

CHAPTER II

THEORETICAL ASPECTS AND LITERATURE REVIEWS

2.1 Surfactant Phenomena

Surfactants, which are commonly known through the detergents that we use in cleaning, can be used for increasing the efficiency of pump-and-treat technology. Surfactants are **amphiphilic molecules** because they consist of polar or hydrophilic portion as head groups and non-polar or lipophilic portion as tail groups in the same molecule. They are classified into four general classes by charge on the polar head group: anionic (a negative charge), cationic (a positive charge), zwitterionic (both negative and positive charges), and non-ionic (no charge) (West and Harwell, 1992). Since surfactants accumulate and are active at interfacial regions (e.g.: air-water, oil-water, and solid-liquid interfaces), they are called surface active agents and they will reduce the interfacial tension (Rosen, 1989).

Surfactants are able to assemble in many different forms of aggregates, depending on the concentration of surfactant in aqueous solution. At low concentration, surfactants called **monomers** act independently from the others. When the surfactant concentration increase until it exceeds the certain point, the surfactant monomers will aggregate to spherical aggregates called **micelles**. The concentration where the first micelle appears is called the **critical micelle concentration (CMC)**. If surfactants are added above the CMC, the incremental surfactants will form additional micelles (West and Harwell, 1992). Figure 2.1 shows the example of surfactant micellization. When a solid phase is added to the surfactant solution, the surfactants will aggregate at the solid-liquid interface. At a high

enough concentration, the adsorbed surfactant molecules interact on the solid surface and form micelle-like structures called **hemimicelles** and **admicelles**, depending on whether the aggregates are monolayer or bilayer. As additional surfactant is added above the CMC, where solid surface saturated by admicelles, additional surfactants will form incremental micelles and the amount of admicelles will not increase.

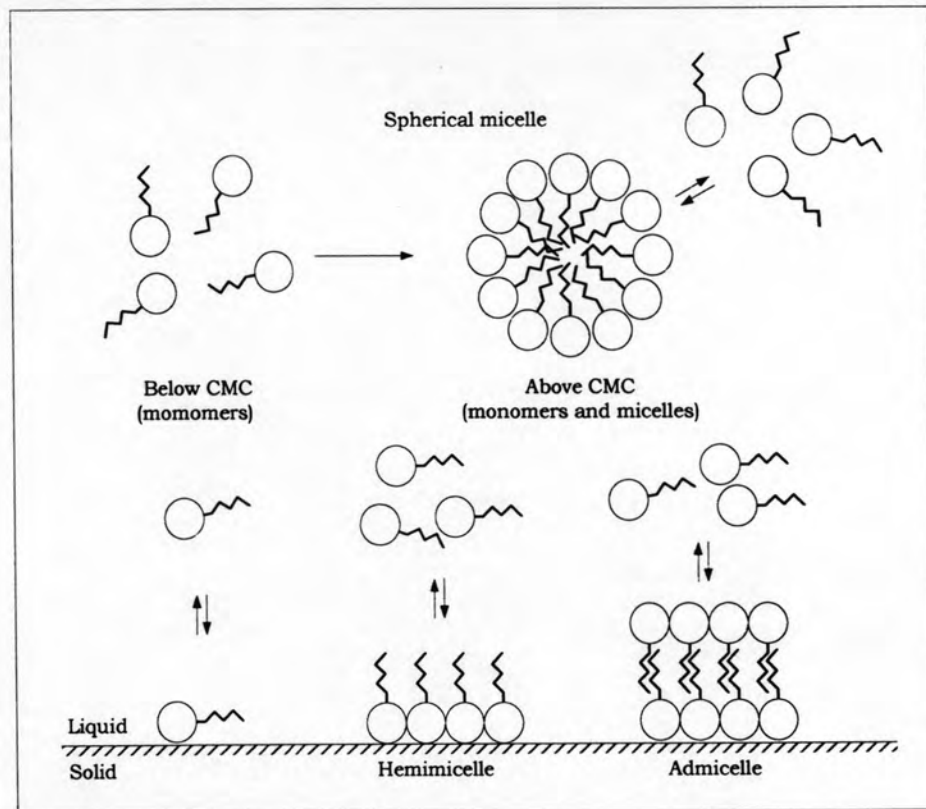


Figure 2.1 Example of surfactant micellization

Surfactant micelles are uniquely composed of hydrophilic head groups (polar) at the outer part and lipophilic tail groups (non-polar) at the inner part. The polar outer part makes the micelles able to dissolve in water, while the non-polar inner part has a portion that take hold of organic solutes in order that organic compound solubility highly increases.

