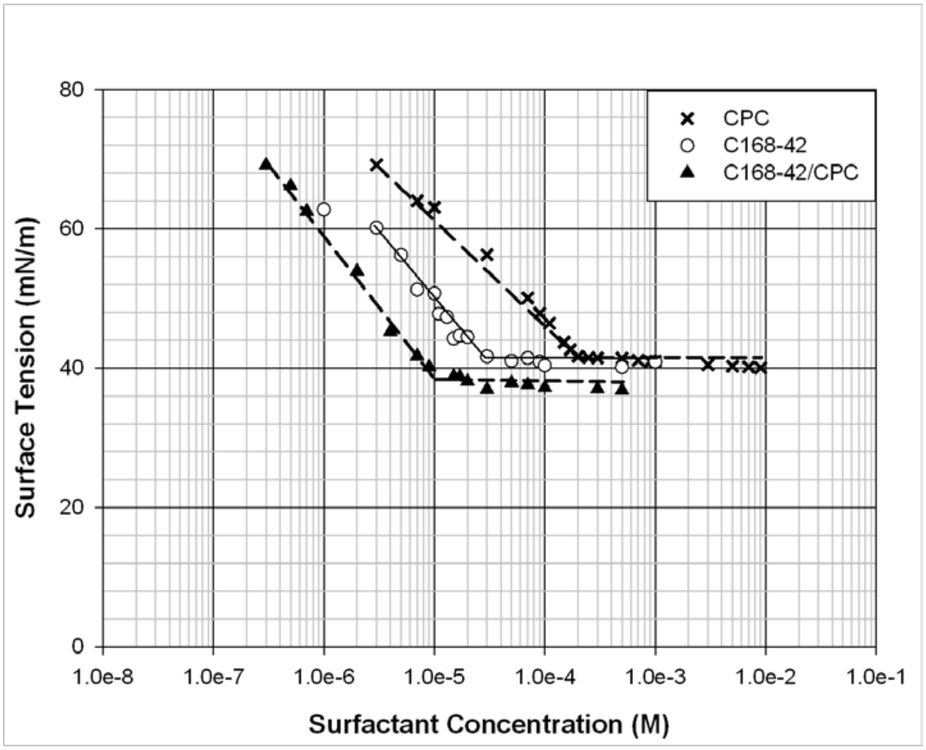


Figure 4-4 (b) The surface tension of CPC, C168-42 and C168-42/CPC at 0.01 M NaCl, solution pH 9 ± 0.5 and temperature 25 ± 2 °C

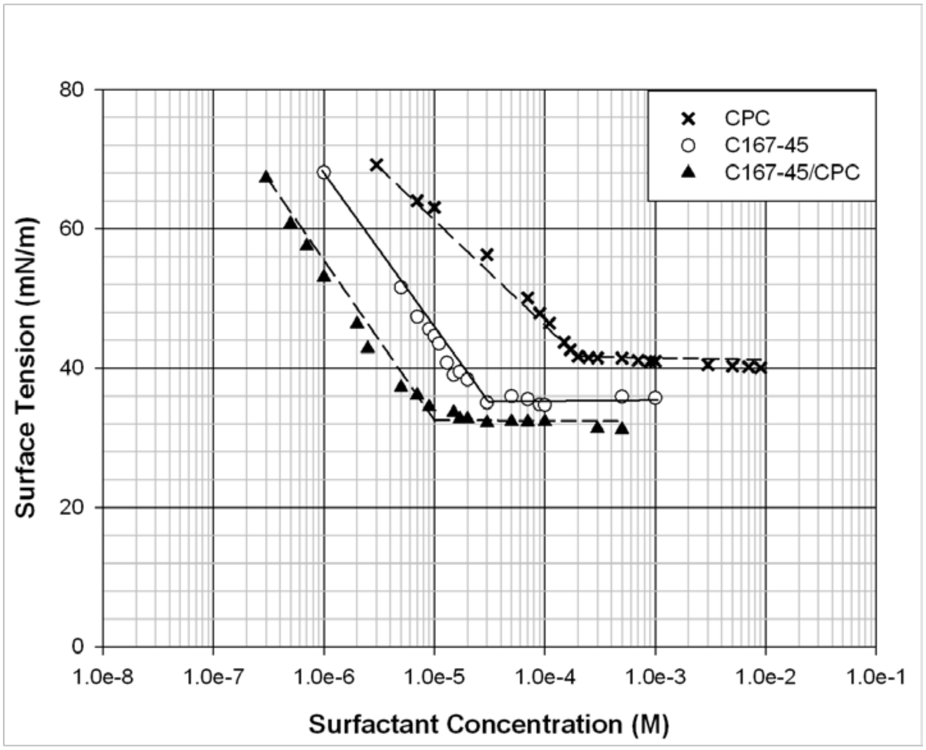


Figure 4-4 (c) The surface tension of CPC, C167-45 and C167-45/CPC at 0.01 M NaCl, solution pH 9 ± 0.5 and temperature 25 ± 2 °C

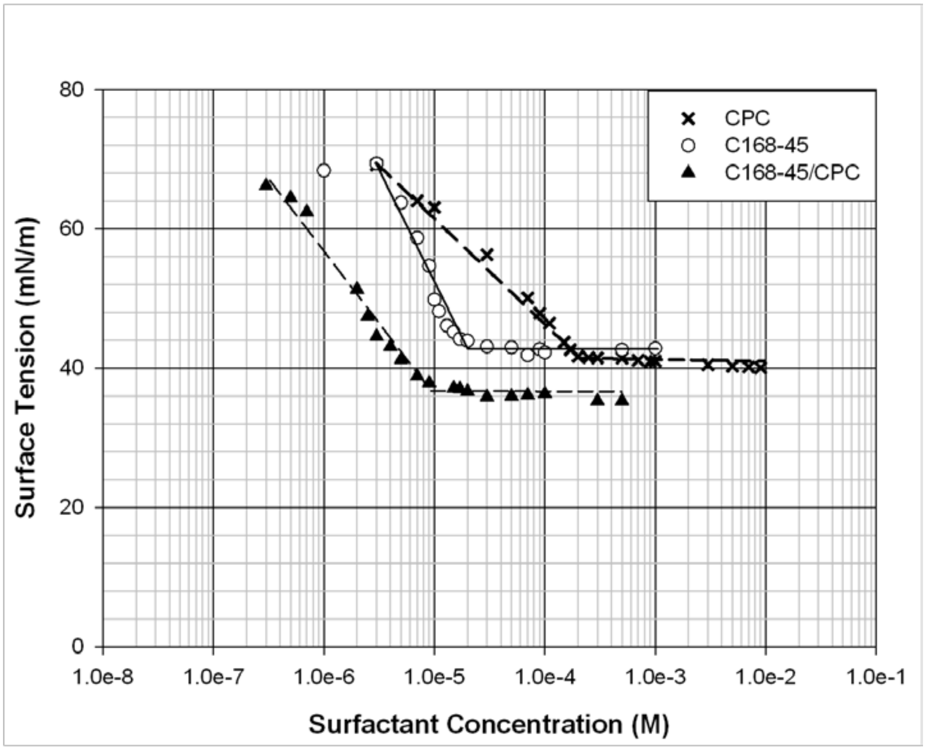


Figure 4-4 (d) The surface tension of CPC, C168-45 and C168-45/CPC at 0.01 M NaCl, solution pH 9 ± 0.5 and temperature 25 ± 2 °C

These results are consistent with previous research (Charoensaeng et al., 2008; Arpornpong et al., 2010) that found the CMC of the extended surfactant to be lower than conventional surfactants. This could be due to the higher hydrophobicity of the extended surfactants which require lower monomers concentrations to form aggregates like micelles in an aqueous solution. Moreover, the CMC values of the mixed surfactant systems are lower than the individual surfactant systems. This result is attributed to the elimination of the unfavorable electrostatic free energy which eventually decreases the electrostatic repulsion between the hydrophilic head groups of the surfactant molecules. Additionally, the hydrophobic chain lengths of the anionic and cationic surfactant are about the same which cause stronger hydrophobic interactions between the surfactants and thus facilitate the mixed micelle formation and lower the CMC values of the mixed surfactant systems.

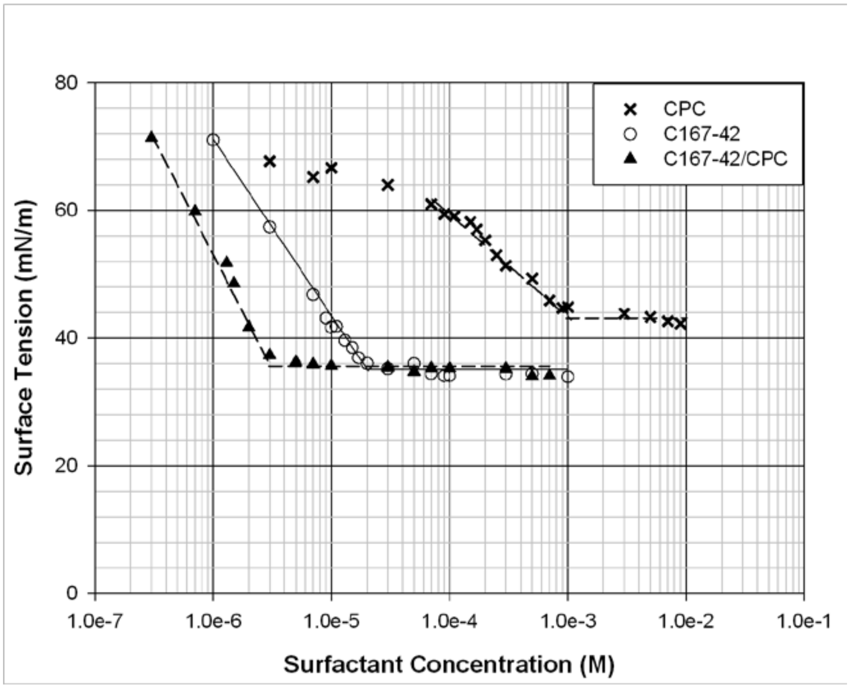


Figure 4-5 (a) The surface tension of CPC, C167-42 and C167-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 ºC

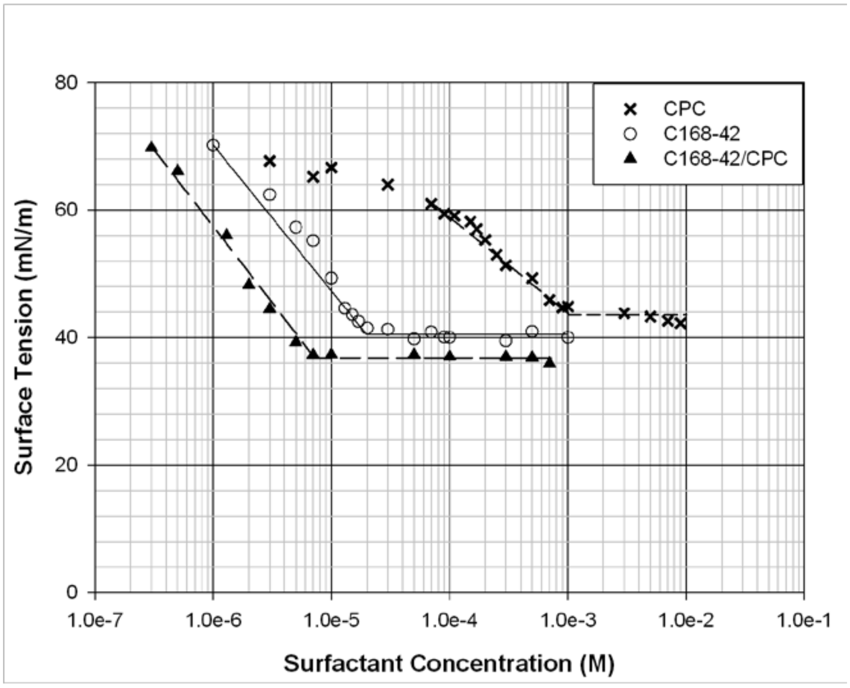


Figure 4-5 (b) The surface tension of CPC, C168-42 and C168-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 ºC

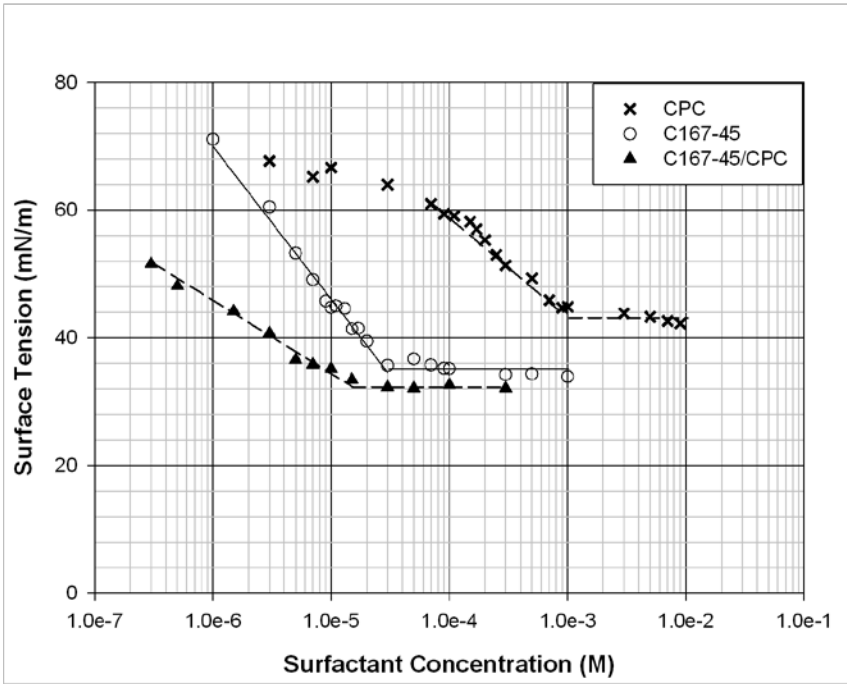


Figure 4-5 (c) The surface tension of CPC, C167-45 and C167-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 ºC

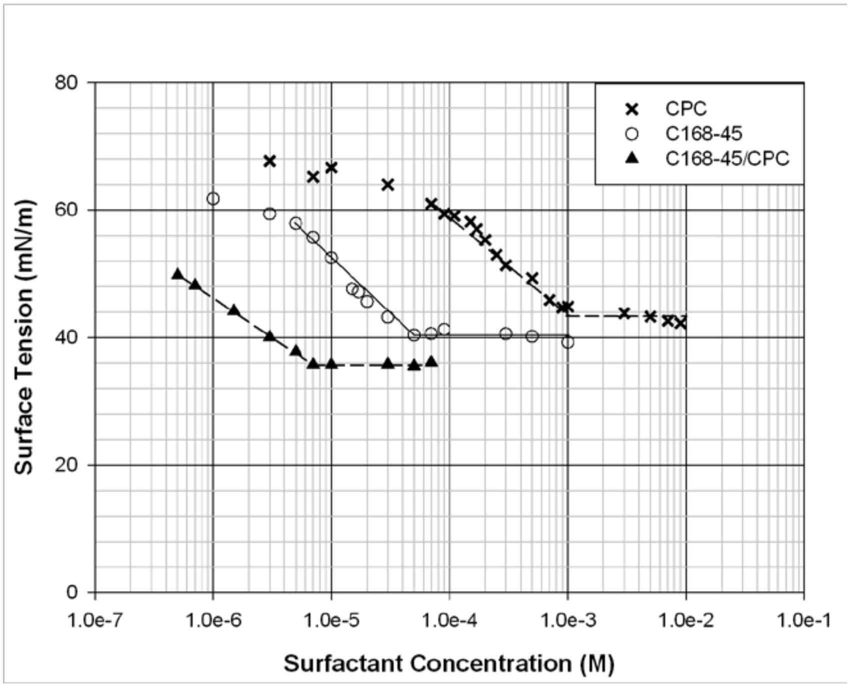


Figure 4-5 (d) The surface tension of CPC, C168-45 and C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 ºC

Table 4-1 CMC values of pure surfactant systems and mixed surfactant system at 0.01 M and 0.001 M NaCl, temperature 25 ± 2°C, and pH 9.0 ± 0.5 at liquid-air interface

Surfactant	CMC[a] (0.01 M NaCl) (mM)	CMC[b] (0.001 M NaCl) (mM)
Individual surfactant		
CPC	0.20	0.60
$C_{16\text{-}17}(PO)_4(EO)_2COONa$	0.03	0.02
$C_{16\text{-}18}(PO)_4(EO)_2COONa$	0.03	0.01
$C_{16\text{-}17}(PO)_4(EO)_5COONa$	0.03	0.02
$C_{16\text{-}18}(PO)_4(EO)_5COONa$	0.02	0.04
Mixed surfactant		
$C_{16\text{-}17}(PO)_4(EO)_2COONa$ /CPC	0.03	0.004
$C_{16\text{-}18}(PO)_4(EO)_2COONa$/CPC	0.01	0.007
$C_{16\text{-}17}(PO)_4(EO)_5COONa$/CPC	0.01	0.004
$C_{16\text{-}18}(PO)_4(EO)_5COONa$/CPC	0.01	0.00

[a] From Figure 4-4 (a), (b), (c), and (d)

[b] From Figure 4-5 (a), (b), (c), and (d)

However, when comparing the CMC values of the mixed surfactant systems that have different electrolyte concentration the results are not as expected. Theoretically, the CMC values of the surfactant in the system that has lower electrolyte concentration supposed to have higher CMC values where the mixed surfactant systems. This observation should be systematically evaluated in future research.

4.3 MOLECULAR INTERACTIONS AND SYNERGISM

It is well known that mixed anionic and cationic surfactant systems exhibit synergism as demonstrated by a lower CMC in the mixtures than in those of individual surfactant systems. The molecular interaction between oppositely charged surfactants at the interface is generally explained by the molecular interaction parameter (β) which indicates the nature and strength of those interactions in a mixed monolayer at an interface and in a mixed micelle in aqueous solution (Rosen, 1998; Vora et al., 1999; Yin et al., 2001; Rosen, 2004). If β is positive, the interaction is repulsive (antagonism), and if β is negative, the interaction is attractive (synergism). The interaction parameter for mixed monolayer formation can be calculated by Equation 2-3 and 2-4 where the molecular interaction parameter for mixed micelle formation proposed by can be calculated by Equation 2-5 and 2-6.

Table 4-2 Molecular interaction parameters and synergisms

Binary System	β^σ	$\lvert\ln (C_1^0/C_2^0)\rvert$	β^M	$\lvert\ln (C_1^M/C_2^M)\rvert$	β^σ- β^M	$\left\lvert\ln \frac{C_1^{0,\mathrm{cmc}} C_2^M}{C_2^{0,\mathrm{cmc}} C_1^M}\right\rvert$
$C_{16\text{-}17}(PO)_4(EO)_2COONa$ /CPC	-12.6	2.30	-5.4	1.90	-7.3	1.4
$C_{16\text{-}18}(PO)_4(EO)_2COONa$/CPC	-11.3	2.01	-9.8	1.90	-1.6	1.5
$C_{16\text{-}17}(PO)_4(EO)_5COONa$/CPC	-13.2	2.53	-9.8	1.90	-3.4	2.3
$C_{16\text{-}18}(PO)_4(EO)_5COONa$/CPC	-12.2	2.12	-9.4	3.00	-2.8	1.4

As can be seen in Table 4-2, the β parameters for mixed monolayer formation and micelle formation are negative which means that all systems show synergism. These results are consistent with observations of other researches (George et al., 1998; Cui and Canselier, 2001; Yin et al., 2001; Rosen, 2004) that the interactions between oppositely charged surfactant are strongly attractive due to the electrostatic forces between the two different hydrophilic head groups. Moreover, the similar trends are also found in the interactions between two different surfactants in mixed micelles which are generally weaker than their interactions in mixed monolayers at the aqueous solution-air interface. Additionally, β^{σ} and β^{M} of the four systems are not much different, thus the effect of ethylene oxide and the alkyl chain length in the surfactant on the β parameter and the tendency is not clear. Moreover, to confirm the existence of synergism, three different types of synergism need to be satisfied (Rosen, 2004).

4.3.1 Synergism in Surface Tension Reduction Efficiency

Efficiency in surface tension reduction exists when a given surface tension can be attained at a total mixed surfactant concentration less than that required of either surfactant by itself (Rosen, 2004). The conditions to evaluate the existence of synergism in surface tension reduction efficiency are:

1. β^{σ} must be negative.

2. $| \beta^{\sigma} | > |\ln (C_1^0/C_2^0)$.

The synergisms in surface tension reduction efficiency for the four systems studied and the degree of synergism are shown in Table 4-2, indicating that all four systems demonstrate synergism in surface tension reduction efficiency.

4.3.2 Synergism in Mixed Micelle Formation in Aqueous Medium

Synergism in mixed micelle formation exists when the CMC of the mixture of two surfactants is smaller than the CMC of either individual surfactant (Rosen, 2004). The conditions for the existence of synergism in mixed micelle formation are:

1. β^M must be negative.

2. $| \beta^M | > |\ln (C_1^M/C_2^M)|$.

The synergism results for mixed micelle formation for the systems studied are shown in Table 4-3. According to the condition for the existence of synergism, it can be seen that the four systems studied have synergism in mixed micelle formation. To put these β^M parameters into context, Rosen (2004) reports β^M values for anionic/cationic mixtures in the range of -10 to -20, while the values report here are in the range of -5 to -10. While the extended surfactants have lower synergism than conventional surfactant mixtures, they also show much lower potential for precipitation as compared to conventional surfactants (see Figure 4-1 and Figure 4-2 and discussion) which means the formulation space is much greater, extending the viability of using these mixtures. The same trend was also observed for branched anionic/cationic mixtures (Upadhyaya et al., 2006) which also showed a lower synergism but much less precipitation. Also, the synergism reported here is still greater than in cationic/nonionic mixtures (-1.0 to -4.6).

4.3.3 Synergism in Surface Tension Reduction Effectiveness

Synergism in surface tension reduction effectiveness is presented when the CMC of the mixture of two surfactants reaches a lower surface tension than that obtained from either individual surfactant (Rosen, 2004). The conditions for this type of synergism are:

1. $\beta^{\sigma} - \beta^{M}$ must be negative.

2. $| \beta^{\sigma} - \beta^{M} | > \ln \frac{\left|C_1^{0,CMC}\, C_2^{M}\right|}{\left|C_2^{0,CMC} C_1^{M}\right|}$.

where $\mathbf{C_1^{0,CMC}}$ and $\mathbf{C_2^{0,CMC}}$ are the molar concentration of individual surfactants 1 and 2, respectively, that required to yield a surface tension value equal to that of mixture of the two surfactants at its CMC. The results regarding the synergism in surface tension reduction effectiveness are shown in Table 4-2 indicating that all systems studied have synergism in surface tension reduction effectiveness.

We have thus shown that extended anionic surfactant – cationic surfactant mixtures have much less precipitation while maintaining synergism in CMC reduction, albeit slightly reduced. Thus, these extended surfactants have the potential to increase formulation space (less precipitation) for anionic – cationic surfactant mixtures while maintaining desirable level of synergism.

4.4 SURFACTANT ADSORPTION STUDIES

Figure 4-6(a)-(d) summarize the adsorption isotherms of the individual surfactant system (CPC) and the mixed surfactant systems (C167-42/CPC, C168-42/CPC, C167-45/CPC, and C168-45/CPC) onto the negatively charge surface, silica (SiO_2), at a constant room temperature (25 ± 2 °C), with 0.001 M NaCl, and a solution pH of 9 ± 0.5. Adsorption isotherms of anionic extended surfactants onto silica are not shown in these figures since the adsorption of anionic surfactants was negligible. However, there are small amounts of anionic extended surfactant adsorbed onto silica which possibly due to the ion pairing between anionic extended surfactants and cationic surfactant adsorbed onto silica. Generally, the adsorption isotherm of surfactants can be subdivided into four regions which the transition point between Region III and IV is similar to critical micelle concentration (CMC) from surface tension measurement (Somasundaran and Fuerstenau, 1966; Scamehorn et al., 1982; Paria and Khilar, 2004; Rosen, 2004; Fuangswasdi et al., 2006a; Upadhyaya et al., 2007; Charoensaeng et al., 2008)

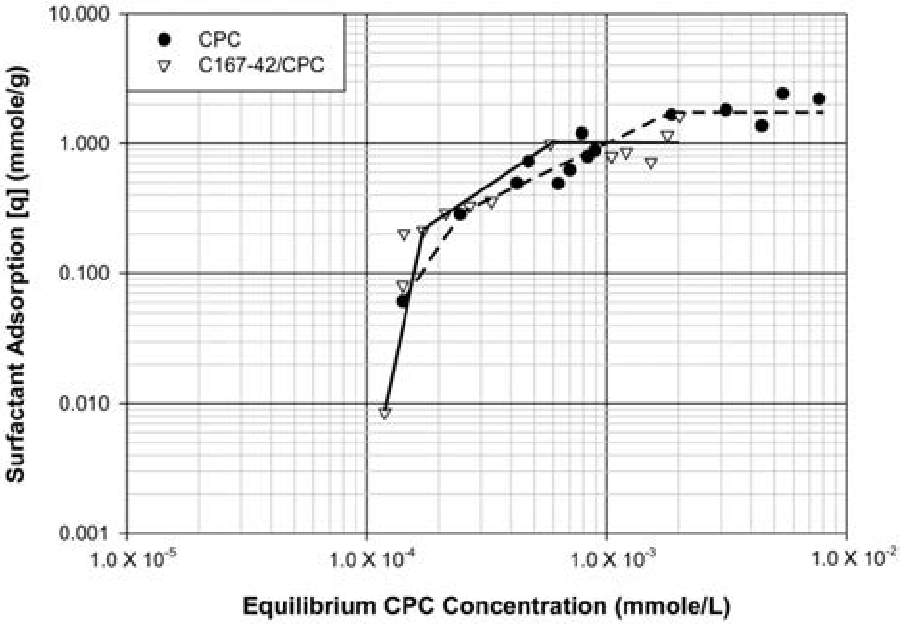


Figure 4-6 (a) Adsorption isotherm of C167-42/CPC on silica at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

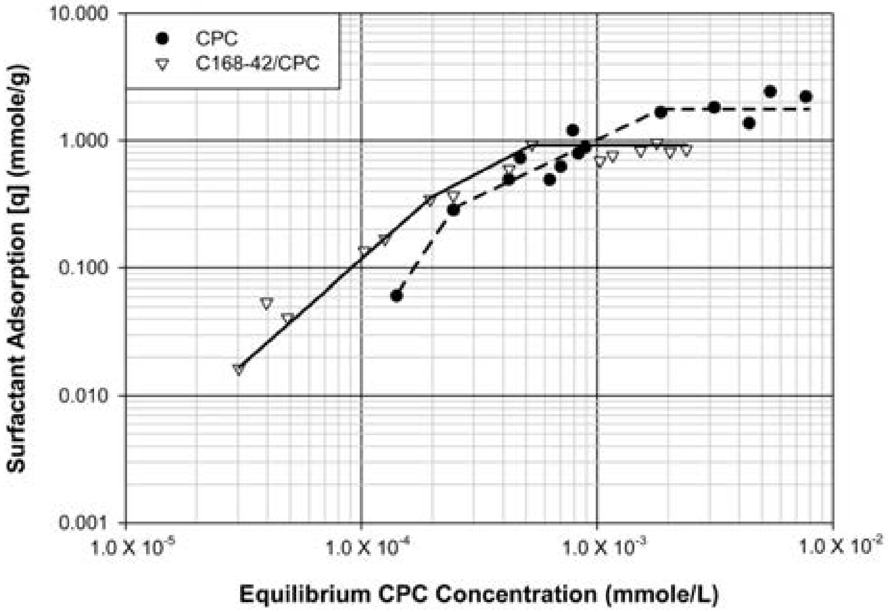


Figure 4-6 (b) Adsorption isotherm of C168-42/CPC on silica at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

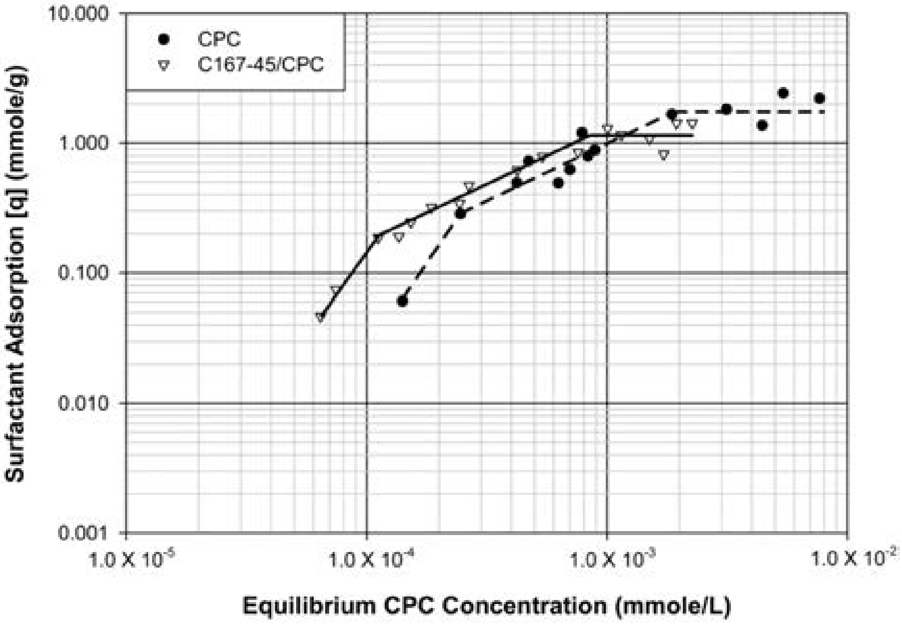


Figure 4-6 (c) Adsorption isotherm of C167-45/CPC on silica at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

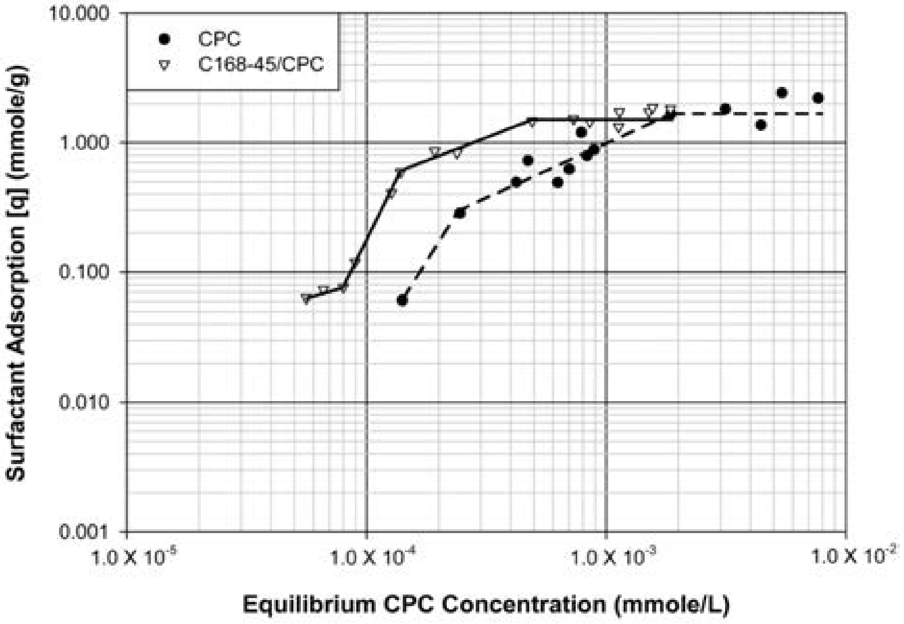


Figure 4-6 (d) Adsorption isotherm of C168-45/CPC on silica at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

As illustrated in the adsorption isotherm, it can be seen that all surfactant systems studied show the characteristics of Region II, III, and IV; detection limit prevented the type I portion of the isotherm from being quantified. The results also showed that the adsorption of all surfactant system studied increases as the equilibrium surfactant concentration increased. The surfactant concentration when maximum adsorption is realized (transition point) and the maximum adsorption capacity of all surfactant systems are summarized in Table 4-3.

