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Study on characteristics and harm of surfactants

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ABSTRACT

Surfactants have wide use all over world. This study summarizes the characteristics and classification of surfactants. Surfactants have wide application in commodity and industry. A large number of surfactant containing wastewater are discharged into the environment, resulting in harming aquatic life, polluting the water and endangering human health. Therefore, it is important to monitor and control emissions of surfactants in environmental water.

Keywords: Surfactants; Classification; Application; Effects

INTRODUCTION

Surfactants are the main components in household detergent. Household detergents include laundry detergent (such as washing powder, laundry soap, laundry detergent, washing paste, and laundry tablets), home cleaning supplies (such as detergent, floor cleaner, toilet fine and clean appliances cleaning), and personal toiletries (such as shampoo, shower gel, hand liquid and cleanser).Surfactant developmentis to promote the home washing detergents and prosperity, and the development of household detergents also stimulates the surfactant growth. Surfactants are widespread in several human activities because of a series of excellent performances like wetting and emulsifying. A large number of surfactant containing wastewater are discharged into the environment, resulting in harming aquatic life, polluting the water and endangering human health. Therefore, it is important to monitor and control emissions of surfactants in environmental water.

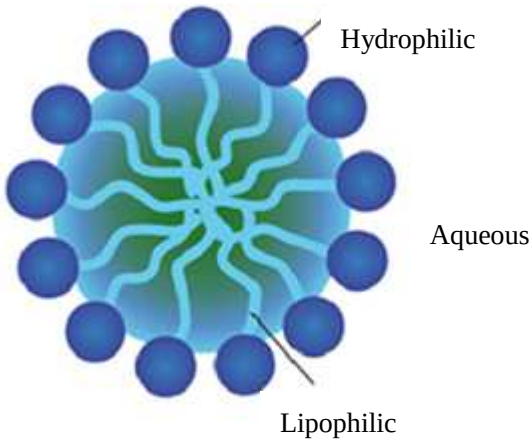

Fig. 1The structure of the surfactant

CHARACTERISTICS OF THE SURFACTANT MOLECULAR STRUCTURE

Surfactant molecular structures consist of two parts. One is called the hydrophilic group which is soluble in water and

hashydrophilic nature. The other part is called the lipophilic group which issoluble in oil butis not soluble in water and has lipophilic nature. Two kinds of groups are in the opposite directions, and both ends are connected to bond in the same molecule, forming an asymmetric and polar structure.The structure is usually referred to "parent structure" (Amphiphilic structure)[1]. Surfactant molecules have amphiphilic structure including an affinity for water and an affinity for oil (Shown in Fig. 1). The hydrophilic group has common-COOH,-SO_3H, and a polyoxyethylene chain; lipophilic group has common-Si,-CF,-CF_2, and a polyoxypropylene chain. The hydrophilia and lipophilicity in surfactant molecules change with molecule composition and structure. When the hydrophilic is stronger than lipophilic, it is the water-soluble surfactant; when hydrophilic is stronger than lipophilic, it is the oil-soluble surfactant. Water-soluble or oil-soluble reflects important physical and chemical parameters of surfactant application.It is an important basis for a reasonable choice of surfactant[2].

Surfactants are to make a significant decrease in surface tension or to reduce the surface tension between two liquids. Through adding the small amount of solvent surfactants, surface tension is reduced andthe state of the interface system is changed. Theyproduce wetting, emulsifying, foaming anddissolving characteristics. Surfactants haveproperties of interfacial tension, surface tension and adsorption orientation, thereby forming the dispersion, foaming, flocculation, disinfection, decontamination, and a sequence of functions. They are widely used in the oil industry, mining, textile, printing and dyeing, pharmaceutical, environmental, food, cosmetics, rubber processing, metal processing and paper industry [3].

CLASSIFICATION AND APPLICATION OF SURFACTANTS

There are many kinds of surfactants, and they are classified by use, properties and chemical structure. The surfactant classification depends on water dissociation and the structure of hydrophilic group. According to the water-soluble, surfactants can be classified into ionic surfactants and nonionic surfactants.Ionic surfactants can be divided into anionic surfactants, cationic surfactants and amphoteric surfactant. Special features or new type surfactant is as special surfactant [4,5].

Anionic surfactants

The anionic surfactantsare dissolved in water with generating the negatively charged surface active group, whoseaqueous solution is neutral or alkaline[6]. Hydrophilic groups according to the type of anionic surfactants can be divided into five peptide condensates: carboxylic acid salt type, sulfate salt type, sulfonate, phosphate ester and fatty acid salt type[7]. Anionic surfactants are the earliest development, the biggest production and the largest species in various types of surfactants. They can be widely used as detergents, foaming agents, emulsifiers, antistatic agents, dispersants and stabilizers in the family and chemical aspects of life.