2.2 Aluminum Oxide Surface Structure

The crystal structure of alpha alumina oxide (Al_2O_3) consists of layers of hexagonally packed oxygen atoms stacked on top of each other in balanced behavior, with aluminum ions placed between the oxygen layers (Figure 2.2). When the alumina contacts water, the crystal surface forms a layer of hydroxyl ions by a two-step process relating on the chemical adsorption of monolayer of water and its separation. As hydroxyl groups cover the alumina surface, hydrogen and hydroxyl ions are potential defining ions for alumina. In addition, there is a physically adsorbed monolayer of water molecules on top of the layer of hydroxyl ions. Thus the solution pH is significant in the adsorption of ionic surfactants, because it controls the alumina surface charge.

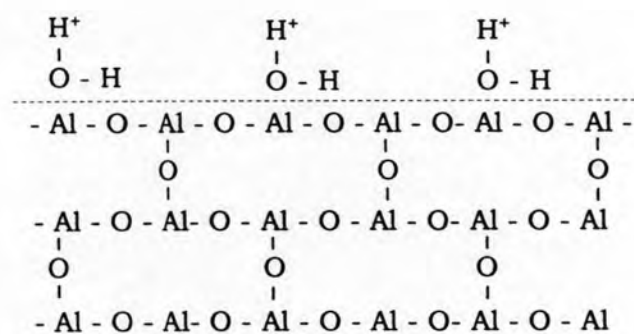


Figure 2.2 Schematic of crystal structure and surface layer of alpha aluminum oxide

The point of zero charge (PZC) or the zero point of charge (ZPC) is the pH at which alumina surface has a net charge density of zero. The PZC is the parameter that can indicate the net charge of alumina surface to be either positive or negative. The PZC of alumina at 25°C has been informed to be pH of 9.1 (Park and Jaffe, 1993; Sun and Jaffe, 1996). At a solution pH below the PZC, the alumina surface is positively charged. On the contrary, at a solution pH above the PZC, the alumina surface is negatively charged. Alumina has been extensively studied as a positively charged adsorbed for anionic surfactants and mixed anionic and nonionic surfactants (Scamehorn et

al., 1982(b); Lopata, 1988). Moreover, alumina has been studied as a negatively charged adsorbent for cationic surfactants at solution of 10 with 0.03 M NaCl as ionic strength (Fan et al., 1997).

2.3 Adsorption of Ionic Surfactants onto Solid Oxide Surface

Adsorption of surfactants onto solid surface is recently well-known technique used in commercial applications and environmental remediation. Detergency, surfactant-modified adsorbents, surfactant-based separation processes, and surfactant-enhanced subsurface remediation are the examples of applications (Thakulsukanant et al., 1997; Luciani et al., 2001; Karapanagioti et al., 2005). Thus, the adsorption fundamental phenomenon should be recognized for understanding surfactant behavior. Because of different adsorption mechanisms namely ion exchange, ion pairing, and hydrophobic bonding, the surfactant adsorption onto solid oxide surfaces such as alumina is a complex process. The adsorption of surfactants has been extensively studied both anionic surfactants onto positively charged surfaces (Scamehorn et al., 1982(a); Harwell et al., 1985) and cationic surfactants onto negatively charged surfaces (Monticone and Treiner, 1994; Goloub and Koopal, 1997; Atkin et al., 2003). The adsorption isotherm, which experimented about the aqueous surfactant concentration and surfactant adsorption onto a solid surface at constant temperature, are used for identifying the adsorption (Kitiyanan, et al., 1996).

Equation 2.1 can be used to calculate the equilibrium adsorption of the surfactant on the solid oxide surface. This equation is assumed that it neglects the adsorption of water or salt and the adsorption of the surfactant have no effect on solution density (Lopata, 1988).

$$\Gamma_i = \frac{(C_{i,b} - C_{i,a})V}{W_g} \quad (2.1)$$

where:

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

V = Volume of sample (liter)

$C_{i,a}$ = Concentration of surfactant at equilibrium (molar)

$C_{i,b}$ = Concentration of surfactant at initial (molar)

W_g = Weight of aluminum oxide (g)

The adsorption isotherm of ionic surfactants on oxide surfaces is typically an elongated 'S'-shaped curve that can be separated into four regions (Somasudaran and Fuerstenau, 1966; Scamehorn, et al., 1982(a)). Figure 2.3 shows these four regions in the plot between the log of the adsorbed surfactant density versus the log of the equilibrium concentration of surfactant.