Table 4-3 Transition point and maximum adsorption values of the adsorption isotherms in the individual surfactant and mixed surfactant systems at solid-liquid interface at 0.001 M NaCl, pH 9 ± 0.5 and 25 ± 2 °C

Surfactants	Transition point of CPC[a] (mM)	CPC maximum adsorption (q_{max}) mmole/g
Individual surfactant system		
CPC	1.90	2.16
Mixed surfactant systems		
$C_{16-17}(PO)_4(EO)_2COONa$/CPC	0.60	1.03
$C_{16-18}(PO)_4(EO)_2COONa$/CPC	0.53	0.97
$C_{16-17}(PO)_4(EO)_5COONa$/CPC	0.85	1.15
$C_{16-18}(PO)_4(EO)_5COONa$/CPC	0.50	1.61

[a] point where adsorption isotherm plateaus

As expected, the plateau adsorption of the mixed anionic extended and cationic surfactant systems occur at a lower surfactant concentration than the individual surfactant system consistent with CMC of the mixed surfactant systems that are an order of magnitude lower than that of the individual surfactant system (Fuangswasdi et al., 2006b). This is attributed to the reduction of the electrostatic repulsion between the similarly charged head groups which can reduce the lateral interaction and allow closer packing density of surfactant on the surface. Similar observations have been reported by Fuangswasdi et al. (2006b) and Upadhyaya et al. (2007). From Table 4-3, the amount of CPC adsorption is approximately the same as reported in (Goloub and Koopal, 1997). For the maximum adsorption, it is found that the adsorption capacity of the CPC is not enhanced in the presence of the anionic extended surfactant. This could be attributed to the steric hindrance of surfactant branching that may also limit synergism in adsorption of the mixed anionic and cationic surfactant system (Upadhyaya et al., 2006; Panswad et al., 2011). However, below plateau adsorption, it is found that mixed surfactant systems show higher adsorption capacity at any given surfactant concentration.

4.5 ADSOLUBILIZATION STUDIES

4.5.1 Phenylethanol Adsolubilization

Table 4-4 summarizes the adsolubilization capacities (log K_{adm}) of phenylethanol in individual and mixed surfactant systems. The adsolubilization isotherms of phenylethanol with an individual and four mixed surfactant admicellar system are shown in Figure 4-7. It can be seen that in every system studied, as phenylethanol aqueous mole fraction (X_{aq}) increased, log K_{adm} decreased suggesting that phenylethanol partition into the palisade region of the admicelle. This observation is consistent with other researches (Lee et al., 1990; Nayyar et al., 1994; Dickson and O'Haver, 2002; Charoensaeng et al., 2009; Arpornpong et al., 2010) since phenylethanol is polar, it was expected to partition into the palisade region. Additionally, as expected, mixed anionic extended and cationic surfactant systems show statistically higher adsolubilization capacities than the individual surfactant system. Moreover, these values are higher than the adsolubilization capacities of the individual anionic extended surfactant systems (Charoensaeng et al., 2009). This result could be due to the larger aggregation of these mixed surfactant systems, resulting in larger palisade layer to adsolubilize more phenylethanol comparing with the individual surfactant system. When comparing the number of carbon chain length, it found that there is no significant effect on log K_{adm}. Results from Table 4-4 and Figure 4-7 also indicate that difference in the number of EO groups does not significantly effect the adsolubilization of phenylethanol. These findings could be inferred that the hydrophobicity of the core does not have significantly impact to the phenylethanol adsolubilization.

Table 4-4 Summary of admicellar partition coefficient values (K_{adm}) of organic solutes

Surfactants	Phenylethanol		Styrene		Ethylcyclohexane	
	K_{adm}	Log K_{adm}	K_{adm}	Log K_{adm}	K_{adm}	Log K_{adm}
Individual surfactant system						
CPC	600	2.75	16700	4.22	650000	5.81
Mixed surfactant systems						
$C_{16\text{-}17}(PO)_4(EO)_2COONa$/CPC	2710	3.43	39100	4.59	2120000	6.33
$C_{16\text{-}18}(PO)_4(EO)_2COONa$/CPC	3180	3.50	25100	4.40	3230000	6.51
$C_{16\text{-}17}(PO)_4(EO)_5COONa$/CPC	3420	3.53	23000	4.36	5380000	6.73
$C_{16\text{-}18}(PO)_4(EO)_5COONa$/CPC	2500	3.40	26500	4.42	4070000	6.61

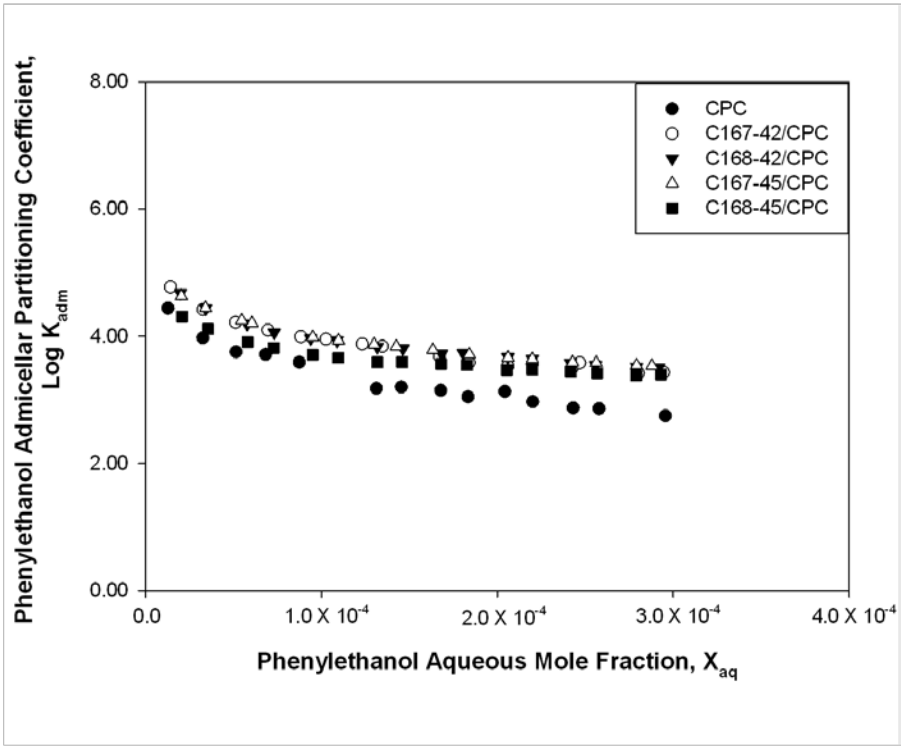


Figure 4-7 Phenylethanol admicellar partitioning coefficient of CPC, C167-42/CPC, C168-42/CPC, C167-45/CPC, and C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

4.5.2 Styrene Adsolubilization

The logarithm of admicellar partition coefficient of styrene as a function of the styrene aqueous mole fraction of in individual and mixed surfactant admicellar systems are shown in Figure 4-8, showing that as styrene aqueous mole fraction (X_{aq}) increased, log K_{adm} slightly decreased. These observations indicating that styrene also partition into the palisade region and the hydrophobic core of the admicelle which could be attributed to the intermediate polarity of styrene. This finding is consistent with the previous research (Kitiyanan et al., 1996), showing that styrene can partition into both palisade layer and the core of the admicelle. Styrene adsolubilization capacities in individual and mixed surfactant systems are summarized in Table 4-4. It is interesting to see that even though the values of log K_{adm} of the mixed surfactant systems are higher than that of the individual surfactant system, they are not significantly different. Moreover, these results are a little higher than the adsolubilization capacities in the anionic extended surfactant alone (Charoensaeng et al., 2008). However, these results are not different from the adsolubilization capacities that found in mixed conventional surfactant systems (log K_{adm} $\approx$ 4.3-4.4) (Fuangswasdi et al., 2006a). Once again, this could be due to the larger aggregation size of the admicelle of the mixed surfactant systems which provide more space for adsolubilization of styrene. However, since styrene has less dipole moment than phenylethanol, thus the log K_{adm} of styrene in all systems studied is higher than that of phenylethanol. In addition, the effect of carbon chain length and number of EO groups are also found to be no significant effect for styrene adsolubilization since styrene mostly partition into the palisade region rather than into the hydrophobic core of the admicelle.

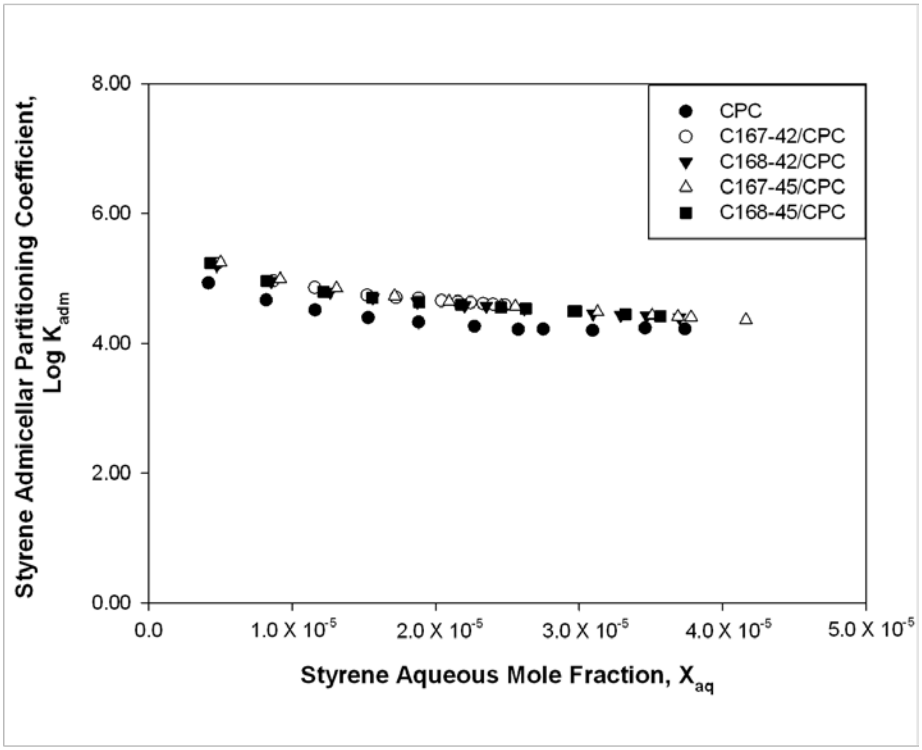


Figure 4-8 Styrene admicellar partitioning coefficient of CPC, C167-42/CPC, C168-42/CPC, C167-45/CPC, and C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

4.5.3 Ethylcyclohexane Adsolubilization

Figure 4-9 shows the logarithm of ethylcyclohexane admicellar partition coefficient as a function of the ethylcyclohexane aqueous mole fraction in individual and mixed surfactant systems. Table 4-4 also summarizes the admicellar partition coefficient of the ethylcyclohexane. The results show that ethylcyclohexane adsolubilization in mixed surfactant systems are significantly higher than that of the individual surfactant system. These results are also significantly higher than the adsolubilization capacities of anionic extended surfactants reported by Charoensaeng et al. (2009) (log Kadm ≈ 4.0 - 4.6) and conventional mixed anionic and cationic surfactant reported by Fuangswasdi et al. (2006a) (log Kadm ≈ 3.8 - 4.2). The reason for this finding could be the more hydrophobicity and the larger aggregate size of the admicelle of the mixed surfactant systems which can facilitate larger amount of ethylcyclohexane partitioning into admicelles. Similarly to phenylethanol and styrene adsolubilization, the different in carbon chain length and number of EO groups have no significant impact on ethylcyclohexane adsolubilization.

Comparing with adsolubilization capacities among three organic solutes, it can be seen that ethylcyclohexane has the highest values of log K_{adm} while phenylethanol has the lowest values of log K_{adm}. This result could be due to the water solubility, polarity and hydrophobicity (K_{ow}) trends of the organic solutes which phenylethanol has the highest water solubility followed by styrene and ethylcyclohexane. Thus, the adsolubilization capacities tend to increase as the water solubility decreased.

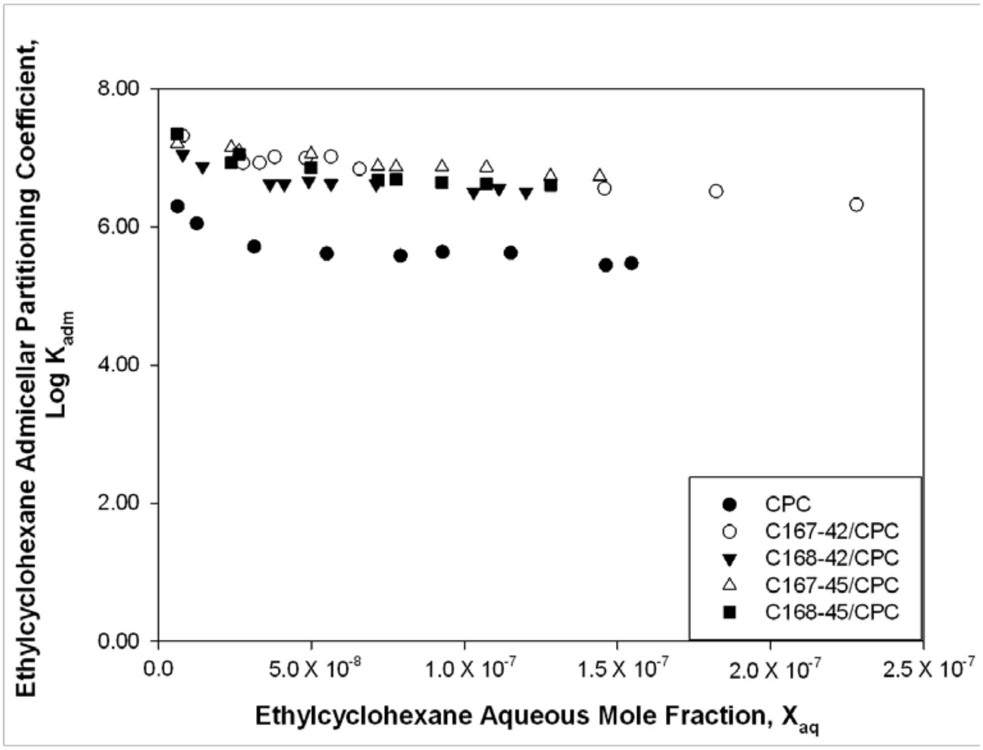


Figure 4-9 Ethylcyclohexane admicellar partitioning coefficient of CPC, C167-42/CPC, C168-42/CPC, C167-45/CPC, and C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

4.6 SOLUBILIZATION STUDIES

The solubilization capacity of organic solutes in a particular surfactant system can be quantified by the molar solubilization ration (MSR) which is obtained from the slope of the plot between organic solute concentrations versus surfactant concentration. The MSR can be calculated by Equation 4-1:

$$\mathrm{MSR} = \frac{(\mathrm{S}_{\mathrm{mic}} - \mathrm{S}_{\mathrm{CMC}})}{(\mathrm{C}_{\mathrm{surf}} - \mathrm{CMC})} \qquad (4\text{-}1)$$

where S_{mic} is the molar solubility of the solubilizate in the aqueous system (mol/l), S_{CMC} its molar solubility at the CMC (mol/l), and C_{surf} the molar concentration of surfactant above CMC. The partition of organic solutes into the micelle can be calculated by the micellar partition coefficient (K_{mic}) as shown in Equation 2-8.

4.6.1 Phenylethanol Solubilization

The solubilization isotherms of phenylethanol by individual surfactant and mixed surfactant systems are illustrated in Figure 4-10. At low surfactant concentration (below the transition point, CMC), phenylethanol concentration is surfactant solution is constant while at higher surfactant concentration (above the CMC), the solubilization capacities of phenylethanol increase linearly with increasing surfactant concentration. This could be due to the increase in solubilization of phenylethanol into surfactant micelles. The sharp change of these two lines indicated the CMC of the system, where the slope of the plot above the CMC is the MSR shown in Figure 4-11. It is noted that the CMCs in solubilization study are different from those of surfactant-only systems due to the presence of the solutes (Charoensaeng et al., 2009).

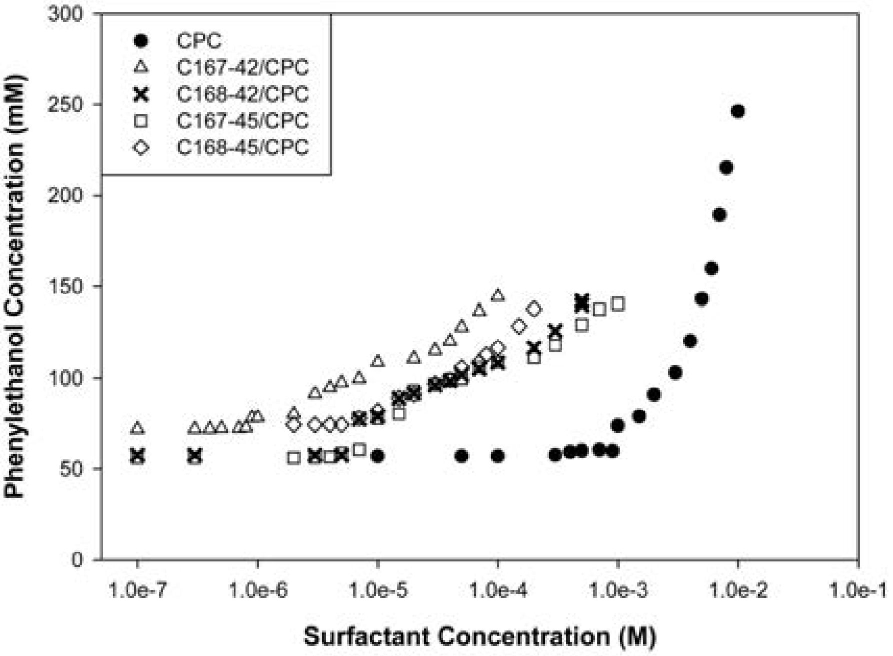


Figure 4-10 Solubilization isotherms of phenylethanol in individual and mixed surfactant systems at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

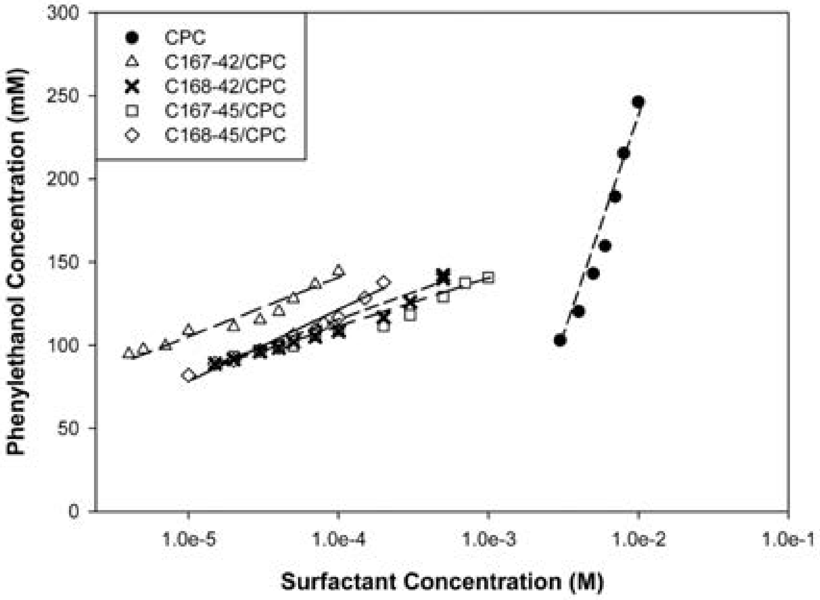


Figure 4-11 Solubilization capacity (MSR) of phenylethanol by individual and mixed surfactant systems at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

Table 4-5 Molar solubilization ratio (MSR) and micellar partition coefficient (K_{mic}) of organic solutes in individual and mixed surfactant systems at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

Surfactant	Phenylethanol			Styrene			Ethylcyclohexane		
	MSR	R^2	Log K_{mic}	MSR	R^2	Log K_{mic}	MSR	R^2	Log K_{mic}
CPC	20.0	0.99	5.84	0.61	0.97	3.85	0.85	0.97	3.17
$C_{16-17}(PO)_4(EO)_2COONa$ /CPC	511	0.95	5.86	2.86	0.97	4.14	66.4	0.98	3.50
$C_{16-18}(PO)_4(EO)_2COONa$/CPC	102	0.95	5.85	4.93	0.96	4.19	140	0.96	3.50
$C_{16-17}(PO)_4(EO)_5COONa$/CPC	60.8	0.95	5.85	4.51	0.98	4.18	144	0.96	3.50
$C_{16-18}(PO)_4(EO)_5COONa$/CPC	276	0.95	5.86	2.32	0.96	4.11	161	0.96	3.50

The MSR and log K_{mic} values of individual surfactant and mixed surfactant systems are summarized in Table 4-5. The results show that the phenylethanol solubilization capacity (log K_{mic}) of the individual surfactant system is not significantly different from the mixed surfactant systems. The results also indicated that the difference in carbon chain length and number of EO group have no significantly effect to the phenylethanol solubilization. The reason for these could be the polarity properties of the phenylethanol which generally is expected to partition into the palisade region. Therefore, the more hydrophobicity of the mixed micelles does not have significantly effect to the solubilization of phenylethanol. When comparing with the phenylethanol solubilization capacity in anionic extended surfactant (C167-45 and C168-45) systems alone (Lewlomphaisan, 2009), it found that the solubilization capacity in CPC show higher log K_{mic} than that of C167-45 and C168-45 (log $K_{mic} \approx 3.5$). The reason for this could be due to the π electron/charged group interactions between cationic head groups and aromatic solutes that can produce higher solubilization in cationic micelles (Scamehorn and Harwell, 1988). Moreover, the mixed micelles in this studied also showed higher phenylethanol solubilization capacity that those of the anionic extended surfactants which could be attributed the EO/PO group in the extended surfactants molecule resulting in larger aggregate size and larger palisade region. When comparing the solubilization capacity of three organic solutes, phenylethanol show the highest log K_{mic}, since the polar solute like phenylethanol tend to solubilize close to the micelle-water interface resulting in a greater solubilization extent than nonpolar organic solutes (Rosen, 2004).

4.6.2 Styrene Solubilization

Figure 4-12 shows the solubilization isotherms of styrene in the individual surfactant and mixed surfactant systems. Once again, results show that above the CMC, the solubilization capacity of styrene increase linearly with increasing surfactant concentration showing that styrene partitioned into micelles. The MSR as shown in Figure 4-13 and log K_{mic} values of styrene in the individual surfactant and mixed surfactant systems are summarized in Table 4-5.

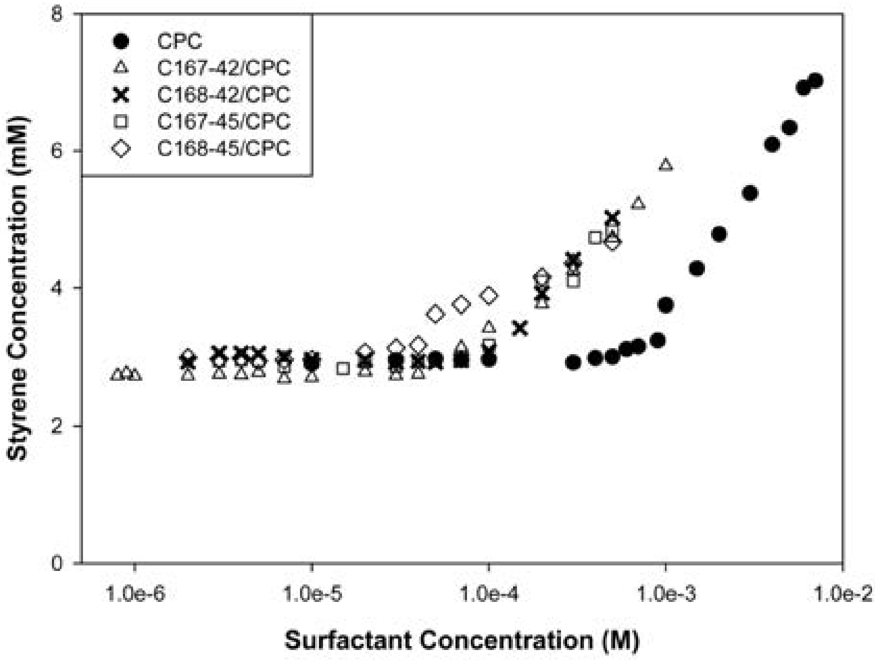


Figure 4-12 Solubilization isotherms of styrene in individual and mixed surfactant systems at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

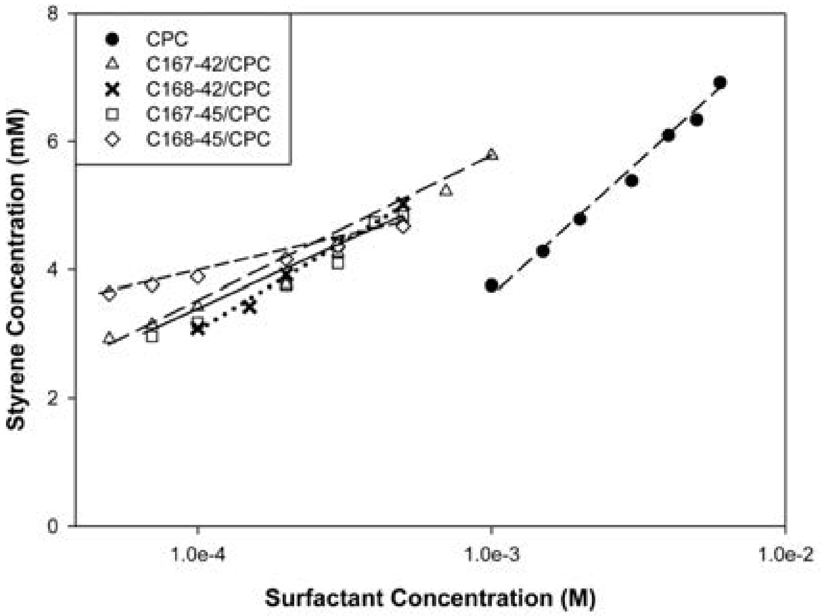


Figure 4-13 Solubilization capacity (MSR) of styrene by individual and mixed surfactant systems at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

The mixed surfactant micelles show greater solubilization capacity than the individual surfactant system. Since styrene is an intermediate polar organic solute which tends to partition into the palisade and core region. Therefore, the more hydrophobicity of mixed micelles is more capable to solubilize more styrene than that of the individual surfactant system. In addition, styrene solubilization capacities in our mixed systems are slightly greater than those conventional mixed surfactant system studied by Fuangswasdi et al. (2006a), who reported the micellar partition coefficient of styrene (log K_{mic}) about 4.0. This can be explained by the fact that the mixed surfactant systems in previous study (Fuangswasdi et al., 2006a) were at higher electrolyte concentration (0.15 M NaCl) which reduce the repulsion between the ionic head group and thus increase the volume of the micelles (Rosen, 2004), thus make the log K_{mic} of styrene approximately the same in this study.

4.6.3 Ethylcyclohexane Solubilization

The solubilization isotherms of ethylcyclohexane in individual surfactant and mixed surfactant systems are shown in Figure 4-14. It can be seen that the surfactant concentration at which the solubility of organic solute begin to increase is corresponding to the CMC of the surfactant system. The MSR of as shown in Figure 6-8 and log K_{mic} values of styrene in the individual surfactant and mixed surfactant systems are summarized in Table 4-5.

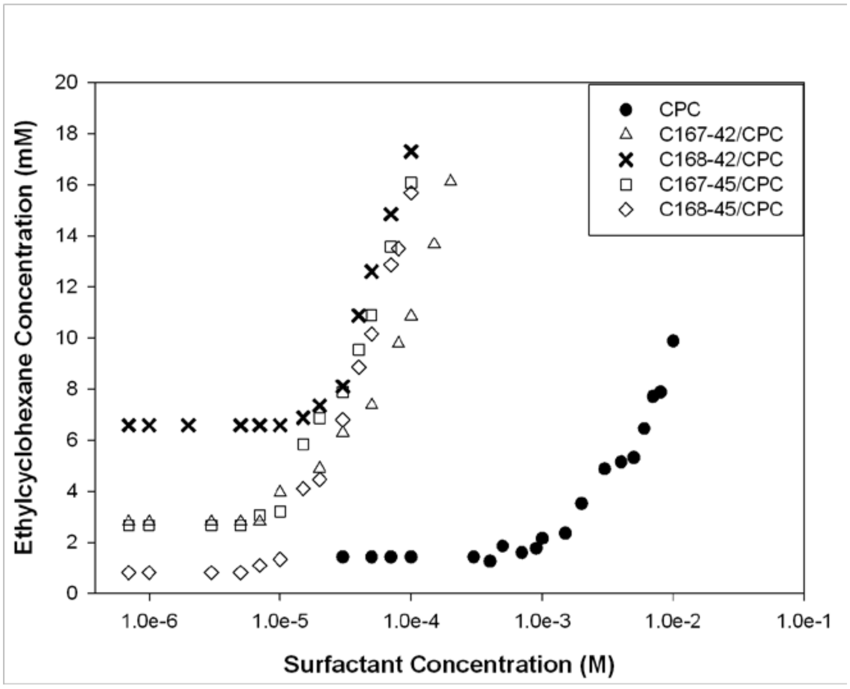


Figure 4-14 Solubilization isotherms of ethylcyclohexane in individual and mixed surfactant systems at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

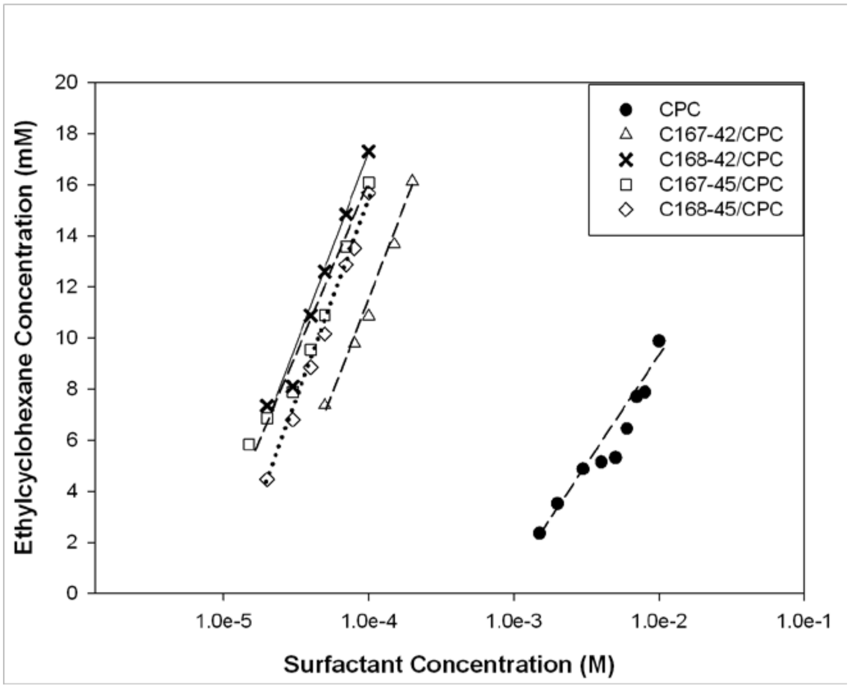


Figure 4-15 Solubilization capacity (MSR) of ethylcyclohexane by individual and mixed surfactant systems at 0.001 M NaCl, solution pH of 9 ± 0.5 and temperature 25 ± 2 °C (1:1 ratio)

It was found that ethylcyclohexane solubilization capacities in the mixed surfactant systems are slightly higher than that of the individual surfactant system suggesting that the mixed surfactant micelles had a larger and more hydrophobic core region than the individual surfactant micelles. Similar observation has been reported by Fuangswadsi et al. (2006a), who showed higher ethylcyclohexane solubilization capacity in mixed surfactant micelles than individual surfactant micelles. However, ethylcyclohexane solubilization capacity in our mixed surfactant systems are lower than that of previous study (Fuangswasdi et al., 2006a). Same explanation, as in styrene solubilization, can be used to discuss this result that the system in previous study has higher electrolyte concentration which can increase the volume of the micelles and thus allow more space for accumulating ethylcyclohexane. Moreover, these results also showed that the difference in carbon chain length and number of EO group do not have impact on the ethylcyclohexane solubilization capacity. The smallest partition behavior of ethylcyclohexane among three organic solutes are not expected since generally the mixed micelle formation of two different surfactants head group are unfavorable for the solubilization of polar solubilizates and are favorable for the solubilization of nonpolar solubilizates that are solubilized in the micellar inner core (Rosen, 2004). This can be explained by the fact that the mixed surfactant system can reduce the repulsion of the ionic head group and thus causes closer packing of the micelles. Thus, the solubilization degree of ethylcyclohexane becomes less since it is hard to penetrate deep into the inner core.

