

The Roles of Surfactant in Tribology Applications of Recent Technology; an overview

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Abstract. In managing friction, wear, and lubricant qualities such as emulsification, demulsification, bio resistance, oxidation resistance, rust prevention, and corrosion resistance, surfactants play a crucial role in tribology. This is an important topic for the development of new materials and gadgets, particularly those created at the Nano-scale. The tribological characteristics of cutting fluids, lubricant performance in relation to steel surfaces, bio lubricants, and novel materials and approaches to friction and wear reduction will all be covered in this most recent edition.

Numerous industries place a high priority on surface science and tribology. Almost all consumer and industrial products are manufactured and used with the aid of sophisticated surface and tribological knowledge. Amphiphilic molecules are those that function as surface-active agents or surfactants. Their tails are hydrophobic while their heads are polar, or hydrophilic. They are dispersible in both water and organic solvents. This article introduces surfactants' nature and physical traits with a focus on their importance in modern science and technology. The primary property of surfactant molecules is the ability to self-assemble into micelles, which gives us a way to apply surfactants. The study of the surfactants results in a number of practical application areas, including food, health and personal care goods, biological systems, mineral and petroleum processing, and even nanotechnology. The organisms, food manufacturing, crop protection, personal care products, mineral and petroleum processing, and other practical application areas serve as examples of what these in turn give rise to a range of operational application domains.

1 Introduction

The study of friction and wear is the focus of the field of tribology. The term "tribology," which derives from the Greek term "rub," refers to the study of the wear and frictional

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properties of surfaces that are moving relative to one another. (Winkless, 2022). Understanding how materials deteriorate through the analysis of resistance allows us design our components to have the lowest possible frictional coefficient. As you can anticipate, tribology is crucial to our development and research. (Williams, 2005).

For many thousands of years, people have been aware of certain features of tribology. A primitive understanding of friction was demonstrated by rubbing sticks together to produce heat and start a fire. The use of lubrication is probably documented in ancient Egyptian artefacts, where it appears that humans were moving heavy statues with the help of oil. (Peck, 2013).

Our grasp of tribology did not advance significantly until the 15th century. One of the earliest researchers to rigorously examine friction and increase our understanding of The Renaissance man himself, Leonardo da Vinci, was there. Nowadays, tribology is an interdisciplinary study that is integrated into a number of technical and scientific fields. Friction, wear, and lubrication are three interconnected categories into which we might generally subdivide the topic. By creating wear resistance, lubrication is a strategy for lowering friction and protecting the contact area. Lubrication is a technique for preventing wear and lowering friction. Friction is defined as the resistance between flat surfaces in relative motion. (Czichos, 2009).

Surfactants offer a significant deal of promise to advance nanotechnology beyond its present constraints in addition to industrial applications. In the case of hydrophobic inorganic nanomaterials like Black phosphorus, transition metal dichalcogenides, graphene, carbon nanotubes, It has been suggested that amphiphilic surfactants act as stabilizers to produce stable dispersions. Since the discovery of the first technique for exfoliating graphene in 2004, known as micromechanical exfoliation, The method has been scaled up by researchers stabilizing exfoliated graphene with solvents. (Whitener et al, 2014). Different organic solvents have been used to stabilize nanomaterials in order to get around this restriction, including N-methyl-pyrrolidone and dimethylformamide. (Mirdamadi et al, 2022).

Surfactants are organic compounds composed of two chemical components with distinct polarities: a tail group with nonpolar phase attraction and a head group with polar phase affinity. Due to their unique structural properties, surfactants are frequently used to reduce surface and interfacial tension between phases. Due to their tendency to construct self-assembled structures in solution, they can also form micelles with diameters ranging from nanometers to microns. Pharmaceutical formulations, corrosion inhibitors for steel and other pour-point metals, corrosive metals wetting agents, de-emulsifiers, oil recovery enhancers, detergents, depressants, and drug delivery systems all benefit from the amphiphilic nature of surfactants.

Surfactant is an additional crucial component in the production of tightly controlled nanoparticles. Because of their ease of use, practical applicability, affordable manufacturing, excellent stability, and high selectivity, colorimetric sensors are in high demand for a wide range of interdisciplinary applications. The use of surfactants in the synthesis of metallic nanoparticles has made colorimetric sensors possible. Surfactants applied during the manufacturing of nanoparticles are essential for increasing the sensitivity and selectivity of the sensor because they directly alter the characteristics of the nanoparticle. In addition, a novel class of magnetic surfactants has been developed that can be used in drug delivery systems. We provide a concise overview of the fundamentals of surfactants and their applications to the growth of nanotechnology in this review. (Zakharova, 2019).

