Determination of Critical Micelle Concentration of Mixed Solution of Zwitterionic-Nonionic Surfactants

Mizani Izni binti Abdul Muthalib

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Supervisor: Miss Azaima Razali

Resources Chemistry

Department of Chemistry

Faculty of Resource Science and Technology

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1. Alkylphenol Hydroxypolyethylene (Triton X-100)
2. Critical Micelles Concentration (CMC)
3. Hydrophile-lipophile balance (HLB)
4. Polyoxyethylene Lauryl Ether (Brij 35)
5. Sodium Chloride (NaCl)
6. Sodium Dihydrogen Phosphate Monohydrate ($NaH_2PO_4.H_2O$)
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Mizani Izni binti Abdul Muthalib

Resource Chemistry Programme
Faculty of Science and Technology
Universiti Malaysia Sarawak

ABSTRACT

Critical micelle concentration (CMC) of zwitterionic surfactant, 3-(*N,N*-Dimethylmyristylammonio) propanesulfonate (TDAPS) with two types of nonionic surfactant which are Brij 35 and Triton X-100 have been determined. The aggregation behavior in mixed system of nonionic-zwitterionic surfactant solution was also studied in this research. Then, the CMC from single and mixed nonionic-zwitterionic surfactant system were compared. Besides, the effect of different concentration of salt solution, sodium chloride (NaCl) to the CMC of mixed nonionic-zwitterionic surfactant solutions was also determined. Determination of the CMC value has been performed in aqueous phosphate buffer at pH 7.0. From this research, we can conclude that mixed surfactant solution system has a better performance compare to single surfactant and addition of sodium chloride lowered the CMC value of the mixed nonionic-zwitterionic surfactant solution system. UV spectrophotometer was used to check the CMC of single TDAPS, Brij 35 and Triton X-100 and their mixture. The theory of "Beer's law" has been used to plot at a wavelength of maximum absorbance versus surfactant concentration.

Keywords: Critical Micelle Concentration (CMC), Surfactant, Spectrophotometer, Mixed Surfactant, Pyrene

ABSTRAK

Kepekatan misel gentian (CMC) pada surfaktan zwiterionik, 3-(N,N-Dimethylmyristylammonio) propanesulfonate (TDAPS) dengan dua jenis surfaktan bukan ionik yang terdiri daripada Brij 35 dan Triton X-100 telah ditentukan. Sifat penggumpulan dalam sistem campuran antara surfaktan bukan ionic dengan surfaktan zwiterionik turut dijalankan dalam kajian ini. Kemudiannya, CMC daripada sistem satu surfaktan dan sistem campuran surfaktan bukan ionik dan zwiterionik dibandingkan. Selain itu, kesan larutan garam sodium chloride (NaCl) yang berbeza kepekatan terhadap CMC larutan campuran surfaktan bukan ionik dan zwiterionik turut ditentukan. Penentuan nilai CMC telah dijalankan di dalam larutan buffer fosfat pada pH 7.0. Daripada kajian yang telah dijalankan, dapat disimpulkan bahawa sistem campuran larutan surfaktan adalah lebih baik berbanding surfaktan tunggal dan penambahan sodium chloride merendahkan nilai CMC bagi sistem campuran larutan bukan ionic dan zwiterionik. Spektrofotometer UV telah digunakan untuk menentukan CMC bagi larutan tunggal TDAPS, Brij 35 dan Triton X-100 serta campuran bagi larutan-larutan tersebut. Dalam pembelajaran ini, teori "Beer's law" telah digunakan untuk memplotkan nilai penyerapan maksima gelombang melawan kepekatan surfaktan.