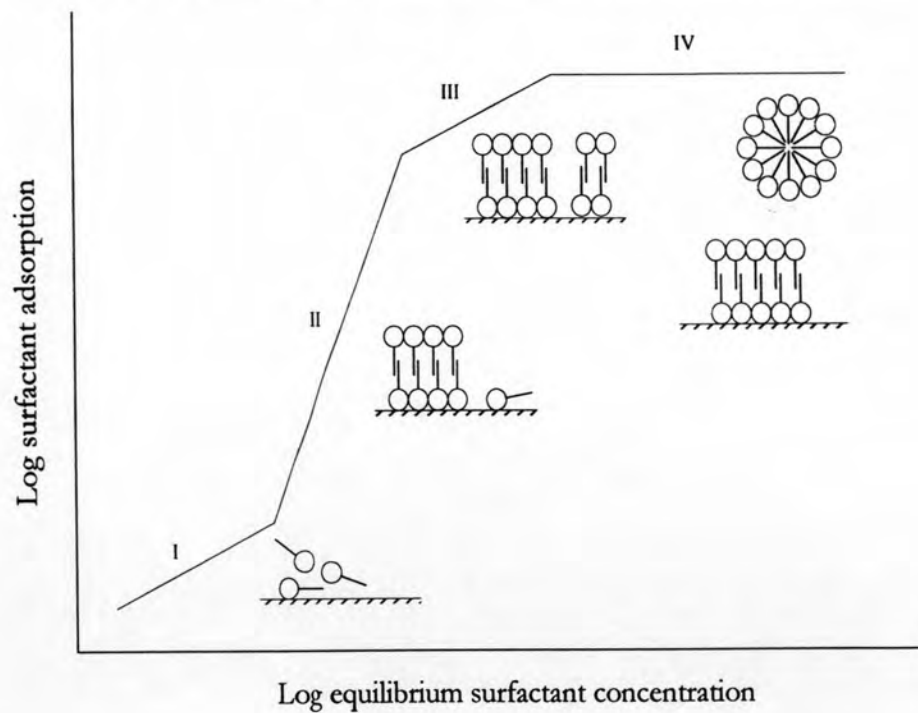


Figure 2.3 Schematic presentation of typical surfactant adsorption isotherm

Region I corresponds to both very low concentration and thus low adsorption of surfactant.

This region is referred to as the Henry's law region because surfactant monomers are infinitely diluted in the surface phase and they do not interact with one another. Thus, the interaction between molecules of surfactants is negligible. Adsorbed surfactants in this region are viewed as being adsorbed alone and not forming any aggregates. For nonionic surfactants and ionic surfactants with some added electrolyte, the slope of the isotherm is one in this region. For ionic surfactants with no added electrolyte, the slope of the isotherm may be less than one (O'Haver et al., 1992).

Region II is isolated by a sharply increased isotherm slope relative to the slope in region I.

This increase in slope indicates the beginning of lateral interactions between surfactant molecules, which results in the aggregation on the most energetic surface patches. When the concentration of surfactants is below the CMC, the adsorbed surfactants form admicelles or hemimicelles, depending upon whether the aggregates are viewed as one or two surfactant layers. The admicelle is considered as a bilayer structure that consists of a lower layer of head groups adsorbed on the substrate surface and an upper layer of head groups in contact with solution. The hemimicelle is a monolayer structure having the head group adsorbed on the solid phase and the tail group touching the aqueous phase. The transition point from region I to region II, representing the first formation of adsorbed surfactant aggregates, is called the critical admicelle concentration (CAC), the hemimicelle concentration (HMC) or the critical hemimicelle concentration (CHMC) (Bitting and Harwell, 1987). There had been the study that showed when a hemimicelle formed, the charge of the surfactant headgroups in the admicelles must be virtually cancelled by a combination of the countercharge on the surface and the charge from counterions inside the diffuse layer. Moreover, it concluded that the hydrophobic contribution to the decrease in the free energy of the system on the formation of the second layer is not large enough to assure that admicelle will be lower energy structure than hemimicelle (Harwell and Yeskie, 1989).

Region III is the region that has the isotherm decreasing from the slope in Region II. This decrease in slope is caused by the beginning of admicelle formation on lower energy surface patches or by the distribution of patch adsorption energies. In addition, the decrease is believed to arise from the interface because of a change in the sign of the surface charge (Bitting and Harwell, 1987). The adsorption now must overcome electrostatic repulsion between closed ions and the similarly charged solid surface. Sometimes it is proposed that a second layer on the adsorbed aggregates does not begin to form until region III including that both the microviscosity and the polarity of the aggregate is constant from region I/II transition through region III (O'Haver et al., 1992).