4.7 SURFACTANT DESORPTION STUDIES

The desorption potential for all surfactant systems in this study are shown in Figure 4-16. The zeta potential of silica without adsorbed surfactant bore a negatively charge surface (-33.9 mv), whereas the zeta potential of silica with adsorbed CPC and

CPC/anionic extended surfactant exhibited a positively charge surface. These results indicate that surfactants can form bilayer coverage on silica and achieve charge reversal by changing from negatively charge to positively charge. As the number of washing increased, the zeta potential of silica become less positive values and remains positive until the 3rd washing as seen in Figure 4-16. The reason why the individual surfactant system can retain its positively charge better than the mixed surfactant systems could be due to the higher number of cationic surfactant molecule that adsorb onto the silica surface. Therefore, after sequential washing, it can be concluded that silica adsorbed with CPC alone is more stable than those adsorbed with CPC/anionic extended surfactant systems. When comparing desorption potential with anionic extended surfactant with carboxylate head group (C167-45) and anionic extended surfactant with sulfate head group adsorbed on alumina studied by Arpornpong et al. (2010) it can be seen that the CPC alone and our mixed surfactant system are easier to desorp than the anionic extended surfactant.

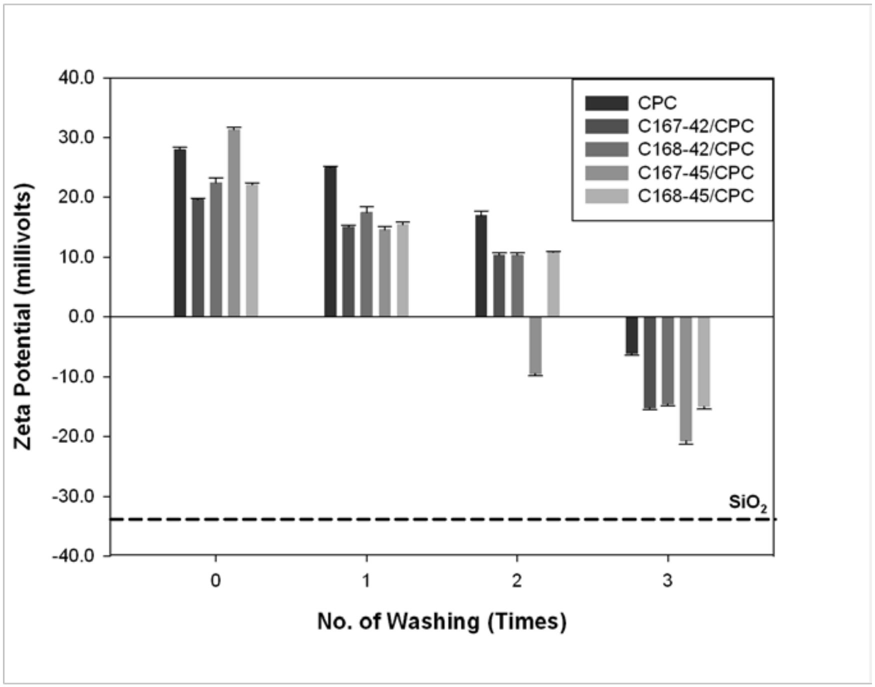


Figure 4-16 Zeta potentials of silica adsorbed with CPC, C167-42/CPC, C168-42/CPC, C167-45/CPC, and C168-45/CPC as a function of the number of the washing

4.8 ATOMIC FORCE MICROSCOPY STUDY

A topography image of an unmodified mica disc is shown in Figure 4-17. The aggregate free surface had a root mean square roughness (RMS) of 0.034 nm which is lower than the previous study (0.068nm) (Asnachinda et al., 2010b). This value is used to provide a baseline for evaluating the change in morphology of mica modified surfaces.

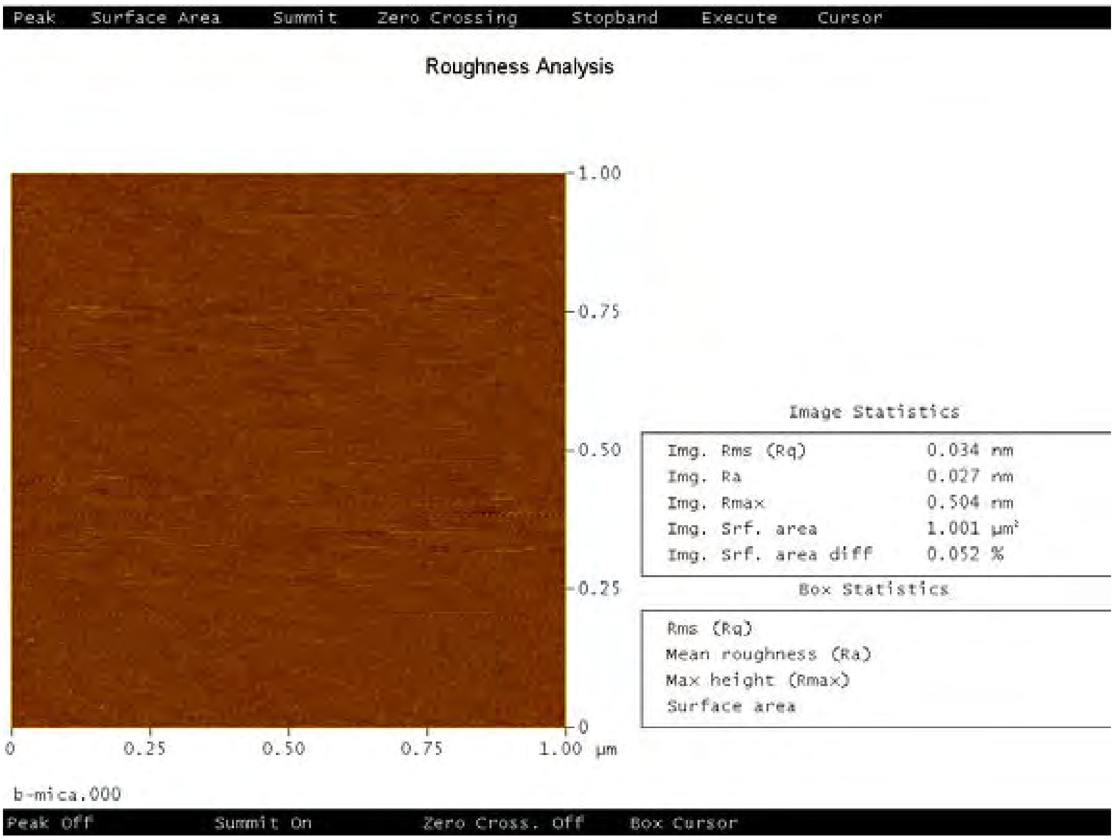


Image Statistics

Img. Rms (Rq)	0.034 nm
Img. Ra	0.027 nm
Img. Rmax	0.504 nm
Img. Srf. area	1.001 μm²
Img. Srf. area diff	0.052 %

Box Statistics

Rms (Rq)
Mean roughness (Ra)
Max height (Rmax)
Surface area

Figure 4-17 Topography image of unmodified mica

Topography image of adsorbed individual surfactant (CPC) films on the surface of mica are shown in Figure 4-18. The image shows the adsorbed surfactant film consists of the spherical aggregates with some stripes which are consistent with previous study of cationic surfactants adsorbed on mica (Schulz and Warr, 2002). However, our image has not shown the continuous monolayer or bilayer at the solid-liquid interface but only discrete aggregates of different shape and size are found.

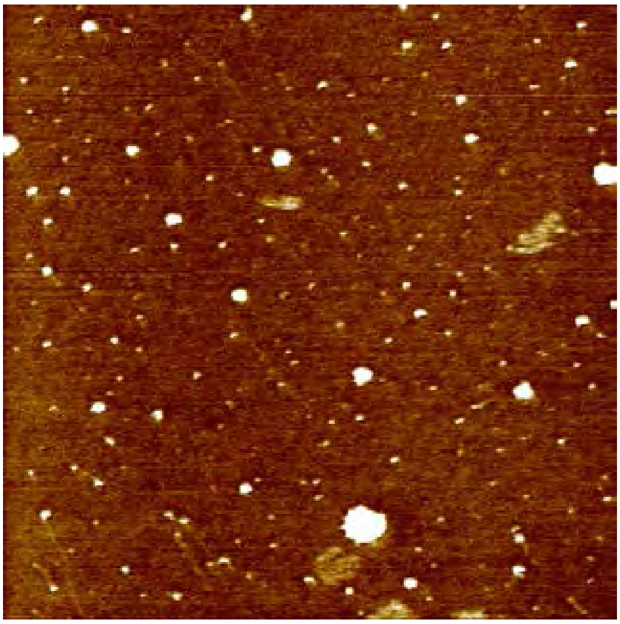


Figure 4-18 Topography image of CPC adsorbed on mica

The topography image of the adsorbed surfactant films of the mixed surfactant systems are show in Figure 4-19 (a)-(d). The results show that at 95% of the CMC values, the topographic images for adsorbed mixed surfactant on the mica surfaces show the spherical aggregates and stripes. When comparing with the topographic image of CPC adsorbed on mica, the images of the mixed surfactant systems show more stripes than the individual surfactant system. One thing that can be confirmed from the presence of such aggregates on the surface is that the surfactant adsorption does occur in our systems even though the surface is not fully coverage as expected. These observations are not consistent either with Asnachinda et al. (2010b), who showed the topographic images of surfactant modified mica surfaces using polymerizable gemini surfactants. Their results showed that at 80% CMC surfactant loading, patchy aggregates or islands of adsorbed surfactant can be seen on the surface. Therefore, the difference in the adsorbed film morphology should be further investigated.

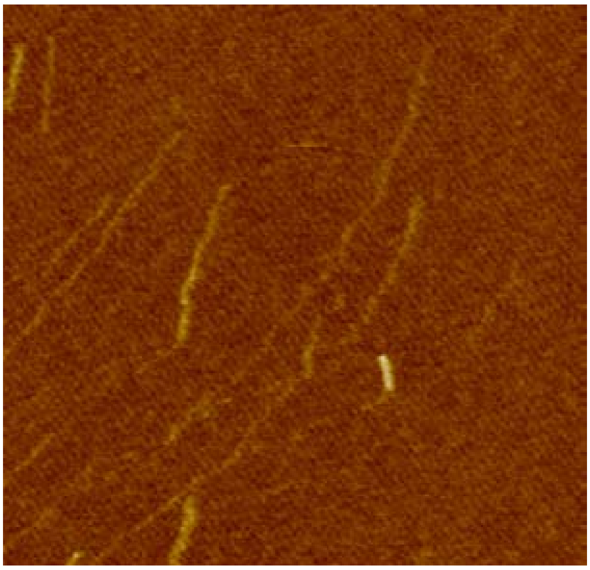


Figure 4-19 (a) Topography image of C167-42/CPC adsorbed on mica

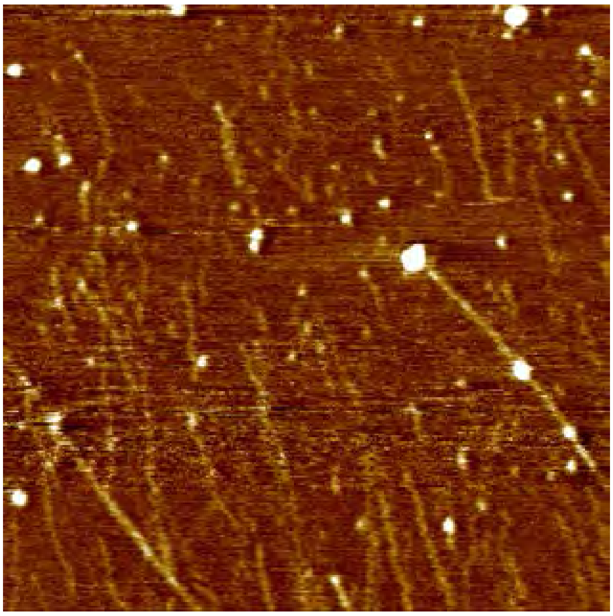


Figure 4-19 (b) Topography image of C168-42/CPC adsorbed on mica

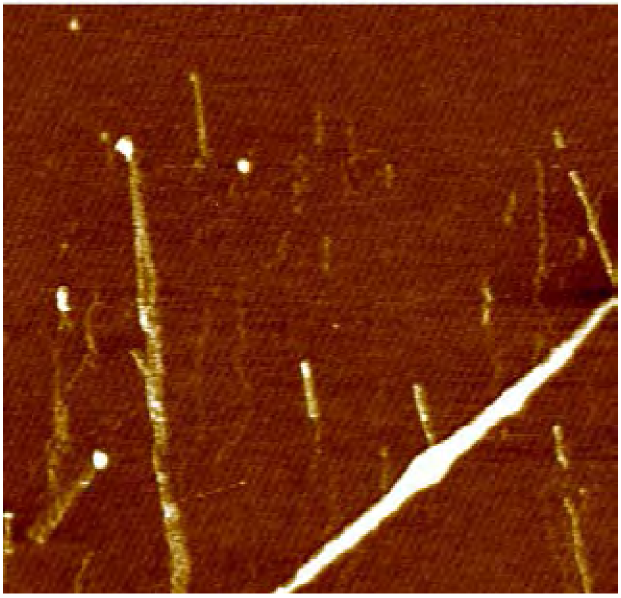


Figure 4-19 (c) Topography image of C167-45/CPC adsorbed on mica

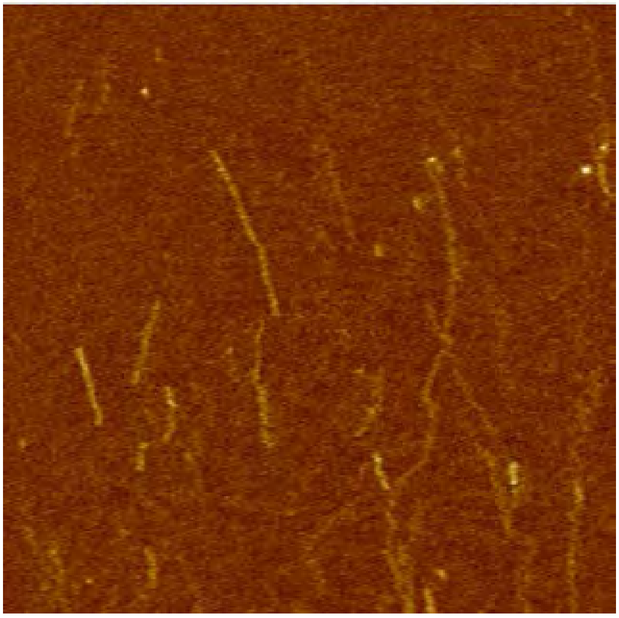


Figure 4-19 (d) Topography image of C168-45/CPC adsorbed on mica

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Surfactant-modified mineral surfaces can provide both a hydrophobic coating for adsorbing organic contaminants and, in the case of ionic surfactants, a charged exterior for adsorbing oppositely charged species. The mixtures of anionic and cationic surfactant are known to exhibit greater synergism than the individual surfactant system and other mixed systems. This study evaluated the mixed anionic extended and cationic surfactant in various properties including precipitation phase boundaries, synergistic behavior, surface tension measurement, adsorption, and desorption potential. Three organic solutes with different dipole moment, phenylethanol, styrene and ethylcyclohexane, were used to study the solubilization and adsolubilization study. In addition, surfactant-modified surfaces by the individual surfactant and mixed surfactant systems were characterized by atomic force microscopy (AFM).

From this study, the precipitation studies were conducted to ensure that all experiments in this research were in regions without precipitate. The results indicated that the precipitation phase boundaries of these mixtures of anionic extended surfactant and cationic surfactant showed greatly reduced precipitation areas as compared to a conventional mixed surfactant system (SDS/DPC) which is attributed to the presence of the ethylene oxide and propylene oxide groups. Addition of neutral electrolyte generally causes a decrease in the precipitation region. However, an increase in ionic strength in this study showed no effect to precipitation regions.

For the surface tension measurement, the critical micelle concentration (CMC) of the individual surfactant system and mixed surfactant systems at 1mM and 10 mM NaCl were evaluated. The results for both ionic strength demonstrated that the CMC of mixed surfactant systems were much lower than that of the individual surfactant systems due to the elimination of the unfavorable electrostatic free energy which eventually decreases the electrostatic repulsion between the hydrophilic head groups of the surfactant molecules. The symmetry between the alkyl chain lengths of the anionic and cationic surfactant also caused stronger hydrophobic interactions between the surfactants and thus facilitate the mixed micelle formation and lower the CMC values of the mixed surfactant systems.

It is well known that mixed anionic and cationic surfactant systems exhibit greater synergism than other mixed surfactant systems interaction between oppositely charged surfactants at the interface is generally explained by the molecular interaction parameter (β) which indicate the nature and strength of those interactions. The results found that all system studied exhibit synergism although slightly reduced from conventional anionic-cationic mixtures reported previously. Also, the synergism reported here is still greater than in cationic and nonionic surfactant mixtures.

The reduction of the electrostatic repulsion between the similarly charged head groups in the mixed anionic and cationic surfactant system is the main reason that cause the adsorption of mixed anionic extended surfactant and cationic surfactant system reached plateau adsorption region at lower surfactant concentration than that of the CPC alone. The maximum adsorption capacity of CPC was not enhanced in our mixed surfactant systems due to the steric hindrance of surfactant branching that may limit synergism in adsorption of the mixed anionic and cationic surfactant system. However, below plateau adsorption, mixed surfactant systems show higher adsorption capacity at any given surfactant concentration. Results from desorption study showed that the surfactant can form bilayer coverage on silica and achieve charge reversal. However, these mixed surfactant systems cannot retain their stabilities better than the individual surfactant system. The topography image of the adsorbed surfactant films of the individual surfactant and mixed surfactant systems in AFM study confirmed that the surfactant adsorption does occur in our systems.

Adsolubilization of three organic solutes in anionic extended surfactant and cationic surfactant mixtures are higher than that of the individual surfactant system. The effect of carbon chain length and number of EO groups are found to be no significant effect to the adsolubilization capacities. The results also showed that ethylcyclohexane has the highest values of log K_{adm} while phenylethanol showed the lowest values. This could be attributed to the water solubility, polarity and hydrophobicity trends of the organic solutes. Phenylethanol has the highest water solubility followed by styrene and ethylcyclohexane, thus the adsolubilization capacities tend to increase as the water solubility decreased.

For solubilization study, mixed surfactant systems exhibit synergism as evidenced by higher solubilization capacity than that of the individual surfactant system. Same as the adsolubilization study, the difference in carbon chain length and number of EO groups do not have significantly effect to the solubilization of organic solutes. The results also suggested that the larger aggregate size and larger palisade region can increase the solubilization capacity of polar and intermediate polar organic solutes. Whereas, the closer packing of the micelles decrease the solubilization degree of nonpolar solute since it is hard to penetrate deep into the inner core.

5.2 ENGINEERING SIGNIFICANCE

Mixed anionic extended surfactant and cationic surfactant systems appear to be a promising system based on the reduction in precipitation region while maintaining a desirable level of synergism. This synergistic behavior can be highly beneficial for the environment as it decrease the amount of surfactant released and hence their impact to be substantially reduced. A change in micellar structure of the anionic extended surfactant and cationic surfactant mixtures can enhance the adsolubilization and solubilization capacities compared to the individual surfactant system. Therefore, these systems can be employed in many environmental applications including enhanced contaminant extraction via micellar solubilization, in-situ retention of contaminants, removing organic pollutants from wastewater.

5.3 RECOMMENDATIONS AND FUTURE WORKS

Anionic extended surfactant and cationic surfactant mixtures appeared to be effective in precipitation reduction and removing organic contaminants in aqueous solution. However, there are some specific issues that should be further investigated, including;

1) The conventional mixed surfactant system that has similar alkyl chain length to our system should be evaluated for a more comparable for their efficiencies.

2) The extended surfactant with different number of PO group should be evaluated in order to clarify the effect of PO groups.

3) Mixed organic solutes should be further investigated to determine the selectivity of the admicellar-based modified adsorbent.

4) Column experiment should be studied to evaluate the behavior of both surfactant and organic solutes in continuous flow systems.

5) Adsorbent regeneration and reuse efficiency require further investigation.

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APPENDICES

APPENDIX A

EXPERIMENTAL RAW DATA

Table A-1 Surface tension measurement of CPC at 0.001 M NaCl

No.	Concentration (M)	[1]	[2]	Average	SD
1	3.00E-06	67.732	67.738	67.735	0.004
2	7.00E-06	65.205	65.220	65.213	0.011
3	1.00E-05	66.678	66.670	66.674	0.006
4	3.00E-05	63.573	64.494	64.034	0.651
5	7.00E-05	60.963	60.950	60.957	0.009
6	9.00E-05	59.409	59.410	59.410	0.001
7	1.10E-04	59.121	59.103	59.112	0.013
8	1.50E-04	57.910	58.438	58.174	0.373
9	1.70E-04	57.789	56.241	57.015	1.095
10	2.00E-04	55.281	55.324	55.303	0.030
11	2.50E-04	56.676	56.652	56.664	0.017
12	3.00E-04	55.401	54.925	55.163	0.337
13	5.00E-04	49.101	49.569	49.335	0.331
14	7.00E-04	46.131	45.644	45.888	0.344
15	9.00E-04	44.813	44.638	44.726	0.124
16	1.00E-03	44.821	44.829	44.825	0.006
17	3.00E-03	43.809	43.827	43.818	0.013
18	5.00E-03	43.278	43.273	43.276	0.004
19	7.00E-03	42.543	42.694	42.619	0.107
20	9.00E-03	42.300	42.223	42.262	0.054

Table A-2 Surface tension measurement of C167-42 at 0.001 M NaCl

No.	Concentration (M)	[1]	[2]	Average	SD
1	1.0E-06	70.919	71.182	71.051	0.186
2	3.0E-06	57.011	57.798	57.405	0.556
4	7.0E-06	47.010	46.599	46.805	0.291
5	9.0E-06	43.446	42.787	43.117	0.466
6	1.0E-05	41.468	41.897	41.683	0.303
7	1.1E-05	41.822	41.815	41.819	0.005
8	1.3E-05	39.583	39.631	39.607	0.034
9	1.5E-05	39.181	37.832	38.507	0.954
10	1.7E-05	36.866	36.934	36.900	0.048
11	2.0E-05	36.417	35.635	36.026	0.553
12	3.0E-05	35.107	35.287	35.197	0.127
13	5.0E-05	35.992	35.970	35.981	0.016
14	7.0E-05	34.401	34.457	34.429	0.040
15	9.0E-05	34.054	34.112	34.083	0.041
16	1.0E-04	34.096	34.061	34.079	0.025
17	3.0E-04	34.402	34.363	34.383	0.028
18	5.0E-04	34.418	34.444	34.431	0.018
19	1.0E-03	33.933	33.915	33.924	0.013

Table A-3 Surface tension measurement of C168-42 at 0.001 M NaCl

No.	Concentration (M)	[1]	[2]	Average	SD
1	1.0E-06	70.194	70.170	70.182	0.017
2	3.0E-06	64.539	60.301	62.420	2.997
3	5.0E-06	57.243	57.351	57.297	0.076
4	7.0E-06	55.172	55.230	55.201	0.041
5	9.0E-06	45.231	45.707	45.469	0.337
6	1.0E-05	49.304	49.329	49.317	0.018
7	1.1E-05	44.045	44.078	44.062	0.023
8	1.3E-05	43.010	46.136	44.573	2.210
9	1.5E-05	43.599	43.578	43.589	0.015
10	1.7E-05	42.509	42.550	42.530	0.029
11	2.0E-05	41.491	41.491	41.491	0.000
12	3.0E-05	41.279	41.273	41.276	0.004
13	5.0E-05	39.788	39.776	39.782	0.008
14	7.0E-05	40.897	40.877	40.887	0.014
15	9.0E-05	39.984	40.177	40.081	0.136
16	1.0E-04	40.028	40.002	40.015	0.018
17	3.0E-04	39.527	39.493	39.510	0.024
18	5.0E-04	41.077	40.815	40.946	0.185
19	1.0E-03	40.039	40.011	40.025	0.020

Table A-4 Surface tension measurement of C167-45 at 0.001 M NaCl

No.	Concentration (M)	[1]	[2]	Average	SD
1	1.0E-06	71.159	71.088	71.124	0.050
2	3.0E-06	67.904	67.105	67.505	0.565
3	5.0E-06	50.269	50.275	50.272	0.004
4	7.0E-06	49.117	49.133	49.125	0.011
5	9.0E-06	45.838	45.673	45.756	0.117
6	1.0E-05	45.033	44.454	44.744	0.409
7	1.1E-05	44.993	44.978	44.986	0.011
8	1.3E-05	44.581	44.598	44.590	0.012
9	1.5E-05	41.047	41.765	41.406	0.508
10	1.7E-05	41.205	41.788	41.497	0.412
11	2.0E-05	39.948	39.023	39.486	0.654
12	3.0E-05	37.942	37.377	37.660	0.400
13	5.0E-05	36.449	36.956	36.703	0.359
14	7.0E-05	35.723	35.756	35.740	0.023
15	9.0E-05	35.204	35.202	35.203	0.001
16	1.0E-04	35.170	35.150	35.160	0.014
17	3.0E-04	34.176	34.321	34.249	0.103
18	5.0E-04	34.155	34.544	34.350	0.275
19	1.0E-03	33.984	33.858	33.921	0.089

Table A-5 Surface tension measurement of C168-45 at 0.001 M NaCl

No.	Concentration (M)	[1]	[2]	Average	SD
1	1.0E-06	61.759	61.774	61.767	0.011
2	3.0E-06	59.420	59.388	59.404	0.023
3	5.0E-06	57.834	57.965	57.900	0.093
4	7.0E-06	56.848	56.595	56.722	0.179
5	9.0E-06	55.397	55.403	55.400	0.004
6	1.0E-05	52.519	52.509	52.514	0.007
7	1.1E-05	47.512	47.608	47.560	0.068
8	1.3E-05	47.567	47.679	47.623	0.079
9	1.5E-05	45.072	46.471	45.772	0.989
10	1.7E-05	46.106	46.207	46.157	0.071
11	2.0E-05	45.409	45.877	45.643	0.331
12	3.0E-05	43.204	43.214	43.209	0.007
13	5.0E-05	41.171	41.601	41.386	0.304
14	7.0E-05	40.124	41.100	40.612	0.690
15	9.0E-05	40.723	41.823	41.273	0.778
17	3.0E-04	40.100	41.058	40.579	0.677
18	5.0E-04	40.188	40.181	40.185	0.005
19	1.0E-03	39.153	39.379	39.266	0.160

Table A-6 Surface tension measurement of C167-42/CPC at 0.001 M NaCl

No.	Concentration (M)	(1)	(2)	Average	SD
1	3.0E-07	71.400	71.389	71.395	0.008
2	7.0E-07	59.728	59.942	59.835	0.151
3	1.3E-06	51.978	51.661	51.820	0.224
4	1.5E-06	48.520	48.54	48.530	0.014
5	2.0E-06	41.876	41.534	41.705	0.242
6	3.0E-06	38.411	36.156	37.284	1.595
7	5.0E-06	37.592	34.906	36.249	1.899
8	7.0E-06	36.378	35.354	35.866	0.724
9	1.0E-05	35.562	35.667	35.615	0.074
10	3.0E-05	35.711	35.091	35.401	0.438
11	5.0E-05	34.388	35.041	34.715	0.462
12	7.0E-05	34.711	35.786	35.249	0.760
13	1.0E-04	35.152	35.418	35.285	0.188
14	3.0E-04	35.040	35.339	35.190	0.211
15	5.0E-04	33.701	34.328	34.015	0.443
16	7.0E-04	33.965	34.336	34.151	0.262

Table A-7 Surface tension measurement of C168-42/CPC at 0.001 M NaCl

No.	Concentration (M)	(1)	(2)	Average	SD
1	3.0E-07	69.426	70.141	69.784	0.506
2	5.0E-07	66.760	65.525	66.143	0.873
3	1.3E-06	56.023	56.074	56.049	0.036
4	2.0E-06	48.285	48.265	48.275	0.014
5	3.0E-06	47.146	41.764	44.455	3.806
6	5.0E-06	41.347	37.104	39.226	3.000
7	7.0E-06	37.549	36.926	37.238	0.441
8	1.0E-05	37.082	37.501	37.292	0.296
9	5.0E-05	37.027	37.520	37.274	0.349
10	1.0E-04	36.881	37.206	37.044	0.230
11	3.0E-04	36.656	37.257	36.957	0.425
12	5.0E-04	37.268	36.413	36.841	0.605
13	7.0E-04	35.930	35.908	35.919	0.016

Table A-8 Surface tension measurement of C167-45/CPC at 0.001 M NaCl

No.	Concentration (M)	(1)	(2)	Average	SD
1	3.0E-07	53.194	50.030	51.612	2.237
2	5.0E-07	48.105	46.236	47.171	1.322
3	1.5E-06	44.069	44.256	44.163	0.132
4	3.0E-06	38.423	34.979	36.701	2.435
5	5.0E-06	37.493	35.608	36.551	1.333
6	7.0E-06	36.960	34.661	35.811	1.626
7	1.0E-05	34.879	35.360	35.120	0.340
8	1.5E-05	33.134	33.766	33.450	0.447
9	3.0E-05	32.322	32.162	32.242	0.113
10	5.0E-05	32.188	31.960	32.074	0.161
11	1.0E-04	32.611	32.716	32.664	0.074
12	3.0E-04	32.069	32.041	32.055	0.020

Table A-9 Surface tension measurement of C168-45/CPC at 0.001 M NaCl

No.	Concentration (M)	(1)	(2)	Average	SD
1	5.0E-07	50.155	49.478	49.817	0.479
2	7.0E-07	49.072	49.213	49.143	0.100
3	1.5E-06	44.123	44.012	44.068	0.078
4	3.0E-06	40.791	39.272	40.032	1.074
5	5.0E-06	38.179	37.387	37.783	0.560
6	7.0E-06	35.665	35.748	35.707	0.059
7	1.0E-05	36.115	35.31	35.713	0.569
8	3.0E-05	35.858	35.683	35.771	0.124
9	5.0E-05	35.282	35.743	35.513	0.326
10	7.0E-05	36.071	36.061	36.066	0.007

