Cleaning Fluids: Soaps and Detergents

Outcomes:

Students will be expected to:

- *Relate personal activities in formal and informal settings to specific science disciplines. (109-10)*
- *Provide examples of scientific knowledge that have resulted in the development of technologies. (111-1)*
- *Describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems. (111-5)*
- *Provide examples of how science and technology affect their lives and their community. (112-7)*

Cleanliness is a very important aspect of living in today's world. Many people have become infatuated with cleanliness as a result of the various advertisements and television commercials that have been produced and broadcasted. Simply consider how many people change their clothes and shower several times each day. Such actions require the use of soaps and detergents, which explains why the manufacturing of such cleaning fluids has become a multi-billion dollar industry. Many people even have strict preferences in relation to soaps and detergents, which explains why there is such a large and complex selection made available to people in retail stores.

A selection of available laundry detergents.

People rarely experience problems with cleaning substances such as mud and clay from their clothes and bodies since both are soluble in water and therefore, can be cleaned off. To the contrary, people often experience problems with cleaning substances such as oil and grease from their clothes and bodies since both are insoluble in water and therefore, cannot be cleaned off easily. A soap or detergent would be required to make cleaning off such substances easier.

Cleaning snowmobile grease from your hands using water is highly problematic.

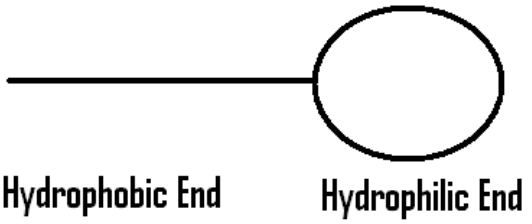
Cleaning snowmobile grease from your hands using soap and water is less problematic.

Soap, by chemical classification, is a surfactant. A surfactant is a material that can greatly reduce the surface tension of water.

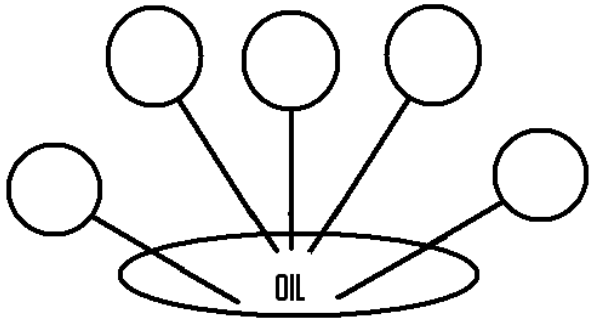
> ***Did You Know?***
> *Surface tension is a force of nature caused by the attractive forces within a liquid. All molecules in a liquid are attracted to one another, but on the surface, the attraction is stronger toward the liquid rather than toward the air or whatever is on the surface of the liquid. This causes the molecules to tighten or form a slight barrier at the surface.*

When this is done, the water becomes "wetter", thereby making it less likely to stick to itself and more likely to interact with oil and grease. The soap molecule, usually containing 8 to 18 carbon atoms, has two different ends. One end is water soluble, called hydrophilic, and the other end is water insoluble, called hydrophobic. Remember that the word phobia means a fear or hatred of something. As a result, it can be concluded that this end of the soap molecule hates water.

The soap molecule is represented in the diagram above (right side):



When the soap molecule comes in contact with oil (or grease), the hydrophobic (water hating) end dissolves into it, leaving the hydrophilic (water loving) end sticking out. Soap molecules will continue to dissolve into the oil (or grease), eventually forming a layer over the oil (or grease).



This newly-formed layer on the oil (or grease) reduces the surface tension and with the motion of the washer, or your hands, causes the oil (or grease) to break away from the surface. Once floating in the water, the new layer surrounding the oil (or grease) acts as a repellant for other oil (or grease) droplets. This prevents the oil (or grease) droplets from coming together? They simply go down the drain with the water instead of reforming on the clothes or hands.

Soaps in our local grocery store come in many different varieties, but the basic cleaning ingredient is this dual ended molecule.

Did You Know?
Companies bubble air through soap when it is hardening to allow it to float.

Companies add ammonium salts to soap to allow it to be a liquid.

Companies add moisturizers and perfumes to soap to aid in selling it.

The basic ingredient in all of the different varieties of soap is the same (i.e. the dual-ended molecule). ***Soap is soap!***

Detergents, also known as synthetic detergents, were developed because of a shortage of fats (animal and vegetable), which were the main ingredient in the manufacture of soap during both World War I and World War II.

Did You Know?
We make a product from fat and grease to remove fat and grease.

Soap is produced by reacting fat and grease with lye (sodium hydroxide). The resulting concoction is glycerin, which is the basis of soap. What type of soap is produced depends on the type of fat and how much is used.

