Cleansing Action of Soaps and Detergents

What are Soaps?

A soap is a water-soluble compound which is made via a process called saponification by the reaction between sodium hydroxide or potassium hydroxide with vegetable or animal oil (fats).

Characteristics of Soap

1. **Hardness –** Harder soap which is a dense bar lasts longer.
2. **Cleansing –** The first reason the majority of people use soap is to get clean. A soap molecule consists of a chain of carbon atoms where one end of the chain attracts oil and the other attracts water. Soap should be balanced and not too much or too less of cleansing ingredient should be added.
3. **Conditioner –** Soap conditioners are referred to as emollients. Once you have washed your hands and what's left behind on your skin after you rinse, depends on the type of soap a person uses. For instance, consider a person with dry skin, he/she should select a soap with moisturizing emollients that can prevent water evaporation.
4. **Lather –** Most people like soap which produces lather. The balance of bubbles and cleansing, soothing cream makes lather so satisfying.
5. **Fragrance –** It is an essential factor. Aromas evoke a unique combination of personal memory and enrich our daily life. Fragrances revitalize us, calm us, and most importantly mask our body odours.

What is Detergent?

Amphipathic molecules that contain charged hydrophilic or polar groups at the end of long lipophilic hydrocarbon groups are called detergents. The charged hydrophilic group is also called the head and the long lipophilic hydrocarbon group is called the tail. Detergents are also known as surfactants as they have the ability to decrease the surface tension of water.

Properties of Detergents

1. The concentration at which micelles formation starts is called as critical micelle concentration (CMC).
2. Aggregation number is the average number of monomers in a micelle.
3. Relative micelle size is indicated by micelle molecular weight.
4. The temperature at which the detergent solution is around or above its critical micelle concentration separates into two phases is called the cloud point.

Cleansing Action of Soaps and Detergents

Soaps and detergents are cleaning agents that help remove dirt, bacteria, and other unwanted particles from the human body as well as other surfaces. Most of the dirt is oily in nature and oil does not dissolve in water. The molecule of soap constitutes sodium or potassium salts of long-chain carboxylic acids. Soap is a kind of molecule in which both the ends have different properties.

- *Hydrophilic end*
- *Hydrophobic end*

The first one is the hydrophilic end which dissolves water and is attracted to it whereas the second one is the hydrophobic end that is dissolved in hydrocarbons and is water repulsive in nature. If on the surface of the water, soap is present then the hydrophobic tail which is not soluble in water will align along the water surface.

Soap molecule

In water, the soap molecule is uniquely oriented. The carbon chain of soap dissolves in oil and the ionic end dissolves in water. Thus, it helps to keep the hydrocarbon part outside the water, as it is water repulsive in nature, and hydrophilic end stays inside the water. When the clusters of molecules are formed then hydrophobic tail comes at the interior of the cluster and the ionic end comes at the surface of the cluster and this formation is called a **micelle.** When the soap is in the form of micelles then it has the ability to clean the oily dirt which gets accumulated at the centre. Therefore, it forms an emulsion in water and helps in dissolving the dirt when we wash our clothes. Therefore, the dirt from the cloth is easily washed away. The soap solution appears cloudy as it forms a colloidal solution which scatters light.

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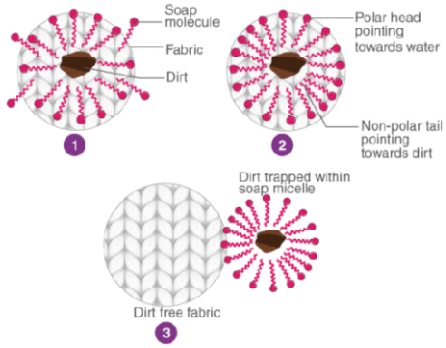
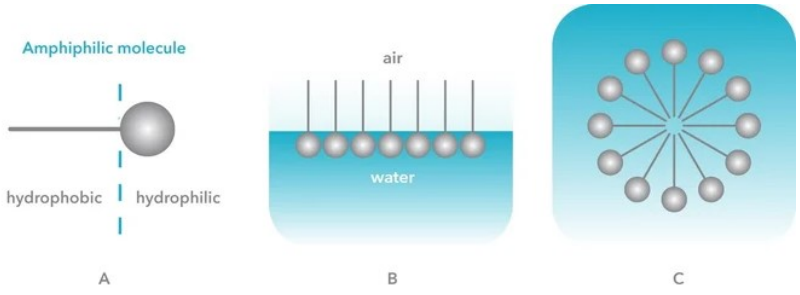


- Soaps and detergents clean by lowering the surface tension of water, emulsifying oil or grease, and holding it in suspension in water.

- Because of the structure of soaps and detergents, they have this ability.
- A long hydrocarbon chain with a carboxylate group on one end makes up a soap anion.
- In oils or grease, the hydrocarbon chain, which is hydrophobic, is soluble.
- The carboxylate group, which is hydrophilic and soluble in water, is the ionic component.
- A detergent's anion part also has a hydrophobic and a hydrophilic component.
- Most of the time, the dirt which is there on any surface is oily in nature, because of which it is also insoluble in water. And because soap is a molecule that is made of long fatty carbon chains which can dissolve in oil helps to clean the surface.
- As we know, the carbon chain dissolves in oil, while the ionic part dissolves in water. Micelles are formed when soap molecules join together to form micelles. Micelles have two finishes: one is oriented toward the oil drop, and the other is oriented toward the outside.
- As a result, it forms an emulsion in water and aids in the dissolution of dirt after we wash our clothes.