Kata kunci: Kepekatan Misel Gentian (CMC), Surfaktan, Spektrofotometer, Campuran Surfaktan, Pyrene

1.0 INTRODUCTION

As a developing country Malaysia has contributed to the major wastewater problems. Industrial wastewater effluents from different industries such as manufacturing, and processing pose effects of our environment and ecosystems. Some of this problem is due to the presence of chemical substance which is called surfactant in water that has been used by human in daily life. Surfactants are organic substances, which significantly decrease the surface tension of water at relatively low concentrations and are at least partially water soluble (Gupta *et al.*, 2003). Surfactants are the organic chemical used in high volumes in detergents, personal care and household cleaning products (Hosseinnia *et al.*, 2006). They are used in various industrial applications such as textile, detergents, fibers, food, paints, polymers, cosmetics, pharmaceuticals, paper, and mining and pulp industries (Vergili *et al.*, 2010).

Surfactant is the major components that have been used in high volume in developed countries. The use of surfactants throughout the world is increasing at a rate in excess of the population growth because of generally improved living conditions and processed material availability in the less industrially developed countries of the third world. The increasing demand of surfactant since the middle of this century is causing a great concern about its role in the environmental pollution (Hosseinnia *et al.*, 2006). Therefore, the quality of human lives and health is related to the availability and safe use of surfactants in the surrounding.

Moreover, surfactants are widely used and are found in a very large number of applications especially in chemical industries. It is because of their remarkable ability to influence the properties of surfaces and interfaces (Schramm *et al.*, 2000). Surfactant which is also called surface active chemical agent tends to accumulate at a surface or interface. An interface is the area of contact between two substances. Where the interface is between two substances not in the same phase, the interface is usually called a surface (Perkins *et al.*, 1998). Surface active agents interfere with the ability of the molecules of a substance to interact with one another and, thereby, lower the surface tension of the substance. Surfactants used in industrial applications usually cause a dramatic decrease in surface tension when used at low concentration (Perkins *et al.*, 1998).

Surfactants are adsorbed mainly on the surface of the solution, creating a thin monolayer. When dissolving them, after they reach a certain value of concentration, molecules or ions of surfactants begin to associate and to organize themselves into more complex units called micelles. The characteristic concentration value, where the association process begins, is called the critical micelle concentration (CMC) (Ghosh *et al.*, 2003). Determination of CMC is generally based on the localization of the position of a breaking point in the concentration dependencies of selected physical or chemical properties of surfactant solutions (Ghosh *et al.*, 2003).

In Malaysia, the most application of the surfactants are used in petroleum industry and also, there is more than one type of surfactants which are added in the preparation of various products. However, some of the surfactant which is available on the market today was too expensive and it will contribute to increase the cost of the product prepared by this surfactant for consumers used. Most of the available industries application was used more than one types of surfactant for the production of various products for the consumer, it is because the uses of the mixture surfactant will reduce the cost of the product and also, the ability of the mixture surfactant function will be increased. Based on Fan *et al.* (2006), there are mixtures of different types of surfactants used in many applications of industry because the solution behaviours of these surfactants can be complementary and found to yield better performance than a single surfactant.

In this research, the CMC of two nonionic surfactants, Brij 35 and Triton X-100 and one zwitterionic surfactant, TDAPS were determined. Also, the CMC of mixed surfactants were determined in order to compare the CMC between single surfactant with the mixed surfactants system. The CMC was studied in this research because of the improved performance of mixture surfactants is predicted due to the formation of CMC. The CMC value of the selected surfactant which is used in this research will be determined in phosphate buffer as a solvent solution. The surfactants that will be used in this experimentation are Brij 35, Triton X-100 and TDAPS.

The objectives of this research are:

(i) To determine the CMC of single nonionic surfactant (Brij 35 and Triton X-100) and zwitterionic surfactant, TDAPS.

(ii) To determine the CMC of mixed surfactants (TDAPS+Brij 35 and TDAPS+Triton X-100)

(iii) To compare the CMC of single surfactants and mixed surfactants.

(iv) To measure the effect of added salt (NaCl) to the mixed surfactants.

