



جامعة النجاح الوطنية
An-Najah National University



An-Najah National University
Faculty of Engineering & Information Technology
Department of Chemical Engineering

Soap and Detergent Manufacturing (10626475)

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Spring 2021

This Course

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- This is an **industry related** course.
- Students can learn more on how to manufacture soap and detergents.
- The course will also equip students with the **chemistry behind soap, detergent** and cosmetic emulsion manufacturing.
- Students will learn more about **surfactants** used in manufacturing soap and detergents.
- Household cleaning and disinfection products will be discussed in this course.

This Course

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- The last topic to be discussed in this course is the mixing roles in soap and detergent manufacturing. All **safety** issues related to soap and detergent manufacturing steps will be covered.
- During the course, students will be asked to make **visits to local chemical industry.**
- Several **assignments** will be based on such visits. **Students will apply what they learn in this course by carrying out experiments in the department's lab.**

Objectives

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By the end of this course, you will be:

- Able to understand the fundamental theories, practical applications, and manufacturing aspects of liquid detergents, from **light duty liquid detergent to heavy duty liquid detergent in** addition to shampoos and conditioners.
- Able to differentiate between **soap and detergent.**
- Able to understand the different type of **surfactants and their characteristics.**
- Able to understand the role of **surfactant** in detergent, household and cosmetic manufacturing.

Objectives

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By the end of this course, you will be:

- Able to analyze **formulated products**.
- Able to **label a detergent** product according to **Palestinian Standards (PS)**.
- Able to choose the **right mixing device** to produce a good quality detergent product.
- Able to produce **lab scale product** and be introduced to commercial scale detergent production line.

Assessment and Grading

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Activity	Percent (%)
Midterm Exam	25 %
Projects and Assignments	35 %
Final Exam	40 %

Expectations for Students

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- Be on time
- Attend lectures, pay attention, listen and take notes.
- Hand in assignments and projects on time
- If you have a cell / mobile phone, please either turn it off or place it in silent mode prior to class.
- **ABSENCE FROM AN EXAM:** Makeup exams will be given only under extremely unusual circumstances.

Soap and Detergents

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- ❑ Soaps and detergents are essential to personal and public health.
- ❑ Through their ability to loosen and remove soil from a surface, they contribute to good **personal hygiene**; **reduce** the presence of germs that cause infectious diseases; **extend** the useful life of clothes, tableware, linens, surfaces and furnishings; and make our homes and workplaces **more pleasant**.

Soap and Detergents

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- **Soaps and detergents found in the home** can be grouped into four general categories:
 1. **Personal Cleansing**
 2. **Laundry**
 3. **Dishwashing and**
 4. **Household Cleaning.**

Within each category are different product types formulated with ingredients selected to perform a broad cleaning function as well as to deliver properties specific to that product. **Knowing the different products and their ingredients helps you select the right product for the cleaning job.**

Soap & Detergent Products

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1. **Personal Cleansing Products:**

- Include products for hand and body washing as well as shampoos, conditioners, and toothpastes.
- They are marketed primarily in bar, gel, and liquid forms.
- A major consideration in formulation of such products is the desired consumer aesthetic such as lather, skin feel, smell, and taste.



Soap & Detergent Products

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2. Laundry Detergents And Laundry Aids.

- These comprise mainframe laundry detergents in powder, liquid, tablet, gel, and bar form.
- Laundry aids: fabric conditioner, pretreaters and bleaches.
- Typical laundry detergents are formulated to provide general cleaning, the ability to maintain whiteness, brightness, softening, dye lock, fiber protection, and disinfectancy.



Soap & Detergent Products

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3. Dishwashing Products

- These include detergents for hand and **machine dishwashing** and are typically provided in liquid, gel, powder, or tablet form.
- Hand dish wash products are formulated to remove and suspend food soils from a variety of surfaces, and they must be **mild to skin**.



Soap & Detergent Products

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3. Dishwashing Products

- Products designed for automatic dishwashing must provide soil removal and suspension, control of **water hardness**.
- **Rinse aids** are specialty detergent formulations for automatic dishwashing designed to promote drainage of water from surfaces via lowering of surface tension. **This helps minimise spotting and filming during drying.**



Soap & Detergent Products

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4. Household Cleaning Products.