Surfactants and Surface tension of water:

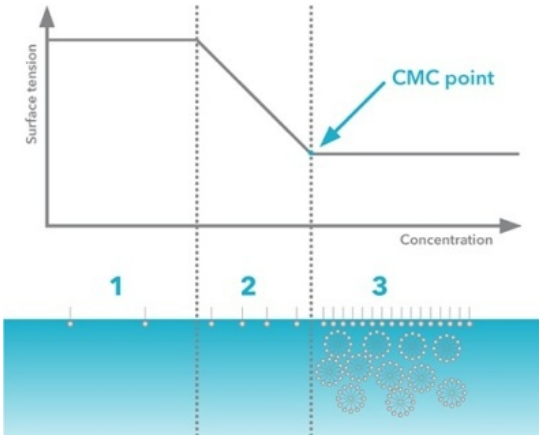
Surfactants are amphiphilic molecules that have hydrophilic and hydrophobic parts (figure 1A). When surfactants are added to water, they orient themselves at the air-water interface so that the hydrophilic part is in water and hydrophobic part in air (figure 1B). Another energetically favorable structure is a micelle (figure 1C), where hydrophobic parts are pointing inwards the spherical structure protected by the hydrophilic outer shell.



The main reason to add surfactants to a solution is to decrease surface tension. The surface tension of water is high due to hydrogen bonding between water molecules. When surfactants are added, they will break those bonds by penetrating at the air-water interface. This will lower the surface tension of water. There are several reasons why the surface tension should be lowered, but maybe the most practical example comes from laundry detergents. While washing clothes, water should penetrate in between the fabric fibers. Due to the high surface tension of water, it is by itself a poor cleaning agent, and thus laundry detergents containing surfactants are added.

Critical micelle concentration (CMC):

As surfactants are added into the detergent mixture, the surface tension will decrease. However, at some point, the surface becomes saturated with surfactant molecules, and micelles start to form (figure 2). **This point is defined as critical micelle concentration**. After this point, the addition of surfactants will no longer affect the surface tension and is therefore unnecessary. Critical micelle concentration can be defined by measuring surface tension as a function of surfactant concentration.

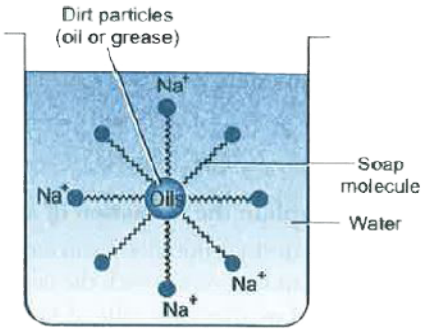


Question: What is micelle?

Answer: In water, the soap molecule is uniquely oriented which helps to keep the hydrocarbon part outside the water. When the clusters of molecules are formed then hydrophobic tail comes at the interior of the cluster and the ionic end comes at the surface of the cluster and this formation is called a micelle. When the soap is in the form of micelles then it has the ability to clean the oily dirt which gets accumulated at the centre. These micelles remain as colloidal solutions.

Question: Explain the cleaning action of detergent.

Answer: A detergent is a made up of two parts: a long hydrocarbon part and a short ionic part containing - $COONa^+$ group. The long hydrocarbon chain is hydrophobic, so the hydrocarbon part of the detergent molecule is insoluble in water but soluble in oil and grease. The ionic part of the detergent molecule is hydrophilic so it is soluble in water but insoluble in oil and grease. When the detergent is added to dirty clothes, which contains grease and oily substances, the greasy and oily dirt particles attach themselves to the hydrocarbon part and ionic part remains attached to the water. When the dirty clothes are agitated in a detergent solution, the dirt particles attached to the hydrocarbon part molecule get washed away in water and the clothes get cleaned.



Question: Explain the Cleansing action of detergents in hard water:

Answer: Synthetic detergents can lather well even in hard water because they do not form insoluble calcium or magnesium salts on reacting with the calcium and magnesium ions present in the hard water. Whereas when we talk about soaps, they are not suitable for hard water as they form insoluble calcium or magnesium salts on reacting with the calcium and magnesium ions present in the hard water.

Question: Explain the cleaning action of soap. Why does soap not work in hard water?

Answer: Cleaning action of soap

1. A soap molecule is composed of sodium or potassium salt of a long-chain carboxylic acid.
2. It is divided into two parts: a lengthy hydrocarbon tail and a negatively charged head. The hydrocarbon tail is hydrophobic which means it is insoluble in water and repels water, but the polar end is water-soluble and hydrophilic.
3. Because dirt is non-polar, the polar end of the soap molecule dissolves in water while the nonpolar end connects it to the dirt molecule when applied to a wet dirty surface. Micelles are spherical clusters formed as a result of this process.
4. The hydrophobic tails of micelles reside in the center of the cluster, whereas the ionic ends are on the surface, ion-ion repulsion keeps the micelle in the solution as a colloid and prevents it from forming a precipitate. As a result, an emulsion is generated, which aids in the dissolution of debris in water before being cleansed with running water and because of the presence of Magnesium and Iron in hard water, soap does not perform.

So due to the presence of Magnesium and Iron in hard water, soap doesn't work in hard water.