2.0 LITERATURE REVIEW

2.1 Surfactant

A surfactant is a chemical that stabilizes mixtures of oil and water by reducing the surface tension at the interface between the oil and water molecules (Salager, 2002). Surfactants contain both strong hydrophobic and hydrophilic moieties (Gupta *et al.*, 2003; Purakayastha *et al.*, 2002). Hydrophobic molecules have a long hydrocarbon radical of carbon atoms while, hydrophilic may or may not ionize depending on the type of surfactant. Beside that, surfactants lower the surface tension of the medium in which it is dissolved, such as air and water, water and stain or between stain and fabric. Also, it has the ability to remove dirt from surfaces such as the human skin, textiles, and other solids (Zhang *et al.*, 2005).

Apart from that, surfactants also called surface active agent is a substance which exhibits some superficial and interfacial activity (Maisuria, 2009). It is known that surfactants are amphipathic molecules which are it consists of two distinctly different characteristics, polar and nonpolar in different parts of the same molecules (Odeh, 2006). Therefore, all amhiphiles do not display such activity, in effect, only the amphiphiles with more or less equilibrated hydrophilic and lipophilic tendencies are likely to migrate to the surface or interface (Salager, 2002).

The surface tension or interfacial tension if the interface is not a surface determines the tendency for surfaces to establish contact with one another. Therefore, surface tension is responsible for the shape of a droplet of liquid. If the surface tension is high, the molecules in the liquid are greatly attracted to one another and not so much to the surrounding air. Surface active agents interfere with the ability of the molecules of a substance to interact with one another and thereby, lower the surface tension of the substance (Salager, 2002).

Hydrophilic molecules in surfactants are composed of ions, polar groups and also non-polar groups consist of electronegative atoms (Farn, 2006). These molecules associate with the hydrogen bonding network in water. Therefore, to classifying the surfactants into such group it is depend on the composition of hydrophilic groups. Surfactants are split into groups depending upon the nature of their hydrophilic head groups (Hargreaves, 2003). Apart from that, surfactants are classified according to their use and many surfactants have several uses as it is very useful compounds.

There are surfactants which carry negative head called anionic, cationic surfactant carry positive head, nonionic is surfactant without any charge in their head, amphoteric or we called it as zwitterionic have both negative and positive head (Hosseinnia *et al.*, 2006). Examples of surfactant are sodium dodecyl sulphate (SDS) which is anionic surfactant, tetradecyl trimethyl ammonium bromide (TTAB) which is cationic surfactant, alkylphenol hydroxypolyethylene (Triton X-100) which is nonionic surfactant and tetradecyl ammonia propane sulfonate (TDAPS) is example of zwitterionic surfactant.

2.1.1 Anionic Surfactant

Anionic surfactants have hydrophilic head groups which carry a negative charge. The negative charge is countered by a positive ion, called the counter ion, which is usually a sodium ion but sometimes potassium or ammonium (Hargreaves, 2003). Anionic are classified according to the polar group. There are some classes of the anionic surfactants which are sulphonates, sulfates, phosphate esters, carboxylates, and soaps. Anionic surfactants account for about 50% of the world production (Salager, 2002). They are the most commonly used surfactants due to their properties.

Anionic surfactants have the ability to emulsify oily soils into wash solutions and can lift soils such as particulate from the surface (Salager, 2002). This is due to the negative charged head group of anionic surfactants is repelled from most surfaces, which tend to be slightly negatively charged the reverse action to a cationic surfactant, where the positively charged head group is adsorbed onto a surface, giving an antistatic and conditioning effect (Farn, 2006). Anionic surfactants are the most common and inexpensive surfactant. This surfactant are sold as alkali metal salts or ammonium salts and mainly used in detergent formulations and personal care products (Farn, 2006).

2.1.2 Cationic Surfactant

Cationic surfactants are carries a positive charge on its hydrophilic head group. It will react with chemical groups with counter ions to form stable compounds; therefore it is capable of disrupting biological systems (Salager, 2002). Cationic surfactants also dissociate in water into a negatively charged ion and a positively charged ion and the hydrophilic head is positively charged. Due to this property of cationic surfactants, it is strongly adsorb onto negatively charged surfaces such as fabric, hair and cell membrane of bacteria (Farn, 2006). Cationic surfactants are used as fabric softeners, hair conditioners and antibacterial agents (Farn, 2006). Also, they are used in textile manufacturing to delay dye adsorption (Salager, 2002).