Region IV is the plateau region that has almost constant surfactant adsorption, while the surfactant concentration increases. Adsorption is independent of concentration. The transition point from region III to region IV, representing the first formation of micelles after the interface is saturated by admicelles, corresponds to the critical micelle concentration (CMC). In some cases, the Region III/Region IV transition point can be reached when the surface of the adsorbent that is completely filled with the adsorbed surfactants (Scamehorn et al., 1982(a); Kitiyanan, et al., 1996; Charoensaeng, 2003).

2.3.1 Surface Tension and Calculation of Surface Concentrations and Area Per Molecule at the Interface Using the Gibbs Equation

Surface tension, or excess surface free energy, is equivalent to a force per unit length or a Gibbs (free) energy per unit area. The surface tension is the parameter that indicates the interaction forces between molecules in the surface region and neighbors. The magnitude of surface tension depends on the cohesive energy density of molecules. Hydrocarbon liquids have lower surface tensions than polar liquids like water because the energies of interaction

in liquid hydrocarbons are weaker (Van der Waal attraction compared to hydrogen bonding).

Table 2.1 is the examples of some surface tensions.

Table 2.1 The examples of some surface tensions at 20°C

Hg	486.5 mN/m
H ₂ O	73.0 mN/m
Benzene	28.9 mN/m
Heptane	20.1 mN/m
Perfluoroheptane	13.2 mN/m

For surface-active solutes, the surface excess concentration, Γ can be considered to be equal to the actual surface concentration without significant error. Therefore, the concentration of surfactant at the interface may be calculated from surface or interfacial tension data by use of the appropriate Gibbs equation. Gibbs equation has been applied to aqueous surfactant solution at constant temperature below CMC (Equation 2.2 and 2.3).

For 1:1 ionic surfactant in the presence of a swamping amount of electrolyte containing a common nonsurfactant ion,

$$\Gamma = -\frac{1}{2.303RT} \left(\frac{\partial \gamma}{\partial \log C_1} \right)_T \quad (2.2)$$

For 1:1 ionic surfactant in the absence of any other solutes,

$$\Gamma = -\frac{1}{4.606RT} \left(\frac{\partial \gamma}{\partial \log C_1} \right)_T \quad (2.3)$$

where;

γ = Interfacial tension (N/m)

R = 8.314 (J mol⁻¹ K⁻¹)

T = 298 (K) at 25°C

C₁ = Surfactant concentration (molar)

The area per molecule at the interface provides information on the degree of packing and the orientation of the adsorbed surfactant molecule when compare with the dimensions of the molecule as obtained by use of molecular models. From the surface excess concentration, the area per molecule at the interface a_1^s , in square angstroms is calculated from the equation 2.4,

$$a_1^s = \frac{10^{23}}{N\Gamma_1} \quad (2.4)$$

where;

N = Avogado's number (6.023×10^{23})

Γ = Surfactant adsorption ($\text{mol}/1000\text{m}^2$)

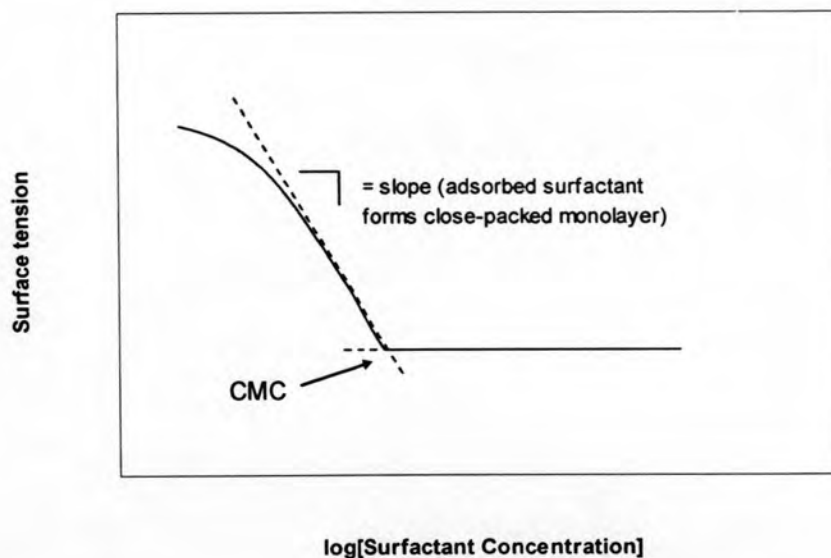


Figure 2.4 Plot of surface tension versus log of the bulk phase concentration for an aqueous solution of a surfactant

From Figure 2.4, the CMCs of surfactants can be evaluated as break point that surface tension turning into the plateau region as minimum surface tension (Rosen, 1989; Harwell, 2006).