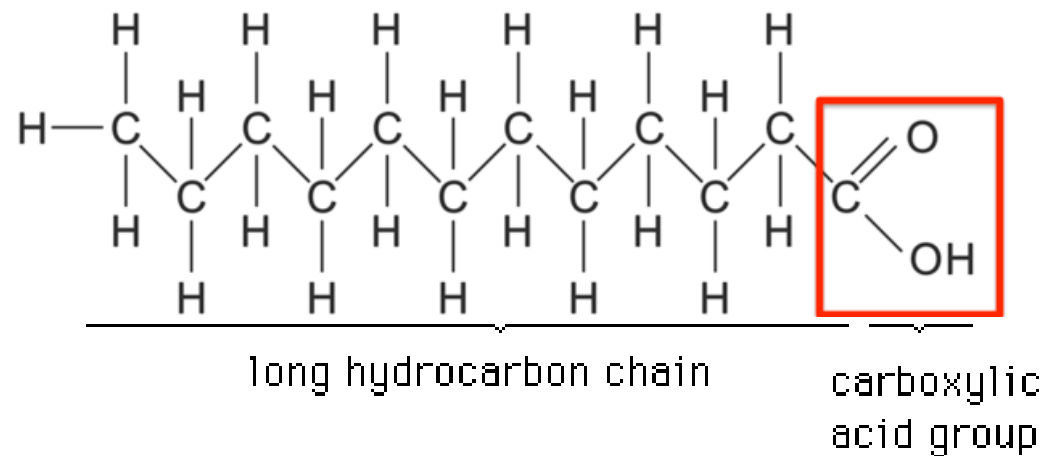
- Called “all-purpose” cleaners are designed to penetrate and loosen soil, control water hardness, and prevent soil from redepositing onto clean surfaces.
- Many of these products also contain low levels of **antibacterial actives**.
- Powdered **abrasive** cleaners remove heavy accumulations of soil via the use of mineral or metallic abrasive particles.
- Some of these products may also bleach and disinfect.



Soap

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- Ordinary household bar soap or toilet soap is a mixture of **long chain fatty acids**. The fatty acids containing 8 to 22 carbon atoms.
- Soap: **any salt of fatty acid and usually made by saponification of fatty oil with caustic soda.**



Essential features of a fatty acid

Soap

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- In most developed countries soap products are now relatively **insignificant** in the domestic markets, except for the **toilet soaps** used for personal washing.
- In less developed countries, household soaps continue to be the main detergent.
- **Raw materials**
 - ▣ Alkali (sodium hydroxide (lye) or potassium hydroxide (potash))
 - ▣ Fats (tallow) and Oils



Soap Raw Materials

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Additives are used to enhance the **colour, texture, and scent** of soap. Fragrances and perfumes are added to the soap mixture to cover the odour of dirt and to leave behind a fresh-smelling scent

□ Additives

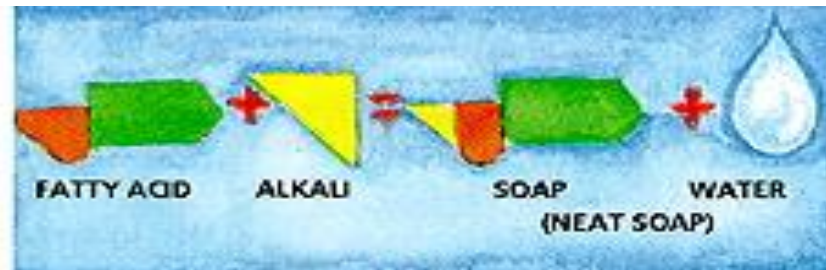
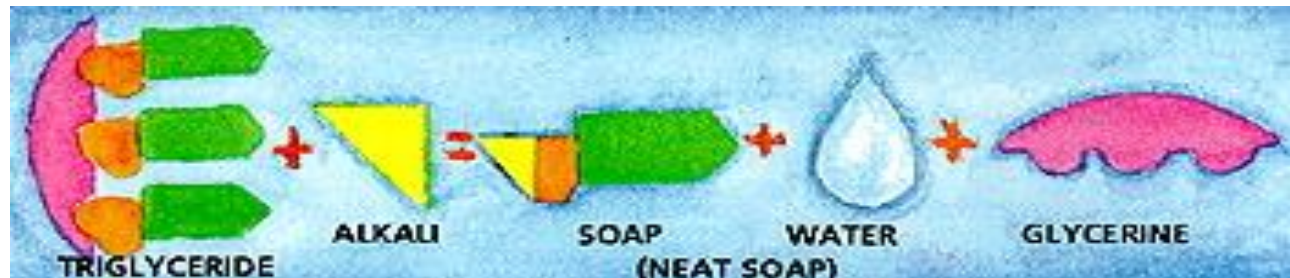
- Optical brightener
- Chelating agent are used to surround unwanted metal ions found in cleaning solutions like **water hardness** (phosphates, EDTA (ethylene diamine tetra acetate), sodium citrate and zeolite compounds).
- Abrasive (enhance the texture of soap include talc, silica and marble pumice)