When the cationic surfactants attracted to an anionic surfactant molecule it produce both hydrophiles bond together (Salager, 2002). The reactivity of surfactants will lose and will form a large molecule that is all lipophile. It is more expensive than anionic surfactant, because of the high pressure hydrogenation reaction to be carried out during their synthesis. Also, only small parts of the original raw material end up as the desired product (Hargreaves, 2003).

There are widely uses of quaternary ammonium compounds, QAC in industries such as tetradecyl trimethyl ammonium bromide, TTMA, ethonium, and benzyl diisobutyl phenoxyetoxy-etoxydimethyl ammonium chloride. These surfactants found in the sewage waters of such industries as oil, petrochemicals, gas, chemicals, fertilizers and automobiles (Ostroumov, 2006).

2.1.3 Nonionic Surfactant

Nonionic surfactants are surface active agents which do not dissociate into ions in aqueous solutions, unlike anionic surfactants which have a negative charge and cationic surfactants which have a positive charge in aqueous solution. Nonionic surfactant does not ionizes in aqueous solution. It is because of their hydrophilic group is of a nondissociable type for example alcohol, phenol, ether, ester or amide (Hargreaves, 2003). Therefore, for nonionic detergents the CMC is relatively unaffected by ionic strength, but increases significantly with higher temperature.

Nonionic surfactants are more widely used as detergents than ionic surfactants because anionic surfactants are insoluble in many hard water and cationic surfactants are considered to be poor cleaners. In addition to detergency, nonionic surfactants show excellent solvency, low foam properties and chemical stability (Farn, 2006). 45% of the overall industrial productions are consisting of nonionic surfactant (Salager, 2002). Non-ionic surfactants are commonly used in the formulation of emulsifier, dispersant and low temperature detergents (Farn, 2006). Nonionic has excellent emulsifying properties and wide variety of different molecular structures. It can be manufactured from a wide range based on their renewable resources.

The hydrophilic group of nonionic surfactants is a polymerized alkene oxide, water soluble polyether with 10 to 100 units length typically (Farn, 2006). They are prepared by polymerization of ethylene oxide, propylene oxide, and butylene oxide in the same molecule. Depending on the ratio and order of oxide addition, together with the number of carbon atoms which vary the chemical and physical properties, nonionic surfactant is used as a wetting agent, a detergent or an emulsifier (Ostroumov, 2006).

2.1.3.1 Alkylphenol Hydroxypolyethylene (Triton X-100)

Triton X-100 (alkylphenol hydroxypolyethylene) is a commercial name for oxyethylated alkyl phenol ether and the molecular weight of this surfactant is 624.9 (Ostroumov, 2006). The molecular formula of Triton X is $C_{14}H_{22}O\ (C_2H_4O)_n$. The range of n value is 9 to 10. The structure of Triton X-100 is:

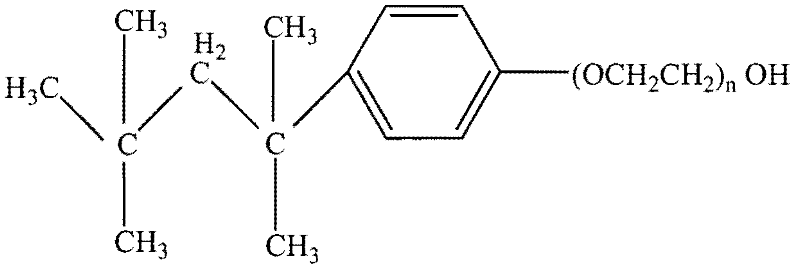

Figure 2: Structure of Triton X-100

Triton X-100 can be used in every type of liquid, paste, and powdered cleaning compound. Triton X-100 is a colourless transparent viscous fluid and it properties; dissolves in hard and soft water, ethanol, benzene, CMC value of 0.24-0.9 mmol/L; aggregation number, 140; mean micellar weight, 90000 the fractions with different boiling temperature have different micellar weights (Ostroumov, 2006).