2 Literature Review

2.1 Lubrication

Studies have shown that 60% of machine parts fail annually due to wear, 30% of primary energy is lost through friction, and 50% of accidents involving mechanical equipment are caused by lubrication failure and/or excessive lubrication. (Olsson, 2021).

New liquid oils and additives, solid coatings, measuring methods, superlubricity, and lubrication theory are just a few of the advancements made in the field of lubrication between 2018 and 2019. (Luo et al, 2021). These findings reveal a change in tribology study toward fresh, cutting-edge areas, such as bio-lubrication, superlubricity, and molecular lubrication. Low viscosity lubricants, green lubrication, and lubricants for harsh environments have all attracted a lot of attention during the last few decades (vacuum, high temperature, and pressure, etc.). An overview of significant advancements in the topic of lubrication is provided below.

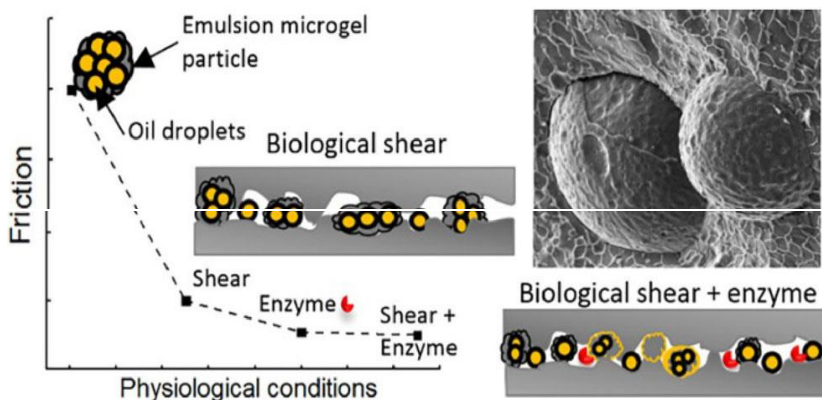


Figure 1 The effectiveness of emulsion micro-gel particles as lubricants under physiological circumstances..

Oil-in-water (O/W) emulsions have a significant industrial application in metal cutting processes like drilling, milling, turning, and sawing. In these processes, an emulsion is produced by combining oil and water with a suitable surfactant and is accessible at the interface between the workpiece and the tool or roller. These "metal cutting fluids," which are also sometimes referred to as "emulsions," are able to lubricate and cool. The aqueous phase of the contact absorbs the generated heat as the lubricant in the emulsion reduces friction between the contact surfaces. Fluids for metalworking also make chip removal easier, prevent corrosion, and resist fire better. They also improve surface finishes and extend tool life, both of which boost machining efficiency. (Liu and others, 2019)

During the machining process, high temperatures are produced on the cutting tools because of the friction between the material and the cutting tool as well as between the cutting tool and the chip (metal released from much of the workpiece as a result of the cutting process).

Increased temperature decrease the quality of the completed workpiece by causing increased surface roughness, increased tool wear, shorter tool lives, and increased friction between tool and the workpiece. As a result of the high temperatures produced by difficult-to-cut materials

being machined, this gets even worse. Numerous techniques have been described to shield cutting equipment from this heat generation. Although it is more expensive, choosing cutting tools with strong coatings is a good alternative for processing some materials, like titanium and heat-resistant alloys. The heat generated during cutting metal can be removed by the cutting fluid, reducing friction and encouraging chip formation. Cutting fluids are typically liquids that improve the cutting atmosphere and easily reach the working region. They help in removing trash and other impurities in addition to cooling. Furthermore, water-based metalworking fluids (MWFs) ought to provide both tools and workpieces with adequate corrosion protection. In general, using cutting fluids should increase output and also the rate of removal of material.[1]

The area of tribology that has grown the fastest in recent years is superlubricity. It will mark a significant turning point in technological advancement. The wear and friction-induced noise are significantly reduced, and there is a significant reduction in the friction coefficient. As a result, superlubricity is a topic that more and more tribologists are researching. Both liquid and solid superlubricity have made significant strides. (Rahman et al, 2022). The external environment, temperature, sliding speed, and normal load (contact force) are key influencing factors that have a significant impact on tribological performance. The reconstruction of the interfacial the conversion of sp²-layered materials into graphene, the creation of graphitic shells, or the stress-triggered local change have all been shown to be effective ways to make FLC and GLC that are sp²-rich or hydrogenated DLC may resist very high contact pressures (up to 1.24 GPa). According to a research of the velocity dependence of superlubricity stability over a broad range of 3-70 cm/s-1, it was discovered that at high sliding velocities, superlubricity fails because there isn't a tribolayer on the contact surface rather than because of the flashing heat effect or the dissolution of hydrogen passivation.

