

Synthesis and Environmental Impact of Soap and Detergents

Your group has been sent to a remote mountain region where life is still primitive. Here, the people still use traditional lye soaps, which have been identified as possible sources of pollution. The soap that has been traditionally produced is extremely harsh, and many of the people have developed skin rashes from using it. In addition the soap seems to vary a lot in quality and feel; sometimes the soap does not lather and instead forms a sort of scum.

The government has charged you with the task of working with the people to develop a safer soap making process that will be more environmentally sound, and that will produce a milder soap. Alternatively, you may recommend that the people synthesize and use detergents instead of soap.

Goals of the Project:

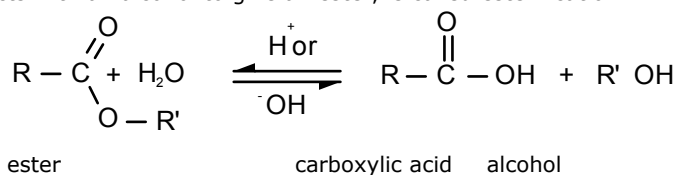
1. Develop and refine a synthesis of soap that gives a product that is mild and lathers well.
2. Develop and refine a synthesis of detergent that gives a product that is mild and lathers well.
3. Identify and minimize environmental problems caused by the syntheses.
4. Compare soap and detergent, for cost, effectiveness, and environmental impact
5. Identify the substances in the water that seem to affect the action of the soap (i.e. make the soap form a scum)
6. Suggest and test remedies for the "scum problem".

Resources available

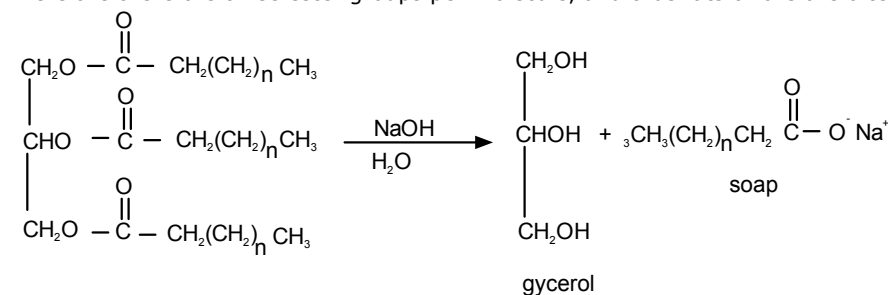
1. A general soap synthesis that you can use as the basis for your product development.
2. A detergent synthesis that might be used as an alternative.
3. All the starting materials that are available to the people
4. Samples of the water that is used for washing and rinsing

Synthesis of Soap.

Soap is prepared by carrying out a hydrolysis reaction in which an ester is treated with water (using an acid or base catalyst) to give a carboxylic acid and an alcohol. When a base is used as the catalyst this process is often called saponification - literally soap making. The reverse reaction in which a carboxylic acid reacts with an alcohol to give an ester, is called esterification.



Fats and oils are esters of glycerol, (CH₂OHCHOHCH₂OH), a tri-alcohol, and three long chain fatty acids. There are therefore three ester groups per molecule, and thus fats or oils are often called triglyceride



Triglyceride

General Procedure

1. Mix about 10mL oil or 10g fat with about 15 mL of 6 M sodium hydroxide (Care) solution and a small amount of glycerol. Stir the mixture with a glass rod
2. Heat the solution to boiling for about 15 minutes until the solution becomes homogeneous. (Heating the solution with a Bunsen Burner is the best way to go - but be careful of material splattering out of the container). Continue heating until the mixture becomes thick and pasty.
3. Let the paste cool and then add about 50 mL of a saturated sodium chloride solution, and some ice, while mixing vigorously with the glass rod. One reason why you do this is to make the slurry easier to filter.
4. Filter the soap using suction filtration and wash it with two 5mL portions of cold water.
5. Allow the soap to air dry until next week before you weigh it.

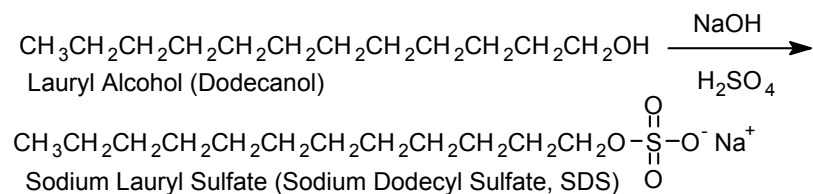
Materials Needed

Lard
Vegetable Oil – liquid
Crisco
Olive oil
6M NaOH

Preparation of a Detergent

Materials

Dodecanol (lauryl alcohol), 15g
Concentrated sulfuric acid
Sodium hydroxide (NaOH) 6M



1. In a beaker add 15 g lauryl alcohol to 10 mL conc sulfuric acid (with great care)
2. In another beaker, add 3 drops of phenolphthalein to 30 mL of 6M NaOH.
3. Slowly add the acidic solution of lauryl alcohol to the NaOH solution with constant stirring, until the pink solution just turns colorless. Keep stirring for a few minutes.
4. Filter the solution and dry the precipitated sodium lauryl sulfate on the filter paper.