According to Zhu *et al.*, it is predicted the CMC of Triton X-100 is 0.2-0.3 mM. Triton X-100 can be found in several types of cleaning compound, ranging from heavy-duty industrial products to gentle detergents. It is also a popular ingredient in homemade vinyl record cleaning fluids together with distilled water and isopropanol (Farn, 2006).

However, Triton X surfactants show different properties when they dissolve in different solvents. The aggregation can occur in some solvents, depending on the interactions between solvent and solute in the system. Therefore, the addition of a surfactant to a solvent will give rise to a solute-solvent interaction and change the solute-solute and solvent-solvent interactions as well.

2.1.3.2 Polyoxyethylene Lauryl Ether (Brij 35)

The molecular formula of Brij 35 is $C_{12}H_{25}O\ (CH_2CH_2O)_{23}H$. The CMC value of Brij 35 is 5 to 9 μM (Ostroumov, 2006). However, at the temperature range about 20-25 °C the CMC of Brij-35 is 0.09 mM. The molecular weight is 1199.56 g/mole while, the boiling point is above 100 °C and melting point is 33 °C.

According to Cheng (1994), polyoxyethylene lauryl ether also known as Brij 35 is widely used in biochemical and chemical processes for their qualities such as high stability, it well-dissolved and the important is the ability of mixing with other surfactants. The reactivity of polyoxyethylene lauryl ether is incompatible with strong oxidizing agents and strong bases. Brij 35 is soluble in cold water and in mineral and vegetable oils.

2.1.4 Amphoteric or Zwitterionic Surfactant

This type of surfactants is very unique because it has the combination properties of two types of surfactants. Amphoteric surfactant form when a single surfactant molecule exhibit both anionic and cationic dissociations (Farn, 2006). It has the ability to support both positive and negative charges and also it is usually have large head groups, the hydrophilic portion of the molecule that exhibits an affinity for the aqueous phase. Amphoteric property makes them desirable secondary surfactants because it has the ability to modify micellar structure (Farn, 2006).

Some amphoteric surfactants are insensitive to pH, whereas others are cationic at low pH and anionic at high pH, with an amphoteric behavior at intermediate pH (Hargreaves, 2003). The pH determines which of the groups would dominate, by favoring one or the other ionization: anionic at alkaline pH and cationic at acid pH (Hargreaves, 2003). Amphoteric surfactants are generally quite expensive, and consequently, their uses are limited to very special applications such as cosmetics where their high biological compatibility and low toxicity is of primary importance (Salager, 2002).

Besides, zwiterionic surfactants are cations in acidic solutions, anions in alkaline solutions and both ionic groups show equal ionization and behave uncharged in an intermediate pH range (Farn, 2006). This surfactant used in toiletries, baby shampoos, daily cleaners and detergents. Also, amphoterics are used in formulations with other types of surfactant such as anionic or nonionic surfactants by modify the solubility, micelle size, foam stability, detergency and viscosity of various cleaning systems and emulsions in industries.

2.1.4.1 Tetradecyl Ammonia Propane Sulfonate (TDAPS)

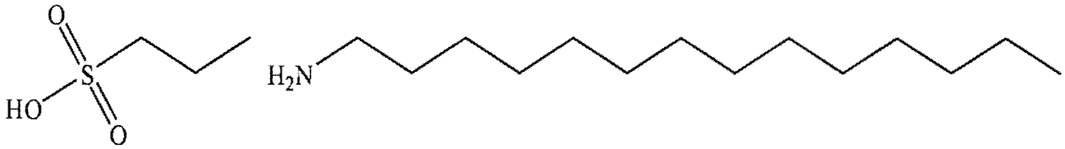

Figure 3: Structure of Tetradecyl Ammonia Propane sulfonate (TDAPS)

Tetradecyl ammonia propane sulfonate (TDAPS) is one of the examples of zwitterionic surfactant. TDAPS molar mass is about 363.6 with chemical formula $C_{19}H_{41}NO_3S$ (Ostroumov, 2006). Normally the CMC value of this surfactant is about 100-400 μM and it is present in white solid form. This CMC value was also reported by Mullally *et al.* (2004).