Table A-10 Surface tension measurement of CPC at 0.01 M NaCl

No.	Concentration (M)	[1]	[2]	Average	SD
1	3.00E-06	68.552	69.826	69.189	0.901
2	7.00E-06	64.035	64.020	64.028	0.011
3	1.00E-05	63.092	63.125	63.109	0.023
4	3.00E-05	56.292	56.279	56.286	0.009
5	7.00E-05	50.108	50.093	50.101	0.011
6	9.00E-05	47.898	47.883	47.891	0.011
7	1.10E-04	46.633	46.295	46.464	0.239
8	1.50E-04	43.714	43.752	43.733	0.027
9	1.70E-04	42.701	42.645	42.673	0.040
10	2.00E-04	41.532	41.848	41.690	0.223
11	2.50E-04	41.534	41.496	41.515	0.027
12	3.00E-04	41.506	41.413	41.460	0.066
13	5.00E-04	41.399	41.434	41.417	0.025
14	7.00E-04	41.041	41.224	41.133	0.129
15	9.00E-04	40.866	41.010	40.938	0.102
16	1.00E-03	40.987	40.991	40.989	0.003
17	3.00E-03	40.533	40.438	40.486	0.067
18	5.00E-03	40.251	40.280	40.266	0.021
19	7.00E-03	40.152	40.189	40.171	0.026
20	9.00E-03	40.079	40.001	40.040	0.055

Table A-11 Surface tension measurement of C167-42 at 0.01 M NaCl

No.	Concentration (M)	[1]	[2]	Average	SD
1	1.0E-06	71.012	72.056	71.534	0.738
2	3.0E-06	59.764	61.843	60.804	1.470
3	5.0E-06	57.038	53.104	55.071	2.782
4	7.0E-06	50.478	50.198	50.338	0.198
5	9.0E-06	48.322	47.148	47.735	0.830
6	1.0E-05	42.979	44.735	43.857	1.242
7	1.1E-05	44.565	43.149	43.857	1.001
8	1.3E-05	43.552	43.324	43.438	0.161
9	1.5E-05	39.595	41.440	40.518	1.305
10	1.7E-05	40.156	41.354	40.755	0.847
11	2.0E-05	39.039	37.950	38.495	0.770
12	3.0E-05	34.866	35.332	35.099	0.330
13	5.0E-05	32.278	35.436	33.857	2.233
14	7.0E-05	33.806	34.859	34.333	0.745
15	9.0E-05	34.661	34.104	34.383	0.394
16	1.0E-04	33.851	33.804	33.828	0.033
17	5.0E-04	32.757	32.691	32.724	0.047
18	1.0E-03	32.988	33.110	33.049	0.086

Table A-12 Surface tension measurement of C168-42 at 0.01 M NaCl

No.	Concentration (M)	[1]	[2]	Average	SD
1	1.0E-06	62.587	62.960	62.774	0.264
2	3.0E-06	60.771	59.569	60.170	0.850
3	5.0E-06	55.678	56.787	56.233	0.784
4	7.0E-06	51.159	51.365	51.262	0.146
6	1.0E-05	50.455	51.054	50.755	0.424
7	1.1E-05	47.061	48.536	47.799	1.043
8	1.3E-05	48.428	46.297	47.363	1.507
9	1.5E-05	44.758	43.740	44.249	0.720
10	1.7E-05	45.291	44.050	44.671	0.878
11	2.0E-05	44.948	44.015	44.482	0.660
12	3.0E-05	41.917	41.445	41.681	0.334
13	5.0E-05	41.018	41.041	41.030	0.016
14	7.0E-05	40.850	42.029	41.440	0.834
15	9.0E-05	40.904	40.970	40.937	0.047
16	1.0E-04	40.196	40.570	40.383	0.264
17	5.0E-04	40.351	39.907	40.129	0.314
18	1.0E-03	40.880	40.941	40.911	0.043

Table A-13 Surface tension measurement of C167-45 at 0.01 M NaCl

No.	Concentration (M)	[1]	[2]	Average	SD
1	1.0E-06	68.636	67.638	68.137	0.706
3	5.0E-06	51.801	51.352	51.577	0.317
4	7.0E-06	47.717	47.074	47.396	0.455
5	9.0E-06	45.696	45.549	45.623	0.104
6	1.0E-05	44.975	44.250	44.613	0.513
7	1.1E-05	42.800	44.242	43.521	1.020
8	1.3E-05	41.319	40.283	40.801	0.733
9	1.5E-05	39.018	39.105	39.062	0.062
10	1.7E-05	40.560	38.468	39.514	1.479
11	2.0E-05	38.262	38.450	38.356	0.133
12	3.0E-05	34.651	35.470	35.061	0.579
13	5.0E-05	36.484	35.465	35.975	0.721
14	7.0E-05	35.863	35.196	35.530	0.472
15	9.0E-05	34.833	34.766	34.800	0.047
16	1.0E-04	34.467	34.989	34.728	0.369
17	5.0E-04	32.943	32.883	32.913	0.042
18	1.0E-03	32.771	32.702	32.737	0.049

Table A-14 Surface tension measurement of C168-45 at 0.01 M NaCl

No.	Concentration (M)	[1]	[2]	Average	SD
1	1.0E-06	69.317	67.429	68.373	1.335
2	3.0E-06	69.463	69.275	69.369	0.133
3	5.0E-06	63.750	63.774	63.762	0.017
4	7.0E-06	58.710	58.720	58.715	0.007
5	9.0E-06	54.684	54.668	54.676	0.011
6	1.0E-05	49.827	49.821	49.824	0.004
7	1.1E-05	46.431	46.463	48.142	2.374
8	1.3E-05	45.869	45.776	46.104	0.463
9	1.5E-05	44.531	44.534	45.202	0.944
10	1.7E-05	44.241	43.883	44.207	0.458
11	2.0E-05	43.571	43.630	43.936	0.432
12	3.0E-05	43.178	42.600	43.086	0.687
13	5.0E-05	42.376	42.799	42.989	0.268
14	7.0E-05	40.634	41.341	41.859	0.732
15	9.0E-05	42.690	44.824	42.729	2.963
16	1.0E-04	42.368	42.832	42.761	0.100
17	5.0E-04	42.866	42.935	42.652	0.401
18	1.0E-03	42.458	42.819	42.843	0.033

Table A-15 Surface tension measurement of C167-42/CPC at 0.01 M NaCl

No.	Concentration (M)	[1]	[2]	Average	STD
1	1.00E-07	71.140	71.153	71.147	0.009
2	3.00E-07	70.933	70.944	70.939	0.008
3	5.00E-07	69.646	69.380	69.513	0.188
4	7.00E-07	68.912	67.020	67.966	1.338
5	1.00E-06	62.886	62.853	62.870	0.023
6	1.70E-06	50.669	50.437	50.553	0.164
7	2.00E-06	47.963	47.970	47.967	0.005
8	3.00E-06	45.048	45.064	45.056	0.011
9	4.00E-06	42.020	42.004	42.012	0.011
10	5.00E-06	41.232	41.132	41.182	0.071
11	7.00E-06	39.085	39.087	39.086	0.001
12	9.00E-06	36.472	38.745	37.609	1.607
13	2.00E-05	34.888	34.372	34.630	0.365
14	3.00E-05	32.913	31.929	32.421	0.696
15	5.00E-05	33.156	33.041	33.099	0.081
16	7.00E-05	31.725	32.684	32.205	0.678
17	1.00E-04	32.089	32.195	32.142	0.075
18	3.00E-04	31.999	32.162	32.081	0.115
19	5.00E-04	31.759	32.040	31.900	0.199

Table A-16 Surface tension measurement of C168-42/CPC at 0.01 M NaCl

No.	Concentration (M)	[1]	[2]	Average	STD
1	3.00E-07	69.153	69.165	69.159	0.008
2	5.00E-07	66.979	65.366	66.173	1.141
3	7.00E-07	62.541	62.514	62.528	0.019
4	2.00E-06	54.276	53.588	53.932	0.486
5	4.00E-06	44.867	45.610	45.239	0.525
6	7.00E-06	41.742	41.728	41.735	0.010
7	9.00E-06	39.861	40.435	40.148	0.406
8	1.50E-05	38.508	39.100	38.804	0.419
9	1.70E-05	38.320	39.157	38.739	0.592
10	2.00E-05	38.084	38.064	38.074	0.014
11	3.00E-05	36.168	37.703	36.936	1.085
12	5.00E-05	37.923	37.896	37.910	0.019
13	7.00E-05	37.437	37.768	37.603	0.234
14	1.00E-04	37.202	37.172	37.187	0.021
15	3.00E-04	36.959	37.046	37.003	0.062
16	5.00E-04	36.927	36.697	36.812	0.163

Table A-17 Surface tension measurement of C167-45/CPC at 0.01 M NaCl

No.	Concentration (M)	[1]	[2]	Average	STD
1	3.00E-07	67.379	67.193	67.286	0.132
2	5.00E-07	60.749	60.715	60.732	0.024
3	7.00E-07	57.639	57.464	57.552	0.124
4	1.00E-06	53.057	53.078	53.068	0.015
5	2.00E-06	46.199	46.511	46.355	0.221
6	2.50E-06	42.835	42.824	42.830	0.008
9	5.00E-06	37.183	37.252	37.218	0.049
10	7.00E-06	36.129	36.149	36.139	0.014
11	9.00E-06	34.235	34.655	34.445	0.297
12	1.50E-05	33.005	34.260	33.633	0.887
13	1.70E-05	32.547	32.932	32.740	0.272
14	2.00E-05	32.615	32.818	32.717	0.144
15	3.00E-05	32.141	32.128	32.135	0.009
16	5.00E-05	32.298	32.308	32.303	0.007
17	7.00E-05	32.246	32.300	32.273	0.038
18	1.00E-04	32.303	32.296	32.300	0.005
19	3.00E-04	31.337	31.336	31.337	0.001
20	5.00E-04	31.168	31.216	31.192	0.034

Table A-18 Surface tension measurement of C168-45/CPC at 0.01 M NaCl

No.	Concentration (M)	[1]	[2]	Average	STD
1	3.00E-07	66.185	66.191	66.188	0.004
2	5.00E-07	64.412	64.441	64.427	0.021
3	7.00E-07	62.428	62.411	62.420	0.012
4	2.00E-06	51.311	51.325	51.318	0.010
5	2.50E-06	47.498	47.348	47.423	0.106
6	3.00E-06	44.527	44.543	44.535	0.011
7	4.00E-06	43.079	43.090	43.085	0.008
8	5.00E-06	41.767	40.737	41.252	0.728
9	7.00E-06	38.275	39.413	38.844	0.805
10	9.00E-06	38.737	36.961	37.849	1.256
11	1.50E-05	37.178	37.021	37.100	0.111
12	1.70E-05	36.989	37.021	37.005	0.023
13	2.00E-05	36.605	36.670	36.638	0.046
14	3.00E-05	35.889	35.887	35.888	0.001
15	5.00E-05	35.970	35.982	35.976	0.008
16	7.00E-05	36.124	36.150	36.137	0.018
17	1.00E-04	36.235	36.402	36.319	0.118
18	3.00E-04	35.278	35.293	35.286	0.011
19	5.00E-04	35.259	35.281	35.270	0.016

Table A-19 Adsorption of CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Conc. (M)	Solution	Initial		Equilibrium		C_{in}-C_{eq}	Silica	q
		(ml)	Area	Conc. (M)	Area	Conc. (M)	(M)	(g)	(mmole/g)
1	9E-05	40	152.25	1.45E-04	145.85	1.41E-04	3.20E-06	0.0021	0.0610
2	1E-04	40	154.45	1.46E-04	137.10	1.37E-04	8.68E-06	0.0021	0.1652
3	2E-04	40	385.85	2.61E-04	354.60	2.46E-04	1.56E-05	0.0022	0.2841
4	3E-04	40	564.7	3.51E-04	415.70	2.76E-04	7.45E-05	0.0051	0.5843
5	4E-04	40	829.5	4.83E-04	706.20	4.22E-04	6.17E-05	0.0050	0.4932
6	5E-04	40	987.95	5.62E-04	806.30	4.72E-04	9.08E-05	0.0050	0.7266
7	6E-04	40	1241.85	6.89E-04	1119.25	6.28E-04	6.13E-05	0.0050	0.4904
8	7E-04	40	1421.4	7.79E-04	1265.35	7.01E-04	7.80E-05	0.0050	0.6242
9	8E-04	40	1733.05	9.35E-04	1527.30	8.32E-04	1.03E-04	0.0052	0.7913
10	9E-04	40	1868.7	1.00E-03	1643.20	8.90E-04	1.13E-04	0.0051	0.8843
11	1E-03	40	2068.9	1.10E-03	1438.45	7.88E-04	3.15E-04	0.0105	1.2009
12	2E-03	40	4453.95	2.30E-03	3587.20	1.86E-03	4.33E-04	0.0104	1.6668
13	3E-03	40	7061.6	3.60E-03	6143.80	3.14E-03	4.59E-04	0.0101	1.8174
14	4E-03	40	9418.3	4.78E-03	8706.85	4.42E-03	3.56E-04	0.0104	1.3682
15	5E-03	40	11902.85	6.02E-03	10688.40	5.41E-03	6.07E-04	0.0100	2.4289
16	6E-03	40	14341.2	7.24E-03	12845.35	6.49E-03	7.48E-04	0.0101	2.9621
17	7E-03	40	16290.95	8.21E-03	15187.10	7.66E-03	5.52E-04	0.0100	2.2077

Table A-20 Adsorption of C167-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Conc. (M)	Solution	Initial		Equilibrium		C_{in}-C_{eq}	Silica	q
		(ml)	Area	Conc. (M)	Area	Conc. (M)	(M)	(g)	(mmole/g)
1	8.00E-05	40	102.1	1.20E-04	101.20	1.19E-04	4.50E-07	0.0021	0.0086
2	9.00E-05	40	154.7	1.46E-04	145.85	1.41E-04	4.43E-06	0.0022	0.0805
3	1.00E-04	40	171.2	1.54E-04	149.00	1.43E-04	1.11E-05	0.0022	0.2018
4	1.10E-04	40	228.7	1.83E-04	206.30	1.72E-04	1.12E-05	0.0021	0.2133
5	1.30E-04	40	262.7	2.00E-04	216.20	1.77E-04	2.33E-05	0.0021	0.4429
6	1.50E-04	40	318.9	2.28E-04	289.90	2.13E-04	1.45E-05	0.0020	0.2900
7	1.70E-04	40	362.5	2.50E-04	341.40	2.39E-04	1.06E-05	0.0022	0.1918
8	2.00E-04	40	431.9	2.84E-04	398.90	2.68E-04	1.65E-05	0.0020	0.3300
9	2.30E-04	40	500.5	3.19E-04	418.10	2.78E-04	4.12E-05	0.0021	0.7848
10	2.50E-04	40	560.8	3.49E-04	525.00	3.31E-04	1.79E-05	0.0020	0.3580
11	3.00E-04	40	502.7	3.20E-04	415.70	2.76E-04	4.35E-05	0.0021	0.8286
12	4.00E-04	40	893	5.15E-04	866.20	5.02E-04	1.34E-05	0.0020	0.2680
13	5.00E-04	40	1136.9	6.37E-04	1027.80	5.82E-04	5.46E-05	0.0022	0.9918
14	7.00E-04	40	1602.9	8.70E-04	1584.1	8.61E-04	9.40E-06	0.0021	0.1790
14	7.00E-04	40	1717.7	9.27E-04	1688.00	9.12E-04	1.49E-05	0.0021	0.2829
15	9.00E-04	40	2041	1.09E-03	1961.20	1.05E-03	3.99E-05	0.0020	0.7980
16	1.00E-03	40	2365.1	1.25E-03	2275.10	1.21E-03	4.50E-05	0.0021	0.8571
17	1.30E-03	40	2997.3	1.57E-03	2921.80	1.53E-03	3.78E-05	0.0021	0.7190
18	1.50E-03	40	3555.1	1.85E-03	3438.90	1.79E-03	5.81E-05	0.0020	1.1620
19	1.70E-03	40	4071.1	2.10E-03	3891.80	2.01E-03	8.96E-05	0.0022	1.6300
20	2.00E-03	40	4798.8	2.47E-03	4575.20	2.36E-03	1.12E-04	0.0022	2.0327

Table A-21 Adsorption of C168-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Conc. (M)	Solution	Initial		Equilibrium		C_{in}-C_{eq}	Silica	q
		(ml)	Area	Conc. (M)	Area	Conc. (M)	(M)	(g)	(mmole/g)
1	8.00E-05	40	106.8	3.11E-05	105.00	3.02E-05	9.00E-07	0.0022	0.0164
2	9.00E-05	40	129.1	4.23E-05	123.70	3.96E-05	2.70E-06	0.0020	0.0540
3	1.00E-04	40	146	5.07E-05	141.70	4.86E-05	2.15E-06	0.0021	0.0410
4	1.10E-04	40	213.9	8.47E-05	84.80	2.01E-05	6.46E-05	0.0021	1.2295
5	1.30E-04	40	264.4	1.10E-04	202.00	7.87E-05	3.12E-05	0.0021	0.5943
5	1.30E-04	40	264.4	1.10E-04	250.20	1.03E-04	7.10E-06	0.0021	0.1352
6	1.50E-04	40	313.4	1.34E-04	296.60	1.26E-04	8.40E-06	0.0020	0.1680
7	1.70E-04	40	416.5	1.86E-04	369.30	1.62E-04	2.36E-05	0.0022	0.4291
8	2.00E-04	40	470.8	2.13E-04	436.40	1.96E-04	1.72E-05	0.0020	0.3440
9	2.30E-04	40	535.2	2.45E-04	510.70	2.33E-04	1.23E-05	0.0021	0.2333
10	2.50E-04	40	572.8	2.64E-04	535.90	2.46E-04	1.85E-05	0.0020	0.3690
11	2.70E-04	40	641.8	2.99E-04	611.70	2.84E-04	1.51E-05	0.0021	0.2867
12	4.00E-04	40	951.2	4.53E-04	891.50	4.23E-04	2.99E-05	0.0020	0.5970
13	5.00E-04	40	1205.9	5.81E-04	1103.40	5.29E-04	5.13E-05	0.0022	0.9318
14	7.00E-04	40	1717.7	8.37E-04	1688.00	8.22E-04	1.49E-05	0.0021	0.2829
15	9.00E-04	40	2170.9	1.06E-03	2101.60	1.03E-03	3.47E-05	0.0020	0.6930
16	1.00E-03	40	2451.7	1.20E-03	2371.60	1.16E-03	4.01E-05	0.0021	0.7629
17	1.30E-03	40	3187	1.57E-03	3099.10	1.53E-03	4.40E-05	0.0021	0.8371
18	1.50E-03	40	3718.7	1.84E-03	3622.90	1.79E-03	4.79E-05	0.0020	0.9580
19	1.70E-03	40	4210.1	2.08E-03	4120.20	2.04E-03	4.50E-05	0.0022	0.8173
20	2.00E-03	40	4918.6	2.44E-03	4825.00	2.39E-03	4.68E-05	0.0022	0.8509

Table A-22 Adsorption of C167-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Conc. (M)	Solution	Initial		Equilibrium		C_{in}-C_{eq}	Silica	q
		(ml)	Area	Conc. (M)	Area	Conc. (M)	(M)	(g)	(mmole/g)
1	8.00E-05	40	112.7	3.41E-05	101.00	2.82E-05	5.85E-06	0.0022	0.1064
2	9.00E-05	40	178.2	6.68E-05	173.30	6.44E-05	2.45E-06	0.0021	0.0467
3	1.00E-04	40	201.1	7.83E-05	193.30	7.44E-05	3.90E-06	0.0021	0.0743
4	1.10E-04	40	237.1	9.63E-05	226.60	9.10E-05	5.25E-06	0.0020	0.1050
5	1.30E-04	40	288.8	1.22E-04	268.30	1.12E-04	1.03E-05	0.0022	0.1864
6	1.50E-04	40	336.8	1.46E-04	316.80	1.36E-04	1.00E-05	0.0021	0.1905
7	1.70E-04	40	376.2	1.66E-04	350.40	1.53E-04	1.29E-05	0.0021	0.2457
8	2.00E-04	40	451.9	2.04E-04	416.80	1.86E-04	1.76E-05	0.0022	0.3191
9	2.30E-04	40	534.8	2.45E-04	497.60	2.27E-04	1.86E-05	0.0023	0.3235
10	2.50E-04	40	569.3	2.62E-04	531.60	2.44E-04	1.89E-05	0.0022	0.3427
11	2.70E-04	40	624	2.90E-04	577.10	2.66E-04	2.35E-05	0.0020	0.4690
12	4.00E-04	40	958.2	4.57E-04	893.20	4.24E-04	3.25E-05	0.0021	0.6190
13	5.00E-04	40	1205.3	5.80E-04	1122.80	5.39E-04	4.13E-05	0.0021	0.7857
14	7.00E-04	40	1650.4	8.03E-04	1561.50	7.58E-04	4.45E-05	0.0021	0.8467
15	9.00E-04	40	2192.1	1.07E-03	2056.10	1.01E-03	6.80E-05	0.0021	1.2952
16	1.00E-03	40	2461.6	1.21E-03	2340.40	1.15E-03	6.06E-05	0.0021	1.1543
17	1.30E-03	40	3162.9	1.56E-03	3049.60	1.50E-03	5.67E-05	0.0021	1.0790
18	1.50E-03	40	3574.9	1.77E-03	3484.80	1.72E-03	4.50E-05	0.0022	0.8191
19	1.70E-03	40	4089.5	2.02E-03	3933.20	1.94E-03	7.82E-05	0.0022	1.4209
20	2.00E-03	40	4717.2	2.34E-03	4567.60	2.26E-03	7.48E-05	0.0021	1.4248

Table A-23 Adsorption of C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Conc. (M)	Solution	Initial		Equilibrium		C_{in}-C_{eq}	Silica	q
		(ml)	Area	Conc. (M)	Area	Conc. (M)	(M)	(g)	(mmole/g)
1	8.00E-05	40	164.1	5.98E-05	156.80	5.61E-05	3.65E-06	0.0023	0.0635
2	9.00E-05	40	184.2	6.98E-05	176.50	6.60E-05	3.85E-06	0.0021	0.0733
3	1.00E-04	40	213.2	8.43E-05	204.80	8.01E-05	4.20E-06	0.0022	0.0764
4	1.10E-04	40	237.2	9.63E-05	224.10	8.98E-05	6.55E-06	0.0022	0.1191
5	1.30E-04	40	274.6	1.15E-04	226.60	9.10E-05	2.40E-05	0.0022	0.4364
6	1.50E-04	40	339.6	1.48E-04	298.70	1.27E-04	2.05E-05	0.0020	0.4090
7	1.70E-04	40	387	1.71E-04	321.90	1.39E-04	3.26E-05	0.0022	0.5918
8	2.00E-04	40	465.2	2.10E-04	427.10	1.91E-04	1.90E-05	0.0021	0.3629
9	2.30E-04	40	520.4	2.38E-04	429.70	1.93E-04	4.54E-05	0.0021	0.8638
10	2.50E-04	40	591.2	2.73E-04	542.20	2.49E-04	2.45E-05	0.0021	0.4667
11	2.70E-04	40	605.9	2.81E-04	522.20	2.39E-04	4.19E-05	0.0020	0.8370
12	4.00E-04	40	929.8	4.43E-04	875.10	4.15E-04	2.73E-05	0.0020	0.5470
13	5.00E-04	40	1180.2	5.68E-04	1026.30	4.91E-04	7.70E-05	0.0021	1.4657
14	7.00E-04	40	1657.3	8.06E-04	1504.80	7.30E-04	7.62E-05	0.0020	1.5250
15	9.00E-04	40	1898.9	9.27E-04	1754.20	8.55E-04	7.24E-05	0.0020	1.4470
16	1.00E-03	40	2450.7	1.20E-03	2298.30	1.13E-03	7.62E-05	0.0023	1.3252
17	1.30E-03	40	2490.2	1.22E-03	2316.80	1.14E-03	8.67E-05	0.0020	1.7340
18	1.50E-03	40	3247.5	1.60E-03	3057.70	1.51E-03	9.49E-05	0.0022	1.7255
19	1.70E-03	40	3350.5	1.65E-03	3164.40	1.56E-03	9.30E-05	0.0020	1.8610
20	2.00E-03	40	3942.4	1.95E-03	3751.60	1.85E-03	9.54E-05	0.0021	1.8171

Table A-24 Phenylethanol adsolubilization of CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

Sample	PHE (µL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in\text{-}eq)}$ (M)	PHE Initial	PHE Equilibrium				PHE $_{(in\text{-}eq)}$ (M)	X_{aq}	Average PHE Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area (1)	Area (2)	Area Sum	Conc. (M)								
1-1	5	4322.9	2.18E-03	3181.2	1.61E-03	5.71E-04	1.03E-03	84.3	0	84.3	6.42E-04	3.91E-04	1.16E-05	7.10E-04	1.28E-05	0.41	0.35	27769.37	4.44
1-2	5	4322.9	2.18E-03	3148.1	1.60E-03	5.87E-04	1.03E-03	87.5	9.6	97.1	7.78E-04	2.56E-04	1.40E-05			0.30			
2-1	10	4322.9	2.18E-03	3170.2	1.61E-03	5.76E-04	2.07E-03	177.8	17.3	195.1	1.82E-03	2.52E-04	3.27E-05	1.81E-03	3.27E-05	0.30	0.31	9429.55	3.97
2-2	10	4322.9	2.18E-03	3208.9	1.63E-03	5.57E-04	2.07E-03	178	17	195	1.81E-03	2.53E-04	3.27E-05			0.31			
3-1	15	4322.9	2.18E-03	3166.4	1.61E-03	5.78E-04	3.10E-03	267.4	25.6	293	2.85E-03	2.49E-04	5.13E-05	2.86E-03	5.15E-05	0.30	0.29	5679.39	3.75
3-2	15	4322.9	2.18E-03	3178	1.61E-03	5.72E-04	3.10E-03	268.1	26.9	295	2.87E-03	2.28E-04	5.17E-05			0.28			
4-1	20	4322.9	2.18E-03	3056.8	1.55E-03	6.33E-04	4.13E-03	342	30.7	372.7	3.70E-03	4.38E-04	6.65E-05	3.80E-03	6.83E-05	0.41	0.35	5158.94	3.71
4-2	20	4322.9	2.18E-03	3192.9	1.62E-03	5.65E-04	4.13E-03	357.2	34.5	391.7	3.90E-03	2.37E-04	7.01E-05			0.30			
5-1	25	4322.9	2.18E-03	3140.9	1.59E-03	5.91E-04	5.17E-03	438.1	41.2	479.3	4.82E-03	3.43E-04	8.68E-05	4.86E-03	8.74E-05	0.37	0.34	3894.06	3.59
5-2	25	4322.9	2.18E-03	3105.2	1.58E-03	6.09E-04	5.17E-03	444.2	41.3	485.5	4.89E-03	2.78E-04	8.80E-05			0.31			
6-1	30	4322.9	2.18E-03	3236.8	1.64E-03	5.43E-04	6.20E-03	548.9	50.8	599.7	6.10E-03	1.02E-04	1.10E-04	6.09E-03	1.10E-04	0.16	0.17	1522.64	3.18
6-2	30	4322.9	2.18E-03	3160	1.60E-03	5.81E-04	6.20E-03	545.9	51.8	597.7	6.08E-03	1.23E-04	1.09E-04			0.18			
7-1	36	4322.9	2.18E-03	3108.6	1.58E-03	6.07E-04	7.44E-03	649.6	59.9	709.5	7.26E-03	1.80E-04	1.31E-04	7.30E-03	1.31E-04	0.23	0.20	1518.69	3.18
7-2	36	4322.9	2.18E-03	3236.9	1.64E-03	5.43E-04	7.44E-03	655.3	60.7	716	7.33E-03	1.11E-04	1.32E-04			0.17			
8-1	40	4322.9	2.18E-03	3057.7	1.55E-03	6.33E-04	8.27E-03	716.6	66.5	783.1	8.04E-03	2.28E-04	1.45E-04	8.08E-03	1.45E-04	0.26	0.23	1588.73	3.20
8-2	40	4322.9	2.18E-03	3125.8	1.59E-03	5.99E-04	8.27E-03	723.6	67.1	790.7	8.12E-03	1.47E-04	1.46E-04			0.20			
9-1	46	4322.9	2.18E-03	3183.9	1.62E-03	5.70E-04	9.51E-03	825	76.9	901.9	9.30E-03	2.10E-04	1.67E-04	9.33E-03	1.68E-04	0.27	0.24	1407.44	3.15
9-2	46	4322.9	2.18E-03	3120.5	1.58E-03	6.01E-04	9.51E-03	830.9	76.4	907.3	9.35E-03	1.53E-04	1.68E-04			0.20			
10-1	50	4322.9	2.18E-03	3164.9	1.61E-03	5.79E-04	1.03E-02	901.2	83.3	984.5	1.02E-02	1.63E-04	1.83E-04	1.02E-02	1.83E-04	0.22	0.20	1114.74	3.05
10-2	50	4322.9	2.18E-03	3195.7	1.62E-03	5.64E-04	1.03E-02	903.5	83.9	987.4	1.02E-02	1.32E-04	1.84E-04			0.19			

Table A-24 Phenylethanol adsolubilization of CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C (cont’)

Sample	PHE (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in-eq)}$ (M)	PHE Initial	PHE Equilibrium				PHE $_{(in-eq)}$ (M)	X_{aq}	Average PHE Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area (1)	Area (2)	Area Sum	Conc. (M)								
11-1	56	4322.9	2.18E-03	3176.6	1.61E-03	5.73E-04	1.16E-02	1004.7	92.1	1096.8	1.14E-02	2.14E-04	2.04E-04	1.14E-02	2.04E-04	0.27	0.28	1348.03	3.13
11-2	56	4322.9	2.18E-03	3142	1.59E-03	5.90E-04	1.16E-02	1001.9	93.5	1095.4	1.13E-02	2.29E-04	2.04E-04			0.28			
12-1	60	4322.9	2.18E-03	3103.3	1.57E-03	6.10E-04	1.24E-02	1080.5	99.7	1180.2	1.22E-02	1.58E-04	2.20E-04	1.22E-02	2.20E-04	0.21	0.22	979.40	2.99
12-2	60	4322.9	2.18E-03	3147.5	1.60E-03	5.88E-04	1.24E-02	1078.9	100	1178.9	1.22E-02	1.72E-04	2.20E-04			0.23			
13-1	66	4322.9	2.18E-03	3132.8	1.59E-03	5.95E-04	1.36E-02	1190.2	109.4	1299.6	1.35E-02	1.34E-04	2.43E-04	1.35E-02	2.43E-04	0.18	0.18	748.37	2.87
13-2	66	4322.9	2.18E-03	3133.9	1.59E-03	5.95E-04	1.36E-02	1189.7	110.2	1299.9	1.35E-02	1.31E-04	2.43E-04			0.18			
14-1	70	4322.9	2.18E-03	3126.6	1.59E-03	5.98E-04	1.45E-02	1256.1	115.5	1371.6	1.43E-02	1.98E-04	2.57E-04	1.43E-02	2.57E-04	0.25	0.25	971.06	2.99
14-2	70	4322.9	2.18E-03	3207.8	1.63E-03	5.58E-04	1.45E-02	1256.5	116.3	1372.8	1.43E-02	1.86E-04	2.57E-04			0.25			
15-1	76	4322.9	2.18E-03	3147.5	1.60E-03	5.88E-04	1.57E-02	1364.9	127	1491.9	1.55E-02	1.65E-04	2.80E-04	1.55E-02	2.80E-04	0.22	0.22	801.27	2.90
15-2	76	4322.9	2.18E-03	3146.4	1.60E-03	5.88E-04	1.57E-02	1366	125	1491	1.55E-02	1.75E-04	2.80E-04			0.23			
16-1	80	4322.9	2.18E-03	3279.9	1.66E-03	5.22E-04	1.65E-02	1438	131.8	1569.8	1.64E-02	1.67E-04	2.95E-04	1.64E-02	2.95E-04	0.24	0.23	790.12	2.90
16-2	80	4322.9	2.18E-03	3208.8	1.63E-03	5.57E-04	1.65E-02	1448.9	121.6	1570.5	1.64E-02	1.60E-04	2.95E-04			0.22			