Characteristics of Soap



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- Soaps are prepared by direct **saponification** of fatty acid (**lauric, myristic, palmitic, stearic and oleic**) involving varieties of fatty acids in the fat, glycerol (glycerine) being by product.
- In the process fats are splitted into **fatty acid and glycerol** and then the separated fatty acids are neutralized to make soap.

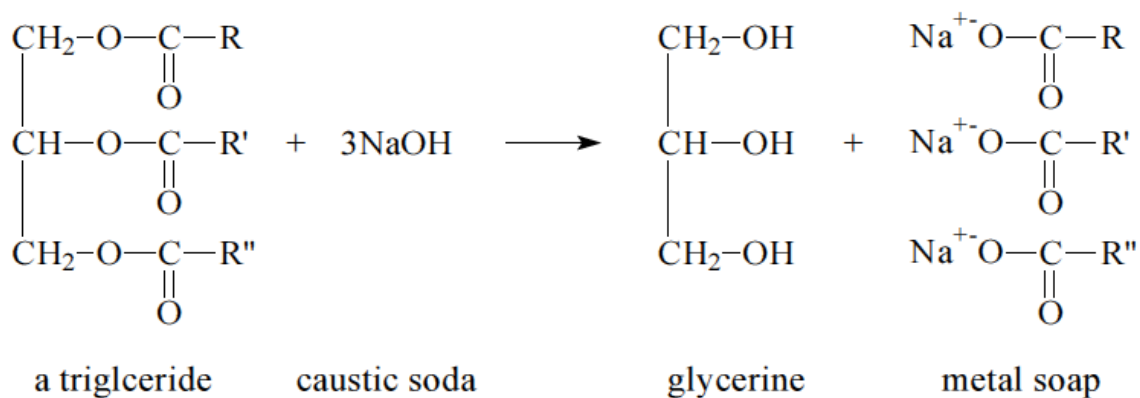


Characteristics of Soap



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- Theoretically for an average 100 kg of fat on **saponification** with 15.4 kg NaOH yields 103.6 kg of pure **sodium soaps** and 11.8 kg of glycerol.



fatty acid salt

Characteristics of Soap.... continued

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- The nature of soap depends mainly upon its component **fatty acid** from which the soap is made.
- The solubility and hardness of sodium salts of various fatty acids differ.
- Hard soaps consists mainly of **sodium oleate or sodium palmitate or sodium stearate**.
- Soft soap consists mainly **of sodium and potassium salts of lauric and myristic acids** which are main composition of coconut oil and palm oil. **Soft soaps are more soluble than hard soaps.**
- Ammonium soaps are more soluble than potassium soaps and potassium soaps are more soluble than sodium soaps.

Characteristics of Soap

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- **Various oils** may produces soaps of various physical appearance, such as **creamy, greasy, waxy**.
- Quality of soaps also varies, some having lasting lather, some have lather vanishing immediately, some remain hard through absorbing water.
- So the character of water soluble soaps are mainly determined by **nature of the fats** used in their **preparation**.
 - Fats containing high percentage of **lauric and myristic acid** produce soaps that are firm (solid) and readily soluble in cold water.