Soap Planning Sheet 1 –

Group Name _____

To be completed before leaving the check-in Laboratory

What is the purpose of this project?

1. Draw out the structure of a generic oil or fat, indicate the functional groups present by naming and circling them
2. Draw out the structure of a generic soap molecule.
3. What solvents do you think the fat will be soluble in?
4. What solvents do you think the soap will be soluble in?
5. Outline how you will determine what solvents the fat, the soap and the detergent will be soluble in.
6. Next week each person will produce a different batch of soap using a different starting material or reaction conditions.
Outline the starting materials and reactions conditions for each person in your group.

7. Next week you will determine the solubility of the starting materials for soap, and produce as many samples of soap as there are people in your group.

Soap Planning Sheet 2

Group Name _____

What was the purpose of this weeks lab?

1. Briefly discuss the results of your solubility tests on the fat or oil that you used to make the soap. What type of solvent was the fat soluble in? Discuss the molecular interactions that are responsible for the solubility of the fat.
2. Give the reaction conditions and results for each soap preparation. Discuss the similarities and any differences that you observed.
3. Next week you will prepare samples of a detergent. Draw out the reaction scheme for the preparation of detergent below. Give the structure of the detergent and indicate the functional groups
5. What do you think the purpose of the phenolphthalein is, in the preparation of the detergent?
6. Compare the structures of soap and detergent. What are the similarities? What are the differences.
6. You may begin testing the soap and detergent next week. How will you test for lathering ability, solubility, cleansing ability? –Note that you should not test the soap by washing your hands or feeling the solutions. You must devise other methods for testing.

Soap Planning Sheet 3

Group Name _____

This week you will prepare at least two samples of detergent

Be sure to retain and label the waste water for further testing.

Note that the preparation of the detergent involves concentrated acids and bases. Make sure that you know how to handle them before you begin the synthesis.

During this time you will also begin the testing of the first batch of soap for solubility, lathering ability, and cleansing action.

After you have decided what makes a good recipe for the soap you will make another batch of the "best" soap. **Be sure to retain and label the waste water for further testing.**

What was the purpose of this weeks lab?

1. Briefly describe the synthesis of the detergent. – What did you observe.
2. What is the structural feature that makes both the soap and detergent effective as cleansing agents. Describe, using molecular pictures, how the soap and detergent act on a molecular level.
3. Discuss the results of your solubility tests on the soap that each of you prepared. What was the soap soluble in? Is there a difference in the solubility of the soap and that of the starting oil or fat. Why or why not?
4. What were the results of your tests for lathering and cleansing action of the soap? Which starting material gave the best results?
5. Next week you will continue with your testing of the soap and detergent action. You will also analyze the waste waters from the preparations and determine how to make them safer for the environment. Outline the tests that you will run on the waste water to find out how potentially damaging it might be to the environment.

Planning sheet 4

Group Name _____

This week you will test the solubility and effectiveness of **both** the soap and detergent, to determine which is more effective and appropriate. The tests must be both quantitative and qualitative. You will also analyze the waste water from each preparation. You will need to identify the contaminants and recommend a remediation procedure.

What was the purpose of this weeks lab?

1. Compare and contrast the action of the soap and the detergent – did you see any differences in their action?
2. Which material – soap or detergent is more appropriate for use by the people you have been assigned to help?
3. What contaminants did you find in the waste water? Next week you will try to remediate the problems, - what suggestions do you have?
4. Next week you will be given samples of the different water sources that have caused problems with the soap use. Outline your plans for testing the water for impurities.

Summary Sheet 5

Group Name _____

This week you will test samples of water that are causing problems. Try to identify the source of the problems, and find ways to solve or alleviate the problems. Bear in mind that you do not want to cause any further environmental damage.

You will also devise and test ways to minimize environmental damage from the wastewater produced during the synthesis.

What was the purpose of this weeks lab?

1. What tests did you perform to determine the source of the contamination?
2. What were the results of these tests?
3. What remedies do you propose for the problems encountered?
4. Describe the results you obtained from the experiments described in Q3
5. What remedies did you use in order to minimize any impact on the environment from your soap and detergent synthesis?
6. Describe the results you obtained from the experiments described in Q5