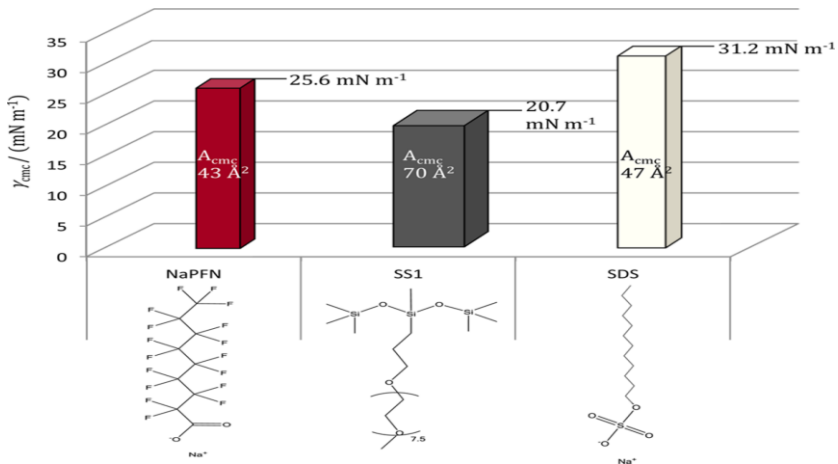


Figure 2. The aqueous limiting surface tension and interfacial molecular are

Figure 2 depicts a linear additive fluorocarbon, silicone, and hydrocarbon surfactant, the aqueous limiting surface tension and related interfacial molecular area are shown. Column width and height are proportional to A_{cmc} and cmc , respectively. Data from the SDS, SS1, and NaPFN.

2.2 Fluorosurfactant

Unexpectedly, 3M made a breakthrough in the 1950s that demonstrated the promise of fluorochemical cleaning solutions, which led to the invention of fluorosurfactants. Fluorosurfactants are currently considered to be a significant class and are used in a wide variety of products, comprised of medicines, firefighting tools, cosmetics, lubricants, paints, polishes, and adhesives. This product category is worth billions of dollars. 21–23 On paper or textiles, for example Low-surface-energy coatings are made using fluorosurfactants., because of their hydrophobic tails, which exhibit both oil and water repellency.

Fluorinated substances with chain lengths of C8 to C15 have been recognized as dangerous pollutants more recently. 25 It has been demonstrated that fluorination is closely related to the bioconcentration and bioaccumulation of perfluorinated acids. 26 Therefore, it is now necessary to create fluorosurfactant substitutes. Therefore, one goal the purpose of this paper is to improve comprehension of structure-function interactions that are crucial for directing the development of fluorocarbon surfactant substitutes.

The special characteristics of fluorine are what give fluorosurfactants a higher surface activity than their hydrocarbon equivalents. The molecules' attractive forces are what give liquids their cohesiveness. The C–F bond in a per-fluorocarbon chain is polarized as a result of fluorine's high electronegativity, but the chain as a whole is nonpolar and has no dipole moment. just the interactions between induced dipoles and induced dipole dispersion are significant in nonpolar liquids. The polarizability of the participating atoms controls how strong this interaction is. Because fluorine is less polarizable than hydrogen, the overall dispersion interaction between fluorine atoms is smaller. Thus, it is anticipated that perfluoroalkane liquids will exhibit fewer attractive intermolecular forces than hydrocarbons of a similar structure.[2].

2.3 SILICONE SURFACTANT

Silicone surfactants, also referred as siloxane surfactants or permethylated siloxane surfactants, are composed of hydrophobic permethylated siloxane groups linked to one or more hydrophilic polar groups. 33 ABA copolymers, rake type copolymers (comb and graft copolymers), and (where B denotes the silicone portion). Trisiloxane surfactants, 34, and silicone surfactants are the three molecular configurations that silicone surfactants most frequently have. (Table 1) The most prevalent polar groups are non-ionic polyoxyethylene (PEO) and polyoxypropylene (PPO), however they can be anionic, cationic, zwitterionic, or cationic. Silicone surfactants, which could also achieve cmc values of 20–30 mN m1, can effectively lower aqueous surface tensions.

The following are the main causes of the low cmc of silicone (SiC) surfactants: 1) The siloxane backbone's exceptional flexibility, which enables it to adopt conformations that best highlight the accessible organic groups, and 2) The low intrinsic surface activity and minimal surface energy of the methyl groups (CH3) (i.e., a surface that is dominated by methyls).

Such systems are commonly employed in applications like stabilizers because they also exhibit distinctive spreading properties, for emulsifiers used in cosmetics, adjuvants in agriculture, conditioners for textiles, coatings, and additives for ink, as well as polyurethane foams. 37

The SiOSi bond is prone to Trisiloxane surfactants' intrinsic hydrolytic instability and hydrolysis in the presence of moisture³⁸ lowers their effectiveness. Additionally, this has caused differences in unpublished works on purportedly similar subjects.