Characteristics of Soap

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- These soaps have good foaming property and are not easily salted out. Because of this property, they are used **where washing water is saline.**
- Soft fats or oils such as olive, cottensead, linseed, soyabean and corn oil containing high **percentage of unsaturated acids** produce soaps whose solubility in lack warm water is quite good.
- These soaps are suggested to be used for washing **delicate surfaces and fibres.**

Characteristics of Soap.... continued

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- A mixture of hard fat such as tallow or similar fat, and soft fat such as coconut oil/palm oil is usually used in the preparation of toilet soaps.
- The ratio of tallow to coconut oil being **60:40** approximately. Sometimes **7 to 10 percent** free fatty acids are added to the mixture.
- Other factors affecting the physical properties are: moisture content, crystal character, mechanical working in finishing process, cooling during solidification.

For information

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- Sodium laurate $\text{C}_{12}\text{H}_{23}\text{O}_2\text{Na}$ (sodium salt of a fatty acid (lauric acid))
- Sodium palmitate $\text{C}_{16}\text{H}_{31}\text{O}_2\text{Na}$ (Sodium palmate is synthesized by reacting palm oil with sodium hydroxide)
- Sodium stearate $\text{C}_{18}\text{H}_{35}\text{O}_2\text{Na}$ (sodium salt of stearic acid)

Soaps can not be used in acid solution, Why?

Because it is decomposed with the liberation of fatty acid and it forms a precipitate with the calcium and magnesium in hard water.

Manufacturing steps

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- Cleaning products come in three principal forms: **bars, powders and liquids**. Some liquid products are so viscous that they are gels.
- **The first phase in manufacturing** all three forms is **the selection of raw materials**.

Raw materials are chosen according to **many criteria**, including their **human and environmental safety, cost, compatibility with other ingredients, and the form and performance characteristics of the finished product**.

While actual production processes may vary from manufacturer to manufacturer, there are steps which are common to all products of a similar form.

Soap Manufacturing Process

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▣ Boiling Process

▣ Continuous Process

▣ Cold & Semiboiled method.

- ▣ Soap and detergent manufacturing consists of a broad range of processing and packaging operations.
- ▣ The size and complexity of these operations vary from small plants employing a few people to **those hundred workers**.
- ▣ Products range from **large-volume** types like laundry detergents that are used on a regular basis to **lower-volume** specialties for less frequent cleaning needs.

Soap Manufacturing

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Sodium soaps can be made by:

1. **Direct saponification, almost always with caustic soda.**
2. Splitting, or hydrolysis of the fat with water to fatty acids plus glycerol followed by the separation of the glycerol and the neutralization of the fatty acids with caustic soda or sodium carbonate to form soap.

Neutralization of the fatty acids produced in other ways, particularly by the oxidation of a petroleum hydrocarbons.

SOAP MANUFACTURING

Step 1 - Saponification

A mixture of tallow (animal fat) and coconut oil is mixed with sodium hydroxide and heated. The soap produced is the salt of a long chain carboxylic acid.

Step 2 - Glycerine removal

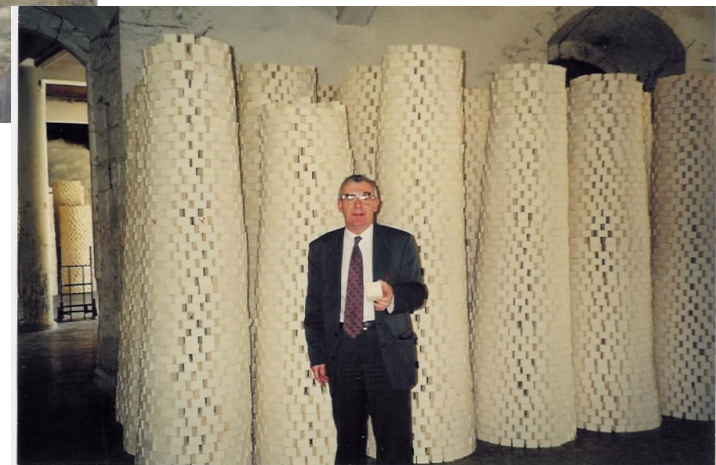
Glycerine is more valuable than soap, so most of it is removed. Some is left in the soap to help make it soft and smooth. Soap is not very soluble in salt water, whereas glycerine is, so salt is added to the wet soap causing it to separate out into soap and glycerine in salt water.