Table A-25 Phenylethanol adsolubilization of C167-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

Sample	PHE (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in\text{-}eq)}$ (M)	PHE Initial	PHE Equilibrium				PHE $_{(in\text{-}eq)}$ (M)	X_{aq}	Average PHE Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area (1)	Area (2)	Area Sum	Conc. (M)								
1-1	5	1052.4	5.49E-04	949.2	4.98E-04	5.16E-05	1.03E-03	90.8	10.1	100.9	8.18E-04	2.15E-04	1.47E-05	7.91E-04	1.42E-05	0.81	0.85	59596.23	4.78
1-2	5	1052.4	5.49E-04	985.1	5.16E-04	3.37E-05	1.03E-03	86.4	9.3	95.7	7.63E-04	2.71E-04	1.37E-05			0.89			
2-1	10	1052.4	5.49E-04	982	5.14E-04	3.52E-05	2.07E-03	174.9	17.2	192.1	1.78E-03	2.83E-04	3.21E-05	1.82E-03	3.27E-05	0.89	0.87	26500.19	4.42
2-2	10	1052.4	5.49E-04	970.8	5.09E-04	4.08E-05	2.07E-03	180.4	17.8	198.2	1.85E-03	2.19E-04	3.33E-05			0.84			
3-1	15	1052.4	5.49E-04	959.7	5.03E-04	4.64E-05	3.10E-03	269.1	25.7	294.8	2.87E-03	2.30E-04	5.17E-05	2.85E-03	5.13E-05	0.83	0.85	16553.64	4.22
3-2	15	1052.4	5.49E-04	967.2	5.07E-04	4.26E-05	3.10E-03	265.7	24.9	290.6	2.83E-03	2.74E-04	5.09E-05			0.87			
4-1	20	1052.4	5.49E-04	985.2	5.16E-04	3.36E-05	4.13E-03	356.2	33.2	389.4	3.87E-03	2.62E-04	6.97E-05	3.87E-03	6.96E-05	0.89	0.87	12488.85	4.10
4-2	20	1052.4	5.49E-04	959.2	5.03E-04	4.66E-05	4.13E-03	355.5	33.1	388.6	3.86E-03	2.70E-04	6.95E-05			0.85			
5-1	25	1052.4	5.49E-04	957.2	5.02E-04	4.76E-05	5.17E-03	446.5	40.9	487.4	4.91E-03	2.58E-04	8.84E-05	4.90E-03	8.83E-05	0.84	0.87	9827.58	3.99
5-2	25	1052.4	5.49E-04	987.2	5.17E-04	3.26E-05	5.17E-03	445.4	41.1	486.5	4.90E-03	2.67E-04	8.82E-05			0.89			
6-1	30	1052.4	5.49E-04	973.8	5.10E-04	3.93E-05	6.20E-03	512.5	51	563.5	5.72E-03	4.86E-04	1.03E-04	5.70E-03	1.03E-04	0.93	0.92	9005.75	3.95
6-2	30	1052.4	5.49E-04	965.7	5.06E-04	4.33E-05	6.20E-03	510.1	50.4	560.5	5.68E-03	5.17E-04	1.02E-04			0.92			
7-1	36	1052.4	5.49E-04	964.2	5.05E-04	4.41E-05	7.44E-03	605.3	66.9	672.2	6.87E-03	5.75E-04	1.24E-04	6.85E-03	1.23E-04	0.93	0.93	7533.65	3.88
7-2	36	1052.4	5.49E-04	959	5.03E-04	4.67E-05	7.44E-03	602.5	66.5	669	6.83E-03	6.09E-04	1.23E-04			0.93			
8-1	40	1052.4	5.49E-04	950.2	4.98E-04	5.11E-05	8.27E-03	662.7	60.2	722.9	7.40E-03	8.65E-04	1.33E-04	7.48E-03	1.35E-04	0.94	0.93	6941.22	3.84
8-2	40	1052.4	5.49E-04	935.8	4.91E-04	5.83E-05	8.27E-03	676.3	60.9	737.2	7.55E-03	7.14E-04	1.36E-04			0.92			
9-1	46	1052.4	5.49E-04	956.3	5.01E-04	4.81E-05	9.51E-03	821.7	76.6	898.3	9.26E-03	2.48E-04	1.67E-04	9.29E-03	1.67E-04	0.84	0.81	4855.17	3.69
9-2	46	1052.4	5.49E-04	944.8	4.96E-04	5.38E-05	9.51E-03	828.6	74.6	903.2	9.31E-03	1.96E-04	1.68E-04			0.79			
10-1	50	1052.4	5.49E-04	960.6	5.03E-04	4.59E-05	1.03E-02	907	82.6	989.6	1.02E-02	1.09E-04	1.84E-04	1.02E-02	1.84E-04	0.70	0.71	3842.08	3.58
10-2	50	1052.4	5.49E-04	959	5.03E-04	4.67E-05	1.03E-02	906	83	989	1.02E-02	1.15E-04	1.84E-04			0.71			

Table A-25 Phenylethanol adsolubilization of C167-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C (cont')

Sample	PHE (µL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in-eq)}$ (M)	PHE Initial	PHE Equilibrium				PHE $_{(in-eq)}$ (M)	X_{aq}	Average PHE Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area (1)	Area (2)	Area Sum	Conc. (M)								
11-1	56	1052.4	5.49E-04	968.9	5.08E-04	4.18E-05	1.16E-02	1023.1	92.7	1105.8	1.15E-02	1.19E-04	2.06E-04	1.14E-02	2.06E-04	0.74	0.70	3382.32	3.53
11-2	56	1052.4	5.49E-04	903.3	4.75E-04	7.46E-05	1.16E-02	1012.5	91.2	1103.7	1.14E-02	1.41E-04	2.06E-04			0.65			
12-1	60	1052.4	5.49E-04	966.5	5.06E-04	4.30E-05	1.24E-02	1087.6	98.7	1176.2	1.22E-02	2.00E-04	2.20E-04	1.22E-02	2.20E-04	0.82	0.81	3670.48	3.56
12-2	60	1052.4	5.49E-04	965.2	5.06E-04	4.36E-05	1.24E-02	1100.7	98.8	1179.5	1.22E-02	1.65E-04	2.20E-04			0.79			
13-1	66	1052.4	5.49E-04	955.8	5.01E-04	4.83E-05	1.36E-02	1193.1	106.8	1299.9	1.35E-02	1.31E-04	2.43E-04	1.35E-02	2.43E-04	0.73	0.77	3178.48	3.50
13-2	66	1052.4	5.49E-04	965.6	5.06E-04	4.34E-05	1.36E-02	1197.6	110.14	1294.5	1.35E-02	1.88E-04	2.42E-04			0.81			
14-1	70	1052.4	5.49E-04	979.4	5.13E-04	3.65E-05	1.45E-02	1201.9	114.1	1316	1.37E-02	7.87E-04	2.46E-04	1.37E-02	2.47E-04	0.96	0.94	3821.78	3.58
14-2	70	1052.4	5.49E-04	947.3	4.97E-04	5.26E-05	1.45E-02	1208.8	114.1	1322.9	1.38E-02	7.14E-04	2.48E-04			0.93			
15-1	76	1052.4	5.49E-04	954.2	5.00E-04	4.91E-05	1.57E-02	1371.7	121.9	1493.6	1.56E-02	1.47E-04	2.80E-04	1.56E-02	2.80E-04	0.75	0.74	2626.24	3.42
15-2	76	1052.4	5.49E-04	955.6	5.01E-04	4.84E-05	1.57E-02	1378.7	125.3	1495.6	1.56E-02	1.26E-04	2.80E-04			0.72			
16-1	80	1052.4	5.49E-04	980.1	5.13E-04	3.62E-05	1.65E-02	1445	129.5	1574.5	1.64E-02	1.17E-04	2.95E-04	1.64E-02	2.95E-04	0.76	0.80	2706.21	3.43
16-2	80	1052.4	5.49E-04	960.6	5.03E-04	4.59E-05	1.65E-02	1437.7	126.8	1564.5	1.63E-02	2.23E-04	2.94E-04			0.83			

Table A-26 Phenylethanol adsolubilization of C168-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

Sample	PHE (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in-eq)}$ (M)	PHE Initial	PHE Equilibrium				PHE $_{(in-eq)}$ (M)	X_{aq}	Average PHE Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area (1)	Area (2)	Area Sum	Conc. (M)								
1-1	6	1016.6	5.31E-04	990.9	5.19E-04	1.29E-05	1.24E-03	116.3	10.5	126.8	1.09E-03	1.48E-04	1.97E-05	1.11E-03	1.99E-05	0.92	0.95	47680.35	4.68
1-2	6	1016.6	5.31E-04	1011.3	5.29E-04	2.65E-06	1.24E-03	118.7	10.7	129.4	1.12E-03	1.20E-04	2.02E-05			0.98			
2-1	10	1016.6	5.31E-04	982.1	5.14E-04	1.73E-05	2.07E-03	188.4	16.3	204.7	1.92E-03	1.50E-04	3.45E-05	1.90E-03	3.43E-05	0.90	0.94	27349.79	4.44
2-2	10	1016.6	5.31E-04	1008.5	5.27E-04	4.05E-06	2.07E-03	185.5	16.7	202.2	1.89E-03	1.77E-04	3.40E-05			0.98			
3-1	16	1016.6	5.31E-04	1005.9	5.26E-04	5.35E-06	3.31E-03	299	26.85	325.85	3.20E-03	1.08E-04	5.76E-05	3.21E-03	5.77E-05	0.95	0.90	15548.39	4.19
3-2	16	1016.6	5.31E-04	982.1	5.14E-04	1.73E-05	3.31E-03	300.1	27.2	327.3	3.21E-03	9.23E-05	5.79E-05			0.84			
4-1	20	1016.6	5.31E-04	990.1	5.18E-04	1.33E-05	4.13E-03	376.7	33.5	410.2	4.09E-03	4.15E-05	7.37E-05	4.06E-03	7.32E-05	0.76	0.84	11424.15	4.06
4-2	20	1016.6	5.31E-04	998.4	5.22E-04	9.10E-06	4.13E-03	371.5	33.5	405	4.04E-03	9.65E-05	7.27E-05			0.91			
5-1	26	1016.6	5.31E-04	970.3	5.08E-04	2.32E-05	5.37E-03	477.7	42.6	520.3	5.26E-03	1.16E-04	9.46E-05	5.22E-03	9.39E-05	0.83	0.87	9240.79	3.97
5-2	26	1016.6	5.31E-04	973.6	5.10E-04	2.15E-05	5.37E-03	470.8	41.8	512.6	5.18E-03	1.98E-04	9.32E-05			0.90			
6-1	30	1016.6	5.31E-04	986.4	5.16E-04	1.51E-05	6.20E-03	548.3	48.3	596.6	6.07E-03	1.35E-04	1.09E-04	6.05E-03	1.09E-04	0.90	0.93	8531.65	3.93
6-2	30	1016.6	5.31E-04	1001.9	5.24E-04	7.35E-06	6.20E-03	544.9	48.5	593.4	6.03E-03	1.69E-04	1.09E-04			0.96			
7-1	36	1016.6	5.31E-04	983.2	5.15E-04	1.67E-05	7.44E-03	656.4	58.3	714.7	7.32E-03	1.25E-04	1.32E-04	7.32E-03	1.32E-04	0.88	0.89	6785.90	3.83
7-2	36	1016.6	5.31E-04	994.2	5.20E-04	1.12E-05	7.44E-03	657.7	58.5	716.2	7.33E-03	1.09E-04	1.32E-04			0.91			
8-1	40	1016.6	5.31E-04	990.7	5.18E-04	1.30E-05	8.27E-03	725.2	64.5	789.7	8.11E-03	1.58E-04	1.46E-04	8.13E-03	1.46E-04	0.92	0.93	6387.08	3.81
8-2	40	1016.6	5.31E-04	1003.1	5.25E-04	6.75E-06	8.27E-03	728.6	65	793.6	8.15E-03	1.17E-04	1.47E-04			0.95			
9-1	46	1016.6	5.31E-04	965.1	5.06E-04	2.57E-05	9.51E-03	831.2	74.1	905.3	9.33E-03	1.74E-04	1.68E-04	9.36E-03	1.68E-04	0.87	0.89	5269.51	3.72
9-2	46	1016.6	5.31E-04	989.4	5.18E-04	1.36E-05	9.51E-03	835.3	74.4	909.7	9.38E-03	1.28E-04	1.69E-04			0.90			
10-1	50	1016.6	5.31E-04	1005.1	5.26E-04	5.75E-06	1.03E-02	901.4	79.7	981.1	1.01E-02	1.99E-04	1.82E-04	1.00E-02	1.81E-04	0.97	0.97	5379.51	3.73
10-2	50	1016.6	5.31E-04	994.2	5.20E-04	1.12E-05	1.03E-02	884.5	78.3	962.8	9.94E-03	3.92E-04	1.79E-04			0.97			

Table A-26 Phenylethanol adsolubilization of C168-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C (cont')

Sample	PHE (µL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in-eq)}$ (M)	PHE Initial	PHE Equilibrium				PHE $_{(in-eq)}$ (M)	X_{aq}	Average PHE Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area (1)	Area (2)	Area Sum	Conc. (M)								
11-1	56	1016.6	5.31E-04	1010.5	5.28E-04	3.05E-06	1.16E-02	1003.6	88.1	1105.8	1.15E-02	1.19E-04	2.06E-04	1.14E-02	2.06E-04	0.97	0.96	4664.51	3.67
11-2	56	1016.6	5.31E-04	1001.5	5.24E-04	7.55E-06	1.16E-02	1014.6	89.6	1104.2	1.14E-02	1.36E-04	2.06E-04			0.95			
12-1	60	1016.6	5.31E-04	1001.2	5.24E-04	7.70E-06	1.24E-02	1091.4	96.6	1176.2	1.22E-02	2.00E-04	2.20E-04	1.22E-02	2.20E-04	0.96	0.96	4359.10	3.64
12-2	60	1016.6	5.31E-04	1000.8	5.24E-04	7.90E-06	1.24E-02	1075.1	96.5	1179.5	1.22E-02	1.65E-04	2.20E-04			0.95			
13-1	66	1016.6	5.31E-04	950.1	4.98E-04	3.33E-05	1.36E-02	1182.9	104.9	1287.8	1.34E-02	2.59E-04	2.41E-04	1.34E-02	2.42E-04	0.89	0.93	3831.21	3.58
13-2	66	1016.6	5.31E-04	1002.7	5.24E-04	6.95E-06	1.36E-02	1187	104.9	1294.5	1.35E-02	1.88E-04	2.42E-04			0.96			
14-1	70	1016.6	5.31E-04	1000.7	5.23E-04	7.95E-06	1.45E-02	1241.2	109.6	1350.8	1.41E-02	4.19E-04	2.53E-04	1.42E-02	2.56E-04	0.98	0.90	3515.97	3.55
14-2	70	1016.6	5.31E-04	981.1	5.14E-04	1.78E-05	1.45E-02	1269.9	112.9	1382.8	1.44E-02	7.99E-05	2.59E-04			0.82			
15-1	76	1016.6	5.31E-04	1000.5	5.23E-04	8.05E-06	1.57E-02	1361.7	121	1482.7	1.54E-02	2.62E-04	2.78E-04	1.55E-02	2.79E-04	0.97	0.92	3311.29	3.52
15-2	76	1016.6	5.31E-04	981.9	5.14E-04	1.74E-05	1.57E-02	1373.2	121.9	1495.6	1.56E-02	1.26E-04	2.80E-04			0.88			
16-1	80	1016.6	5.31E-04	982.3	5.14E-04	1.72E-05	1.65E-02	1421.5	125.4	1546.9	1.61E-02	4.10E-04	2.90E-04	1.62E-02	2.92E-04	0.96	0.93	3175.81	3.50
16-2	80	1016.6	5.31E-04	960.6	5.03E-04	2.80E-05	1.65E-02	1436.6	126.8	1563.4	1.63E-02	2.35E-04	2.93E-04			0.89			

Table A-27 Phenylethanol adsolubilization of C167-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

Sample	PHE (µL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in-eq)}$ (M)	PHE Initial	PHE Equilibrium				PHE $_{(in-eq)}$ (M)	X_{aq}	Average PHE Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area (1)	Area (2)	Area Sum	Conc. (M)								
1-1	6	1817.8	9.32E-04	1778	9.12E-04	1.99E-05	1.24E-03	121.8	11.3	133.1	1.16E-03	8.13E-05	2.09E-05	1.13E-03	2.03E-05	0.80	0.87	42611.84	4.63
1-2	6	1817.8	9.32E-04	1796.8	9.22E-04	1.05E-05	1.24E-03	116.7	10.9	127.6	1.10E-03	1.39E-04	1.98E-05			0.93			
2-1	10	1817.8	9.32E-04	1803.4	9.25E-04	7.20E-06	2.07E-03	193.4	17.8	211.2	1.99E-03	8.12E-05	3.57E-05	1.89E-03	3.41E-05	0.92	0.95	27765.46	4.44
2-2	10	1817.8	9.32E-04	1804.5	9.25E-04	6.65E-06	2.07E-03	177.5	16.5	194	1.80E-03	2.63E-04	3.25E-05			0.98			
3-1	16	1817.8	9.32E-04	1801.6	9.24E-04	8.10E-06	3.31E-03	284.8	25.6	310.4	3.04E-03	2.71E-04	5.46E-05	3.04E-03	5.47E-05	0.97	0.97	17738.12	4.25
3-2	16	1817.8	9.32E-04	1800.5	9.23E-04	8.65E-06	3.31E-03	285.4	25.3	310.7	3.04E-03	2.68E-04	5.47E-05			0.97			
4-1	20	1817.8	9.32E-04	1772.9	9.10E-04	2.24E-05	4.13E-03	308.7	32.8	341.5	3.37E-03	7.69E-04	6.06E-05	3.36E-03	6.05E-05	0.97	0.97	16082.51	4.21
4-2	20	1817.8	9.32E-04	1775.7	9.11E-04	2.10E-05	4.13E-03	307.3	33.2	340.5	3.35E-03	7.79E-04	6.04E-05			0.97			
5-1	26	1817.8	9.32E-04	1799.4	9.23E-04	9.20E-06	5.37E-03	479.1	41.9	521	5.27E-03	1.09E-04	9.48E-05	5.28E-03	9.50E-05	0.92	0.92	9656.90	3.98
5-2	26	1817.8	9.32E-04	1802.4	9.24E-04	7.70E-06	5.37E-03	480.3	43.3	523.6	5.29E-03	8.12E-05	9.53E-05			0.91			
6-1	30	1817.8	9.32E-04	1808.4	9.27E-04	4.70E-06	6.20E-03	550	49.6	599.6	6.10E-03	1.03E-04	1.10E-04	6.10E-03	1.10E-04	0.96	0.94	8560.90	3.93
6-2	30	1817.8	9.32E-04	1799.6	9.23E-04	9.10E-06	6.20E-03	550.4	48.8	599.2	6.09E-03	1.08E-04	1.10E-04			0.92			
7-1	36	1817.8	9.32E-04	1802.5	9.24E-04	7.65E-06	7.44E-03	649.7	58.2	707.9	7.24E-03	1.97E-04	1.30E-04	7.22E-03	1.30E-04	0.96	0.97	7442.40	3.87
7-2	36	1817.8	9.32E-04	1802.78	9.25E-04	7.51E-06	7.44E-03	645	57.8	702.8	7.19E-03	2.51E-04	1.29E-04			0.97			
8-1	40	1817.8	9.32E-04	1801.1	9.24E-04	8.35E-06	8.27E-03	708.4	65.3	773.7	7.94E-03	3.27E-04	1.43E-04	7.92E-03	1.43E-04	0.98	0.98	6871.13	3.84
8-2	40	1817.8	9.32E-04	1806	9.26E-04	5.90E-06	8.27E-03	704.6	65.4	770	7.90E-03	3.66E-04	1.42E-04			0.98			
9-1	46	1817.8	9.32E-04	1803	9.25E-04	7.40E-06	9.51E-03	804.5	73.9	878.4	9.05E-03	4.59E-04	1.63E-04	9.07E-03	1.63E-04	0.98	0.99	6034.23	3.78
9-2	46	1817.8	9.32E-04	1806.8	9.27E-04	5.50E-06	9.51E-03	808.5	74.5	883	9.10E-03	4.10E-04	1.64E-04			0.99			
10-1	50	1817.8	9.32E-04	1808.3	9.27E-04	4.75E-06	1.03E-02	908.5	81.3	989.8	1.02E-02	1.06E-04	1.84E-04	1.02E-02	1.84E-04	0.96	0.95	5144.00	3.71
10-2	50	1817.8	9.32E-04	1802.4	9.24E-04	7.70E-06	1.03E-02	909.3	79.9	989.2	1.02E-02	1.13E-04	1.84E-04			0.94			

Table A-27 Phenylethanol adsolubilization of C167-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C (cont')

Sample	PHE (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in-eq)}$ (M)	PHE Initial	PHE Equilibrium				PHE $_{(in-eq)}$ (M)	X_{aq}	Average PHE Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area (1)	Area (2)	Area Sum	Conc. (M)								
11-1	56	1817.8	9.32E-04	1804.3	9.25E-04	6.75E-06	1.16E-02	1020.3	90.2	1105.8	1.15E-02	1.19E-04	2.06E-04	1.15E-02	2.06E-04	0.95	0.95	4588.32	3.66
11-2	56	1817.8	9.32E-04	1803.1	9.25E-04	7.35E-06	1.16E-02	1015	90	1105	1.14E-02	1.27E-04	2.06E-04			0.95			
12-1	60	1817.8	9.32E-04	1795.6	9.21E-04	1.11E-05	1.24E-02	1107.7	98.1	1176.2	1.22E-02	2.00E-04	2.20E-04	1.22E-02	2.20E-04	0.95	0.96	4345.38	3.64
12-2	60	1817.8	9.32E-04	1805.4	9.26E-04	6.20E-06	1.24E-02	1104.1	97.1	1179.5	1.22E-02	1.65E-04	2.20E-04			0.96			
13-1	66	1817.8	9.32E-04	1809.5	9.28E-04	4.15E-06	1.36E-02	1195	105.9	1300.9	1.35E-02	1.20E-04	2.43E-04	1.35E-02	2.43E-04	0.97	0.94	3883.50	3.59
13-2	66	1817.8	9.32E-04	1784.6	9.15E-04	1.66E-05	1.36E-02	1189.4	104.4	1294.5	1.35E-02	1.88E-04	2.42E-04			0.92			
14-1	70	1817.8	9.32E-04	1802	9.24E-04	7.90E-06	1.45E-02	1256	112.1	1368.1	1.42E-02	2.35E-04	2.56E-04	1.42E-02	2.56E-04	0.97	0.97	3801.83	3.58
14-2	70	1817.8	9.32E-04	1808.9	9.28E-04	4.45E-06	1.45E-02	1258.6	110.3	1368.9	1.42E-02	2.27E-04	2.56E-04			0.98			
15-1	76	1817.8	9.32E-04	1798.1	9.22E-04	9.85E-06	1.57E-02	1360.9	121.1	1482	1.54E-02	2.70E-04	2.78E-04	1.55E-02	2.79E-04	0.96	0.97	3459.43	3.54
15-2	76	1817.8	9.32E-04	1809.1	9.28E-04	4.35E-06	1.57E-02	1362.1	122.6	1495.6	1.56E-02	1.26E-04	2.80E-04			0.97			
16-1	80	1817.8	9.32E-04	1801.6	9.24E-04	8.10E-06	1.65E-02	1406.6	129.2	1535.8	1.60E-02	5.27E-04	2.88E-04	1.60E-02	2.88E-04	0.98	0.98	3416.04	3.53
16-2	80	1817.8	9.32E-04	1797.2	9.22E-04	1.03E-05	1.65E-02	1407.5	125.7	1533.2	1.60E-02	5.55E-04	2.88E-04			0.98			

Table A-28 Phenylethanol adsolubilization of C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

Sample	PHE (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in-eq)}$ (M)	PHE Initial	PHE Equilibrium				PHE $_{(in-eq)}$ (M)	X_{aq}	Average PHE Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area (1)	Area (2)	Area Sum	Conc. (M)								
1-1	6	920.4	4.83E-04	845	4.46E-04	3.77E-05	1.24E-03	122	11.4	133.4	1.16E-03	7.81E-05	2.09E-05	1.16E-03	2.09E-05	0.67	0.57	27487.73	4.44
1-2	6	1020.4	5.33E-04	829.1	4.38E-04	9.56E-05	1.24E-03	121	11.7	132.7	1.15E-03	8.55E-05	2.08E-05			0.47			
2-1	10	1020.4	5.33E-04	852.7	4.49E-04	8.38E-05	2.07E-03	190.6	19.3	209.9	1.97E-03	9.50E-05	3.55E-05	1.97E-03	3.55E-05	0.53	0.51	14432.72	4.16
2-2	10	1020.4	5.33E-04	832.5	4.39E-04	9.39E-05	2.07E-03	190.8	19.4	210.2	1.98E-03	9.18E-05	3.56E-05			0.49			
3-1	16	1020.4	5.33E-04	874.6	4.60E-04	7.29E-05	3.31E-03	300.2	27.9	328.1	3.22E-03	8.39E-05	5.80E-05	3.23E-03	5.81E-05	0.53	0.53	9107.10	3.96
3-2	16	1020.4	5.33E-04	874.9	4.61E-04	7.28E-05	3.31E-03	301.3	27.2	328.5	3.23E-03	7.96E-05	5.81E-05			0.52			
4-1	20	1020.4	5.33E-04	874	4.60E-04	7.32E-05	4.13E-03	372.5	33.4	405.9	4.05E-03	8.70E-05	7.28E-05	4.05E-03	7.29E-05	0.54	0.54	7368.92	3.87
4-2	20	1020.4	5.33E-04	874.2	4.60E-04	7.31E-05	4.13E-03	371.6	34.7	406.3	4.05E-03	8.28E-05	7.29E-05			0.53			
5-1	26	1020.4	5.33E-04	869	4.58E-04	7.57E-05	5.37E-03	479.7	42.8	522.5	5.28E-03	9.28E-05	9.51E-05	5.28E-03	9.51E-05	0.55	0.54	5708.03	3.76
5-2	26	1020.4	5.33E-04	868.3	4.57E-04	7.61E-05	5.37E-03	479.1	43.9	523	5.29E-03	8.75E-05	9.52E-05			0.54			
6-1	30	1020.4	5.33E-04	851.5	4.49E-04	8.45E-05	6.20E-03	551.1	48.7	599.8	6.10E-03	1.01E-04	1.10E-04	6.09E-03	1.10E-04	0.55	0.55	5032.47	3.70
6-2	30	1020.4	5.33E-04	838.6	4.42E-04	9.09E-05	6.20E-03	549	49.5	598.5	6.09E-03	1.15E-04	1.10E-04			0.56			
7-1	36	1020.4	5.33E-04	860	4.53E-04	8.02E-05	7.44E-03	651.3	58.8	710.1	7.27E-03	1.74E-04	1.31E-04	7.32E-03	1.32E-04	0.68	0.57	4302.66	3.63
7-2	36	1020.4	5.33E-04	870.1	4.58E-04	7.52E-05	7.44E-03	661.6	59.1	720.7	7.38E-03	6.15E-05	1.33E-04			0.45			
8-1	40	1020.4	5.33E-04	836.1	4.41E-04	9.21E-05	8.27E-03	719.3	63.8	783.1	8.04E-03	2.28E-04	1.45E-04	8.11E-03	1.46E-04	0.71	0.62	4223.93	3.63
8-2	40	1020.4	5.33E-04	844.8	4.46E-04	8.78E-05	8.27E-03	730.2	65.4	795.6	8.17E-03	9.54E-05	1.47E-04			0.52			
9-1	46	1020.4	5.33E-04	853	4.50E-04	8.37E-05	9.51E-03	833	74.7	907.7	9.36E-03	1.49E-04	1.68E-04	9.34E-03	1.68E-04	0.64	0.66	3923.50	3.59
9-2	46	1020.4	5.33E-04	840.6	4.43E-04	8.99E-05	9.51E-03	830.1	73.7	903.8	9.32E-03	1.90E-04	1.68E-04			0.68			
10-1	50	1020.4	5.33E-04	863.8	4.55E-04	7.83E-05	1.03E-02	901.7	80.4	982.1	1.01E-02	1.88E-04	1.83E-04	1.02E-02	1.83E-04	0.71	0.69	3795.19	3.58
10-2	50	1020.4	5.33E-04	880.2	4.63E-04	7.01E-05	1.03E-02	906	79.6	985.6	1.02E-02	1.51E-04	1.83E-04			0.68			

Table A-28 Phenylethanol adsolubilization of C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C (cont')

Sample	PHE (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in\text{-}eq)}$ (M)	PHE Initial	PHE Equilibrium				PHE $_{(in\text{-}eq)}$ (M)	X_{aq}	Average PHE Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area (1)	Area (2)	Area Sum	Conc. (M)								
11-1	56	1020.4	5.33E-04	846.3	4.46E-04	8.71E-05	1.16E-02	1006.8	89.1	1105.8	1.15E-02	1.19E-04	2.06E-04	1.14E-02	2.05E-04	0.58	0.66	3194.41	3.50
11-2	56	1020.4	5.33E-04	874.4	4.60E-04	7.30E-05	1.16E-02	1008.5	89.3	1097.8	1.14E-02	2.03E-04	2.05E-04			0.74			
12-1	60	1020.4	5.33E-04	861	4.54E-04	7.97E-05	1.24E-02	1085.5	93.9	1176.2	1.22E-02	2.00E-04	2.20E-04	1.22E-02	2.20E-04	0.72	0.71	3240.54	3.51
12-2	60	1020.4	5.33E-04	885.6	4.66E-04	6.74E-05	1.24E-02	1094.1	96.7	1179.5	1.22E-02	1.65E-04	2.20E-04			0.71			
13-1	66	1020.4	5.33E-04	859.4	4.53E-04	8.05E-05	1.36E-02	1186.6	105.4	1292	1.34E-02	2.14E-04	2.42E-04	1.34E-02	2.42E-04	0.73	0.72	2993.21	3.48
13-2	66	1020.4	5.33E-04	875.1	4.61E-04	7.26E-05	1.36E-02	1189.7	104.2	1294.5	1.35E-02	1.88E-04	2.42E-04			0.72			
14-1	70	1020.4	5.33E-04	871.7	4.59E-04	7.43E-05	1.45E-02	1262.4	111.5	1373.9	1.43E-02	1.74E-04	2.57E-04	1.43E-02	2.57E-04	0.70	0.73	2822.76	3.45
14-2	70	1020.4	5.33E-04	880.2	4.63E-04	7.01E-05	1.45E-02	1259.4	111.1	1370.5	1.43E-02	2.10E-04	2.57E-04			0.75			
15-1	76	1020.4	5.33E-04	885	4.66E-04	6.77E-05	1.57E-02	1359.6	120.6	1480.2	1.54E-02	2.89E-04	2.78E-04	1.55E-02	2.79E-04	0.81	0.73	2614.55	3.42
15-2	76	1020.4	5.33E-04	884	4.65E-04	6.82E-05	1.57E-02	1354.6	120.7	1495.6	1.56E-02	1.26E-04	2.80E-04			0.65			
16-1	80	1020.4	5.33E-04	876.1	4.61E-04	7.21E-05	1.65E-02	1432.3	127.1	1559.4	1.63E-02	2.77E-04	2.93E-04	1.63E-02	2.93E-04	0.79	0.78	2648.14	3.42
16-2	80	1020.4	5.33E-04	878.4	4.62E-04	7.10E-05	1.65E-02	1438.1	126.4	1564.5	1.63E-02	2.23E-04	2.94E-04			0.76			

