Name________________________________

Date________________ Class________________

EXPERIMENT D13

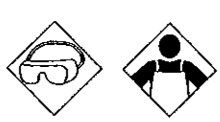
A Close Look at Soaps and Detergents

- **Observe** the action of surfactants in reducing surface tension.
- **Evaluate** the foaming capacity of commercial soaps and synthetic detergents.
- **Determine** the efficiency of soaps and synthetic detergents in emulsifying a fat sample in water.

Soap is a surface-active agent (surfactant) that lowers the surface tension of water, allowing fat or oil-bearing soil particles to be suspended in water (emulsification). Although soaps are excellent cleansers in soft water, they are ineffective in hard-water conditions. Hard water contains aqueous salts of magnesium, calcium, and iron. When soap is used in hard water, the insoluble calcium salts of the fatty acids and other precipitates are deposited as curds. This precipitate is commonly referred to as bathtub ring or scale. To overcome this problem, inexpensive synthetic detergents were developed around 1950. Although immensely popular, these compounds were not biodegradable and were replaced in the mid-1960s.

Synthetic detergents, like soaps, have a long hydrocarbon chain labeled as a tail that is attached to a hydrophilic head. Synthetic surfactants are classified as anionic, cationic, or nonionic, depending on the type of hydrophilic head. The hydrophilic portion of a synthetic detergent is often a sulfonate, phosphate, or something other than the carboxyl group that is found in the soap. Therefore, synthetic surfactants are effective in both hard and soft water. No precipitates form when calcium, magnesium, or iron ions are present in solution. The most widely used group of synthetic detergents is the linear alkyl sulfonates (LAS). LAS are straight-chain compounds that have 10 or more carbon atoms and are easily degraded by bacteria.

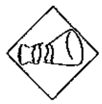
Because water is a polar substance, it cannot remove dirt from fabrics if the dirt is suspended in oil and grease, which are nonpolar. The hydrocarbon tail of a detergent molecule dissolves itself in an oily substance but leaves the polar head outside the oily surface. Many detergent molecules continue to orient themselves in this way until the dirt containing oil is encapsulated. The oil droplet is then lifted away from the fabric and suspended in the water as a droplet or micelle.



Always wear safety goggles and a lab apron to protect your eyes and clothing. If you get a chemical in your eyes, immediately flush the chemical out at the eyewash station while calling to your teacher. Know the location of the emergency lab shower and the eyewash station and the procedures for using them.

Do not touch any chemicals. If you get a chemical on your skin or clothing, wash the chemical off at the sink while calling to your teacher. Make sure you carefully read the labels and follow the precautions on all containers of chemicals that you use. If there are no precautions stated on the label, ask your teacher what precautions you should follow. Do not taste any chemicals or items used in the laboratory. Never return leftovers to their original containers; take only small amounts to avoid wasting supplies.

Call your teacher in the event of a spill. Spills should be cleaned up promptly, according to your teacher's directions.



Never put broken glass in a regular waste container. Broken glass should be disposed of properly.

Never stir with a thermometer because the glass around the bulb is fragile and might break.

- 0.5% alcohol solution of Sudan IV
- 4% $CaCO_3$ solution
- 1.5% detergent solution
- detergent (powdered and liquid)
- lard
- soap (bar and liquid)
- 500 mL beaker
- 125 mL Erlenmeyer flask
- balance
- fabric, two 2-in. squares
- hot plate
- medicine dropper
- metric ruler
- No. 5 solid rubber stopper
- stirring rod
- thermometer
- wax paper
- wax pencil

Part 1: Investigating the action of a surface-acting agent (surfactant)

1. Using a medicine dropper, carefully add single drops of distilled water to a square of clean fabric. Describe what occurs.

2. Using a second medicine dropper, carefully add drops of detergent solution on top of the beaded water drops. Describe what happens.

Part 2: Evaluating cleansing characteristics of soaps and synthetic detergents

3. Use a wax pencil to label a set of five 5 Erlenmeyer flasks 1, 2, 3, 4, and 5.

4. Obtain five soap solutions from your teacher. Record in the **Data Table** the manufacturer's brand name next to each sample number. Then add 10 mL of each soap or detergent sample to its respective numbered flask.

5. Stopper flask 1 securely with a rubber stopper. Hold the flask with your thumb on the stopper, and shake it vigorously for 15 seconds. Allow the solution to stand for 30 seconds. Observe and measure the level of the foam. Record this value in the **Data Table.** Repeat this process for flasks 2 through 5. Which product has the highest foam level?

6. To each flask add 4 drops of 4% $CaCO_3$ solution from a medicine dropper. Stopper the flask, and with your thumb on the stopper, shake vigorously for 15 seconds. Allow the solution to stand for 30 seconds. Observe and measure the level of foam. Record this value in the **Data Table.** Describe how $CaCO_3$ affects a surfactant's ability to foam.

Part 3: Evaluating the effectiveness of soaps and synthetic detergents in emulsifying fat

7. Fill a 500 mL beaker with 250 mL of distilled water. Set the beaker on a hot plate and heat the water to 55°C. Try to maintain this temperature as closely as possible throughout the experiment.

8. Measure a 0.1 g sample of colored fat onto a piece of wax paper.

9. Add the fat sample to the water in the beaker. Use a glass stirring rod to swirl the water and fat. Describe what happens.

10. Fill a graduated cylinder with exactly 100 mL of test sample 1.

11. While stirring constantly, slowly add sample 1 to the water/lard mixture until the fat is completely emulsified, as evidenced by the dispersion of the colored fat in water. Record in the **Data Table** the volume of detergent necessary to completely emulsify the lard (fat) globule.

12. Identify each sample tested as either a detergent or a soap in the **Data Table.** Based upon emulsification data, which soap and synthetic detergent brand is the most effective emulsifier? Give reasons for your answer.

Cleanup and Disposal

13. Clean all apparatus and your lab station. Return equipment to its proper place. Dispose of chemicals and solutions in the containers designated by your teacher. Do not pour any chemicals down the drain or put them in the trash unless your teacher directs you to do so. Wash your hands thoroughly after all work is finished and before you leave the lab.

Data Table 1—*Comparing Soap and Detergent Brands*

Sample number	Foam level in water (cm)	Foam level in 4% $CaCO_3$ (cm)	Volume needed to emulsify 0.1 g of fat (mL)	Efficiency rating (g/mL)	Soap or detergent
1					
2					
3					
4					
5					
6					

1. **Organizing Data** For each sample tested, calculate its relative efficiency as a dirt and grease remover by dividing the 0.1 g of fat emulsified by the volume in milliliters of detergent added to the fat/water mixture.

2. **Organizing Data** Construct a bar graph comparing the efficiency of soaps and detergents in emulsifying fat. Place surfactant samples along the x-axis and the efficiency along the y-axis.

1. **Applying Conclusions** You are demonstrating the effect of hard water on sudsing. You have all the demonstration materials except a source of hard water. All that is available to you is milk or a roll of antacid tablets. Can the demonstration proceed? Justify your answer.

2. **Analyzing Data and Inferring Conclusions** According to entries in the **Data Table,** which would be more efficient at dirt removal: a liquid detergent or a solid detergent? Explain.

1. **Inferring Conclusions** Many product labels on detergents state that the product will not harm septic systems. Suggest a reason for this based on your foam data.