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A Cryptic Review on Surfactants and its Application

Thrivikram Devatha[1], **Dr Jinal Gajjar**[2]

Department of Chemistry, Monark Univeristy. Degam, Gujarat, India

Abstract: ***Surfactants are usually organic compounds that are akin to amphiphilic, which means that this molecule, being as double - agent, each contains a hydrophilic "water - seeking" group (the head), and a hydrophobic "water - avoiding" group (the tail).*** [3] ***As a result, a surfactant contains both a water - soluble component and a water - insoluble component. Surfactants diffuse in water and get adsorbed at interfaces between air and water, or at the interface between oil and water in the case where water is mixed with oil. The water - insoluble hydrophobic group may extend out of the bulk water phase into a non - water phase such as air or oil phase, while the water - soluble head group remains bound in the water phase. Surface active agents constitute an interesting class of substances with unique structural features. This review is a review of the article which had appeared in IJSR on 2018 "Surfactants and its application" and provides an introduction to the nature and physical properties of surfactants, its trade name, types, characteristics and their basic applications. The hydrophobic tail may be either lipophilic ("oil - seeking") or lipophobic ("oil - avoiding") depending on its chemistry. Hydrocarbon groups are usually lipophilic, for use in soaps and detergents, while fluorocarbon groups are lipophobic, for use in repelling stains or reducing surface tension. World production of surfactants is estimated at 15 million tons per year, of which about half are soaps. Other surfactants produced on a particularly large scale are linear alkylbenzene sulfonates (1.7 million tons/y), lignin sulfonates (600, 000 tons/y), fatty alcohol ethoxylates (700, 000 tons/y), and alkylphenol ethoxylates (500, 000 tons/y).*** [4]

Keywords: Surfactants, amphiphilic, hydrophilic, hydrophobic, adsorbed, Zwitterions

1. Introduction

Surfactants have been part of our modern lives since ages. Surfactant is an abbreviation of the term Surface active agents having dual characteristics of hydrophilicity and hydrophobicity and it itself suggests the surface active nature of these classes of compounds and their tendency to adsorb at interfaces. The polar portion exhibits a strong affinity or attraction towards polar solvents and it is often called hydrophilic part or hydrophile. Thepolar part is called hydrophobe or lipophile having attraction towards oil.

Surfactants are chemical compounds that decrease the surface tension or interfacial tension between two liquids, a liquid and a gas, or a liquid and a solid. Surfactants may function as emulsifiers, wetting agents, detergents, foaming agents, or dispersants.

Many important surfactants include a polyether chain terminating in a highly polar anionic group. The polyether groups often comprise ethoxylated (polyethylene oxide - like) sequences inserted to increase the hydrophilic character of a surfactant. Polypropylene oxides conversely, may be inserted to increase the lipophilic character of a surfactant.

Image of surfactant

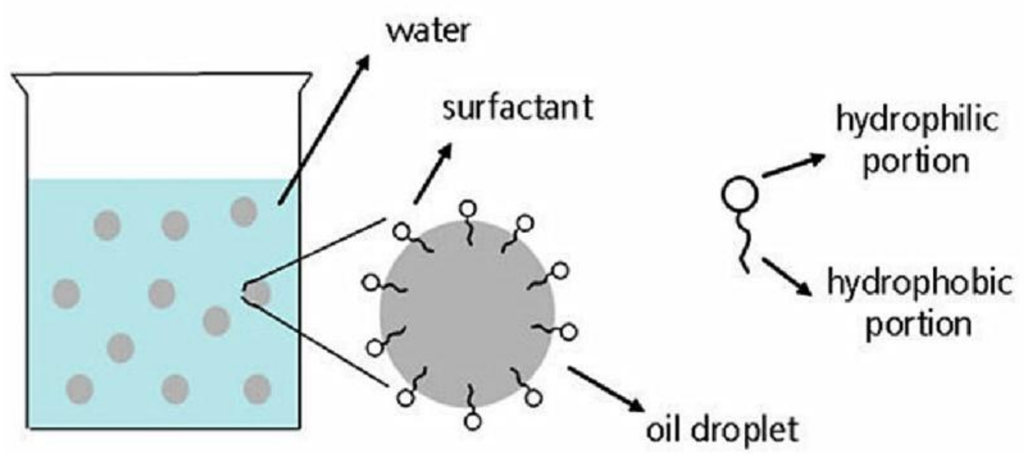

Table 1: Etymology

English	Greek	latin
Oil	Lipo	oleo
water	hydro	aqua
solvent	lyo	solvo
both	amphi	
affinity	philic	
Lacking of affinity	phobic	

Technical terms are formed by combinations of these words, such as:
- amphipathic = combining both natures (oil and water)
- amphiphilic = with affinity for both (oil and water)
- hydrophilic = with affinity for water
- lipophilic = with affinity for oil
- lyophilic = with affinity for the solvent

• lyophobic = lack of affinity for the solvent

How do we categorise Surfactants:
We can classify the Surfactants into four broad categories: anionic, cationic, amphoteric andnonionic.