At high pH tetradecyl ammonia propane sulfonate, TDAPS is good detergent and foaming agent. However, due to their carboxylic acid groups, these surfactants are sensitive to divalent cations. They are generally based on amino acid structure and the most biodegradable surfactants available to the formulator (Farn, 2006). TDAPS have the minimal impact on the environmental.

They are found in softeners for textiles, hair rinse formulas, and corrosion inhibition additives (Salager, 2002). Also, it have good hard water tolerance and have applications including metal cleaning as well as personal cleansing (Farn, 2006).

2.2 Mixed Surfactant

There are more than one surfactant have being used in order to improve the properties of certain products. Through the research on mixture surfactants, it was proved that the mixture of surfactants was found to have better performance than a single surfactant in many applications in industries. In addition, when the different types of the surfactant are added together it is expected to have various physical properties and also, aggregation morphology (Shiloach *et al.*, 1998).

According to Farn (2006), the CMC of the mixture is either the intermediate value between the CMC values of each surfactant, less than any of the surfactant CMC (positive synergism) or larger than any of the surfactant CMC(negative synergism). The CMC of the mixture system which contain two surfactants and mixed micelles can be shown through this equation:

$$\frac{1}{CMC_{mixture}} = \frac{x}{CMC_1} + \frac{(1 - x)}{CMC_2} \qquad \textbf{(1)}$$

Where x is the mole fraction of the surfactant 1 in the solution on a surfactant base and CMC_1 and CMC_2 are the critical micelle concentrations of pure surfactants 1 and 2 respectively.

Based on the review of scientific literature on the effect of surfactant mixture of nonionic and anionic surfactants which has been conducted to determine their effects on bacterial oxidation in crude oil was proved the mixture surfactant have perform better than the individual components (Bruheim *et al.*, 1999). Also, there is a studies related to foam dynamic properties through the surfactant mixture contain an anionic surfactant and zwitterionic surfactant for the control of bubble surface mobility (Golemanov *et al.*, 2008). The mixture of two oppositely charged polyelectrolytes shows a strongly associative behavior which can be demonstrated by a strong tendency to phase separation (Holmberg, 2002). A mixture of an opposite charged surfactant will also associate strongly.

As the mixture surfactants are more effectiveness and more valuable to be used in industries nowadays, many researching have being conducted by scientists in order to find the way to improve the properties of the surfactant to be function well. There is a research reports on the evaluation of synergism of adsorption onto solid surfaces by using anionic and cationic surfactants mixture (Fuangswasdi *et al.*, 2006). Research conducted by Zhang (2005) has found that CMC of mixed surfactant will become lower than their single CMC value of the surfactants. This is based on the result gain from the mixture of anionic surfactant, sodium dodecyl sulphate (SDS) and cationic surfactant, cetyl trimethyl ammonium bromide (CTAB) which gave the CMC value of 0.11 mM and 0.135 mM respectively, where the value is significantly lowered than single surfactant of SDS which is 7 mM and CTAB is 0.9 mM.

2.3 Critical Micelle Concentration (CMC)

CMC is the concentration at which aggregation occurs. As the lipophilic section of the surfactant chain increases in length its water solubility gets less and this corresponds to a lowering of the CMC (Hargreaves, 2003). The CMC can be described as it is the solution concentration at which surfactant molecules begin to self-associate to form stable aggregates known as micelles. Therefore, CMC is an important parameter used in a wide variety of industrial applications involving adsorption of surfactant molecules at interfaces such as foams, emulsions, suspensions and surface coatings (Holmberg, 2002).