Step 3 - Soap purification

Any remaining sodium hydroxide is neutralised with a weak acid such as citric acid and two thirds of the remaining water removed.

Step 4 - Finishing

Additives such as preservatives, colour and perfume are added and mixed in with the soap and it is shaped into bars for sale.



Cleaning Mechanism

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- In solution the molecules of soap are dispersed in clusters, each of which may contain hundred of soap molecules.
- Each molecule has one end **polar “-COONa”** and the other end is **non polar**, the long chain of carbon.
- The polar end is soluble **in polar solvent water** and non polar end which is insoluble in water is soluble in non polar ends of other soap molecules which therefore clinch (settle) together at the centre of the cluster called **micelle**.
- Each polar end is surrounded by an **ionic** atmosphere. The repulsion between similar charges keep the **micelle** dispersed.

Cleaning Mechanism

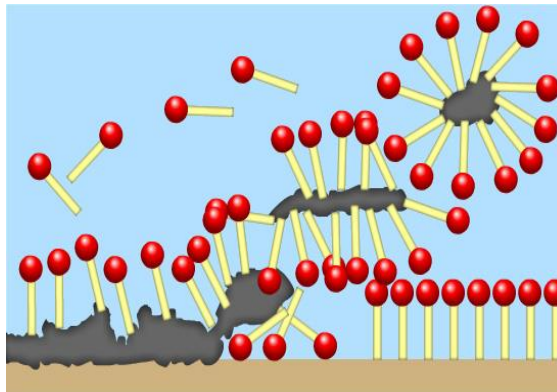
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- Soap molecules being big enough (each chain of mostly 12 to 18 or more carbon atoms) each end clearly displays its own solubility behavior.
- Such dual solubility behavior gives soaps and detergent their cleansing power.
- Reducing soap **interfacial tension**, soap solution increases the wetting ability of water which easily penetrates the fabrics and reaches the soil.

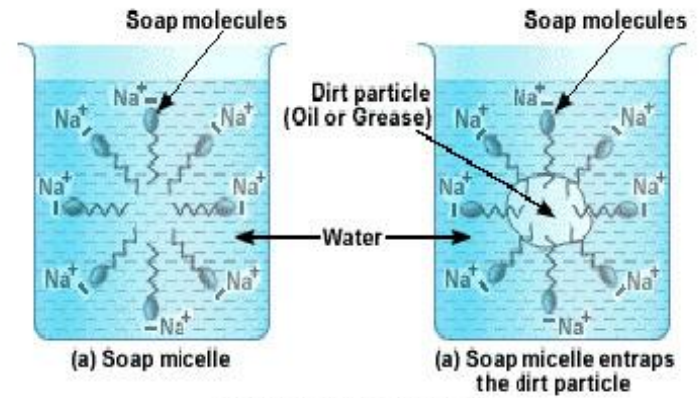
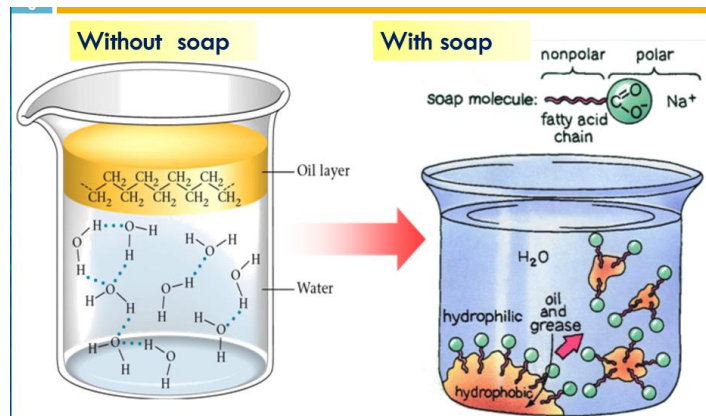
Cleaning mechanism

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- **Non polar ends** of soap molecules dissolve in dirt holding grease and oils.
- **The polar ends** of molecules projecting in to the surrounding water layer keep dirt as stable emulsion.
- Washing process thus removes the soil which is kept in the washing liquid as emulsion, suspension in solution.