At a pH of about 7.0, the reaction is sluggish and is catalyzed by either an acid or a basic (ref 38). Degradation can be accelerated on glass surfaces with remaining acidity or basicity, necessitating the use of plastic or glass that has undergone hydrophobic silanization

treatment. In addition, hydrolysis causes most trisiloxane surfactants experience a rapid decrease of surfactancy at prolonged temperatures over 70 °C (ref 38).

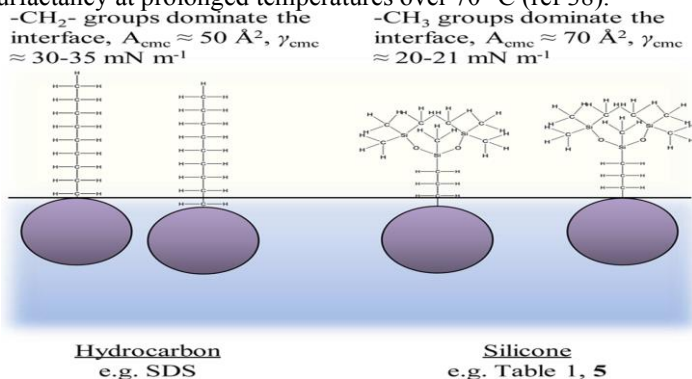


Figure 3 Comparison of silicone and hydrocarbon surfactants' surface characteristics

A linear hydrocarbon as well as silicone surfactant's typical A_{cmc} and cmc values are given. based on a new drawing made from the ref. 37 illustration.

2.4 Hydrocarbon Surfactant

The relationship between the chemical composition of the interfacial film and the limiting tension (energy) cmc is dependent on a number of variables.

However, hydrocarbon surfactants may offer potential substitutes due to their high hydrolytic stability and overall environmental acceptability, compared to fluorocarbons' low hydrolytic stability and trisiloxane surfactants' environmental toxicity. strongly branched hydrocarbon (HC) surfactants with low have been created (ref 51), and the following are the key factors that cause them to do so: (1) Low surface energy of methyl groups (CH₃); with (2) Highly branched tails providing dense outer surface of CH₃ groups with worse tail-tail interactions compared to those found in linear-chain HC tails Could the most popular silicone and fluorocarbon surfactants be replaced by more effective ones by analyzing and improving structure-function attributes for hydrocarbon surfactants?

Because of fluorine's low polarizability and the fluorocarbon chain's higher volume, Reduced surface tension is a property of perfluorocarbon surfactants than their hydrocarbon equivalents, as was previously mentioned. Moreover, it has been demonstrated that due to the special The siloxane backbone's adaptability, surfactants containing siloxane chains produce lower CMC values than conventional linear-chain hydrocarbon surfactants. Hydrocarbon surfactants initially seem to be a little less effective.

2.5 Surfactant Constituents

When added to a liquid, surfactants (surface-active substances) reduce the surface tension, enhancing the liquid's spreading and wetting properties. The water surface tension is decreased by a few surfactant molecules are present at the water-air interface. [3]. Surfactants are described as molecules that can associate to form micelles. They are also known as amphiphiles, tensides, or paraffin chain salts in extremely old literature. The word "surfactant" was first used as a trademark for certain surface-active items before becoming freely available to the public [4].

These are typically amphipathic organic compounds, which means they have at least two parts: a lyophilic head and a lyophobic tail. The lyophilic head is soluble in all solvents. When

water is used as a solvent the terms used are hydrophobic and hydrophilic. This is seen in the figure below

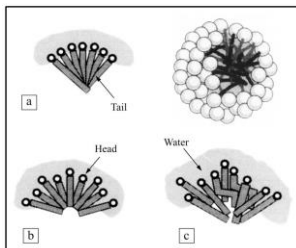


Figure 4 Organisation of surfactant molecules (Obtained from (Schramm et al., 2003)
The notable properties of surfactants are;

- i) they tend to create aggregates out of a monomer in solution known as a micelle; this aggregation process is known as micellization. Critical micelle concentration refers to the point of concentration where micelles first emerge (CMC). Surfactant concentrations at which micelles develop cause the system's free energy to drop. The minimum temperature required for their formation is termed 'Kraft point'
- ii) It is a process known as solubilization is used to increase the solubility of components that are typically insoluble or poorly soluble in the dispersion medium; a spontaneous dissolution of a nonsoluble compound into an isotropic soluble solution by a surfactant
- iii) When a surfactant solution containing an oxyethylene group is heated, it turns turbid at a specific temperature range, producing a cloudy solution. The aforementioned temperature range is known as "Cloud point." The length of the polyoxyethylene chains in the surfactant will determine this. Lyotropic liquid crystals are another type of aggregate, can develop when the surfactant concentration rises. [5].