Table A-29 Styrene adsolubilization of CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

Sample	Styrene (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in\text{-}eq)}$ (M)	Styrene Initial	Styrene Equilibrium		Styrene $_{(in\text{-}eq)}$ (M)	X_{aq}	Average Styrene Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area	Conc. (M)								
1-1	2	12240.5	1.77E-03	9601.2	1.39E-03	3.77E-04	4.36E-04	7698.9	2.21E-04	2.15E-04	3.98E-06	2.31E-04	4.17E-06	0.36	0.36	85549.33	4.93
1-2	2	12240.5	1.77E-03	9703.9	1.41E-03	3.62E-04	4.36E-04	8105.5	2.42E-04	1.95E-04	4.35E-06			0.35			
2-1	3	12240.5	1.77E-03	10095.1	1.46E-03	3.06E-04	6.55E-04	12547.6	4.64E-04	1.91E-04	8.35E-06	4.55E-04	8.20E-06	0.38	0.38	46410.56	4.67
2-2	3	12240.5	1.77E-03	9843.4	1.43E-03	3.42E-04	6.55E-04	12216.4	4.47E-04	2.07E-04	8.05E-06			0.38			
3-1	4	12240.5	1.77E-03	9613.6	1.39E-03	3.75E-04	8.73E-04	16048.1	6.39E-04	2.34E-04	1.15E-05	6.44E-04	1.16E-05	0.38	0.38	32516.06	4.51
3-2	4	12240.5	1.77E-03	9581.7	1.39E-03	3.80E-04	8.73E-04	16266.5	6.50E-04	2.23E-04	1.17E-05			0.37			
4-1	5	12240.5	1.77E-03	9461.3	1.37E-03	3.97E-04	1.09E-03	20331.3	8.53E-04	2.38E-04	1.54E-05	8.50E-04	1.53E-05	0.37	0.38	25024.78	4.40
4-2	5	12240.5	1.77E-03	9579.1	1.39E-03	3.80E-04	1.09E-03	20212.7	8.47E-04	2.44E-04	1.52E-05			0.39			
5-1	6	12240.5	1.77E-03	9441.9	1.37E-03	4.00E-04	1.31E-03	24079.3	1.04E-03	2.69E-04	1.87E-05	1.05E-03	1.88E-05	0.40	0.40	21156.69	4.33
5-2	6	12240.5	1.77E-03	9448.6	1.37E-03	3.99E-04	1.31E-03	24271.3	1.05E-03	2.59E-04	1.89E-05			0.39			
6-1	7	12240.5	1.77E-03	9672.2	1.40E-03	3.67E-04	1.53E-03	28765	1.27E-03	2.53E-04	2.29E-05	1.26E-03	2.27E-05	0.41	0.42	18453.51	4.27
6-2	7	12240.5	1.77E-03	9646.6	1.40E-03	3.71E-04	1.53E-03	28229.8	1.25E-03	2.80E-04	2.25E-05			0.43			
7-1	8	12240.5	1.77E-03	9061.9	1.31E-03	4.54E-04	1.75E-03	31646.6	1.42E-03	3.27E-04	2.55E-05	1.43E-03	2.58E-05	0.42	0.42	16479.88	4.22
7-2	8	12240.5	1.77E-03	9436.4	1.37E-03	4.01E-04	1.75E-03	32131.9	1.44E-03	3.03E-04	2.60E-05			0.43			
8-1	9	12240.5	1.77E-03	8499.2	1.23E-03	5.34E-04	1.96E-03	33974	1.54E-03	4.29E-04	2.76E-05	1.53E-03	2.75E-05	0.45	0.46	16664.56	4.22
8-2	9	12240.5	1.77E-03	8758.1	1.27E-03	4.97E-04	1.96E-03	33675.6	1.52E-03	4.44E-04	2.74E-05			0.47			
9-1	10	12240.5	1.77E-03	8855.5	1.28E-03	4.84E-04	2.18E-03	37405.5	1.71E-03	4.75E-04	3.07E-05	1.72E-03	3.09E-05	0.50	0.49	15884.75	4.20
9-2	10	12240.5	1.77E-03	8910.7	1.29E-03	4.76E-04	2.18E-03	37878.8	1.73E-03	4.52E-04	3.11E-05			0.49			
10-1	11	12240.5	1.77E-03	9524.1	1.38E-03	3.88E-04	2.40E-03	37374	1.71E-03	6.95E-04	3.07E-05	1.71E-03	3.07E-05	0.64	0.62	20113.33	4.30
10-2	11	12240.5	1.77E-03	8931.5	1.30E-03	4.73E-04	2.40E-03	37438.5	1.71E-03	6.92E-04	3.08E-05			0.59			

Table A-29 Styrene adsolubilization of CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C (cont')

Sample	Styrene (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in\text{-}eq)}$ (M)	Styrene Initial	Styrene Equilibrium		Styrene $_{(in\text{-}eq)}$ (M)	X_{aq}	Average Styrene Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area	Conc. (M)								
11-1	12	12240.5	1.77E-03	8841.9	1.28E-03	4.86E-04	2.62E-03	41231.7	1.90E-03	7.20E-04	3.42E-05	1.92E-03	3.46E-05	0.60	0.60	17335.29	4.24
11-2	12	12240.5	1.77E-03	9122.7	1.32E-03	4.45E-04	2.62E-03	42175.2	1.95E-03	6.73E-04	3.50E-05			0.60			
12-1	13	12240.5	1.77E-03	8649.4	1.25E-03	5.13E-04	2.84E-03	44141.8	2.04E-03	7.93E-04	3.68E-05	2.08E-03	3.74E-05	0.61	0.63	16732.76	4.22
12-2	13	12240.5	1.77E-03	9411.5	1.36E-03	4.04E-04	2.84E-03	45432.5	2.11E-03	7.29E-04	3.79E-05			0.64			

Table A-30 Styrene adsolubilization of C167-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

Sample	Styrene (μL)	Surfactant Initial (CPC)		Surfactant Equilibrium (CPC)		Sur $_{(in-eq)}$ (M)	Styrene Initial	Styrene Equilibrium		Styrene $_{(in-eq)}$ (M)	X_{aq}	Average Styrene Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area	Conc. (M)								
1-1	2	3354.2	4.98E-04	3050.4	4.55E-04	4.34E-05	4.36E-04	8854.6	2.79E-04	1.57E-04	5.02E-06	2.64E-04	4.75E-06	0.78	0.80	169264.41	5.23
1-2	2	3354.2	4.98E-04	3077	4.59E-04	3.96E-05	4.36E-04	8254.8	2.49E-04	1.87E-04	4.48E-06			0.83			
2-1	3	3354.2	4.98E-04	3018	4.50E-04	4.80E-05	6.55E-04	12666.9	4.70E-04	1.85E-04	8.46E-06	4.83E-04	8.69E-06	0.79	0.80	92442.61	4.97
2-2	3	3354.2	4.98E-04	3096.9	4.62E-04	3.68E-05	6.55E-04	13182.9	4.95E-04	1.59E-04	8.92E-06			0.81			
3-1	4	3354.2	4.98E-04	3020.2	4.51E-04	4.77E-05	8.73E-04	15365.4	6.05E-04	2.68E-04	1.09E-05	6.43E-04	1.16E-05	0.85	0.84	72263.88	4.86
3-2	4	3354.2	4.98E-04	3070	4.58E-04	4.06E-05	8.73E-04	16911.2	6.82E-04	1.91E-04	1.23E-05			0.82			
4-1	5	3354.2	4.98E-04	3053.4	4.55E-04	4.30E-05	1.09E-03	20268.3	8.50E-04	2.41E-04	1.53E-05	8.46E-04	1.52E-05	0.85	0.84	55245.44	4.74
4-2	5	3354.2	4.98E-04	3004	4.48E-04	5.00E-05	1.09E-03	20100.8	8.41E-04	2.50E-04	1.51E-05			0.83			
5-1	6	3354.2	4.98E-04	2957.8	4.42E-04	5.66E-05	1.31E-03	22482.7	9.60E-04	3.49E-04	1.73E-05	9.57E-04	1.72E-05	0.86	0.87	50607.05	4.70
5-2	6	3354.2	4.98E-04	3028	4.52E-04	4.66E-05	1.31E-03	22356.9	9.54E-04	3.55E-04	1.72E-05			0.88			
6-1	7	3354.2	4.98E-04	3103.8	4.63E-04	3.58E-05	1.53E-03	24148.7	1.04E-03	4.84E-04	1.88E-05	1.04E-03	1.88E-05	0.93	0.93	49247.43	4.69
6-2	7	3354.2	4.98E-04	3061.5	4.57E-04	4.18E-05	1.53E-03	24165.7	1.04E-03	4.83E-04	1.88E-05			0.92			
7-1	8	3354.2	4.98E-04	3005.1	4.49E-04	4.99E-05	1.75E-03	26057.8	1.14E-03	6.06E-04	2.05E-05	1.13E-03	2.04E-05	0.92	0.93	45377.35	4.66
7-2	8	3354.2	4.98E-04	3017.1	4.50E-04	4.82E-05	1.75E-03	25826	1.13E-03	6.18E-04	2.03E-05			0.93			
8-1	9	3354.2	4.98E-04	3024.2	4.51E-04	4.71E-05	1.96E-03	27106.3	1.19E-03	7.72E-04	2.15E-05	1.20E-03	2.15E-05	0.94	0.95	43904.29	4.64
8-2	9	3354.2	4.98E-04	3069.8	4.58E-04	4.06E-05	1.96E-03	27313.9	1.20E-03	7.62E-04	2.16E-05			0.95			
9-1	10	3354.2	4.98E-04	3052	4.55E-04	4.32E-05	2.18E-03	28123.8	1.24E-03	9.39E-04	2.24E-05	1.25E-03	2.24E-05	0.96	0.96	42591.40	4.63
9-2	10	3354.2	4.98E-04	3043.8	4.54E-04	4.43E-05	2.18E-03	28263.8	1.25E-03	9.32E-04	2.25E-05			0.95			
10-1	11	3354.2	4.98E-04	3056.9	4.56E-04	4.25E-05	2.40E-03	29441	1.31E-03	1.09E-03	2.36E-05	1.30E-03	2.33E-05	0.96	0.96	41180.08	4.61
10-2	11	3354.2	4.98E-04	3008.7	4.49E-04	4.94E-05	2.40E-03	28914.1	1.28E-03	1.12E-03	2.31E-05			0.96			

Table A-30 Styrene adsolubilization of C167-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C (cont')

Sample	Styrene (μL)	Surfactant Initial (CPC)		Surfactant Equilibrium (CPC)		Sur $_{(in-eq)}$ (M)	Styrene Initial	Styrene Equilibrium		Styrene $_{(in-eq)}$ (M)	X_{aq}	Average Styrene Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area	Conc. (M)								
11-1	12	3354.2	4.98E-04	3028.4	4.52E-04	4.65E-05	2.62E-03	29849	1.33E-03	1.29E-03	2.39E-05	1.33E-03	2.40E-05	0.97	0.97	40268.69	4.60
11-2	12	3354.2	4.98E-04	3046.6	4.54E-04	4.39E-05	2.62E-03	30002.7	1.34E-03	1.28E-03	2.41E-05			0.97			
12-1	13	3354.2	4.98E-04	3031.4	4.52E-04	4.61E-05	2.84E-03	30775.9	1.38E-03	1.46E-03	2.48E-05	1.38E-03	2.48E-05	0.97	0.97	39117.61	4.59
12-2	13	3354.2	4.98E-04	3074.4	4.58E-04	4.00E-05	2.84E-03	30945.9	1.38E-03	1.45E-03	2.49E-05			0.97			

Table A-31 Styrene adsolubilization of C168-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

Sample	Styrene (μL)	Surfactant Initial (CPC)		Surfactant Equilibrium (CPC)		Sur $_{(in-eq)}$ (M)	Styrene Initial	Styrene Equilibrium		Styrene $_{(in-eq)}$ (M)	X_{aq}	Average Styrene Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area	Conc. (M)								
1-1	2	3475.7	5.16E-04	3113.7	4.64E-04	5.17E-05	4.36E-04	8548.4	2.64E-04	1.73E-04	4.75E-06	2.64E-04	4.75E-06	0.77	0.76	159469.12	5.20
1-2	2	3475.7	5.16E-04	3064.4	4.57E-04	5.88E-05	4.36E-04	8554.6	2.64E-04	1.72E-04	4.75E-06			0.75			
2-1	3	3475.7	5.16E-04	3097	4.62E-04	5.41E-05	6.55E-04	12785.2	4.76E-04	1.79E-04	8.56E-06	4.75E-04	8.55E-06	0.77	0.78	90671.63	4.96
2-2	3	3475.7	5.16E-04	3123.6	4.65E-04	5.03E-05	6.55E-04	12753.9	4.74E-04	1.81E-04	8.53E-06			0.78			
3-1	4	3475.7	5.16E-04	3163.3	4.71E-04	4.46E-05	8.73E-04	17191.2	6.96E-04	1.77E-04	1.25E-05	7.03E-04	1.27E-05	0.80	0.79	62161.73	4.79
3-2	4	3475.7	5.16E-04	3144.2	4.68E-04	4.74E-05	8.73E-04	17472.9	7.10E-04	1.63E-04	1.28E-05			0.77			
4-1	5	3475.7	5.16E-04	3056.8	4.56E-04	5.98E-05	1.09E-03	20443.4	8.59E-04	2.32E-04	1.55E-05	8.68E-04	1.56E-05	0.80	0.79	50497.32	4.70
4-2	5	3475.7	5.16E-04	3060.1	4.56E-04	5.94E-05	1.09E-03	20818.6	8.77E-04	2.14E-04	1.58E-05			0.78			
5-1	6	3475.7	5.16E-04	3115	4.64E-04	5.15E-05	1.31E-03	24431.5	1.06E-03	2.51E-04	1.90E-05	1.04E-03	1.87E-05	0.83	0.82	44011.06	4.64
5-2	6	3475.7	5.16E-04	3028.3	4.52E-04	6.39E-05	1.31E-03	23712.3	1.02E-03	2.87E-04	1.84E-05			0.82			
6-1	7	3475.7	5.16E-04	3088.1	4.60E-04	5.54E-05	1.53E-03	27694.2	1.22E-03	3.06E-04	2.20E-05	1.22E-03	2.20E-05	0.85	0.84	38029.10	4.58
6-2	7	3475.7	5.16E-04	3032.8	4.52E-04	6.33E-05	1.53E-03	27762.2	1.22E-03	3.03E-04	2.20E-05			0.83			
7-1	8	3475.7	5.16E-04	3089.8	4.61E-04	5.51E-05	1.75E-03	29609.9	1.32E-03	4.29E-04	2.37E-05	1.31E-03	2.35E-05	0.89	0.89	37741.67	4.58
7-2	8	3475.7	5.16E-04	3086.7	4.60E-04	5.56E-05	1.75E-03	29213.1	1.30E-03	4.49E-04	2.33E-05			0.89			
8-1	9	3475.7	5.16E-04	3100.2	4.62E-04	5.36E-05	1.96E-03	32640.5	1.47E-03	4.95E-04	2.64E-05	1.45E-03	2.62E-05	0.90	0.90	34452.99	4.54
8-2	9	3475.7	5.16E-04	3075.5	4.59E-04	5.72E-05	1.96E-03	32076.3	1.44E-03	5.24E-04	2.59E-05			0.90			
9-1	10	3475.7	5.16E-04	3084.6	4.60E-04	5.59E-05	2.18E-03	38197	1.75E-03	4.36E-04	3.14E-05	1.72E-03	3.10E-05	0.89	0.89	28766.31	4.46
9-2	10	3475.7	5.16E-04	3075.7	4.59E-04	5.71E-05	2.18E-03	37156	1.69E-03	4.88E-04	3.05E-05			0.90			
10-1	11	3475.7	5.16E-04	3084.5	4.60E-04	5.59E-05	2.40E-03	40249.3	1.85E-03	5.51E-04	3.33E-05	1.83E-03	3.29E-05	0.91	0.90	27479.45	4.44
10-2	11	3475.7	5.16E-04	3008	4.49E-04	6.68E-05	2.40E-03	39361.9	1.80E-03	5.96E-04	3.25E-05			0.90			

Table A-31 Styrene adsolubilization of C168-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C (cont')

Sample	Styrene (μL)	Surfactant Initial (CPC)		Surfactant Equilibrium (CPC)		Sur $_{(in-eq)}$ (M)	Styrene Initial	Styrene Equilibrium		Styrene $_{(in-eq)}$ (M)	X_{aq}	Average Styrene Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area	Conc. (M)								
11-1	12	3475.7	5.16E-04	3099.7	4.62E-04	5.37E-05	2.62E-03	41373.2	1.90E-03	7.13E-04	3.43E-05	1.93E-03	3.47E-05	0.93	0.92	26581.87	4.42
11-2	12	3475.7	5.16E-04	3037.4	4.53E-04	6.26E-05	2.62E-03	42262.5	1.95E-03	6.69E-04	3.51E-05			0.91			
12-1	13	3475.7	5.16E-04	3015.8	4.50E-04	6.57E-05	2.84E-03	44303.6	2.05E-03	7.85E-04	3.69E-05	2.05E-03	3.70E-05	0.92	0.93	25071.08	4.40
12-2	13	3475.7	5.16E-04	3075.2	4.59E-04	5.72E-05	2.84E-03	44420.4	2.06E-03	7.79E-04	3.70E-05			0.93			

Table A-32 Styrene adsolubilization of C167-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

Sample	Styrene (μL)	Surfactant Initial (CPC)		Surfactant Equilibrium (CPC)		Sur $_{(in-eq)}$ (M)	Styrene Initial	Styrene Equilibrium		Styrene $_{(in-eq)}$ (M)	X_{aq}	Average Styrene Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area	Conc. (M)								
1-1	2	5298.6	7.76E-04	5135.4	7.53E-04	2.33E-05	4.36E-04	8672	2.70E-04	1.66E-04	4.86E-06	2.79E-04	5.02E-06	0.88	0.89	176302.53	5.25
1-2	2	5298.6	7.76E-04	5174.2	7.58E-04	1.78E-05	4.36E-04	9030.4	2.88E-04	1.49E-04	5.18E-06			0.89			
2-1	3	5298.6	7.76E-04	5150.7	7.55E-04	2.11E-05	6.55E-04	13838.4	5.28E-04	1.26E-04	9.51E-06	5.09E-04	9.17E-06	0.86	0.89	97310.55	4.99
2-2	3	5298.6	7.76E-04	5208.6	7.63E-04	1.29E-05	6.55E-04	13078.2	4.90E-04	1.64E-04	8.83E-06			0.93			
3-1	4	5298.6	7.76E-04	5229.2	7.66E-04	9.91E-06	8.73E-04	17739.4	7.23E-04	1.49E-04	1.30E-05	7.27E-04	1.31E-05	0.94	0.92	70358.83	4.85
3-2	4	5298.6	7.76E-04	5193.8	7.61E-04	1.50E-05	8.73E-04	17896.6	7.31E-04	1.42E-04	1.32E-05			0.90			
4-1	5	5298.6	7.76E-04	5207.8	7.63E-04	1.30E-05	1.09E-03	22252.2	9.49E-04	1.42E-04	1.71E-05	9.52E-04	1.71E-05	0.92	0.92	53628.15	4.73
4-2	5	5298.6	7.76E-04	5216.9	7.64E-04	1.17E-05	1.09E-03	22362.9	9.54E-04	1.36E-04	1.72E-05			0.92			
5-1	6	5298.6	7.76E-04	5218.6	7.65E-04	1.14E-05	1.31E-03	26358.7	1.15E-03	1.55E-04	2.08E-05	1.16E-03	2.09E-05	0.93	0.93	44263.32	4.65
5-2	6	5298.6	7.76E-04	5216.8	7.64E-04	1.17E-05	1.31E-03	26701.3	1.17E-03	1.38E-04	2.11E-05			0.92			
6-1	7	5298.6	7.76E-04	5217.7	7.65E-04	1.16E-05	1.53E-03	30979.3	1.39E-03	1.42E-04	2.49E-05	1.37E-03	2.46E-05	0.92	0.93	37960.41	4.58
6-2	7	5298.6	7.76E-04	5220.1	7.65E-04	1.12E-05	1.53E-03	30196	1.35E-03	1.81E-04	2.42E-05			0.94			
7-1	8	5298.6	7.76E-04	5202	7.62E-04	1.38E-05	1.75E-03	27900.4	1.23E-03	5.14E-04	2.22E-05	1.42E-03	2.55E-05	0.97	0.95	37093.94	4.57
7-2	8	5298.6	7.76E-04	5215.6	7.64E-04	1.19E-05	1.75E-03	35409.1	1.61E-03	1.39E-04	2.89E-05			0.92			
8-1	9	5298.6	7.76E-04	5198.3	7.62E-04	1.43E-05	1.96E-03	38071.1	1.74E-03	2.24E-04	3.13E-05	1.74E-03	3.13E-05	0.94	0.94	30202.71	4.48
8-2	9	5298.6	7.76E-04	5214.1	7.64E-04	1.21E-05	1.96E-03	37985.8	1.74E-03	2.28E-04	3.12E-05			0.95			
9-1	10	5298.6	7.76E-04	5173.3	7.58E-04	1.79E-05	2.18E-03	42058.1	1.94E-03	2.43E-04	3.49E-05	1.95E-03	3.51E-05	0.93	0.95	26954.20	4.43
9-2	10	5298.6	7.76E-04	5233	7.67E-04	9.37E-06	2.18E-03	42438.8	1.96E-03	2.24E-04	3.53E-05			0.96			
10-1	11	5298.6	7.76E-04	5183	7.60E-04	1.65E-05	2.40E-03	44005.1	2.04E-03	3.64E-04	3.67E-05	2.05E-03	3.69E-05	0.96	0.95	25830.94	4.41
10-2	11	5298.6	7.76E-04	5170.6	7.58E-04	1.83E-05	2.40E-03	44495.5	2.06E-03	3.39E-04	3.71E-05			0.95			

Table A-32 Styrene adsolubilization of C167-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C (cont')

Sample	Styrene (μL)	Surfactant Initial (CPC)		Surfactant Equilibrium (CPC)		Sur $_{(in-eq)}$ (M)	Styrene Initial	Styrene Equilibrium		Styrene $_{(in-eq)}$ (M)	X_{aq}	Average Styrene Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area	Conc. (M)								
11-1	12	5298.6	7.76E-04	5143.7	7.54E-04	2.21E-05	2.62E-03	46721.1	2.17E-03	4.46E-04	3.91E-05	2.10E-03	3.78E-05	0.95	0.96	25401.92	4.40
11-2	12	5298.6	7.76E-04	5159.5	7.56E-04	1.99E-05	2.62E-03	43812.8	2.03E-03	5.91E-04	3.65E-05			0.97			
12-1	13	5298.6	7.76E-04	5114.1	7.50E-04	2.64E-05	2.84E-03	49210.2	2.30E-03	5.40E-04	4.13E-05	2.31E-03	4.16E-05	0.95	0.96	22994.96	4.36
12-2	13	5298.6	7.76E-04	5151.1	7.55E-04	2.11E-05	2.84E-03	49803.5	2.33E-03	5.10E-04	4.19E-05			0.96			

Table A-33 Styrene adsolubilization of C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

Sample	Styrene (μL)	Surfactant Initial (CPC)		Surfactant Equilibrium (CPC)		Sur $_{(in\text{-}eq)}$ (M)	Styrene Initial	Styrene Equilibrium		Styrene $_{(in\text{-}eq)}$ (M)	X_{aq}	Average Styrene Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area	Conc. (M)								
1-1	2	2869.9	4.29E-04	2414.1	3.64E-04	6.51E-05	4.36E-04	8312.8	2.52E-04	1.84E-04	4.54E-06	2.40E-04	4.32E-06	0.74	0.75	173311.70	5.24
1-2	2	2869.9	4.29E-04	2401.2	3.62E-04	6.70E-05	4.36E-04	7825.3	2.28E-04	2.09E-04	4.10E-06			0.76			
2-1	3	2869.9	4.29E-04	2398	3.62E-04	6.74E-05	6.55E-04	12347.1	4.54E-04	2.01E-04	8.17E-06	4.57E-04	8.23E-06	0.75	0.75	91659.14	4.96
2-2	3	2869.9	4.29E-04	2443.2	3.68E-04	6.10E-05	6.55E-04	12493.4	4.61E-04	1.94E-04	8.30E-06			0.76			
3-1	4	2869.9	4.29E-04	2443.3	3.68E-04	6.09E-05	8.73E-04	16777.5	6.75E-04	1.98E-04	1.22E-05	6.76E-04	1.22E-05	0.76	0.77	63020.95	4.80
3-2	4	2869.9	4.29E-04	2461.2	3.71E-04	5.84E-05	8.73E-04	16818.1	6.77E-04	1.96E-04	1.22E-05			0.77			
4-1	5	2869.9	4.29E-04	2426.9	3.66E-04	6.33E-05	1.09E-03	20686.8	8.71E-04	2.20E-04	1.57E-05	8.66E-04	1.56E-05	0.78	0.79	50626.05	4.70
4-2	5	2869.9	4.29E-04	2472.5	3.72E-04	5.68E-05	1.09E-03	20502	8.61E-04	2.30E-04	1.55E-05			0.80			
5-1	6	2869.9	4.29E-04	2491	3.75E-04	5.41E-05	1.31E-03	24479.6	1.06E-03	2.49E-04	1.91E-05	1.05E-03	1.88E-05	0.82	0.82	43717.23	4.64
5-2	6	2869.9	4.29E-04	2463.4	3.71E-04	5.81E-05	1.31E-03	23936.7	1.03E-03	2.76E-04	1.86E-05			0.83			
6-1	7	2869.9	4.29E-04	2478	3.73E-04	5.60E-05	1.53E-03	28030.3	1.24E-03	2.90E-04	2.23E-05	1.21E-03	2.18E-05	0.84	0.86	39447.81	4.60
6-2	7	2869.9	4.29E-04	2542.8	3.82E-04	4.67E-05	1.53E-03	26921.3	1.18E-03	3.45E-04	2.13E-05			0.88			
7-1	8	2869.9	4.29E-04	2507.4	3.77E-04	5.18E-05	1.75E-03	30548.2	1.36E-03	3.82E-04	2.45E-05	1.36E-03	2.45E-05	0.88	0.88	35826.68	4.55
7-2	8	2869.9	4.29E-04	2499.7	3.76E-04	5.29E-05	1.75E-03	30545.4	1.36E-03	3.82E-04	2.45E-05			0.88			
8-1	9	2869.9	4.29E-04	2477.8	3.73E-04	5.60E-05	1.96E-03	32276	1.45E-03	5.14E-04	2.61E-05	1.46E-03	2.63E-05	0.90	0.90	34262.59	4.53
8-2	9	2869.9	4.29E-04	2482.4	3.74E-04	5.54E-05	1.96E-03	32668.2	1.47E-03	4.94E-04	2.65E-05			0.90			
9-1	10	2869.9	4.29E-04	2527.2	3.80E-04	4.90E-05	2.18E-03	36340.3	1.65E-03	5.29E-04	2.98E-05	1.64E-03	2.96E-05	0.92	0.92	30939.36	4.49
9-2	10	2869.9	4.29E-04	2517.7	3.79E-04	5.03E-05	2.18E-03	35960.5	1.63E-03	5.48E-04	2.94E-05			0.92			
10-1	11	2869.9	4.29E-04	2488	3.75E-04	5.46E-05	2.40E-03	37746.9	1.72E-03	6.76E-04	3.10E-05	1.65E-03	2.98E-05	0.93	0.93	31268.11	4.50
10-2	11	2869.9	4.29E-04	2481.9	3.74E-04	5.54E-05	2.40E-03	34953.1	1.58E-03	8.16E-04	2.85E-05			0.94			

Table A-33 Styrene adsolubilization of C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C (cont')

Sample	Styrene (μL)	Surfactant Initial (CPC)		Surfactant Equilibrium (CPC)		Sur $_{(in-eq)}$ (M)	Styrene Initial	Styrene Equilibrium		Styrene $_{(in-eq)}$ (M)	X_{aq}	Average Styrene Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Conc. (M)	Area	Conc. (M)								
11-1	12	2869.9	4.29E-04	2576.4	3.87E-04	4.19E-05	2.62E-03	40220.2	1.85E-03	7.71E-04	3.33E-05	1.85E-03	3.32E-05	0.95	0.94	28320.04	4.45
11-2	12	2869.9	4.29E-04	2479.36	3.73E-04	5.58E-05	2.62E-03	40132.5	1.84E-03	7.75E-04	3.32E-05			0.93			
12-1	13	2869.9	4.29E-04	2528	3.80E-04	4.88E-05	2.84E-03	42896.2	1.98E-03	8.55E-04	3.57E-05	1.98E-03	3.57E-05	0.95	0.95	26533.48	4.42
12-2	13	2869.9	4.29E-04	2529.8	3.81E-04	4.86E-05	2.84E-03	42885.6	1.98E-03	8.56E-04	3.57E-05			0.95			