After World War II, the demand for detergents increased dramatically.

Sales of Soaps and Detergents

Year	**Soaps (X 1000 tones)**	**Detergents (X 1000 tons)**
1940	1410	4.5
1950	1340	655
1960	583	1645
1970	587	4448

With increasing sales comes increasing competition. Companies started making improvements to their detergents.

1. **Builders:**
Builders, such as sodium phosphate, were added to make the water more basic. These builders removed extra magnesium and calcium ions from the water (water containing these ions is called "hard water" and is found in many places in Newfoundland and Labrador). With these ions removed from the water, no "scum" (or "ring-around-the-tub") will form and stick to the clothes.

2. **Anti-redeposition Agents:**
It was discovered that detergents were removing mud and clay (i.e. dirt) from the knees of jeans, but it was simply "re-sticking" to the clothes. A chemical called sodium carboxymethylcellulose (CMC) was added. This chemical gave the fabric a small negative charge, which repelled the negatively charged dirt (i.e. the hydrophilic end of the detergent is negatively charged and it soaks into the dirt, thus producing negatively charged dirt).

3. **Optical Brighteners:**
These were used to make white clothing "whiter". This can be noticed when ultra-violet light is shone on white clothing and it will "glow" bluish-white. Optical brighteners are very complex organic molecules that absorb ultra-violet light and then give it off as a visible light. This process is called fluorescence.

4. **Inert Fillers:**
Sulfate compounds were added to make the detergent powder flow freely. Without it, the detergent would stick together and become one big block.

5. **Anti-corrosion Agents:**
Chemicals such as sodium silicate were added so that metal objects like buttons and zippers would not rust or corrode.

6. **Perfumes:**
Organic molecules with pleasant smells were added to give the clothes aromas such as "spring morning" or "summer breeze".

7. **Enzymes:**
Enzymes are organic compounds that attack or breakdown proteins. These compounds would clean grass and blood stains by destroying the proteins found in them.

Did You know?
Each of these additions were responses to the consumers who simply wanted better cleaning power and whiter whites. They were added with little thought on their impact on the environment and much thought on their impact on selling the products.

In response to a variety of health and environmental concerns over the past several years, the detergent industry has made some major changes:

1. **Phosphate Pollution:**
Lakes and ponds near residences started showing increased levels of algae (i.e. green slime). Algae consume a large amount of dissolved oxygen from the water and as a result, can reduce the number and diversity of aquatic life forms over time (e.g. trout). Phosphate, a chemical compound in detergents, serves as "food" for algae. As a result, industry was forced to remove it from detergents.

Algae lives on phosphates in the water (from detergents) and consumes the dissolved oxygen in the water. Photograph courtesy Wikimedia Commons.

2. **Sewage Treatment:**
River and well systems near household water discharge locations were producing water that foamed. It was discovered that a chemical called alkyl benzene sulphonate in detergents was not being broken down by bacteria and was therefore, finding its way into the river and well systems. The industry found a safe biodegradeable substitute called fatty acid sulphates, which bacteria could break down.

3. **Landfill:**
People were using a tremendous amount of detergents and therefore, producing a large amount of garbage. The industry responded by producing

a higher concentrated detergent that required less per washer load and less packaging. At the same time, it decreased the amount of garbage going to landfills, decreased transportation pollution, and decreased the amount of detergent entering the environment.

4. **Perfume Allergies:**
Because more and more people were becoming sensitive or allergic to heavy perfumes and additives, the industry responded by introducing lines of products that were "free" of heavy perfumes and additives. The industry responded this way despite knowing that they were losing some of their past marketing ploys.

Analysis Questions:

1. Using diagrams, explain how soap works to remove oil or grease from your hands.

2. Describe the function of each of the following, which exists in detergents:
   a. Builders
   b. Anti-redeposition Agents
   c. Optical Brighteners
   d. Inert Fillers
   e. Anti-corrision Agents
   f. Perfumes
   g. Enzymes

3. Why do we still use soap for washing our hands and not detergents?

4. With the mentioned problems in mind, do you think we should still use detergents? Explain your answer.

5. Some detergents are more "environmentally friendly" than others. Should everyone be buying these "environmentally friendly" detergents? Why are some people still not using these detergents?

6. Discuss the pros and cons of antibacterial soaps.

7. Why do you think the demand for detergents increased so much after World War II?

8. Graph the data in the table entitled, "Sales of Soaps and Detergents". Predict the data for the sales of soaps and detergents today.

Activity:

Students could design an experiment to test the cleaning ability of different soaps and/or detergents on different stains.

Sources:

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Chemistry.co.nz/surfactants.htm

Chemistry.about.com/od/howthingswork/f/detergentfaq.htm

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Home.howstuffworks.com/question692.htm