As there is a vast number of research articles on surfactants, their properties and applications in various fields, this work aims to review and highlight some of the main points in these works.

2.6 Classification of Surfactants

From a commercial viewpoint depending on their use, surfactants are frequently categorized. This means of classification is less than ideal because many surfactants have several uses, and this may cause unnecessary confusion. The surfactant categorization that is widely accepted and supported by science is according to charge groupings in their head and are as such classified as follows:

1. Anionic Surfactants: The head has a negative charge while in solution. They make up roughly 50% of the world's production and among surfactants, they are most frequently utilized. Detergents and soaps are frequent examples. Anionic surfactants are very good at cleaning oily surfaces. However, they can also partially deactivate by interacting in wash water also with positively charged calcium and magnesium ions from water hardness. The anionic surfactant system is more susceptible to deactivation the more magnesium and calcium molecules there are in the water. This can be avoided by adding extra detergent to hard water and using other substances like builders (Ca/Mg sequestrants) to assist anionic surfactants.

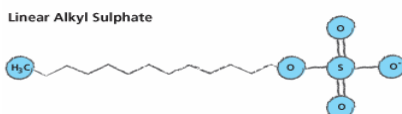


Figure 5 Anionic Surfactant

2. Cationic Surfactants: The head of these surfactants are positively charged in solution. Since they have effective bactericidal capabilities Most often, cationic surfactants—quaternary ammonium compounds—are used as disinfectants and preservatives. To heal burns or open sores, they are applied directly to the skin. The most widely used cationic surfactant is cetrimide, which contains only trace amounts of dodecyl and hexadecyl compounds and tetradecyl trimethyl ammonium bromide. Benzalkonium chloride and cetylpyridinium chloride are other cationic surfactants.

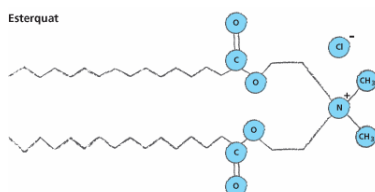


Figure 6 Cationic surfactant

3. Nonionic Surfactants: Since they are electrically neutral, the hardness of the water loses its resistance. These surfactants are less irritating than anionic and cationic ones. This class does not ionize in aqueous solutions regarding the non nature of their hydrophilic groups (such as phenol, ester, alcohol, ether, or amide), whereas the hydrophobic part contains saturated or unsaturated fatty acids as well as fatty alcohols. They function well as emulsifiers and oil removers. Ethers and fatty alcohols are the most typical examples.

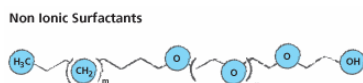


Figure 7 Nonionic Surfactant

4. Amphoteric/Zwitterionic Surfactants: According to the water's pH, they can be non-ionic (chargeless), cationic (positively charged), or anionic (negatively charged) in solution. Their skull may have many charge groups, with the positive group most likely being ammonium and the negative group possibly being different (sulphate, carbocylate, sulphonate). Because they are often quite expensive, amphoteric surfactants are only utilized in a very small number of industries, such as cosmetics and shampoos, where their great biological compatibility and low toxicity are crucial. Due to their excellent foaming capabilities, they can be utilized in dishwashing liquids.[3], [6].

2.7 Overview of Surfactant in Tribology

The oil Industry, drugs, cleaning products, foams for fighting fires, paints, inks, and paintbrushes, electronic printing, and medical and biological technology, and others all depend on surfactants, which are among the most versatile chemicals. 1–5 The amphiphilic nature of surfactant molecules, which have both polar and water-soluble portions (known as the "head group"), nonpolar molecules, and molecules that are not soluble in water (referred to as the "tail"), is the source of the molecules' intrinsic versatility. Surface adsorption and

bulk solution self-assembly are two important qualities of surfactant molecules that are associated by their dual characteristics, which give them a broad range of behaviours.[7]

A surface liquid's attractive intermolecular interactions are out of balance leads to surface tension. Since they have no neighbours above them, Final surface layer molecules are pulled into the bulk. This discrepancy between the appealing interactions between molecules generates more liquid surfaces will constrict and reduce the specific surface area due to the surface free energy, which is energy that is present at the surface but not in the bulk. Air-water interface adsorption of surfactants occurs spontaneously at low concentrations and results in orientation influences the free surface energy of a monolayer, the interfacial free energy per unit area is the liquid's surface tension, expressed in units of J m^2 or N m^1 , however it only applies to gas-liquid interfaces. (According to convention, interfacial tension refers to surfaces between liquids and solids). When something expands, only a small quantity of effort (W_{min}) is required to produce the additional surface, and W_{min} is equal to dA because surface tension is a factor in both.