2.3.2 Parameters affecting surfactant adsorption

There are a number of parameters involving the adsorption of surfactants on solid surfaces from aqueous solution, for example, the nature of the structural groups of the solid surface, the molecular structure of surfactant adsorbed on the solid surfaces. Not only these two parameters, but also the environment of the aqueous solution influences the mechanism, the efficiency and effectiveness of surfactant adsorption.

In this study, the nature of the structural group of aluminum oxide surface has already been stated in Chapter 2.2. The other parameters as the environment of aqueous solution are equilibrium pH, temperature, and electrolyte type and concentration (Esumi et al., 1996).

2.3.1.1 Equilibrium pH

pH causes significantly changes in the adsorption of ionic surfactants onto charged solid surface because the amount of protons or hydroxyl ions adsorbing on charged site depends on pH of solution (Harwell et al., 1985). As the pH of the aqueous solution is lowered, a solid surface will usually turn into more positive, or less negative, because of adsorption of additional protons from the solution. Consequently, the adsorption of anionic surfactants increases, whereas the adsorption of cationic surfactants decreases. The reverse is true when the pH of the aqueous solution is raised, a solid surface also turn into more negative, or less positive. Equilibrium pH is usually higher than the initial pH of solution after anionic surfactants adsorb onto alumina surface because the anionic surfactants exchange the ions with the adsorbed counter ions and hydroxyl ions on the alumina surface. Thus, the equilibrium pH and the surfactant adsorption are directly related together.

2.3.1.2 Temperature

A rise in temperature generally results in the efficiency and effectiveness of adsorption of ionic surfactants decrease, by relatively small effects compared to that caused by pH change. However, temperature increase usually causes an increase in the adsorption of nonionic surfactants containing a polyelectrolyte chain as the hydrophilic group. This has been consequently attributed to decrease solute-solvent interaction.

2.3.1.3 Electrolyte type and concentration

Counter ions can influence the adsorbed surfactants because they reduce the electrostatic repulsion between the adsorbed ionic surfactant head groups. Because the repulsion between ionic surfactant is lower when counter ions are present in the system, the admicelles form more easily. Admicelles patches with complete bilayer coverage are also capable of larger aggregation numbers of surfactant molecules because of the reduced electrostatic repulsion. The higher the counter-ion concentration, the more easily admicelles are formed. The maximum surfactant adsorption also increases (Lopata, 1988; Charoensaeng, 2003).

Moreover, the type of counter ions is also important because the charge of the counter ions and the hydrated radius of the counter ions can indicate the magnitude of charge that can be placed between the adsorbed surfactant head groups. Counter ions with a small hydrated radius can easily fit between the surfactant head groups. It has been reported that in order of increasing size of the crystal radius of the counter ions is the reverse of in order of increasing size of the hydrated radius. The counter ions that has the largest crystal radius, also has the smallest hydrated radius. Consequently, it can easily fit between the ionic surfactant head groups (Bitting and Harwell, 1987).

2.4 Solubilization and Adsolubilization of Organic Solutes

The partition of organic solutes from aqueous solution will be soluble in the hydrophobic portion or the core, depending on whether they are adsorbed on micelles or admicelles.

Adsolubilization is phenomenon that the organic solutes are adsorbed on admicelles (surfactant bilayer). Similarly, solubilization is phenomenon that the organic solutes are adsorbed on micelles.

Figure 2.5 shows the phenomena of solubilization and adsolubilization.