Table A-34 Ethylcyclohexane adsolubilization of CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	ECH (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in\text{-}eq)}$ (M)	ECH Initial			ECH Equilibrium			ECH $_{(in\text{-}eq)}$ (M)	X_{aq}	AVG ECH Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Area	Conc. (mg/L)	Conc. (M)	Area	Conc. (mg/L)	Conc. (M)								
1-1	0.130	4135.9	2.09E-03	3286.2	1.67E-03	4.25E-04	230.9	3.155	2.81E-05	49	0.949	8.46E-06	1.97E-05	1.52E-07	8.12E-06	1.46E-07	0.04	0.04	279708.6	5.45
1-2	0.130	4135.9	2.09E-03	2998.4	1.52E-03	5.69E-04	245.9	3.362	3.00E-05	45.2	0.873	7.78E-06	2.22E-05	1.40E-07			0.04			
2-1	0.125	4135.9	2.09E-03	3454.3	1.75E-03	3.41E-04	229.9	3.141	2.80E-05	49	0.949	8.46E-06	1.95E-05	1.52E-07	8.59E-06	1.55E-07	0.05	0.05	298627.5	5.48
2-2	0.125	4135.9	2.09E-03	2983.2	1.51E-03	5.76E-04	258.7	3.540	3.15E-05	50.4	0.978	8.71E-06	2.28E-05	1.57E-07			0.04			
3-1	0.120	4135.9	2.09E-03	3501.7	1.77E-03	3.17E-04	210	2.866	2.55E-05	36.4	0.696	6.20E-06	1.93E-05	1.12E-07	6.40E-06	1.15E-07	0.06	0.05	422792.8	5.63
3-2	0.120	4135.9	2.09E-03	3220.7	1.63E-03	4.58E-04	210.5	2.873	2.56E-05	38.6	0.740	6.59E-06	1.90E-05	1.19E-07			0.04			
4-1	0.110	4135.9	2.09E-03	3396.6	1.72E-03	3.70E-04	187.9	2.560	2.28E-05	30.7	0.581	5.18E-06	1.76E-05	9.32E-08	5.16E-06	9.29E-08	0.05	0.04	435997.6	5.64
4-2	0.110	4135.9	2.09E-03	3170	1.61E-03	4.83E-04	188.4	2.567	2.29E-05	30.5	0.577	5.14E-06	1.77E-05	9.25E-08			0.04			
5-1	0.100	4135.9	2.09E-03	3026.4	1.54E-03	5.55E-04	170.6	2.321	2.07E-05	26.9	0.504	4.49E-06	1.62E-05	8.09E-08	4.40E-06	7.91E-08	0.03	0.03	384013.7	5.58
5-2	0.100	4135.9	2.09E-03	3122.4	1.58E-03	5.07E-04	175.4	2.387	2.13E-05	25.8	0.482	4.30E-06	1.70E-05	7.74E-08			0.03			
6-1	0.080	4135.9	2.09E-03	3074.7	1.56E-03	5.31E-04	129.7	1.755	1.56E-05	20.6	0.377	3.36E-06	1.23E-05	6.06E-08	3.06E-06	5.51E-08	0.02	0.02	413967.7	5.62
6-2	0.080	4135.9	2.09E-03	2978.7	1.51E-03	5.79E-04	135.5	1.836	1.64E-05	17.2	0.309	2.75E-06	1.36E-05	4.96E-08			0.02			
7-1	0.060	4135.9	2.09E-03	2971.2	1.51E-03	5.82E-04	97.4	1.309	1.17E-05	11.4	0.192	1.71E-06	9.95E-06	3.08E-08	1.74E-06	3.13E-08	0.02	0.02	521131.3	5.72
7-2	0.060	4135.9	2.09E-03	2952.9	1.50E-03	5.92E-04	94.4	1.267	1.13E-05	11.7	0.198	1.77E-06	9.53E-06	3.18E-08			0.02			
8-1	0.040	4135.9	2.09E-03	3037.8	1.54E-03	5.49E-04	68	0.902	8.04E-06	5.3	0.069	6.18E-07	7.42E-06	1.11E-08	6.99E-07	1.26E-08	0.01	0.01	1129019.1	6.05
8-2	0.040	4135.9	2.09E-03	3120.4	1.58E-03	5.08E-04	72.2	0.960	8.56E-06	6.2	0.088	7.80E-07	7.78E-06	1.40E-08			0.02			
9-1	0.030	4135.9	2.09E-03	3253	1.65E-03	4.41E-04	53.1	0.696	6.20E-06	3.9	0.041	3.67E-07	5.83E-06	6.61E-09	3.49E-07	6.29E-09	0.01	0.01	2003439.5	6.30
9-2	0.030	4135.9	2.09E-03	3218.7	1.63E-03	4.59E-04	51.2	0.670	5.97E-06	3.7	0.037	3.31E-07	5.64E-06	5.96E-09			0.01			
10-1	0.010	4135.9	2.09E-03	3058.7	1.55E-03	5.39E-04	15.8	0.180	1.60E-06	3.2	0.027	2.41E-07	1.36E-06	4.35E-09	2.33E-07	4.19E-09	0.00	0.00	650446.9	5.81
10-2	0.010	4135.9	2.09E-03	3278	1.66E-03	4.29E-04	14.8	0.166	1.48E-06	3.1	0.025	2.24E-07	1.26E-06	4.02E-09			0.00			

Table A-35 Ethylcyclohexane adsolubilization of C167-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	ECH (µL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in-eq)}$ (M)	ECH Initial			ECH Equilibrium			ECH $_{(in-eq)}$ (M)	X_{aq}	AVG ECH Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Area	Conc. (mg/L)	Conc. (M)	Area	Conc. (mg/L)	Conc. (M)								
1-1	0.020	1219.5	6.33E-04	1143.2	5.95E-04	3.81E-05	25.7	0.765	6.81E-06	3.4	0.045	4.01E-07	6.41E-06	7.22E-09	4.44E-07	8.00E-09	0.14	0.17	20952618.2	7.32
1-2	0.020	1219.5	6.33E-04	1160.9	6.04E-04	2.93E-05	27.8	0.832	7.42E-06	3.7	0.055	4.88E-07	6.93E-06	8.78E-09			0.19			
2-1	0.030	1219.5	6.33E-04	1168.8	6.08E-04	2.53E-05	35.9	1.094	9.75E-06	7.4	0.174	1.55E-06	8.20E-06	2.79E-08	1.54E-06	2.77E-08	0.24	0.23	8489941.1	6.93
2-2	0.030	1219.5	6.33E-04	1156.5	6.01E-04	3.15E-05	39.2	1.200	1.07E-05	7.3	0.171	1.52E-06	9.17E-06	2.74E-08			0.23			
3-1	0.040	1219.5	6.33E-04	1164.2	6.05E-04	2.76E-05	49.5	1.533	1.37E-05	8.5	0.210	1.87E-06	1.18E-05	3.36E-08	1.84E-06	3.31E-08	0.30	0.28	8542711.9	6.93
3-2	0.040	1219.5	6.33E-04	1155.3	6.01E-04	3.21E-05	48.9	1.513	1.35E-05	8.3	0.203	1.81E-06	1.17E-05	3.26E-08			0.27			
4-1	0.050	1219.5	6.33E-04	1157	6.02E-04	3.12E-05	76	2.388	2.13E-05	9.1	0.229	2.04E-06	1.92E-05	3.67E-08	2.11E-06	3.80E-08	0.38	0.39	10381461.3	7.02
4-2	0.050	1219.5	6.33E-04	1162.7	6.04E-04	2.84E-05	77.8	2.446	2.18E-05	9.6	0.245	2.18E-06	1.96E-05	3.93E-08			0.41			
5-1	0.060	1219.5	6.33E-04	1165.7	6.06E-04	2.69E-05	86.9	2.740	2.44E-05	11	0.290	2.59E-06	2.18E-05	4.66E-08	2.67E-06	4.81E-08	0.45	0.48	9898482.6	7.00
5-2	0.060	1219.5	6.33E-04	1176.1	6.11E-04	2.17E-05	88.5	2.791	2.49E-05	11.6	0.310	2.76E-06	2.21E-05	4.97E-08			0.50			
6-1	0.070	1219.5	6.33E-04	1184.9	6.16E-04	1.73E-05	98.6	3.117	2.78E-05	13.7	0.377	3.36E-06	2.44E-05	6.06E-08	3.13E-06	5.64E-08	0.59	0.59	10484710.5	7.02
6-2	0.070	1219.5	6.33E-04	1186.3	6.16E-04	1.66E-05	97.8	3.092	2.76E-05	12.1	0.326	2.90E-06	2.46E-05	5.23E-08			0.60			
7-1	0.090	1219.5	6.33E-04	1132.5	5.89E-04	4.35E-05	132.8	4.221	3.76E-05	14.5	0.403	3.59E-06	3.40E-05	6.47E-08	3.65E-06	6.57E-08	0.44	0.46	6980671.3	6.84
7-2	0.090	1219.5	6.33E-04	1135.9	5.91E-04	4.18E-05	148.4	4.725	4.21E-05	14.9	0.416	3.71E-06	3.84E-05	6.68E-08			0.48			
8-1	0.100	1219.5	6.33E-04	1153.7	6.00E-04	3.29E-05	146.8	4.673	4.16E-05	30	0.903	8.05E-06	3.36E-05	1.45E-07	8.09E-06	1.46E-07	0.51	0.53	3644666.0	6.56
8-2	0.100	1219.5	6.33E-04	1167.3	6.07E-04	2.61E-05	144.4	4.595	4.10E-05	30.3	0.913	8.14E-06	3.28E-05	1.46E-07			0.56			
9-1	0.120	1219.5	6.33E-04	1173.1	6.10E-04	2.32E-05	164.5	5.244	4.67E-05	36.9	1.126	1.00E-05	3.67E-05	1.81E-07	1.01E-05	1.82E-07	0.61	0.60	3290634.1	6.52
9-2	0.120	1219.5	6.33E-04	1168.7	6.07E-04	2.54E-05	162.8	5.189	4.62E-05	37.5	1.146	1.02E-05	3.60E-05	1.84E-07			0.59			
10-1	0.130	1219.5	6.33E-04	1185.5	6.16E-04	1.70E-05	178.5	5.696	5.08E-05	44.6	1.375	1.23E-05	3.85E-05	2.21E-07	1.27E-05	2.28E-07	0.69	0.48	2117537.7	6.33
10-2	0.130	1219.5	6.33E-04	1174.8	6.11E-04	2.24E-05	176.7	2.405	2.14E-05	47.5	1.468	1.31E-05	8.35E-06	2.36E-07			0.27			

Table A-36 Ethylcyclohexane adsolubilization of C168-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	ECH (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in\text{-}eq)}$ (M)	ECH Initial			ECH Equilibrium			ECH $_{(in\text{-}eq)}$ (M)	X_{aq}	AVG ECH Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Area	Conc. (mg/L)	Conc. (M)	Area	Conc. (mg/L)	Conc. (M)								
1-1	0.020	1325.7	6.86E-04	1175.2	6.11E-04	7.53E-05	23.9	0.707	6.30E-06	3.5	0.048	4.30E-07	5.87E-06	7.74E-09	4.44E-07	8.00E-09	0.07	0.09	11207091.1	7.05
1-2	0.020	1325.7	6.86E-04	1219.1	6.33E-04	5.33E-05	25.8	0.768	6.84E-06	3.6	0.051	4.59E-07	6.38E-06	8.26E-09			0.11			
2-1	0.030	1325.7	6.86E-04	1207.7	6.27E-04	5.90E-05	28.7	0.862	7.68E-06	4.9	0.093	8.33E-07	6.85E-06	1.50E-08	8.04E-07	1.45E-08	0.10	0.11	7515576.4	6.88
2-2	0.030	1325.7	6.86E-04	1215.7	6.31E-04	5.50E-05	29.2	0.878	7.82E-06	4.7	0.087	7.75E-07	7.05E-06	1.40E-08			0.11			
3-1	0.040	1325.7	6.86E-04	1212.1	6.29E-04	5.68E-05	45.2	1.394	1.24E-05	9.9	0.255	2.27E-06	1.02E-05	4.09E-08	2.03E-06	3.65E-08	0.15	0.15	4229943.8	6.63
3-2	0.040	1325.7	6.86E-04	1212.3	6.29E-04	5.67E-05	44.9	1.384	1.23E-05	8.2	0.200	1.78E-06	1.06E-05	3.21E-08			0.16			
4-1	0.050	1325.7	6.86E-04	1212.1	6.29E-04	5.68E-05	50.1	1.552	1.38E-05	10.3	0.268	2.39E-06	1.14E-05	4.29E-08	2.29E-06	4.11E-08	0.17	0.17	4202173.7	6.62
4-2	0.050	1325.7	6.86E-04	1229.8	6.38E-04	4.80E-05	45.7	1.410	1.26E-05	9.6	0.245	2.18E-06	1.04E-05	3.93E-08			0.18			
5-1	0.060	1325.7	6.86E-04	1223.7	6.35E-04	5.10E-05	69.9	2.191	1.95E-05	11.3	0.300	2.67E-06	1.69E-05	4.81E-08	2.73E-06	4.92E-08	0.25	0.23	4662325.9	6.67
5-2	0.060	1325.7	6.86E-04	1206.7	6.26E-04	5.95E-05	66.7	2.088	1.86E-05	11.7	0.313	2.79E-06	1.58E-05	5.02E-08			0.21			
6-1	0.070	1325.7	6.86E-04	1215	6.31E-04	5.54E-05	70.4	2.207	1.97E-05	13.7	0.377	3.36E-06	1.63E-05	6.06E-08	3.13E-06	5.64E-08	0.23	0.24	4249062.3	6.63
6-2	0.070	1325.7	6.86E-04	1214.6	6.30E-04	5.56E-05	77.1	2.424	2.16E-05	12.1	0.326	2.90E-06	1.87E-05	5.23E-08			0.25			
7-1	0.090	1325.7	6.86E-04	1208.1	6.27E-04	5.88E-05	98.4	3.111	2.77E-05	16.4	0.465	4.14E-06	2.36E-05	7.45E-08	3.95E-06	7.12E-08	0.29	0.30	4191144.0	6.62
7-2	0.090	1325.7	6.86E-04	1220.2	6.33E-04	5.28E-05	97.6	3.085	2.75E-05	15.1	0.423	3.77E-06	2.37E-05	6.78E-08			0.31			
8-1	0.100	1325.7	6.86E-04	1212.8	6.30E-04	5.65E-05	108.8	3.447	3.07E-05	20.3	0.590	5.26E-06	2.55E-05	9.47E-08	5.72E-06	1.03E-07	0.31	0.33	3233780.8	6.51
8-2	0.100	1325.7	6.86E-04	1238.7	6.42E-04	4.35E-05	106.9	3.385	3.02E-05	23.5	0.694	6.18E-06	2.40E-05	1.11E-07			0.36			
9-1	0.120	1325.7	6.86E-04	1209.9	6.28E-04	5.79E-05	150.4	4.789	4.27E-05	23.4	0.690	6.15E-06	3.65E-05	1.11E-07	6.18E-06	1.11E-07	0.39	0.40	3623709.1	6.56
9-2	0.120	1325.7	6.86E-04	1220.1	6.33E-04	5.28E-05	156.4	4.983	4.44E-05	23.6	0.697	6.21E-06	3.82E-05	1.12E-07			0.42			
10-1	0.130	1325.7	6.86E-04	1258.3	6.52E-04	3.37E-05	173.5	5.535	4.93E-05	24.6	0.729	6.50E-06	4.28E-05	1.17E-07	6.67E-06	1.20E-07	0.56	0.39	3233723.4	6.51
10-2	0.130	1325.7	6.86E-04	1220.7	6.33E-04	5.25E-05	176.4	2.401	2.14E-05	25.8	0.768	6.84E-06	1.46E-05	1.23E-07			0.22			

Table A-37 Ethylcyclohexane adsolubilization of C167-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	ECH (μL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in-eq)}$ (M)	ECH Initial			ECH Equilibrium			ECH $_{(in-eq)}$ (M)	X_{aq}	AVG ECH Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Area	Conc. (mg/L)	Conc. (M)	Area	Conc. (mg/L)	Conc. (M)								
1-1	0.020	1952.4	9.99E-04	1885.6	9.66E-04	3.34E-05	14.2	0.394	3.51E-06	3.3	0.042	3.72E-07	3.13E-06	6.71E-09	3.44E-07	6.19E-09	0.09	0.10	16196753.8	7.21
1-2	0.020	1952.4	9.99E-04	1894.2	9.70E-04	2.91E-05	16.2	0.458	4.08E-06	3.1	0.035	3.15E-07	3.77E-06	5.67E-09			0.11			
2-1	0.030	1952.4	9.99E-04	1922.2	9.84E-04	1.51E-05	23.3	0.687	6.12E-06	6.9	0.158	1.41E-06	4.72E-06	2.53E-08	1.32E-06	2.38E-08	0.24	0.34	14132703.5	7.15
2-2	0.030	1952.4	9.99E-04	1936.6	9.91E-04	7.90E-06	27.4	0.820	7.30E-06	6.3	0.139	1.24E-06	6.07E-06	2.22E-08			0.43			
3-1	0.040	1952.4	9.99E-04	1917.7	9.82E-04	1.74E-05	46.4	1.433	1.28E-05	7	0.161	1.44E-06	1.13E-05	2.59E-08	1.47E-06	2.64E-08	0.40	0.33	12549620.3	7.10
3-2	0.040	1952.4	9.99E-04	1892.4	9.69E-04	3.00E-05	45.2	1.394	1.24E-05	7.2	0.168	1.49E-06	1.09E-05	2.69E-08			0.27			
4-1	0.050	1952.4	9.99E-04	1924.7	9.85E-04	1.38E-05	53.4	1.659	1.48E-05	11.9	0.319	2.85E-06	1.19E-05	5.12E-08	2.77E-06	4.99E-08	0.46	0.57	11373417.8	7.06
4-2	0.050	1952.4	9.99E-04	1940.3	9.93E-04	6.05E-06	54.7	1.701	1.52E-05	11.4	0.303	2.70E-06	1.25E-05	4.86E-08			0.67			
5-1	0.060	1952.4	9.99E-04	1930.9	9.89E-04	1.07E-05	61.1	1.907	1.70E-05	15.8	0.445	3.97E-06	1.30E-05	7.14E-08	3.98E-06	7.17E-08	0.55	0.54	7591476.2	6.88
5-2	0.060	1952.4	9.99E-04	1929.9	9.88E-04	1.13E-05	61.9	1.933	1.72E-05	15.9	0.448	4.00E-06	1.32E-05	7.19E-08			0.54			
6-1	0.070	1952.4	9.99E-04	1924	9.85E-04	1.42E-05	74.2	2.330	2.08E-05	19.8	0.574	5.12E-06	1.56E-05	9.21E-08	4.31E-06	7.76E-08	0.52	0.58	7407791.7	6.87
6-2	0.070	1952.4	9.99E-04	1932.4	9.89E-04	1.00E-05	72.4	2.272	2.02E-05	14.2	0.394	3.51E-06	1.67E-05	6.31E-08			0.63			
7-1	0.090	1952.4	9.99E-04	1943.5	9.95E-04	4.45E-06	79.3	2.495	2.22E-05	19.5	0.565	5.03E-06	1.72E-05	9.06E-08	5.15E-06	9.27E-08	0.79	0.68	7360298.0	6.87
7-2	0.090	1952.4	9.99E-04	1927	9.87E-04	1.27E-05	78.7	2.475	2.21E-05	20.3	0.590	5.26E-06	1.68E-05	9.47E-08			0.57			
8-1	0.100	1952.4	9.99E-04	1949.1	9.98E-04	1.65E-06	98.9	3.127	2.79E-05	24.2	0.716	6.38E-06	2.15E-05	1.15E-07	5.95E-06	1.07E-07	0.93	0.78	7312298.8	6.86
8-2	0.100	1952.4	9.99E-04	1927.5	9.87E-04	1.25E-05	97.6	3.085	2.75E-05	21.2	0.619	5.52E-06	2.20E-05	9.94E-08			0.64			
9-1	0.120	1952.4	9.99E-04	1935.8	9.91E-04	8.30E-06	128.9	4.095	3.65E-05	26.9	0.803	7.16E-06	2.93E-05	1.29E-07	7.12E-06	1.28E-07	0.78	0.70	5450141.4	6.74
9-2	0.120	1952.4	9.99E-04	1918.7	9.82E-04	1.68E-05	121	3.840	3.42E-05	26.6	0.794	7.07E-06	2.72E-05	1.27E-07			0.62			
10-1	0.130	1952.4	9.99E-04	1912.6	9.79E-04	1.99E-05	136.3	4.334	3.86E-05	30.1	0.907	8.08E-06	3.05E-05	1.45E-07	8.01E-06	1.44E-07	0.61	0.78	5384713.8	6.73
10-2	0.130	1952.4	9.99E-04	1951.4	9.99E-04	5.00E-07	139.8	1.895	1.69E-05	29.6	0.891	7.94E-06	8.95E-06	1.43E-07			0.95			

Table A-38 Ethylcyclohexane adsolubilization of C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	ECH (µL)	Surfactant Initial		Surfactant Equilibrium		Sur $_{(in-eq)}$ (M)	ECH Initial			ECH Equilibrium			ECH $_{(in-eq)}$ (M)	X_{aq}	AVG ECH Equilibrium	Average X_{aq}	X_{adm}	Average X_{adm}	K_{adm}	log K_{adm}
		Area	Conc. (M)	Area	Conc. (M)		Area	Conc. (mg/L)	Conc. (M)	Area	Conc. (mg/L)	Conc. (M)								
1-1	0.020	1198.3	6.22E-04	1122.5	5.84E-04	3.79E-05	22.9	0.674	6.01E-06	3.3	0.042	3.72E-07	5.64E-06	6.71E-09	3.44E-07	6.19E-09	0.13	0.14	22031789.8	7.34
1-2	0.020	1198.3	6.22E-04	1138.4	5.92E-04	2.99E-05	20.5	0.597	5.32E-06	3.1	0.035	3.15E-07	5.00E-06	5.67E-09			0.14			
2-1	0.030	1198.3	6.22E-04	1134.6	5.90E-04	3.19E-05	34.1	1.036	9.23E-06	6.9	0.158	1.41E-06	7.82E-06	2.53E-08	1.32E-06	2.38E-08	0.20	0.20	8460192.2	6.93
2-2	0.030	1198.3	6.22E-04	1127.3	5.87E-04	3.55E-05	38.2	1.168	1.04E-05	6.3	0.139	1.24E-06	9.17E-06	2.22E-08			0.21			
3-1	0.040	1198.3	6.22E-04	1153	6.00E-04	2.27E-05	46.4	1.433	1.28E-05	7	0.161	1.44E-06	1.13E-05	2.59E-08	1.47E-06	2.64E-08	0.33	0.30	11357069.2	7.06
3-2	0.040	1198.3	6.22E-04	1137.9	5.92E-04	3.02E-05	45.2	1.394	1.24E-05	7.2	0.168	1.49E-06	1.09E-05	2.69E-08			0.27			
4-1	0.050	1198.3	6.22E-04	1155.4	6.01E-04	2.15E-05	53.6	1.665	1.48E-05	11.9	0.319	2.85E-06	1.20E-05	5.12E-08	2.77E-06	4.99E-08	0.36	0.36	7153886.4	6.85
4-2	0.050	1198.3	6.22E-04	1150.2	5.98E-04	2.41E-05	57.6	1.794	1.60E-05	11.4	0.303	2.70E-06	1.33E-05	4.86E-08			0.36			
5-1	0.060	1198.3	6.22E-04	1142.6	5.94E-04	2.79E-05	67.8	2.123	1.89E-05	15.8	0.445	3.97E-06	1.50E-05	7.14E-08	3.98E-06	7.17E-08	0.35	0.34	4733917.7	6.68
5-2	0.060	1198.3	6.22E-04	1138.9	5.93E-04	2.97E-05	66.6	2.085	1.86E-05	15.9	0.448	4.00E-06	1.46E-05	7.19E-08			0.33			
6-1	0.070	1198.3	6.22E-04	1139	5.93E-04	2.97E-05	80.2	2.524	2.25E-05	19.8	0.574	5.12E-06	1.74E-05	9.21E-08	4.31E-06	7.76E-08	0.37	0.38	4882129.0	6.69
6-2	0.070	1198.3	6.22E-04	1139.3	5.93E-04	2.95E-05	79.4	2.498	2.23E-05	14.2	0.394	3.51E-06	1.88E-05	6.31E-08			0.39			
7-1	0.090	1198.3	6.22E-04	1149	5.98E-04	2.47E-05	81.8	2.575	2.29E-05	19.5	0.565	5.03E-06	1.79E-05	9.06E-08	5.15E-06	9.27E-08	0.42	0.42	4482789.8	6.65
7-2	0.090	1198.3	6.22E-04	1145.6	5.96E-04	2.64E-05	83.9	2.643	2.36E-05	20.3	0.590	5.26E-06	1.83E-05	9.47E-08			0.41			
8-1	0.100	1198.3	6.22E-04	1143.3	5.95E-04	2.75E-05	100.8	3.188	2.84E-05	24.2	0.716	6.38E-06	2.20E-05	1.15E-07	5.95E-06	1.07E-07	0.44	0.45	4211016.9	6.62
8-2	0.100	1198.3	6.22E-04	1139.6	5.93E-04	2.94E-05	107.3	3.398	3.03E-05	21.2	0.619	5.52E-06	2.48E-05	9.94E-08			0.46			
9-1	0.120	1198.3	6.22E-04	1142.7	5.94E-04	2.78E-05	127.6	4.053	3.61E-05	26.9	0.803	7.16E-06	2.90E-05	1.29E-07	7.12E-06	1.28E-07	0.51	0.52	4068435.5	6.61
9-2	0.120	1198.3	6.22E-04	1148.1	5.97E-04	2.51E-05	125.9	3.998	3.56E-05	26.6	0.794	7.07E-06	2.86E-05	1.27E-07			0.53			
10-1	0.130	1198.3	6.22E-04	1106.3	5.76E-04	4.60E-05	145.2	4.621	4.12E-05	30.1	0.907	8.08E-06	3.31E-05	1.45E-07	8.01E-06	1.44E-07	0.42	0.33	2300046.8	6.36
10-2	0.130	1198.3	6.22E-04	1136.8	5.92E-04	3.08E-05	148	2.008	1.79E-05	29.6	0.891	7.94E-06	9.96E-06	1.43E-07			0.24			

Table A-39 Phenylethanol solubilization of CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	PHE Conc. (M)	PHE Area (1-1)	PHE Area (1-2)	PHE Area Total (1)	PHE Area (2-1)	PHE Area (2-2)	PHE Area Total (2)	PHE AVG
1	3.00E-04	5.76E-02	4677.5	414.3	5091.8	5078.8	441	5519.8	5305.8
2	4.00E-04	5.94E-02	4953.1	428.1	5381.2	5099.5	451.3	5550.8	5466
3	5.00E-04	6.01E-02	5055.8	437.6	5493.4	5121.3	445.2	5566.5	5529.95
4	7.00E-04	6.06E-02	5143.2	446.9	5590.1	5120.3	453.8	5574.1	5582.1
5	9.00E-04	5.99E-02	5088.6	443.1	5531.7	5052.5	440	5492.5	5512.1
6	1.00E-03	7.49E-02	6231.7	559.8	6791.5	6448.5	580.4	7028.9	6910.2
7	1.50E-03	7.89E-02	6723	586.9	7309.9	6661.2	594.6	7255.8	7282.85
8	2.00E-03	9.08E-02	7692.3	692.3	8384.6	7655.6	736.3	8391.9	8388.25
9	3.00E-03	1.03E-01	8866	726.6	9592.6	8687.3	743.6	9430.9	9511.75
10	4.00E-03	1.20E-01	10529.6	896.8	11426.4	9933.3	901	10834.3	11130.35
11	5.00E-03	1.43E-01	12262.2	938.4	13200.6	12351.4	937.6	13289	13244.8
12	6.00E-03	1.60E-01	13779.4	1043.9	14823.3	13656.1	1091.1	14747.2	14785.25
13	7.00E-03	1.89E-01	15170.8	1084.1	16254.9	17758.8	1062.4	18821.2	17538.05
14	8.00E-03	2.15E-01	18499.1	1234.3	19733.4	18890.2	1274.8	20165	19949.2
15	1.00E-02	2.46E-01	21131.3	1285.5	22416.8	21938.1	1278.1	23216.2	22816.5

Table A-40 Phenylethanol solubilization of C167-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	PHE Conc. (M)	PHE Area (1-1)	PHE Area (1-2)	PHE Area Total (1)	PHE Area (2-1)	PHE Area (2-2)	PHE Area Total (2)	PHE AVG
1	4.00E-07	7.20E-02	3152.2	211.9	3364.1	3145.6	216.5	3362.1	3363.1
2	5.00E-07	7.25E-02	3145.8	224.9	3370.7	3168.7	228.9	3397.6	3384.15
3	7.00E-07	7.24E-02	3147.6	225.6	3373.2	3157.9	231.4	3389.3	3381.25
4	8.00E-07	7.28E-02	3153.4	236.9	3390.3	3180.7	231	3411.7	3401
5	9.00E-07	7.82E-02	3273.4	289.7	3563.1	3441.1	306.7	3747.8	3655.45
6	1.00E-06	7.84E-02	3354.4	290.5	3644.9	3384.7	298.7	3683.4	3664.15
7	2.00E-06	8.02E-02	3489.6	288.6	3778.2	3419.2	301.2	3720.4	3749.3
8	3.00E-06	9.13E-02	3939.9	329	4268.9	3941.2	330.2	4271.4	4270.15
9	4.00E-06	9.46E-02	4091.1	340	4431.1	4085.4	342	4427.4	4429.25
10	5.00E-06	9.74E-02	4187.1	369.6	4556.7	4189.7	370.3	4560	4558.35
11	7.00E-06	9.96E-02	4289.7	377.3	4667	4283.6	376.6	4660.2	4663.6
12	1.00E-05	1.09E-01	4678.3	404.4	5082.7	4678.9	415.6	5094.5	5088.6
13	2.00E-05	1.11E-01	4758.6	417.8	5176.4	4788.2	421.4	5209.6	5193
14	3.00E-05	1.15E-01	4962.2	436.8	5399	4956.2	437.1	5393.3	5396.15
15	4.00E-05	1.20E-01	5181.7	450.4	5632.1	5180.4	457.1	5637.5	5634.8
16	5.00E-05	1.28E-01	5480.6	507	5987.6	5479.5	514.5	5994	5990.8
17	7.00E-05	1.37E-01	5900.1	518.6	6418.7	5884.7	499	6383.7	6401.2
18	1.00E-04	1.44E-01	6267.2	525	6792.2	6233.5	522.8	6756.3	6774.25

Table A-41 Phenylethanol solubilization of C168-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	PHE Conc. (M)	PHE Area (1-1)	PHE Area (1-2)	PHE Area Total (1)	PHE Area (2-1)	PHE Area (2-2)	PHE Area Total (2)	PHE AVG
1	3.00E-06	5.76E-02	2414.2	209.6	2623.8	2527.3	219.2	2746.5	2685.15
2	5.00E-06	5.76E-02	2426.1	214.9	2641	2503.3	221.2	2724.5	2682.75
3	7.00E-06	7.74E-02	3275.5	282.6	3558.1	3378.5	300	3678.5	3618.3
4	1.00E-05	7.90E-02	3394.4	292.8	3687.2	3400.3	292.7	3693	3690.1
5	1.50E-05	8.88E-02	3770.5	327.8	4098.3	3875.3	333.9	4209.2	4153.75
6	2.00E-05	9.15E-02	3945	340	4285	3941.6	336.6	4278.2	4281.6
7	3.00E-05	9.60E-02	4110.9	353.8	4464.7	4153.2	368.2	4521.4	4493.05
8	4.00E-05	9.84E-02	4260.6	366	4626.6	4219.4	365.2	4584.6	4605.6
9	5.00E-05	1.02E-01	4349.8	418.6	4768.4	4356	411.3	4767.3	4767.85
10	7.00E-05	1.05E-01	4507.9	406.5	4914.4	4517.7	407.2	4924.9	4919.65
11	1.00E-04	1.08E-01	4654.9	429.7	5084.6	4643.4	431.1	5074.5	5079.55
12	2.00E-04	1.17E-01	5035.8	424.4	5460.2	5046.8	425.6	5472.4	5466.3
13	3.00E-04	1.26E-01	5388.7	498.7	5887.4	5399.2	515	5914.2	5900.8
14	5.00E-04	1.42E-01	6143.5	514.1	6657.6	6161.8	517.2	6679	6668.3
15	1.00E-03	1.40E-01	6082.1	523.4	6605.5	6030	517.4	6547.4	6576.45