A substance that adheres to surfaces and significantly alters the surface tension (interfacial tension) is known as a surfactant. The amount of effort required to expand the liquid surface is altered as a result. Polyetheramines include glycols, castor oil ethoxylates, glycol ethers, phosphate esters, fatty acid ethoxylates, sodium isethionate, alkylphenol ethoxylates, primary amines, and tertiary amines, among the surfactants frequently utilized in the MWF. This category includes alkylphenol ethoxylates, polyetheramines, linear alcohols, fatty acid ethoxylates, alcohol ethoxylates, alcohol alcoxylates, and castor oil ethoxylates as emulsifying agents. copolymers of ethylene oxide and phosphate esters. Coemulsifying agents include linear alcohols, glycols, alcohol ethoxylates, and alcohol alcoxylates.

2.8 Application of Surfactant on Recent Technology

Numerous vital responsibilities for surface science and tribology exist across numerous sectors. Advanced surface and tribological knowledge is used in the production and use of consumer and industrial goods. Because of their distinct physical and chemical properties from bulk materials or individual molecules, the manufacture and utilization of nanometer-sized particles has attracted a lot of attention in recent years. In the tribological discipline, some of the surfactant-modified nanoparticles have been successfully produced and used as an addition in liquid paraffin (LP), where they exhibit outstanding anti-wear performance.

They can be used for washing, anti-corrosion, emulsifying or deemulsifying, wetting or adhering, foaming or defoaming, solution, dispersion, anti-static, and other applications due to their physics and chemistry effects. The class of flexible and adaptable fine chemical products includes surfactants. Surfactants can almost completely cover all fine chemical domains, with the exception of their use in everyday life as detergents. (Schramm and others, 2003)

Is a key component of skin care products used in the cosmetics industry, including face washes, emulsions, creams, and makeup removers.

1. Defoamings and foaming

The medical industry commonly uses surfactants as well. In the formulation of the agent, surfactant plays crucial roles as an humidifier, foaming agent, emulsifier, suspension aid and defoaming agent. To create a clear solution and boost concentration, it can be used to increase the solubility of certain steroid hormones, volatile fat-soluble cellulose, and other insoluble medicines. The medical industry commonly uses surfactants as well. In the formulation of the agent, surfactant plays crucial roles as an humidifier, foaming agent, emulsifier, suspension aid, and defoaming agent. To create a clear solution and boost concentration, it

can be used to increase the solubility of certain volatile fat-soluble cellulose, steroid hormones, and other insoluble medicines.

In contrast to foam extinguishers, which are substances and mixtures that destabilize and reduce foam, foaming systems are made up of gas bubbles that are trapped in a liquid or solid.

Examples include:

- I. Shampoos, body washes, face washes, and hair coloring products are examples of cosmetics.
- II. Using mouthwash and toothpaste for oral care
- III. Detergents and cleaning supplies for domestic usage, such as those for washing dishes and food, as well as for use on industrial machinery
- IV. Foods - Sweets, such as whipped cream, mousse, and sponge cakes

2. Suspensive

Concentrated emulsions, emulsifiable oils, and wettable powders all require a specific quantity of surfactants in the pesticide industry. For instance, the raw medications contained in wettable powders, which are mostly organic compounds, exhibit hydrophobicity only when surfactants are present. If the surface tension of the water is decreased, water may moisten the drug particles and produce water suspensions.

Emulsions are immiscible liquid mixes of two or more that are stable and in which one liquid, known as the "dispersed" phase, is distributed into the other. (the "continuous" phase).

A few examples of preparations are:

- i. Cosmetics and pharmaceuticals include topical lotions and creams containing microemulsions, liposomes, and oil-in-water (O/W), water-in-oil (W/O), and multiple formulations (W/O/W, O/W/O).
- ii. Foods: sauces, dairy products, mayonnaise, margarine, and so forth
- iii. Cleansing waxes and polishers for the home
- iv. Additional – Emulsion-style inks and paints

3. Hard water immunity

When exposed to magnesium and calcium ions, betaine surfactants shown good stability, withstanding both the dispersion of calcium soap and the hard ions of calcium and magnesium. Enhance the effect while using calcium soap to stop precipitation.

4. Sterilization, Disinfection

They have applications in the medical field as fungicides and disinfectants. They possess the sterilizing and disinfecting qualities due to their potent interactions involving bacterial Biofilm proteins that cause their denaturation and loss of function. These disinfectants can be used to clean surfaces such as skin, mucous membranes, surgical instruments, and the environment prior to surgery because they have a significant water solubility depending on the concentration utilized. When certain surfactants affect the status of the human body, such as when they cause the production of proteins and lipids or modify the structure of cell membranes, they are said to demonstrate biological activity. Natural surfactants, which are regarded as being safer than synthetic surfactants, frequently mirror chemicals found in the human body.

