

Soap

Big Ideas

- Mixing of substances
- Chemistry of water
- Solubility
- Surfactant properties
- Detergent action and cleaning
- Hydrophobicity and hydrophilicity

Learning Objectives

- Students understand on a molecular level what is unique about a soap molecule.
 - Students experience and eventually can predict chemical reactions that will make soap.
 - Students understand how soap molecules “clean.”
 - Students understand that soap is complex and that they can begin to understand its complexity by working on more manageable ideas first (mixing, chemistry of water, solubility, hydrophobicity & hydrophilicity) and then synthesizing these ideas.
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Part 1 (approximately 45 minutes)

Soap Creation Lab. Students create their own soap in the lab.

Purpose

This activity serves two purposes: it gives students an introductory activity where they have a hands-on experience making soap, and it provides a situation for them to start asking important chemical questions. During this activity the students should be instructed to pay particular attention to:

- what substances combine to make soap
- what evidence there is for a chemical reaction
- what is the importance of stirring

Background Discussion

Each lab group will do a write-up of the investigation using the ChemSense Portfolio™. Their write-up should be concise, completed during the period, and should include the following:

- General procedure – what did they do/need to make their soap?
- Any data collected – pH and/or other measurements
- Their ideas regarding the above three points – we are not interested in students looking up “answers” in their text, but rather in knowing what they think, what conceptions they have.

Time should be spent by the teacher discussing the above three points the following day, and homework could be given to provide students with a general background on soap,

observations of changes due to chemical reactions, and the mechanism of “mixing.” In this part of the “Soap” module the bigger idea of **Aggregation** should be introduced and developed, with particular emphasis on what it means for two or more substances to “be mixed” as well emphasis on the action of mixing.

They will be monitoring the pH of the soap for 2-3 weeks since the reaction takes time to complete. The monitoring of the pH could be done using a Pasco pH probe that is set up to continually collect data during the 2-3 week time period. On the monitor the students see a graph showing pH vs. time (only one soap will be monitored—the computer should be placed in a highly visible place so students can see the graph and how it is changing each day they come into class). If a single computer cannot be dedicated to this use, a handheld pH meter or pH paper may be used periodically through the 2-3 weeks and the results manually shown on the board.

Materials

(See lab procedures hand-out, Appendix A)

Procedure

(See lab procedures hand-out, Appendix A)

Part 2 (approximately 45 minutes)

Particle Description Activity. Students create representations of various particles.

Purpose

To have students describe what they think various substances look like at the particulate level

Background Discussion

In this part of the “Soap” module the bigger ideas of **Connectivity** and **Shape** should be introduced and discussed, and the idea of **Aggregation** revisited. At this point students are (should be) starting to think of substance at the particulate level and how particle type (including shape of molecule) may be directly linked to both the physical properties of substances and the interactions between substances.

Materials and Procedure

(See also lab procedures hand-out, Appendix B, for a variation on this activity)

Students will be given samples of oil, water, and salt. They are to describe what they think the particles of each substance look like by creating a picture of each particle using the ChemSense Drawing tool. Once they have created their drawings they should open a new document in the ChemSense Portfolio, import their drawings, and add text describing the features of each particle and the properties they are familiar with for each substance.

In addition, each lab group will mix each combination of substances (water + salt, water + oil, oil + salt). In Portfolio they will record their observations. In addition, they will record their responses to the following questions:

- How are these substances similar? Different?
- How do these substances interact (or not)? Why?

Part 3 (approximately 45 minutes)

Miscibility Lab. Students conduct an experiment to observe the miscibility of substances.

Purpose

For students to observe that soaps are miscible in both oil and water, and that most other substances are not.

Background Discussion

This part of the module revisits the idea of **Aggregation**. Since the students have had some experience with this idea in their lab activities, discussion, and reading over the past few days, their write-ups should include a more detailed discussion of mixing. The idea of **Connectivity** should be revisited as students start to hypothesize about what makes soap (in particular soap at the particulate level) different from other substances. A driving question might be “What features of a soap molecule might make it different from other substances’ molecules such that it can dissolve in both oil *and* water whereas the other substances can’t?” It would be helpful at this point for there to be class discussion/reading around the mechanism of soap (including hydrophobicity and hydrophilicity.) Depending on the discussion, the idea of **Shape** should be revisited as well.