Cationic surfactants

Cationic surfactantsare dissolved in water with generating the surface activity positive ions[8]. They have good surface activity in an acidic medium and are likely to precipitate and lose activity in alkaline medium. Cationic surfactantsareclassifiedinto open-chain cationic surfactants, heterocyclic group cationic surfactantsand bonded intermediate connectioncationic surfactants according to the chain structure. Cationic surfactants are widely used for sterilization, rust, corrosion, breaking, corrosion and mineral flotation.

Amphoteric surfactants

Amphoteric surfactants which take with both positive and negative ions can be divided into imidazoline, betaine, lecithin, and amino acid-type type according to the anion type[9]. The toxicity of amphoteric surfactantsis very low. It isgentle to the skin, and hasgood biodegradability. Amphoteric surfactantshave wide application in the personal protective equipment such as shampoo, shower gel, cosmetics, etc. and also can be used in industrial softeners and antistatic agents.

Non-ionic surfactants

Nonionic surfactantsdid not ionize any form of ions in an aqueous solution,and a number of oxygen-containing groups form hydrophilic,achieving dissolution by hydrogen bonding with water[10]. Most of non-ionic surfactants are in liquid and slurry form, their solubility in water decrease with the increasing temperature.Non-ionic surfactants have different physicochemical properties from ionic surfactantsdue to their structural features. Hydrophilic groupsare divided into four categories such as polyethylene glycol type, polyhydric alcohols, polyether type and glycosidic type[11]. Non-ionic surfactants are widely used in the textile, paper, food, plastic, glass, fiber, medicines, pesticides, dyes and other industries. They are a lot better performance than ionic surfactants, theproduction is second to the anionic surfactants.

Specialty surfactants

Specialty surfactants havemany special properties which conventional surfactants do not have.Wherein the

fluorocarbon surfactant is the most important species, has high surface activity, high thermal stability and high chemical stability, in many areas with a common surfactant irreplaceable role, so they are widely used in fire protection, textile, paper, mineral processing, leather, pesticides and chemical industries. Furthermore, Ti, Sn and Ge elements are also used to improve the surfactant molecules[12].

Macromolecule surfactants

Macromolecule surfactants generally refer to polymeric surfactantswhose relative molecular mass aregreater than 10000, having a surface-active substance.According to the natural source, they can be divided intonatural type, modified natural material and composing categories[13]. Polymer surfactants can be used as thickener, gelling agent, fluidity-improving agent, emulsifier, dispersing agent and antistatic agent.It has become an important member of the surfactants family.

Bio-surfactants

Bio-surfactants refer to culturing the microorganism under certain conditions, dissolving out surface active metabolites in its metabolism. Depending on the chemical structure, biological surfactants can be divided into single sugar esters, polysaccharides esters, proteins and phospholipid esters[14]. Bio-surfactants are widely applied in the petrochemical industry, and are extensively used for emulsification, emulsion breaking, wetting, foaming and anti-static.They also have important applications in the textile, cosmetics, pharmaceutical, food and other fields.

Surfactantsare important auxiliary in the production process, theyare usually used as wetting, emulsification, dispersion, penetration, levelness.They facilitate or improve the physical and chemical action of the tanning process, shorten the production cycle, save chemical materials, increase productivity and improve the quality of leather into purpose.

THE EFFECTS OF SURFACTANTS

Surfactants are widely used in various field of the national economy,will continue to expand its scope of application andthe consumption is also increasing. In use, the waste water containing surfactants inevitably is discharged into water bodies, and cause serious dangerous harm on ecosystems.

The effects of surfactants on aquatic plants

The damage degree of surfactants to aquatic plants relates to its concentration. When the content of surfactants is high in the water, it will affect the growth of algae and other microorganisms in water, resulting in decreased primary productivity of water bodies, thereby undermining the food chain of aquatic organisms in water bodies. The reason that surfactants causing acute poisoning can lead to membrane permeability increase, so that the material exosmose and cell structure gradually disintegrate. The content of superoxide dismutase, catalase, peroxidase activity and chlorophyll decrease[15]. The accumulation of surfactants increase with time.

From the chemical structure, the relationship between the chemical structure of surfactantsand thetoxicity of water to aquatic organisms can be summarized as the following three points:
(1) The greater hydrophobicity (HLB value is smaller) of surfactants, the greater the aquatic toxicity;
(2) The more ethoxylate group,the lower toxicity of aquatic organisms;
(3) Compared with non-ionic surfactants, the toxicity of anionic surfactants decreases[16].