Examples of surfactants with biological activity include:

- a. For safe, non-irritating skincare, use natural surfactants such phytosterols and derivatives of lecthin.
- b.

5. Descaling and washing
Grease and grime cleanup is a difficult process that is connected to the bubbling and moist impacts already discussed.
6. Viscosity and Bubbling

Surfactants alter the solution system by improving the foam's viscosity, thickening as well as enhancing it, and adjusting the viscosity of the solution. They are frequently utilized in certain specialized cleaning and mining industries.

Last but not least, it is important to point out that surfactants frequently function because of a combination of factors rather than just one. It can be used as a food ingredient, an antistatic agent, a waste resin barrier control ingredient, a glue ingredient, a defoaming agent, a softener, a scale retardant, an oil remover, and a sterilization ingredient, among other things. Algae, agents against corrosion, etc. Surfactants are used as performance enhancers in formulations for a variety of industrial uses, such as the treatment of metal, industrial cleaning, oil extraction, pesticides, and personal and home care.

2.9 Roles of Surfactant in Tribology Application in Recent Technology

Application of tribology test for cationic surfactant-based fabric softeners quality assessment; environmentally friendly tribology. To encounter tribology in daily life, one need not work in mechanical engineering. Your sneakers' soles, for instance, are expertly crafted to provide the best grip. Biotribology has applications in the medical field, where the finest, most natural movement is made possible through hip joint tribology.[3]

Nanotribology is a significant area of tribological system study, and tribological research is currently going toward the nanoscale. Researchers in the field of nanotribology analyze friction just at nanoscale and then use their results in fields like magnetic storage devices. In order to reduce friction, companies must make sure that their applications are dependable, strong, and have a long useful life. Reliable components are produced in large part as a result of tribological study. Creating consistent, controlled friction, for instance, can lessen wear, noise, vibration, and corrosion

1. Personal Care

Surfactants for personal care are essential ingredients in products like body wash, shampoo, and conditioner for hair. The development of green, environmentally friendly surfactants to lessen human motivation will be based on natural raw materials.

2. Paper Making

Surfactant is an essential component of the chemicals used in papermaking. It has a big effect on pulping, wet-end processing, surface sizing, and coating. Along with the paper manufacturing industry, new surfactant product series will be developed to meet consumer demand.

3. The Food Sector

The food industry ranks among the top surfactant consumers., although there are restrictions on the types and amounts of surfactants that can be utilized due to concerns about contamination as well as potential toxicity. Emulsifiers, thickeners, stabilizers, antioxidants, and other uses are the most common ones.

4. Detergent

A detergent is a surfactant, or a surfactant mixture, with "cleaning properties in diluted solutions." Because of their chemical make-up, detergent surfactants can be created to work well in a variety of circumstances. These surfactants are generally not film-forming and sensitivity to water's hardness minerals is lower than that of soap. Detergents, also known as surfactants or surfactant mixtures, are used to clean a variety of surfaces of impurities like

protein, grease, and grime. On a variety of surfaces, such as clothing materials, home appliances, and office equipment, they are widely employed as cleaning agents.

5. Leather

At every stage of leather production, surface active agents, an essential component of leather processing technology, have been utilized. Among the primary applications are wetting and penetration, increasing solubility and foam, decentralization, disinfection, emulsification, evening dye, and antibacterial action. The production cycle can be shortened, chemical raw materials can be saved, and the finished product's quality can be improved as a result. All aspects of physics and chemistry are encouraged and made more effective in each process by these applications.

6. Oil Field

All aspects of the petroleum industry use surfactants. Surfactants in improved oil recovery have a sizable potential market, but there are still numerous economic and technological issues that need to be resolved. However, it appears that enough of those technical issues will be resolved as we approach the "petroleum age's" closing decades and that some methods for better oil recovery will be supported by the oil we leave behind.

7. Agric

Currently, surfactants are used in all dosage forms, not just herbicides, and work as adjuvants to reduce surface tension throughout the water's outer layers. Nonionic and anionic surfactants are most frequently used in agriculture.

8. Paint

The physical characteristics of paints are significantly impacted by surfactants Initial aggregate and film generation of paint are indeed important. impacted by surfactants, as is how the paint behaves over the lifetime of the created coating. In paints and other applications, surfactants are also used to keep the polymer particles dispersed during emulsion polymerization.

3 Contribution

The contribution of surfactant to humanity has gone a long way in various fields under tribology such as biotribology and nanotribology. The purpose of surfactants is to significantly lessen the two liquids' respective surfaces tensions.