Categorisation of Surfactants

Surfactant type	Example	Use
Anionic	Alcylsulfates, Soaps	50 percent of overall Industrial production, Laundry Detergent, dishwashing Liquids and Shampoos
Cationic	Quaternery Ammonium Salts	Used together with non - ionic but not with Anionic, softners in textile, anti static additives
Amphoteric	Ethoxylated Aliphatic alcohol, Polyethelene Surfactants	45 percent of overall industrial production, a wetting agent in coatings
Non Ionic	Betanes, Amphoacetates	Expensive, Special use in cosmetics

Anion Surfactant
It is known that, Anionic surfactants will give negatively charged surfactant ion upon dissolution into the water. It is the mostwidely usedsurfactant for Cleaning, dishwashing liquids and shampoos because of its excellent cleaning properties. Major percentage of the anionic surfactants are carboxylate, sulfateand sulfonate ions. In fact, most commonly used anionic surfactants are alkyl sulphates, alkyl ethoxylate sulphates and soaps. Anionic surfactants are relatively nontoxic. The straight chain is a saturated/unsaturated C12 - C18 aliphatic group. The water solubility potential of thesurfactant is determined by the presence of double bonds in it. In solution, the head is negatively charged. This surfactant is good in keeping the dirt away from fabrics, and removing residues offabric softenerfrom fabrics. Figure 3 represent the structure of anionic surfactant, Sodium dodecyl sulfate.

Sodium dodecyl sulphate

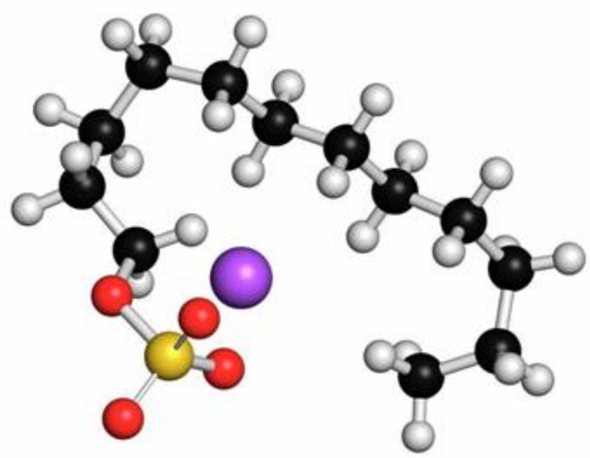

Figure 3

Cationic Surfactants:
When it is dissolved in solution, the head is positively charged. As emulsifying agents, they are very good. These are good bactericidal too and hence find its use as topical antiseptics. Their germicidal properties make them especially useful in bathroom and hand sanitizers. Cationic surfactants are attracted to negatively - charged sites; they can bind to these sites and provide the fabric with a soft, comfortable feel. Due to this reason, they are often used as fabric softeners. CTAB is suitable example of cationic surfactant and is shown in Figure 4.

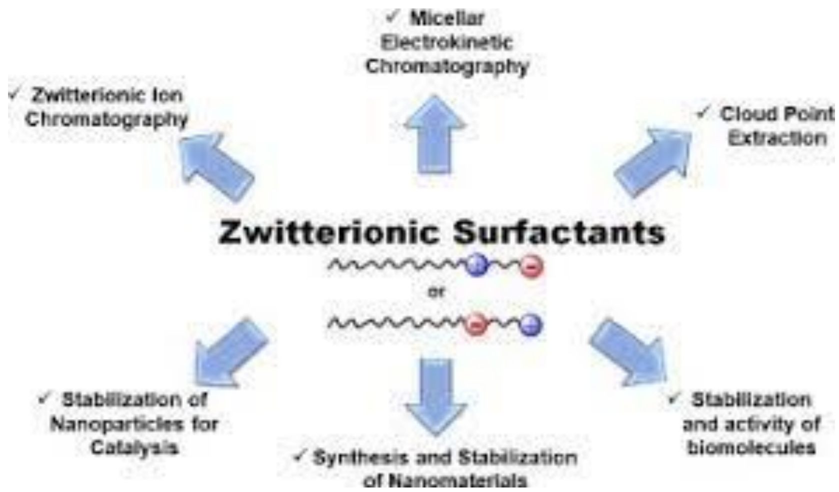

Figure 4

The term 'Zwitterion' is originally derived from the German word 'zwitter', which can be roughly translated as 'hybrid' or 'hermaphrodite'. A zwitterion is an ion that contains two functional groups. In simple terms, it is an ion possessing both positive and negative electrical charges. Therefore, zwitterions are mostly electrically neutral (the net formal charge is usually zero). Zwitterions are sometimes referred to as "inner salts". Usually, dipolar compounds are not classified as zwitterions. The distinction lies in the fact that the plus and minus signs on the amine oxide signify formal charges. Zwitterions may be worthy of medicinal chemistry design considerations when working with acid, basic or neutral leads.