The effects of surfactants on aquatic animals

A certain toxicity of surfactantswill pass into the animal through animal feeding and skin penetration way. When the surfactant concentration in water is too high, surfactants can enter the gills, blood, kidney, pancreas, gallbladder and liver, and produce aquatic toxicity effect [17].

Table 1 ECO_{50} for several surfactants

Name		ECO_{50} /mg·L^{-1}	
		Water flea	Alga
Anionic surfactants	Linear AlkylbenzeneSulfonates (LAS)	4~250	
	Linear ether sulfate	5~70	60
	Octylphenolpolyoxyethylene m sodium	5~70	10~100
	Soaps		10~50
	Phosphate	3~20	3~20
Non-ionic surfactants	Lauryl alcohol ethoxylates(7EO)	10	50
	Polyoxyethylenestearyl ether(10EO)	48	
	Polyoxyethylenestearyl ether(20EO)		
	Nonylphenolethoxylates(9EO~11EO)	42	50
Cationic surfactants	Cetyltrimethyl ammonium chloride	82	

Fish is very easy to absorbsurfactants by the body surface and gills, and with the blood circulation they distribute to body tissues and organs. When the fish expose to the surfactants, serum transaminases and alkaline acid phosphatase activity increase, it indicates that fish produce the adverse effects. Contamination fish enter the body through the food chain and produce inhibition to various enzymes in the human body, thus reducing the body's immunity.The toxicity of surfactants on bacteria and algae can be expressed in ECO_{50}, which means the suppression degree of surfactants on the movement of aquatic bacteria and algae within 24 h [18].Table 1 is ECO_{50} for several surfactants.

The effects of surfactants on the water environment

Surfactants-containing wastewater discharged into the environment can cause water pollution problems. When the concentration of the surfactant reaches to 0.1mg/L, the water may appear persistent foams.A lot of bubbles are not easy to disappear in the water, forming foam insulating layer. The insulating layer weakens exchange between the water body and gas atmosphere, leading to reduction of dissolved oxygen.A large number of micro-organisms are dead due to hypoxia, resulting in deterioration of water bodies. Below the critical micelle concentration (CMC), with the increase of surfactants concentration,and surface tension decrease rapidly. When the surfactant concentration exceeds CMC in the water column, it can increase the concentration of insoluble or soluble-water pollutants in the water. They take substance which have no original adsorption energy into adsorption layer material, this solubilization behavior can lead to indirect pollution and change the properties of water [19]. Surfactants can also kill microorganisms in the environment and inhibit the degradation of other toxic substances.

Since most detergents contain large amounts of polyphosphate as net agent, the wastewater contains large amounts of phosphorus, which could easily lead to eutrophication. In sewage treatment of plant wastewater, when the concentration of surfactants exceeds a certain concentration, it will affect aeration, sedimentation, sludge nitrification and many other processes andincrease the difficulty of wastewater treatment. Surfactants promote emulsification and dispersion in water-insoluble oil and polychlorinated organics, reducing the efficiency of pollutant treatment.

The effects of surfactants on the human body

The effects of surfactants on the human body are divided into effects on the skin and into the body. The main ingredients of modern life detergents are surfactants, long-term use cause skin irritation effect and lead to some degree of damage. After the surfactantsenter into the human body, they damage the enzyme activity and thus disrupt the body's normal physiological function. Surfactants have some toxicity and may accumulate in the human body, so it is difficult to degrade [20].

In general, nonionic surfactants are not electrically charged, not combined with protein. They haveminimal irritation to the skin. The toxicity of cationic surfactants is the biggest, and the toxicity of anionic surfactants is between that of nonionic surfactants and cationic surfactants. There have been the reports that SDBS (sodium dodecyl benzene sulfonate) is absorbed through the skin, they damage to the liver and cause narrowing and other chronic symptoms, as well as teratogenic and carcinogenic[21].

CONCLUSION

Surfactants are as an important component of the national economy.Their level of development has been regarded as an important indicator of high-tech chemical technology industry all over the countries. It has become the world's chemical industry competitive focus.There is no doubt that the expandingof surfactants applicationfield is as well as the increasing of consumption. At last,the harm to the environment will be more serious. Therefore, the detection of environmental water surfactants content is very important. At present, facing great dangers from surfactants, people should take timely measures to minimize the amount of surfactant, as soon as the development of corresponding fast, easy and accurate detection technology of surfactants, in order to protect the water environment and improve water quality.

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