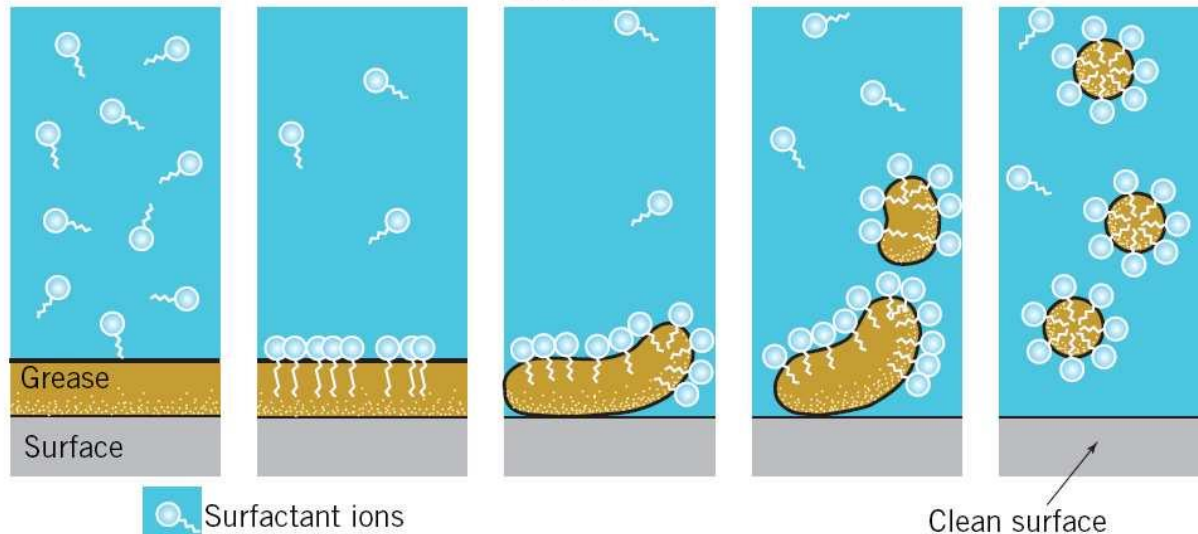
How Soap & Detergent Work !!!



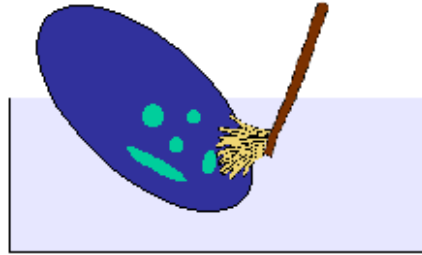
Cleansing action of soap

- (a) Soap or detergent dissolves in water
- (b) Surfactant ions orientate themselves in grease and water
- (c) Agitation begins to separate grease from surface

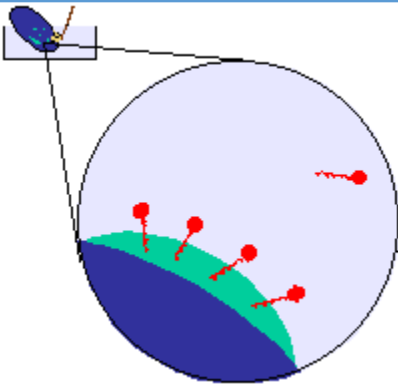
- (d) Process continues
- (e) Cleaning complete



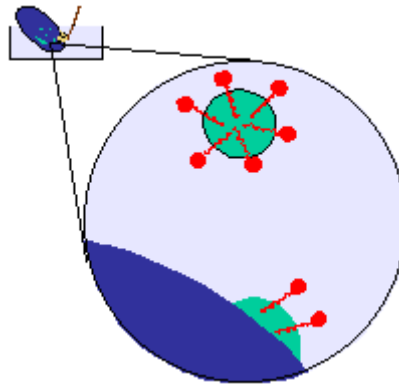
The Cleaning Action of Soaps And Detergents



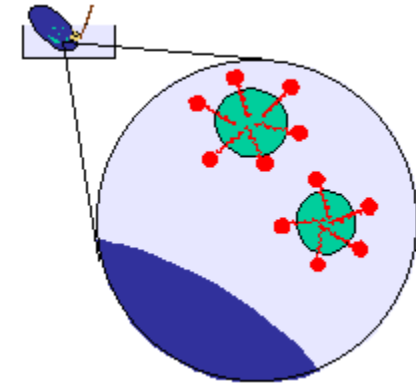
Step # 1: You take the plate with some grease on it and dip it in sudsy water then agitate.