Materials and Procedure

(See also lab procedures hand-out, Appendix C)

Students bring in two non-soap liquids and two soap-type liquids. The activity centers around mixing different substances in oil and water and deciding which they are miscible in and which they are not (the ideas of mixing and solubility are played out here.) The emphasis should be on students noticing that soaps are miscible in both oil and water and most other substances are not. Each lab group is responsible for their own design of the lab, including equipment needed and how they are going to record their data (table, simple bar graph, other.) Using Portfolio and any other ChemSense tool, they will create a write-up of this lab.

Substance	Miscible in oil	Miscible in water
Water	No	Yes
Oil	Yes	No
Gasoline	Yes	No

Vinegar	No	Yes
Dishwashing liquid	Yes	Yes
Orange Juice	No	Yes
Etc.		

Sample miscibility table

Part 3 continued (approximately 45 minutes)

Simulation Activity. Students generate simulations of molecules of pure water, oil, and liquid soaps.

Purpose

To have students see how soap is different from other substances at the molecular level.

Background Discussion

Now that they have seen a physical property unique to soap, we want students to see, on the molecule level, how soap is different from other substances. Students will use the ChemSense Dynamic Modeling Tool to generate simulations of molecules of pure water, oil, and liquid soaps. Students should be able to interact with this tool to identify attractive forces between molecules in the liquid state. After this activity, students should be able to identify the molecular structure unique to soap (one end of soap is polar, the other is non-polar).

In this part of the soap module students will collect representations that, to them, explain what makes soap unique. These representations are to be brought into a new Portfolio document. This new document is created as a place to collect visual explanations, so text and other representations (including ones they have created previously) should be included as well. For example, one lab pair might entitle their Portfolio document as “What Soap Looks Like” and include any images and simulations that they think provides a good representation of soap.

Here the ideas of *Aggregation* and possibly *Connectivity* should be revisited.

Part 4 (1/2 hour to one hour)

Homework Assignment. Students make a model of a soap molecule

Purpose

For students to make a personal representation of a soap molecule to be used within the ChemSense environment.

Background Discussion

Students make a model of a soap molecule using materials available to them at home. The model should clearly show the unique characteristic of soap's molecular structure (example: a ball of yarn with a magnet tied to the end.) At some point during the next day pictures of their models will be taken with a digital camera and entered into ChemSense. Once in the ChemSense environment their representation can be shared and used among other students.

This homework assignment incorporates the *Connectivity* idea and which should be emphasized when assigned.

Part 5 (approximately 45 minutes)

Testing of Materials to Create Soap Activity. Students use a ChemSense tool that allows them to simulate the testing of various substances to create a soap.

Purpose

For students to understand what type of components are needed to make soap

Background Discussion

At this point in the Soap module, students should have an informed idea of the structure of a soap molecule and what makes it different from other substances at both the macro and micro levels. They will now test these ideas by selecting chemical reactions that they think will produce soap. Here they will use a ChemSense tool that allows them to select reactants, chemically react them, and then view the product. These reactions are viewed as the interaction of an aggregate of molecules. The goal here is that they come up with the general reaction of fat + base = soap.

For this part, students are expected to create another Portfolio document that a) records their predictions of what (class of) reactants they chose to make soap, b) describes why they chose those reactants, citing evidence for their decision(s), and c) explains (in their words) how soap is produced chemically. They may use any representations they have created or collected previously as part of this document. Ultimately, each lab pair will make a presentation on Soap (in front of the class, on the web, etc.) and will use the materials they have collected and constructed in Portfolio to do this.

In this part of the module *Connectivity*, *Shape*, and *Aggregation* should all be emphasized and revisited as the students go about running various reactions in the Reaction Arena™ and pulling their results into Portfolio™.

Homework assignment

Two to four page reading provided by the teacher on how soaps clean.

Part 6 (approximately 45 minutes)

Presentation. Students create and give a presentation on their understanding of soap.

Purpose

To draw links between the various labs and activities in the Soap module to create a coherent understanding of “soap.”

Background Discussion

At this point each lab pair pulls together all they have done during the Soap module to create a presentation. Since they have spent their time directly and indirectly working with the ideas of mixing, the chemistry of water, solubility, and hydrophobicity & hydrophilicity, they now have the opportunity to present how they have synthesized these ideas around understanding soap.