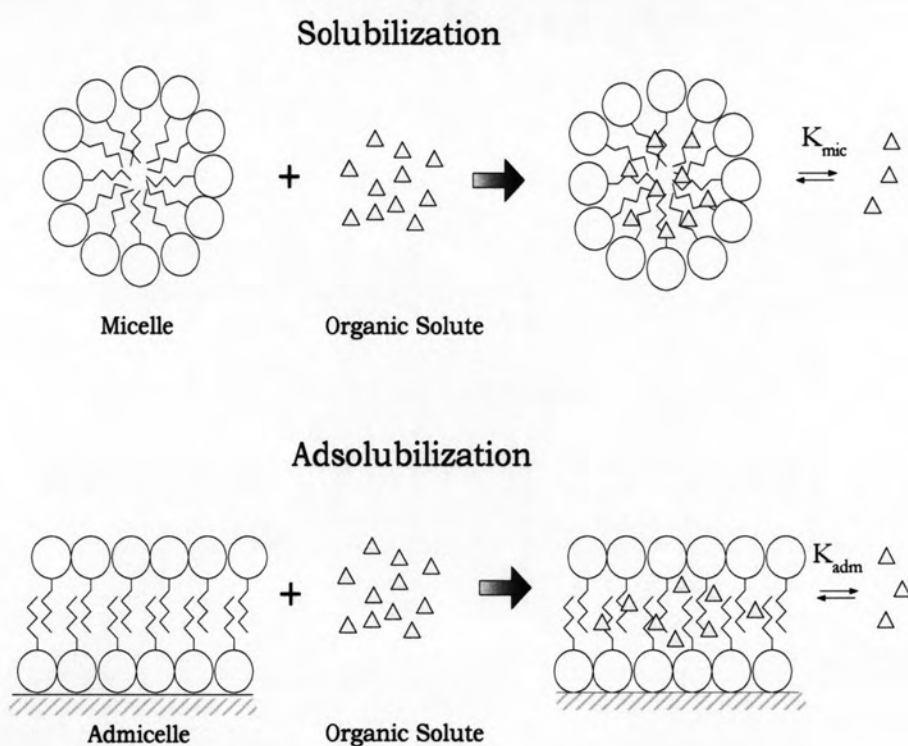


Figure 2.5 Phenomena of solubilization and adsolubilization

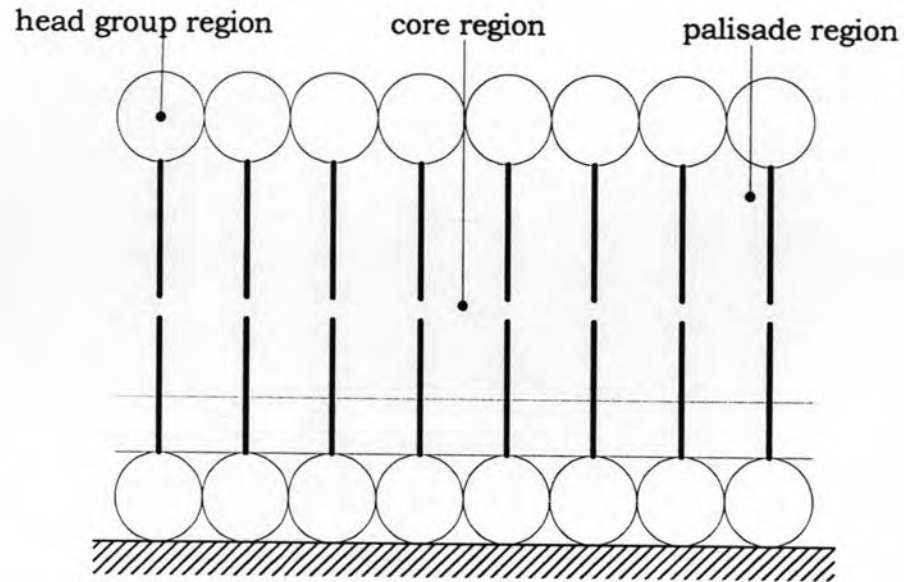


Figure 2.6 The bilayer structure of surfactant admicelles at the solid-liquid interface

Figure 2.6 shows that the admicelle which has the bilayer structure is divided into three- regions similar to a micelle. The outer region is the most polar or ionic region because it is comprised of the surfactant head group. The inner region or the **core region** is non-polar region because it is comprised of the hydrocarbon chain of surfactant tail groups. The **palisade region** has intermediate polarity because it is the region between surfactant head groups and the core region (Nayyar et al.,1994; Dickson and O'Haver, 2002). The partition of various organic solutes into the admicelles can be described by admicellar partition coefficient as shown in equation 2.5 (Nayyar et al., 1994);

$$K_{adm} = \frac{X_{adm}}{X_{aq}} \quad (2.5)$$

where;

X_{adm} = The mole fraction of organic solute in the admicelle phase

X_{aq} = The mole fraction of organic solute in the aqueous phase

For this study, X_{adm} values are calculated as:

$$X_{adm} = \frac{(C_{i,S} - C_{f,S})}{(C_{i,S} - C_{f,S}) + (S_i - S_f)} \quad (2.6)$$

where;

X_{adm}	=	Mole fraction of organic solute in admicelle
$C_{i,S}$	=	Initial concentration of organic solute (molar)
$C_{f,S}$	=	Final concentration of organic solute (molar)
S_i	=	Initial concentration of surfactant (molar)
S_f	=	Final concentration of surfactant (molar)

and,

$$X_{aq} = \frac{C_{f,s}}{C_{f,s} + 55.55} \quad (2.7)$$

where;

55.55 represent 1/molar volume of water

The adsolubilization has been applied in very different areas such as pharmacy, cosmetic, soil remediation, wastewater treatment, ultra thin film formation. In addition, the adsolubilization has been used as the important phenomenon in many processes, for example, admicellar polymerization, and admicellar chromatography (Esumi et al., 1998; Merino et al., 2003).