Table A-42 Phenylethanol solubilization of C167-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	PHE Conc. (M)	PHE Area (1-1)	PHE Area (1-2)	PHE Area Total (1)	PHE Area (2-1)	PHE Area (2-2)	PHE Area Total (2)	PHE AVG
1	2.00E-06	5.62E-02	2414.2	209.6	2623.8	2399.6	208.5	2608.1	2615.95
2	3.00E-06	5.64E-02	2412.5	214.9	2627.4	2409.5	216.7	2626.2	2626.8
3	4.00E-06	5.66E-02	2426.1	213.6	2639.7	2421.6	212.5	2634.1	2636.9
4	5.00E-06	5.88E-02	2439	208.9	2647.9	2606.6	228.7	2835.3	2741.6
5	7.00E-06	6.07E-02	2602.3	230.2	2832.5	2601.3	225.7	2827	2829.75
6	1.00E-05	7.80E-02	3267.1	283.2	3550.3	3434	302.9	3736.9	3643.6
7	1.50E-05	8.04E-02	3449	298.7	3747.7	3461.7	305.9	3767.6	3757.65
8	2.00E-05	9.32E-02	4058.5	333.4	4391.9	3983.7	343.4	4327.1	4359.5
9	3.00E-05	9.64E-02	4186.7	347.5	4534.2	4142.4	350.1	4492.5	4513.35
10	4.00E-05	9.94E-02	4274.2	370.6	4644.8	4281.6	379	4660.6	4652.7
11	5.00E-05	9.97E-02	4325.6	374.6	4700.2	4263.6	367	4630.6	4665.4
12	7.00E-05	1.06E-01	4543.9	409.1	4953	4550.1	420.7	4970.8	4961.9
13	1.00E-04	1.09E-01	4671.8	420.7	5092.5	4679.8	421.5	5101.3	5096.9
14	2.00E-04	1.11E-01	4765.9	437.6	5203.5	4793.8	449	5242.8	5223.15
15	3.00E-04	1.18E-01	5117.2	452.3	5569.5	5103.9	402.9	5506.8	5538.15
16	5.00E-04	1.29E-01	5580.4	509.4	6089.8	5511.1	509	6020.1	6054.95
17	7.00E-04	1.38E-01	5946.4	494.3	6440.7	5949.8	513.6	6463.4	6452.05
18	1.00E-03	1.41E-01	5971.4	504	6475.4	6179.4	530.9	6710.3	6592.85

Table A-43 Phenylethanol solubilization of C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	PHE Conc. (M)	PHE Area (1-1)	PHE Area (1-2)	PHE Area Total (1)	PHE Area (2-1)	PHE Area (2-2)	PHE Area Total (2)	PHE AVG
1	5.00E-06	7.45E-02	3229.5	209.4	3438.9	3306.6	215.7	3522.3	3480.6
2	7.00E-06	7.80E-02	3290.8	282.3	3573.1	3421.6	294.3	3715.9	3644.5
3	1.00E-05	8.19E-02	3518.6	293.1	3811.7	3550.4	296.8	3847.2	3829.45
4	1.50E-05	8.90E-02	3725.7	319.7	4045.4	3939.3	337.6	4276.9	4161.15
5	2.00E-05	9.10E-02	3926.2	336.8	4263	3916	336.2	4252.2	4257.6
6	3.00E-05	9.69E-02	4133.8	357.8	4491.6	4217.1	361	4578.1	4534.85
7	4.00E-05	9.87E-02	4271.5	372.6	4644.1	4232.6	368.4	4601	4622.55
8	5.00E-05	1.06E-01	4584.4	392.9	4977.3	4540.4	410.8	4951.2	4964.25
9	7.00E-05	1.09E-01	4702.1	401.3	5103.4	4700.6	401.5	5102.1	5102.75
10	8.00E-05	1.13E-01	4878.7	417.2	5295.9	4854.9	431.2	5286.1	5291
11	1.00E-04	1.17E-01	5040.2	432.3	5472.5	5030.4	430.8	5461.2	5466.85
12	1.50E-04	1.28E-01	5536.9	484.4	6021.3	5516.9	504.2	6021.1	6021.2
13	2.00E-04	1.38E-01	5935	505.6	6440.6	5980.6	505	6485.6	6463.1
14	3.00E-04	1.39E-01	5913.9	493.3	6407.2	6086.7	509.9	6596.6	6501.9
15	5.00E-04	1.39E-01	6033.4	504	6537.4	6038.1	508.4	6546.5	6541.95

Table A-44 Styrene solubilization of CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	Styrene Conc. (M)	Styrene Area (1)	Styrene Area (2)	Styrene AVG
1	1.00E-05	2.91E-03	17357.2	17873.6	17615.4
2	3.00E-05	2.96E-03	17820.1	18015.3	17917.7
3	5.00E-05	2.98E-03	18067.2	18021.6	18044.4
4	7.00E-05	2.96E-03	17890.1	17981.3	17935.7
5	1.00E-04	2.98E-03	18023.7	17987.9	18005.8
6	3.00E-04	2.93E-03	17467.2	17963.6	17715.4
7	4.00E-04	2.99E-03	18120.1	18113.3	18116.7
8	5.00E-04	3.01E-03	18156.7	18291.9	18224.3
9	6.00E-04	3.12E-03	18529.4	19253.4	18891.4
10	7.00E-04	3.16E-03	19360.3	18905.6	19132.95
11	9.00E-04	3.25E-03	19740	19557	19648.5
12	1.00E-03	3.76E-03	22363.7	23017.3	22690.5
13	1.50E-03	4.28E-03	26092.6	25622.3	25857.45
14	2.00E-03	4.78E-03	28998.1	28700.3	28849.2
15	3.00E-03	5.38E-03	32204.8	32714.8	32459.8
16	4.00E-03	6.09E-03	36654	36761	36707.5
17	5.00E-03	6.34E-03	38041.4	38338	38189.7
18	6.00E-03	6.92E-03	41754.9	41609.9	41682.4
19	7.00E-03	7.02E-03	42280.4	42281.7	42281.05
20	1.00E-02	7.07E-03	42804.9	42375.1	42590

Table A-45 Styrene solubilization of C167-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	Styrene Conc. (M)	Styrene Area (1)	Styrene Area (2)	Styrene AVG
1	8.00E-07	2.74E-03	16600.8	16542.6	16571.7
2	9.00E-07	2.77E-03	16644.7	16936.1	16790.4
3	1.00E-06	2.73E-03	16504.4	16580.4	16542.4
4	2.00E-06	2.73E-03	16517.9	16579	16548.45
5	3.00E-06	2.76E-03	16776.3	16628.4	16702.35
6	4.00E-06	2.75E-03	16692.8	16595.7	16644.25
7	5.00E-06	2.79E-03	16708	17024.7	16866.35
8	7.00E-06	2.69E-03	15865.4	16724.9	16295.15
9	1.00E-05	2.71E-03	16205.5	16640.4	16422.95
10	2.00E-05	2.80E-03	16917.7	16934	16925.85
11	3.00E-05	2.74E-03	16485.9	16673.2	16579.55
12	4.00E-05	2.76E-03	16804.1	16631.4	16717.75
13	5.00E-05	3.09E-03	18603.5	18813.5	18708.5
14	7.00E-05	3.15E-03	18997.6	19098.3	19047.95
15	1.00E-04	3.43E-03	20612.1	20844.5	20728.3
16	2.00E-04	3.77E-03	22998.5	22543.8	22771.15
17	3.00E-04	4.26E-03	25346.6	26097.4	25722
18	5.00E-04	4.73E-03	28869.8	28205.3	28537.55
19	7.00E-04	5.22E-03	31714	31242.9	31478.45
20	1.00E-03	5.78E-03	34934.6	34739.9	34837.25

Table A-46 Styrene solubilization of C168-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	Styrene Conc. (M)	Styrene Area (1)	Styrene Area (2)	Styrene AVG
1	2.00E-06	2.94E-03	18284.6	17244.7	17764.65
2	3.00E-06	3.06E-03	17995.8	19053.8	18524.8
3	4.00E-06	3.06E-03	19009.9	18012.7	18511.3
4	5.00E-06	3.06E-03	18626.1	18358.4	18492.25
5	7.00E-06	3.01E-03	18588.2	17856.2	18222.2
6	1.00E-05	2.97E-03	18160	17794.7	17977.35
7	2.00E-05	2.97E-03	17575.6	18329.5	17952.55
8	3.00E-05	2.93E-03	17810.3	17656.9	17733.6
9	4.00E-05	2.95E-03	17879.5	17778.9	17829.2
10	5.00E-05	2.93E-03	17828.8	17633.3	17731.05
11	7.00E-05	2.96E-03	17962.9	17920.9	17941.9
12	1.00E-04	3.09E-03	18568.6	18839.5	18704.05
13	1.50E-04	3.43E-03	20876	20567.8	20721.9
14	2.00E-04	3.92E-03	23836.2	23540.1	23688.15
15	3.00E-04	4.41E-03	26754.3	26521.6	26637.95
16	5.00E-04	5.02E-03	30122.8	30483.5	30303.15

Table A-47 Styrene solubilization of C167-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	Styrene Conc. (M)	Styrene Area (1)	Styrene Area (2)	Styrene AVG
1	3.0E-06	2.95E-03	17701.3	18023.9	17862.6
2	4.0E-06	2.97E-03	17911.7	18003.5	17957.6
3	5.0E-06	2.95E-03	17808.5	17925	17866.75
4	7.0E-06	2.87E-03	17434.3	17305.4	17369.85
5	1.5E-05	2.84E-03	17147.4	17228.6	17188
6	2.0E-05	2.94E-03	17691.9	17856.2	17774.05
7	3.0E-05	2.87E-03	17209.8	17536.6	17373.2
8	4.0E-05	2.95E-03	17447.9	18199.9	17823.9
9	5.0E-05	2.96E-03	17495	18351.8	17923.4
10	7.0E-05	2.97E-03	17526.9	18368.7	17947.8
11	1.0E-04	3.18E-03	18643.5	19832.5	19238
12	2.0E-04	3.76E-03	22870.2	22616.4	22743.3
13	3.0E-04	4.10E-03	25143.7	24358.4	24751.05
14	4.0E-04	4.74E-03	28260.4	28876.4	28568.4
15	5.0E-04	4.83E-03	28762.2	29480.3	29121.25

Table A-48 Styrene solubilization of C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	Styrene Conc. (M)	Styrene Area (1)	Styrene Area (2)	Styrene AVG
1	2.00E-06	3.00E-03	18054.3	18234.9	18144.6
2	3.00E-06	2.98E-03	17989.4	18069.4	18029.4
3	4.00E-06	2.99E-03	18160.7	18071.5	18116.1
4	5.00E-06	2.95E-03	17932.4	17766.1	17849.25
5	7.00E-06	2.97E-03	18109.6	17811.1	17960.35
6	1.00E-05	2.97E-03	17999.7	17947.2	17973.45
7	2.00E-05	3.07E-03	18943.7	18247.7	18595.7
8	3.00E-05	3.14E-03	18915.4	19067.3	18991.35
9	4.00E-05	3.18E-03	19353.2	19125.9	19239.55
10	5.00E-05	3.63E-03	21826.1	22029.6	21927.85
11	7.00E-05	3.77E-03	22595	22899.6	22747.3
12	1.00E-04	3.89E-03	23873.5	23116.7	23495.1
13	2.00E-04	4.16E-03	25098	25145.5	25121.75
14	3.00E-04	4.36E-03	26502.4	26156.6	26329.5
15	5.00E-04	4.67E-03	28187.2	28183	28185.1

Table A-49 Ethylcyclohexane solubilization of CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	CPC Conc. (M)	ECH ini Conc. (UL)	ECH ini Conc. (M)	Area (1)	Area (2)	Area Avg	ECH Eq Conc. (1) (M)	ECH Eq Conc.(2) (M)	ECH Eq Conc. Avg (M)
1	3.00E-05	5	1.03E-03	6037.3	5362.7	5700	1.51E-03	1.34E-03	1.42E-03
2	5.00E-05	5	1.03E-03	6037.3	5362.7	5700	1.51E-03	1.34E-03	1.42E-03
3	7.00E-05	5	1.03E-03	6037.3	5362.7	5700	1.51E-03	1.34E-03	1.42E-03
4	1.00E-04	5	1.03E-03	6037.3	5362.7	5700	1.51E-03	1.34E-03	1.42E-03
5	3.00E-04	5	1.03E-03	6037.3	5362.7	5700	1.51E-03	1.34E-03	1.42E-03
6	4.00E-04	5	1.03E-03	4892.5	5194.9	5043.7	1.22E-03	1.30E-03	1.26E-03
7	5.00E-04	10	2.07E-03	7771.6	7085.7	7428.65	1.94E-03	1.77E-03	1.86E-03
8	7.00E-04	10	2.07E-03	7788.1	4956.8	6372.45	1.95E-03	1.24E-03	1.59E-03
9	9.00E-04	12	2.48E-03	6232.7	7897.3	7065	1.56E-03	1.97E-03	1.77E-03
10	1.00E-03	12	2.48E-03	8377.9	8831.6	8604.75	2.09E-03	2.21E-03	2.15E-03
11	1.50E-03	14	2.89E-03	9284.9	9549.1	9417	2.32E-03	2.39E-03	2.35E-03
12	2.00E-03	14	2.89E-03	13389.2	14739.8	14064.5	3.35E-03	3.68E-03	3.52E-03
13	3.00E-03	20	4.13E-03	19684.8	19299.2	19492	4.92E-03	4.82E-03	4.87E-03
14	4.00E-03	20	4.13E-03	20642.8	20540.3	20591.55	5.16E-03	5.13E-03	5.15E-03
15	5.00E-03	25	5.17E-03	22248.8	20258.6	21253.7	5.56E-03	5.06E-03	5.31E-03
16	6.00E-03	25	5.17E-03	25749.5	25883.7	25816.6	6.44E-03	6.47E-03	6.45E-03
17	7.00E-03	30	6.20E-03	30730	30978.5	30854.25	7.68E-03	7.74E-03	7.71E-03
18	8.00E-03	30	6.20E-03	31267.5	31785.6	31526.55	7.82E-03	7.95E-03	7.88E-03
19	1.00E-02	30	6.20E-03	40377.5	38663	39520.25	1.01E-02	9.67E-03	9.88E-03

Table A-50 Ethylcyclohexane solubilization of C167-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	ECH ini Conc. (UL)	ECH ini Conc. (M)	Area (1)	Area (2)	Area Avg	ECH Eq Conc. (1) (M)	ECH Eq Conc.(2) (M)	ECH Eq Conc. Avg (M)
1	7.00E-07	5	1.03E-03	11345.5	11095.6	11220.55	2.84E-03	2.77E-03	2.80E-03
2	1.00E-06	5	1.03E-03	11345.5	11095.6	11220.55	2.84E-03	2.77E-03	2.80E-03
3	3.0E-06	5	1.03E-03	11345.5	11095.6	11220.55	2.84E-03	2.77E-03	2.80E-03
4	7.0E-06	5	1.03E-03	11345.5	11095.6	11220.55	2.84E-03	2.77E-03	2.80E-03
5	1.0E-05	10	2.07E-03	15471.9	16177	15824.45	3.87E-03	4.04E-03	3.96E-03
6	2.0E-05	10	2.07E-03	19953.6	19179.5	19566.55	4.99E-03	4.79E-03	4.89E-03
7	3.0E-05	10	2.07E-03	25125.2	25155.4	25140.3	6.28E-03	6.29E-03	6.28E-03
8	5.0E-05	15	3.10E-03	29956.4	29011.9	29484.15	7.49E-03	7.25E-03	7.37E-03
9	8.0E-05	15	3.10E-03	39176.1	39087.1	39131.6	9.79E-03	9.77E-03	9.78E-03
10	1.0E-04	15	3.10E-03	43737.9	43098.6	43418.25	1.09E-02	1.08E-02	1.09E-02
11	1.5E-04	20	4.13E-03	54642.3	54678.3	54660.3	1.37E-02	1.37E-02	1.37E-02
12	2.0E-04	20	4.13E-03	64289.2	64742.1	64515.65	1.61E-02	1.62E-02	1.61E-02

Table A-51 Ethylcyclohexane solubilization of C168-42/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	ECH ini Conc. (UL)	ECH ini Conc. (M)	Area (1)	Area (2)	Area Avg	ECH Eq Conc. (1) (M)	ECH Eq Conc.(2) (M)	ECH Eq Conc. Avg (M)
1	7.00E-07	10	2.07E-03	26564.5	26130	26347.25	6.64E-03	6.53E-03	6.59E-03
2	1.00E-06	10	2.07E-03	26564.5	26130	26347.25	6.64E-03	6.53E-03	6.59E-03
3	2.00E-06	10	2.07E-03	26564.5	26130	26347.25	6.64E-03	6.53E-03	6.59E-03
4	5.00E-06	10	2.07E-03	26564.5	26130	26347.25	6.64E-03	6.53E-03	6.59E-03
5	7.00E-06	10	2.07E-03	26564.5	26130	26347.25	6.64E-03	6.53E-03	6.59E-03
6	1.0E-05	10	2.07E-03	26564.5	26130	26347.25	6.64E-03	6.53E-03	6.59E-03
7	1.5E-05	10	2.07E-03	27925.7	27161.1	27543.4	6.98E-03	6.79E-03	6.89E-03
8	2.0E-05	15	3.10E-03	29328.8	29486.6	29407.7	7.33E-03	7.37E-03	7.35E-03
9	3.0E-05	15	3.10E-03	32729.8	32089.3	32409.55	8.18E-03	8.02E-03	8.10E-03
10	4.0E-05	15	3.10E-03	43899.6	43131.4	43515.5	1.10E-02	1.08E-02	1.09E-02
11	5.0E-05	20	4.13E-03	50181.6	50657.2	50419.4	1.25E-02	1.27E-02	1.26E-02
12	7.0E-05	20	4.13E-03	59544.3	59229.7	59387	1.49E-02	1.48E-02	1.48E-02
13	1.0E-04	20	4.13E-03	69116.8	69369.4	69243.1	1.73E-02	1.73E-02	1.73E-02

Table A-52 Ethylcyclohexane solubilization of C167-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	ECH ini Conc. (UL)	ECH ini Conc. (M)	Area (1)	Area (2)	Area Avg	ECH Eq Conc. (1) (M)	ECH Eq Conc.(2) (M)	ECH Eq Conc. Avg (M)
1	7.00E-07	5	1.03E-03	10413.1	10917.9	10665.5	2.60E-03	2.73E-03	2.67E-03
2	1.00E-06	5	1.03E-03	10413.1	10917.9	10665.5	2.60E-03	2.73E-03	2.67E-03
3	3.00E-06	5	1.03E-03	10413.1	10917.9	10665.5	2.60E-03	2.73E-03	2.67E-03
4	5.0E-06	5	1.03E-03	10413.1	10917.9	10665.5	2.60E-03	2.73E-03	2.67E-03
5	7.0E-06	5	1.03E-03	11840.3	12624.3	12232.3	2.96E-03	3.16E-03	3.06E-03
6	1.0E-05	5	1.03E-03	12696.6	12993.1	12844.85	3.17E-03	3.25E-03	3.21E-03
7	1.5E-05	10	2.07E-03	23557.6	23196.9	23377.25	5.89E-03	5.80E-03	5.84E-03
8	2.0E-05	10	2.07E-03	27726.6	27173.5	27450.05	6.93E-03	6.79E-03	6.86E-03
9	3.0E-05	15	3.10E-03	31402.4	31727.3	31564.85	7.85E-03	7.93E-03	7.89E-03
10	4.0E-05	15	3.10E-03	38100.2	38236.1	38168.15	9.52E-03	9.56E-03	9.54E-03
11	5.0E-05	15	3.10E-03	43456.9	43653	43554.95	1.09E-02	1.09E-02	1.09E-02
12	7.0E-05	20	4.13E-03	54025.9	54607.6	54316.75	1.35E-02	1.37E-02	1.36E-02
13	1.0E-04	20	4.13E-03	64551.9	64176.1	64364	1.61E-02	1.60E-02	1.61E-02

Table A-53 Ethylcyclohexane solubilization of C168-45/CPC at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C

No.	Surfactant Conc. (M)	ECH ini Conc. (UL)	ECH ini Conc. (M)	Area (1)	Area (2)	Area Avg	ECH Eq Conc. (1) (M)	ECH Eq Conc.(2) (M)	ECH Eq Conc. Avg (M)
1	7.00E-07	5	1.03E-03	3121.3	3377.7	3249.5	7.80E-04	8.44E-04	8.12E-04
2	1.00E-06	5	1.03E-03	3121.3	3377.7	3249.5	7.80E-04	8.44E-04	8.12E-04
3	3.00E-06	5	1.03E-03	3121.3	3377.7	3249.5	7.80E-04	8.44E-04	8.12E-04
4	5.0E-06	5	1.03E-03	3121.3	3377.7	3249.5	7.80E-04	8.44E-04	8.12E-04
5	7.0E-06	10	2.07E-03	4527.2	4227.3	4377.25	1.13E-03	1.06E-03	1.09E-03
6	1.0E-05	10	2.07E-03	5293.5	5361.8	5327.65	1.32E-03	1.34E-03	1.33E-03
7	1.5E-05	10	2.07E-03	16191	16646.8	16418.9	4.05E-03	4.16E-03	4.10E-03
8	2.0E-05	15	3.10E-03	17981.2	17663.1	17822.15	4.50E-03	4.42E-03	4.46E-03
9	3.0E-05	15	3.10E-03	27135.5	27278.7	27207.1	6.78E-03	6.82E-03	6.80E-03
10	4.0E-05	15	3.10E-03	35178	35674.3	35426.15	8.79E-03	8.92E-03	8.86E-03
11	5.0E-05	20	4.13E-03	40355.2	40952.4	40653.8	1.01E-02	1.02E-02	1.02E-02
12	7.0E-05	20	4.13E-03	51659.7	51288	51473.85	1.29E-02	1.28E-02	1.29E-02
13	8.0E-05	20	4.13E-03	53959.6	54093.4	54026.5	1.35E-02	1.35E-02	1.35E-02
14	1.0E-04	25	5.17E-03	62580.8	62878.4	62729.6	1.56E-02	1.57E-02	1.57E-02

Table A-54 Zeta potential of silica at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C: Adsorption

Surfactant	Concentration (M)	No. of measurement										Average	PZC Average	Std.Dev.
		1	2	3	4	5	6	7	8	9	10			
CPC	1.80E-03	32.13	28.64	28.05	28.70	27.95	28.22	26.15	26.67	25.52	24.95	27.70	27.94	0.36
		30.67	30.04	28.75	26.00	28.12	27.60	29.10	26.35	29.65	27.32	28.36		
		29.53	27.53	28.96	29.71	26.46	26.52	28.85	27.95	26.46	25.75	27.77		
CPC: C167-42	5.00E-04	19.67	19.69	18.90	18.72	19.23	20.39	19.49	18.46	19.11	19.74	19.34	19.51	0.29
		20.39	19.19	20.36	18.39	18.09	19.88	20.20	20.07	18.84	18.06	19.35		
		18.65	19.97	19.82	19.09	19.32	20.49	20.39	20.32	20.86	19.57	19.85		
CPC: C168-42	5.00E-04	21.02	21.49	21.06	19.90	21.09	20.14	22.46	21.11	22.42	22.80	21.35	22.33	0.91
		24.26	20.79	21.17	22.38	22.88	21.77	23.72	22.31	21.96	23.72	22.50		
		22.96	23.53	22.42	22.80	24.76	23.53	20.74	24.26	22.78	23.68	23.15		
CPC: C167-45	8.00E-04	32.13	31.02	32.06	30.74	29.39	30.10	29.71	31.44	30.74	31.50	30.88	31.29	0.43
		29.65	32.13	30.46	30.40	32.35	31.50	32.89	31.21	30.81	31.21	31.26		
		32.06	30.27	29.21	34.17	31.84	29.21	33.66	32.13	31.76	33.05	31.74		
CPC: C168-45	4.75E-04	20.58	23.14	23.34	22.60	21.02	22.27	22.02	22.78	20.36	21.06	21.92	22.05	0.34
		22.00	23.80	21.60	23.46	20.20	22.65	23.46	22.92	22.21	21.96	22.43		
		20.29	22.10	21.67	22.78	23.26	20.96	22.02	21.25	20.07	23.53	21.79		

Table A-55 Zeta potential of silica at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C: 1st washing

Surfactant	Concentration (M)	No. of measurement										Average	PZC Average	Std.Dev.
		1	2	3	4	5	6	7	8	9	10			
CPC	1.80E-03	24.23	23.72	25.14	25.39	25.69	24.90	25.39	24.69	24.20	25.32	24.87	24.89	0.25
		26.20	24.53	24.09	26.64	24.90	24.49	26.10	25.69	24.69	24.20	25.15		
		23.02	24.85	25.22	26.10	21.88	25.39	24.80	24.72	25.14	25.46	24.66		
CPC: C167-42	5.00E-04	15.34	14.78	15.57	16.32	14.25	14.48	13.93	14.17	16.57	15.23	15.06	15.08	0.26
		16.06	14.60	13.78	15.92	14.09	15.25	15.12	14.24	15.31	13.97	14.83		
		16.85	15.64	14.64	15.29	14.37	13.85	15.50	16.66	16.57	14.17	15.35		
CPC: C168-42	5.00E-04	16.31	16.56	16.19	17.46	17.42	17.04	18.21	15.31	16.27	15.85	16.66	17.53	0.84
		18.36	18.77	17.21	16.69	18.02	16.94	17.75	16.85	17.02	18.09	17.57		
		19.88	16.90	18.59	17.74	17.44	18.77	19.72	16.29	19.01	19.09	18.34		
CPC: C167-45	8.00E-04	13.49	14.60	14.43	15.18	14.39	15.39	15.26	14.13	14.84	14.74	14.63	14.63	0.50
		13.26	13.37	13.24	15.52	13.32	13.14	15.37	13.83	14.91	15.35	14.13		
		15.57	15.70	16.26	15.03	14.76	15.57	14.72	14.32	14.32	15.00	15.13		
CPC: C168-45	4.75E-04	15.35	14.43	15.92	15.12	15.24	15.89	15.10	14.16	15.49	14.63	15.13	15.42	0.48
		16.56	15.49	15.14	14.60	16.67	14.16	14.23	14.52	15.21	14.96	15.15		
		16.07	16.67	16.65	16.41	16.47	15.60	14.74	16.05	16.00	15.13	15.98		

Table A-56 Zeta potential of silica at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C: 2nd washing

Surfactant	Concentration	No. of measurement										Average	PZC	Std.Dev.
	(M)	1	2	3	4	5	6	7	8	9	10		Average	
CPC	1.80E-03	16.26	16.85	15.73	15.08	17.21	17.08	15.67	14.47	16.27	17.42	16.20	16.95	0.79
		17.48	18.72	17.65	17.71	18.09	17.65	17.67	17.21	17.37	18.17	17.77		
		17.69	18.72	17.63	14.78	18.17	17.94	16.64	17.63	15.28	14.18	16.87		
CPC: C167-42	5.00E-04	9.28	11.10	9.52	10.07	9.39	8.90	10.24	10.82	10.18	9.63	9.91	10.34	0.38
		10.62	10.96	11.35	11.39	10.84	10.17	10.03	10.82	10.39	9.98	10.65		
		9.69	9.80	9.71	9.29	10.93	10.95	10.84	11.89	11.20	10.24	10.45		
CPC: C168-42	5.00E-04	10.35	9.21	9.23	9.30	10.55	11.08	11.60	10.95	10.39	10.20	10.29	10.34	0.40
		10.07	10.17	10.15	9.79	10.00	9.84	9.61	9.48	10.07	10.59	9.98		
		9.66	11.12	10.92	10.14	10.20	10.81	11.66	11.26	10.59	11.36	10.77		
CPC: C167-45	8.00E-04	-10.90	-9.14	-10.10	-9.92	-10.10	-9.65	-9.07	-10.20	-9.75	-10.30	-9.87	-9.47	0.36
		-9.05	-8.92	-9.83	-8.09	-9.10	-10.70	-9.32	-8.97	-8.96	-10.40	-9.33		
		-8.46	-9.23	-8.64	-10.90	-8.09	-8.92	-8.47	-9.57	-11.50	-8.17	-9.20		
CPC: C168-45	4.75E-04	11.39	11.21	11.93	9.92	11.40	10.67	10.80	10.54	11.16	10.43	10.95	10.81	0.11
		10.96	11.12	10.59	10.97	9.87	11.28	11.22	10.07	10.63	10.67	10.74		
		10.79	11.07	11.60	11.71	11.53	10.36	10.10	10.57	9.49	10.36	10.76		

Table A-57 Zeta potential of silica at 0.001 M NaCl, solution pH of 9 ± 0.5 and at temperature of 25 ± 2 °C: 3rd washing

Surfactant	Concentration (M)	No. of measurement										Average	PZC Average	Std.Dev.
		1	2	3	4	5	6	7	8	9	10			
CPC	1.80E-03	-6.74	-7.60	-5.32	-6.52	-5.05	-5.46	-5.56				-6.04	-6.08	0.32
		-6.26	-7.20	-5.78	-6.79	-6.57	-5.93					-6.42		
		-5.35	-6.82	-5.26	-5.51	-5.83	-5.98					-5.79		
CPC: C167-42	5.00E-04	-13.30	-14.20	-14.70	-14.10	-14.10	-16.70	-16.40	-14.60	-15.10	-15.30	-14.85	-15.19	0.34
		-15.90	-17.70	-16.40	-16.70	-15.20	-14.20	-13.00	-16.40	-14.50	-15.20	-15.52		
		-13.40	-13.30	-15.90	-15.70	-14.90	-16.70	-18.10	-14.80	-14.20	-15.10	-15.21		
CPC: C168-42	5.00E-04	-14.20	-14.10	-13.40	-15.00	-14.10	-15.00	-15.60	-16.70	-14.20	-14.60	-14.69	-14.57	0.29
		-12.90	-12.50	-13.20	-13.70	-15.70	-13.80	-15.90	-14.30	-16.40	-14.00	-14.24		
		-12.60	-13.90	-16.70	-14.70	-14.60	-14.20	-16.40	-16.20	-14.70	-13.90	-14.79		
CPC: C167-45	8.00E-04	-18.90	-19.00	-19.10	-20.70	-22.70	-20.00	-19.80	-20.20	-20.50		-20.10	-20.76	0.58
		-21.40	-22.60	-22.90	-22.20	-24.00	-21.80	-18.80	-20.10	-19.00	-18.80	-21.16		
		-20.40	-20.10	-19.50	-21.40	-22.20	-22.50					-21.02		
CPC: C168-45	4.75E-04	-12.80	-14.10	-13.80	-15.00	-15.30	-15.90					-14.48	-14.98	0.46
		-17.40	-16.00	-16.30	-15.20	-14.50	-14.80	-15.80	-13.20			-15.40		
		-13.30	-14.40	-13.20	-15.70	-15.80	-16.60	-16.50				-15.07		

APPENDIX B

LIST OF ACCEPTED ARTICLE AND CONFERENCE

Journal articles:

1) Panswad, D., Sabatini, D.A., Khaodhiar, S. (2011). "**Precipitation and Micellar Properties of the Novel Mixed Anionic Extended Surfactants and a Cationic Surfactant**". Journal of surfactant and detergent. (Accepted)

2) Panswad, D., Sabatini, D.A., Khaodhiar, S. (2011). "**Adsorption, Desorption and Adsolubilization Properties of Mixed Anionic Extended Surfactants and a Cationic Surfactant**". Journal of colloid and interface science. (Submitted)

3) Panswad, D., Sabatini, D.A., Khaodhiar, S. (2011). "**Solubilization of Mixed Anionic Extended Surfactants and a Cationic Surfactant**". Journal of surfactant and detergent. (In preparation)

Conferences:

1) Panswad, D., Sabatini, D.A., Khaodhiar, S. "**Precipitation and Micellar Properties of the Novel Mixed Anionic Extended Surfactants and a Cationic Surfactant**". The 102nd American Oil and Chemists' Society (AOCS) Annual Meeting and Expo, Duke Energy Center, Cincinnati, Ohio, USA on May 1-4 2011.

BIOGRAPHY

Mrs. Donyaporn Panswad was born on June 9, 1980 in Bangkok, Thailand. She received her Bachelor of Engineering in civil engineering from Sirindhorn International Institute of Technology, Thammasat University, Thailand in 2001. In year 2003, she received her Master of Environmental Engineering from Melbourne University, Australia. She started her career as a lecturer at the Department of Environmental Science, Faculty of Science, Ramkhamhaeng University. After working for 3 years, she pursued her Doctoral Degree study at the International Postgraduate Programs in Environmental Management, Chulalongkorn University in 2008.