By adding a small amount of solvent surfactants, the interface system's condition is altered and the tension in the continuum is decreased. They have properties that dissolve, moisten, emulsify, and froth. Dispersion, foaming, flocculation, disinfection, and decontamination are just a few of the functions that surfactants perform thanks to their interfacial tension, surface tension, and adsorption orientation properties. They are used extensively in the rubber, oil, mining, paper, printing, metal, textile, cosmetic, environmental, pharmaceutical, food, and dyeing industries, as well as in the rubber, oil, and mining industries.

The consumption of surfactants is rising as well as their use, which is widespread across many sectors of the national economy. Surfactant-containing wastewater is unavoidably dumped into water bodies during use, which is extremely dangerous for ecosystems.

1. Surfactants on aquatic plants

Depending on their concentration, surfactants can harm aquatic plants to varying degrees. The growth of algae and other microorganisms in water will be hampered by high surfactant levels, which will also reduce the water body's main productivity and threaten the aquatic species' food webs. Surfactants can cause acute poisoning by increasing membrane

permeability, which causes material to exosmose and cells to gradually lose their structural integrity.

The three major points sum up how water toxicity to aquatic life and surfactant chemical structure are related.

- I. Less HLB value means a surfactant is more hydrophobic,
- II. The toxicity of aquatic life decreases with increasing ethoxylate group and increases in aquatic toxicity.
- III. The greater the toxic effects of anionic surfactants relative to non-ionic surfactants.

2. Surfactants on aquatic animals

Surfactant toxicity primarily reaches animals through skin penetration and animal feeding. Too much surfactant in the water can cause aquatic poisoning since it can go into the kidney, gills, pancreas, blood, liver, and other internal organs.

3. Effects of surfactants in the aquatic environment

Wastewater containing surfactants that is released into the surrounding area may result in water contamination problems. Persistent foams may form when the water's surfactant content reaches 0.1 mg/L. Because they are difficult to remove, a lot of water bubbles condense into an insulating foam layer. The reduced contact between the water body and gas environment caused by the insulating layer results in less dissolved oxygen being created. Hypoxia impairs the condition of water bodies by killing a lot of bacteria. Surface tension rapidly decreases as surfactant concentration increases decreased from the critical micelle concentration (CMC). The concentration of soluble or insoluble water contaminants in the water may rise in the water column when surfactant concentration exceeds CMC. They absorb substances into materials with low initial adsorption energy, and this solubilisation tendency may lead to indirect contamination and alter the characteristics of water. Surfactants not only kill environmental germs but also prevent other harmful compounds from degrading. Wastewater typically contains a lot of phosphorus because polyphosphate is used as a net agent in detergents. This means that waste water can easily cause eutrophication, sedimentation, sludge nitrification, aeration, and many other processes. When the concentration of surfactants in wastewater from sewage treatment facilities rises above a certain threshold, wastewater treatment will be more difficult. Pollution remediation is less effective when surfactants are used because they increase emulsification and dispersion in polychlorinated organics and water-insoluble oils.

4. Surfactants on the human body

Surfactants' effects on human health, including those on the skin and inside the body, can be separated. Surfactants are today essential components of detergents, but prolonged use can irritate the skin and even cause harm in some instances. Surfactants disrupt the enzymes' actions once they enter a human body, interfering with the body's overall physiological functions. Surfactants are somewhat poisonous and can accumulate in the human body, making their breakdown challenging. Non-ionic surfactants rarely contain protein and frequently lack an electrical charge. They only slightly irritate the skin. The toxicity of anionic and cationic surfactants is comparable, with cationic surfactants having the highest level of toxicity. SDBS, or sodium dodecylbenzene sulfonate, has been linked to teratogenic and carcinogenic effects on the liver, constriction, and other chronic symptoms, and it is absorbed through the epidermis.

There are both negative and positive economic effects of surfactant in tribology and our contribution to this is that if a better way can be proposed for the modification of surfactant to help in the improvement of climate change, that is the reduction of toxicity in aquatic

plants and animals, also the efficiency in cutting fluid, the lubrication on surfaces and reduce the irritation it causes on human skin.

Conclusion

In conclusion, the national economy heavily depends on surfactants. Their degree of development has been used as a barometer for the high-tech chemical technology industry across the globe. In the field of tribology, surfactants are crucial. They enable control of a variety of lubricant properties, including oxidation resistance, emulsification/demulsification, bio resistance and rust/corrosion prevention, in addition to friction and wear. Extracts of lung tissue or alveolar wash are also employed in therapeutic settings (organic solvent).

It has evolved into the competitive focus of the global chemical industry. There is no question that both the consumption and the application of surfactants are growing. The environmental damage will eventually worsen. As a result, it is crucial to detect the presence of water surfactants in the environment. Due to the significant risks posed by surfactants, individuals should act quickly to reduce their use as soon as a quick, simple, and accurate method of surfactant detection is developed. This will help to safeguard the environment and enhance the quality of the water.

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