Step # 2: At the molecular level the detergent molecules are adsorbing onto the grease,



Step # 3: your agitation or scrubbing is breaking the grease into small droplets.



Step # 4: The role of the detergent is to prevent the droplets coalescing and redepositing on the plate

Difference between Soap and Detergent?

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- Soaps are produced from natural products, and detergents are synthetic, or man-made.
- To make soap, the first step is to start with fats and oils that are reduced to fatty acids and glycerine with a **high pressure steam**. The fatty acids then combine with either sodium or potassium salts (an alkali or base) to produce **soap and water**.
- After this process, the soap possesses a **hydrophilic** end that is attracted to water and a **hydrophobic** end that is repelled by water, allowing the soap to break down materials that dissolve in both oil and water.

Difference between Soap and Detergent?

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- Detergents are **created through a similar process** and produce an almost identical product, a **sodium salt**.
- The first ingredient used in creating detergents is the compound propylene, **$\text{CH}_3\text{-CH=CH}_2$** , which used to just be burnt off as waste by the petroleum industry. **Propylene molecules** are manipulated to form a compound that will react with sulfuric acid.
- Next, **sodium hydroxide** is added to neutralize the sulfuric acid resulting in a **sodium salt** similar to the one present in soap. In general, since soaps are a **more natural product, they are used on the body, and detergents are used on clothes**. But detergents are the more prevalent of the two and are often used in combination with natural soaps.

Difference between Soap and Detergent?

- Both soaps and detergents share a critical chemical property - they are surface-active agents, or **surfactants**.
- Soaps possess a number of qualities that make them preferable to detergents. First, as mentioned earlier, they are:
 - *Natural products*
 - *Less harmful to the human skin and the environment.*
 - *Soaps are biodegradable and do not create pollution in our rivers and streams.*
- Since the **soap does not rinse** out as well as detergent, it tends to build up on clothes, and over a long period of time, causes the **fabric to deteriorate while leaving an odor**.
- Another shortcoming of **soap is that it is less powerful than synthetic detergent** and tends to lose its cleaning power over time. **So don't wash your laundry with soap**

Differences between Soap and Detergent



- ❑ **Soap is a detergent**, but the word “detergent” is frequently confined to non -soapy surfactants and products based on them.
- ❑ These are called non soapy detergent (**NSDs**). These are called **soapless detergents or synthetic detergents**.

	Soap	Detergent
Cleaning	Good detergency	Better detergency with higher emulsification power
Active Agent	A long chain fatty acids salts of alkali metals having anionic functional group	Long chain composed of aliphatic and aromatic organic compounds. The functional groups may vary from anionic, nonionic and cationic



Differences between Soap and Detergent




	Soap	Detergent
Solubility of Ca^{2+} , Mg^{2+}	Precipitate might form in hard water reduce their cleaning ability	They form soluble salt of Ca^{2+} , Mg^{2+} or at least keep insoluble salt are formed it has the ability to flocculate
Acidic Conditions	It can't work under acidic conditions	Because its salts of strong acid it produces neutral solution
Textile Texture	Good cleaning power for cotton and wool	Good for cotton but very low penetrating ability for wool also doesn't work for silk as the silk is very sensitive to aromatic compounds



Differences between Soap and Detergent



	Soap	Detergent
Varity of Products	Because of its composition of fatty acid and anionic group, it has limited type of products	It has large number of products due to its composition (anionic, nonionic, cationic, amphoteric)
Biodegradability 	Easily biodegradable (are usually manufactured) using natural materials; fats and oils of plants and animals	May of detergents are not biodegradable (are generally synthetic)