2.5 Polymerizable Surfactants

Polymerizable surfactants, which are categorized as reactive surfactants, are molecules having hydrophilic and hydrophobic parts together with a polymerizable group such as double bond and a vinyl group in their structure. Polymerizable surfactants have a characteristic property of forming micelles in water in the same manner as conventional surfactants. It means that they can form micelles above a certain concentration, the so-called critical micelle concentration(CMC), similar to the other surfactants. Recently the polymerizable surfactants are of interest in consequence of a number of potential technological advantages due to their surface activity and polymerizability for example polymer emulsions and particulate encapsulation.

Some polymerizable surfactants can spontaneously polymerize at 35-80°C, even at room temperature in water (or non-polar solvent) without initiator when the surfactants form micelles. On the contrary, some vinyl monomers, such as styrene, would polymerize spontaneously on heating above 100°C by removing polymerization inhibitors as impurities and dissolved oxygen in the monomers. Besides, the polymerizability of polymerizable surfactants depends on monomer concentration below and above their CMC because micellization of the monomer accelerated the polymerization (Yasuda, 1999). Among other parameters, polymerizable surfactant composition and molecular structure play an extremely important role in the polymerization processes (Summers and Eastoe, 2003).

One of the problems of using surfactant modified adsorbent is the loss of surfactant from the surface during application. A previous column study showed that surfactant loss occurred when the solution pH contacting with admicelles changed (Krajangpan, 2004). Heating, difference of pH, and dilution of the surfactant concentration make the equilibrium shift and the surfactant desorb from the adsorbent surface (Esumi, et al., 1993).

Recently, there have been many studies on polymerizable surfactant. Polymerizable surfactant is a surfactant that can be polymerized at the double bond in the molecule (Esumi et al., 1989 and 1991; Berg and Claesson, 1994; Hirai et al., 2000). Polymerization of the surfactant can enhance dispersion stability of the alumina with the polymerized film (Esumi, et al., 1989 and 1991). Thus, it reduces the desorption of the surfactant from the alumina surface.

2.6 Dispersion Stability and Surface Modification by Polymerizable Surfactants

When ionic surfactants adsorb onto solid oxide particles, the dispersion stability of the particles depended on the surfactant concentration. The particles without surfactant aggregate have

high dispersion stability. When low concentration of surfactants is added to the particle, the stability of dispersed particle decreases, but it becomes high at high surfactant concentration. This is called "dispersion-flocculation-redispersion". As mentioned, when the ionic surfactants are added to oppositely charged adsorbent, a bilayer of the surfactant is formed on the adsorbent. In this bilayer, the interaction between the first and the second layer is the hydrophobic forces, so that the outer layer desorbs easily by dilution. There is a possibility to fix the bilayer by polymerization using polymerizable surfactant because polymerization resulted in a stabilization of the aggregate structure that the surfactants themselves form (Berg and Claesson, 1994; Esumi, 2001). Therefore, they are more difficult to compress and push out from the surfaces. This is supported by the double layer force measured after polymerization being larger than that measured before polymerization.

2.7 Admicellar Polymerization and Ultrathin Polymer Film

The thin film via surfactant template (TFST) technique is the technique that combine admicellar polymerization with an already-formed template nanoscale polymer patterns (Esumi et al., 1990; Glatzhofer et al., 1993; Funkhouse et al., 1995). This TFST method has potential for the formation of anticorrosion and lubricating coating. In addition, this technique can produce the composite materials that may be valuable for use as pigments, suspension aids, and chromatographic packings.