Zwitterionic surfactants also known as amphoteric surfactants have both cationic and anionic centers attached to the same molecule. These are less common than anionic, cationic and non ionic ones. They are very mild, making them particularly suited for use in personal care and household cleaning products. They are compatible with all other classes of surfactants and are soluble and effective in the presence of high concentrations of electrolytes, acids and alkalis. These surfactants may contain two charged groups of different sign. Whereas the positive charge is almost always ammonium, the source of the negative charge may vary (carboxylate, sulphate, sulphonate). These surfactants have excellent dermatological properties. They are frequently used in shampoos and other cosmetic products, and also in hand dishwashing liquids because of their high foaming properties. Typical example of zwitterionic surfactant is alkyl betaine and lecithin which is shown in Figure 5

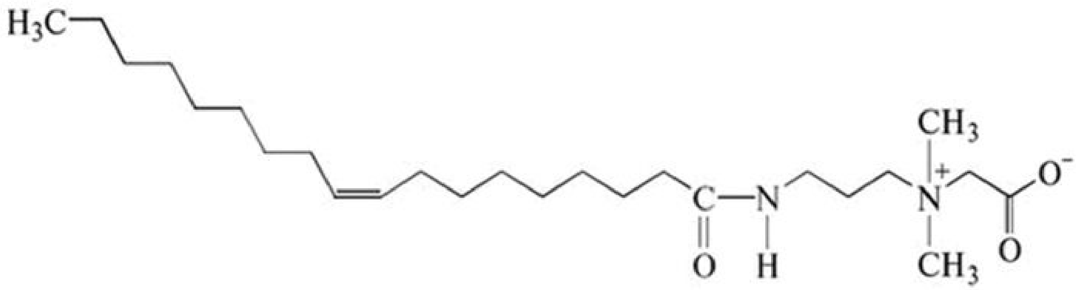

Figure 5: Zwitter Ion

A Concise Review on Surfactants and Its Significance

Nonionicsurfactants:

Nonionic surfactants are those surfactants that do not have any ions. They are the esters of high molecular mass and are generally neutral in nature. In nonionic surfactants, the water solubility is also relatively low. Surfactants that do not ionize in aqueous solution, due their hydrophilic group are of a non - dissociable type, such as alcohol, phenol, ether, ester, or amide. These surfactants do not have an electrical charge, which makes them resistant to water hardness deactivation. They are excellent grease removers that are used in laundry products, household cleaners and hand dishwashing liquids. A large proportion of these nonionic surfactants are made hydrophilic by the presence of a polyethylene glycol chain, obtained by the polycondensation of ethylene oxide. Non ionic surfactants are probably the ones used most frequently in drug delivery applications. The nonionic surfactant can be of polyol esters, polyoxyethylene esters, and poloxamers or pluronics. Polyoxyethylene esters majorly include polyethylene glycol (PEGs).

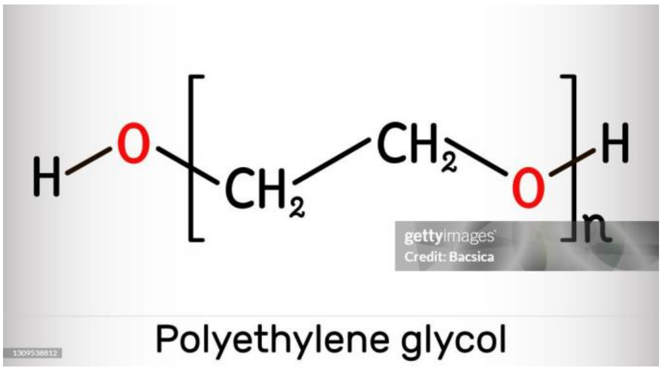

Figure 6

The most commonly used nonionic surfactants are ethers of fatty Alcohol. Non - ionic surfactants contribute to making the surfactant system less hardness sensitive

Physicochemical properties of surfactants:

Surfactants are usually organic compounds that are akin to amphiphilic, which means that this molecule, being as double - agent, each contains a hydrophilic "water - seeking" group (the *head*), and a hydrophobic "water - avoiding" group (the *tail*). [3] As a result, a surfactant contains both a water - soluble component and a water - insoluble component. Surfactants diffuse in water and get adsorbed at interfaces between air and water, or at the interface between oil and water in the case where water is mixed with oil. The water - insoluble hydrophobic group may extend out of the bulk water phase into a non - water phase such as air or oil phase, while the water - soluble head group remains bound in the water phase. Basic physicochemical property of surface active agents is that monomers in solutions tend to form aggregates, called micelles or in other words, in aqueous solution, molecules having both polar and non - polarregions form aggregates called micelles. [16] In a micelle, polar heads form an outer shell in contact with water, while non - polar tails are sequestered in the interior. Hence, the core of a micelle, being formed of long non polar tails. Structure of micelle formation is shown in Figure 7

The concentration at which micelles start to form is called critical micelle concentration (CMC). It is an important phenomenon since surfactant molecules behave very differently depending on whether they are present in micelles or as free monomers. The micelles influence the solubility of organic hydrocarbons and oils in aqueous solution and also influence the important property called viscosity. The size of the micelle is measured by the aggregation number which is the number of surfactant molecules associated with a micelle. Only surfactant monomers contribute to surface and interfacial tension lowering. Wetting and foaming are governed by the concentration of free monomers in solution. It was suggested by Adam [18] and Hartley [19] that micelles are spherical in shape. In general the shape of the micelle is dependent on thestructure of the surfactant, typically the relative size ofthe head group and tail group. Ionic surfactant form smaller

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micelles (aggregation number ~10 - 70) than non - ionic surfactants (Nagg≥ 100). This is because the electrostatic repulsion between ionic head - groups is greater than the steric repulsion between non - ionic headgroups. The structure of a micelle could be of various shapes, spherical to rod - or disc - like to lamellar. [20 - 25] in concentrated solution (much above the CMC); lamellar micelles form, such that water molecules occupy the region between parallel sheets of surfactant. [Figure 8]

Krafft point and Cloud Point

Krafft point Definition: the temperature solubility of **ionic surfactant rapidly increasing**. Typically, to ionic surfactants, krafft point is present. Cloud point Definition: the temperature that solution of non - ionic surfactant appears cloudy and separates surfactant out. The solubility of micelle forming surfactants shows a strong increase above a certain temperature, termed the Krafft point (KP). The Krafft point of ionic surfactant may be defined as the temperature at which the solubility of surfactant becomes equal to its CMC. Krafft point represents the temperature at which the alkyl chains melt resulting in the dissolution of surfactant crystals into micelles and monomers as illustrated Kraff point phenomenon figure.

Surfactants in Human Body

The human body produces diverse surfactants. Pulmonary surfactant is produced in the lungs in order to facilitate breathing by increasing total lung capacity, and lung compliance. In respiratory distress syndrome or RDS, surfactant replacement therapy helps patients have normal respiration by using pharmaceutical forms of the surfactants. One example of a pharmaceutical pulmonary surfactant is Survanta (beractant) or its generic form Beraksurf, produced by Abbvie and Tekzima respectively. Bile salts, a surfactant produced in the liver, play an important role in digestion. (26) [

2. Conclusions

Surfactants and newer surfactant molecules have rapidly grown in the consumer market and now it has become essential to focus on the types and its essential impact on the human usage. It has again become very necessary to have the basic fundamental knowledge of the surfactant science. Newer and better molecules are paving way for more scientific research in this area.

Safety and environmental risks

Most anionic and non - ionic surfactants are non - toxic, having LD50 comparable to table salt. The toxicity of quaternary ammonium compounds, which are antibacterial and antifungal, varies. Dialkyldimethylammonium chlorides (DDAC, DSDMAC) used as fabric softeners have high LD50 (5 g/kg) and are essentially non - toxic, while the disinfectant alkylbenzyldimethylammonium chloride has an LD50 of 0.35 g/kg. Prolonged exposure to surfactants can irritate and damage the skin because surfactants disrupt the lipid membrane that protects skin and other cells. Skin irritancy generally increases in the series non - ionic, amphoteric, anionic, cationic surfactants. [4]

Surfactants are routinely deposited in numerous ways on land and into water systems, whether as part of an intended process or as industrial and household waste. [18] [19] [20]

Anionic surfactants can be found in soils as the result of sewage sludge application, wastewater irrigation, and remediation processes. Relatively high concentrations of surfactants together with multimetals can represent an environmental risk. At low concentrations, surfactant application is unlikely to have a significant effect on trace metal mobility. [21] [22]

In the case of the Deepwater Horizon oil spill, unprecedented amounts of Corexit were sprayed directly into the ocean at the leak and on the sea - water's surface. The apparent theory was that the surfactants isolate droplets of oil, making it easier for petroleum - consuming microbes to digest the oil. The active ingredient in Corexit is dioctyl sodium sulfosuccinate (DOSS), sorbitan monooleate (Span 80), and polyoxyethylenatedsorbitan monooleate

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