At the CMC, solutions containing surfactants exhibit drastic changes in physical and chemical properties such as surface tension, electrical conductivity and detergent activity. There is several numbers of methods that can be used to determine the CMC including capillary electrophoresis, tensiometry, conductometry, fluorescence anisotropy probe, light scattering, fluorimetry, calorimetry, spectrophotometry, ion-selective electrodes, polarography and nuclear magnetic resonance (NMR) spectroscopy (Tan *et al.*, 2010). It is also proved by Deguchi and Meguro (1971), the CMC of nonionic surfactants can be determined by many methods such as surface tension and dye solubilization. Experimentally, the CMC is determined from the discontinuity or infection point in the plot of a physical property of the solution as a function of surfactant concentration (Holmberg, 2002).

Apart from that, there are many factors which can make the CMC value different from that determined in pure water such as addition of electrolytes, buffer pH, temperature, addition of organic modifiers, ionic strength of the aqueous solution and presence of additives (Fuguet *et al.*, 2005). Normally, the typical CMC values at room temperature are 10^{-3}-10^{-2} M for anionic surfactants, 10^{-3}-10^{-1} M for amphoteric and cationic surfactants and 10^{-5}-10^{-4} M for non-ionic surfactants according to Farn (2006). A review of scientific literature by Muherei *et al.* (2009) found that there is a study of surfactant mixture in soil which CMC was became the most important parameter in terms of the ability of a surfactant to mobilize or solubilize hydrophobic contaminants in contaminated soil.

2.4 Pyrene and Surfactant

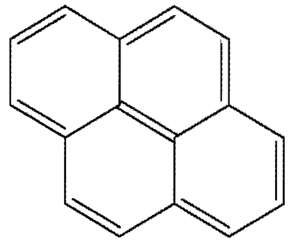

Figure 4: Structure of Pyrene

Pyrene is one of a group of chemicals called polycyclic aromatic hydrocarbons (PAHs). These compounds formed in both natural and manmade processes and widely found in human environment. The molecular formula for pyrene is $C_{16}H_{10}$ with molar mass is 202.25 g/mol. The melting point for pyrene is 145-148 °C and it boilng point is 404 °C. There are four aromatic fused rings in pyrene sturucture, as shown above in the Figure 4. Also, it presence as colorless crystal-like solid but can also look yellow. Most of the PAHs are used to conduct research because it is used to make dyes, plastics and pesticides.

PAHs are slightly soluble in organic solvents and insoluble in water. Therefore, pyrene was used as an indicator to detect the specific absorbance of the solution systems at certain wavelength. According to Diaz *et al.* (2007), pyrene was used to absorb light below 350 nm through spectroscopic methods. Most of the absorption activity in the solution system was depended on the concentration of the pyrene presence in.

Pyrene used as a dye and it is the most important substance which can be used to determine the CMC in the surfactant solution. There is a major study involve the uses of pyrene in the research of micelle activity. Ones of the research is based on the surface and bulk interaction of ionic and nonionic surfactant which used the pyrene to detect the interaction between surfactant and polymer (Turro *et al.*, 1986). It is reported that pyrene was used to obtain the information on comicellization of ionic and nonionic surfactant in bulk solution. Pyrene will be removed from aqueous phase after the micelle aggregated. This is because the micelles provide less polar environmental for the pyrene molecules in which near the CMC.

Apart from that, there is also a research done by Zhu and Chiou (2004) about pyrene use in single and mixed surfactants for the comparison of water solubility enhancement for both. In addition, there is also reported that pyrene has been used as an additive in the aqueous SDS micellar solution to synthesis the gold as a metal of nanoparticles and it is because pyrene has the effect to decrease the size of gold and also, in narrowing their size distribution (Deng *et al.*, 2005). According to Zhu *et al.* (2003), the water solubility of pyrene is enhanced by mixed surfactant micelles, the pyrene was tend to moves into mixed micelles than single micelles because the polarity of former is lower.