The three-step process for the formation of ultrathin polymer films has been reported in recent years. In the first step, aggregates of surfactant molecules are formed on the solid substrates as admicelles (or hemimicelles). These surfactants aggregates can be formed under appropriate system conditions leading adsorption behavior in such a way as to bring about bilayer coverage of the entire surface with surfactant. In the second step of the process, a polymerizable monomers with

low water solubility is allowed to partition into admicelles(adsolubilization). In the third step, polymerization on the solid surface by chemical, thermal, or photochemical processes is initiated. An optional washing step can be added to leave a thin polymer coating for some application (Wu et al., 1987 a and b; Glatzhofer et al., 1993; O'Haver et al., 1994; Sakhalkar and Hirt, 1995; Yuan et al., 2002; Nontasorn et al., 2005; Yasuda, 1999). In this study, adsorbed polymerizable surfactants onto solid surfaces have been polymerized without adsolubilization of polymerizable monomers because the surfactants used for polymerization have been polymerizable surfactants and can be polymerized by themselves without the other polymerizable monomers. In addition, the modified adsorbent will be ready for many applications, and it can be prepared in a large quantity for industrial scale application.

2.8 Literature Reviews

It is well known that the bilayer of the surfactants is formed on the particles when surfactants are adsorbed on particles that have the opposite charge of the surfactant. In this bilayer, the interaction between the first and second layer is attributed to hydrophobic forces of the surfactants which results from the monomer concentration in solution. Upon dilution, the reduced monomer concentration can easily break up the bilayer, through desorption.

In recent years, there have been studies that focus on the polymerizable surfactant. For example, after sodium 10-undecenoate had been shown to adsorb onto alumina, polymerization was carried out by UV irradiation or free radical initiator in the bilayer of the surfactant on alumina surface.

In 1989, Esumi et. al. studied the polymerization of polymerizable surfactant bilayer on alumina surface. A bilayer of sodium 10-undecenoate was formed on the positively charge alumina surface. Then, this bilayer was polymerized by UV irradiation. As a result, the dispersion stability of

alumina coated with polymerized film was enhanced (Esumi et al., 1989). After that, they studied the adsolubilization of styrene in a bilayer of sodium 10-undecenoate on alumina and its subsequent polymerization by UV irradiation in 1991. Subsequent polymerization in the presence of an initiator enhanced dispersion stability of alumina compared with the polymerization of surfactant bilayer alone. In addition, the physicochemical properties of alumina were characterized before and after polymerization (Esumi et al., 1991).

Following upon their previous work, Esumi et. al. studied another polymerizable surfactant in 1993. They could polymerize ammonium 31-(p-nonyl benzoxymethyl)-3,6,9,12,15,18,21,24,27,30,32-undeca-oxa-penta-triacont-34-eno-1-yl sulfate or SE-10N onto alumina surface by UV irradiation. This polymerized film adsorbed strongly on the surface and was not desorbed even after the washing process (Esumi et al., 1993).

In 1994, Berg and Claesson studied about forces between surface coated with a polymerizable surfactants before and after polymerization. They reported that the forces measured can indicate the stability of cationic polymerizable surfactant, cetyl p-vinylbenzyl dimethyl ammonium chloride (CVDAC) adsorbed onto muscovite mica both before and after partial UV irradiation. The results show that when the bilayer structure is polymerized, it is stabilized with respect to both mechanical forces and dilution of surrounding solution (Berg and Claesson, 1994).

In our previous studies, we used mixture of anionic and cationic surfactants with single and twin head groups of surfactants adsorbed onto alumina and silica surfaces. We found that the solubilization and adsolubilization capacity of organic solutes in micelles and admicelles are enhanced by using mixtures of anionic and cationic surfactants. In addition, the solubilization capacity depended on the molecular structure of the surfactant and the ratio of the mixture of anionic

and cationic surfactant in micelles and admicelles (Charoensaeng, 2003; Fuangswasdi et al., 2006a and b).

Moreover, in term of the application for subsurface remediation, the adsorbent coated with the surfactant can be contacted with the different pH of solution, causing the surfactant to be desorbed from the adsorbent surface (Krajangpan, 2004).

The purposes of this study are to evaluate stability of the surfactant adsorbed on the alumina coated with polymerized film of polymerizable surfactants related with the desorption of the surfactant, to compare the surfactant adsorption and the organic solute adsolubilization capacity with and without polymerization of surfactant, and to examine the effect of polarity of organic solutes on the adsolubilization capacity with the goal to enhance the ability of surfactant modified adsorbent for environmental remediation.

2.9 Scopes of the Study:

This research intends to improve the ability of modified adsorbent material for reducing surfactant loss by surfactant polymerization. The adsorption of surfactant and the adsolubilization of organic solutes were conducted in batch experiments at room temperature ($25 \pm 2^\circ\text{C}$), constant pH solution in the range of 6.5-7.5, and electrolyte concentration of 0.001 M NaCl. The adsolubilization of organic solutes, styrene and ethylcyclohexane were conducted to evaluate the adsolubilization capacity of organic solutes with different degree of polarity in admicelles.