The presentation can be in front of the class as a whole or in front of smaller groups (in which case several groups can present at the same time in various places around the classroom.) Here they will use Portfolio to synthesize all of the pieces they have worked on previously. If done correctly, this part of the module should pull together the **Connectivity**, **Shape**, and **Aggregation** ideas. These ideas should be emphasized and discussed in the student presentations.

Appendix A

SOAPMAKING

Soap is something that you probably use every day. You can buy it at your local store, and soap manufacturing is an important industrial process. However, in the past, many people have made their own soap at home and some still do.

Soap is produced when a fat or oil undergoes a chemical process called *saponification*. This process involves heating the fat or oil in a basic solution. In this activity, you will make your own soap. The fat you will use is vegetable shortening and the basic solution is sodium hydroxide (NaOH) in water. As the heated mixture is stirred, the fats react with NaOH to give glycerol and sodium salts, which we call soap.

Material:

Vegetable shortening (fat) such as Crisco	thermometer
6M NaOH	hot plate
10 mL graduated cylinder	Styrofoam cup
two beakers	

Procedure:

1. Melt 20 grams of fat in a small beaker; allow it to cool to about 45°C, and pour in the Styrofoam cup.

Caution: NaOH is extremely corrosive. Rinse any spills immediately with large amounts of cold water and call your instructor.

2. Measure 10 mL of 6M NaOH with a graduated cylinder and pour it into a small beaker. Heat the solution gently on a hot plate until its temperature is nearly the same as that of the liquid fat, that is about 45°C. Do not overheat or boil the solution. The temperatures of the liquid fat and the NaOH should be within 5°C of each other when you mix them.
3. Slowly pour the NaOH into the liquid fat while stirring slowly and constantly with a stirring rod. Describe what happens as you mix the NaOH solution into the liquid fat.
4. Continue stirring slowly, smoothly and constantly for 10 - 15 minutes. The mixture should thicken to about the consistency of cold honey. If it has not thickened after being stirred for 15 minutes, let it stand for 3 - 5 minutes and then stir again for a few minutes.
5. Leave the thickened mixture in the cup, which will act as a mold, for two for three days while the soap hardens.

Carefully and completely clean the graduated cylinder and beakers, making sure they are rinsed several times with cold water before you put them away.

6. Test the soap's pH by wiping a piece of pH paper across the top of your soap.
Do not touch the soap.
7. Keep testing the pH of the soap every few days until the pH is close to neutral, that is, 7.

ChemSense Instructions

Now you should make drawings of what you think has been happening at the molecular level as the soap is being made. As you complete your drawing, please explain your drawing? Be sure to write down your ideas about what is happening at the molecular level.

Next, please answer the questions:

- What makes you think this is a good drawing of what's happening at the molecular level? What made you decide to draw it this way?

Finally, please answer the question:

- Are your ideas about the structure of soap likely to change or to stay the same? Explain why.

Appendix B

PARTICLE DESCRIPTION LAB

Introduction

In order to begin to understand how soaps work, first we need to find out:

- what makes soaps different from other substances (for instance, you probably know not to wash your clothes in maple syrup);
- why it has the properties it has (for instance, you probably know not to take bath in vinegar).

In this lab we will be studying three very common substances in order to understand how they interact with each other. The purpose of choosing these three substances is that they are the first step in deciphering the complexities of soap.

Materials

Water, oil, lye (NaOH, also known as *Draino*) and test tubes

Pre-Lab

Prepare a data chart for this lab. Also, make a duplicate data chart in which you make a prediction as to what you think each of your observations will be when you actually do the mixing. Be sure to fill out this chart before you come to class.

Procedure

Since lye (NaOH) is very caustic (dangerous), you **must wear goggles** at any time you are using this chemical.

1. Put about 10 mL of water into a test tube. Add only a few mL of oil. Shake and observe.
2. **Put on your goggles.** Put another 10 mL into a second test tube and add a small pellet of lye. Shake and observe.
3. Put about 10mL of oil into a third test tube. Add a small pellet of lye. Shake the test tube the same amount of time as the other test tubes.
4. **Remove the goggles after you have cleaned up.**
5. Make sure that you wash the test tubes with lots of soapy water and rinse them well before returning them.

Analysis of results

1. Compare your predictions with your test results. Which ones were the same? Which ones were different? Compare with other members of your group. Make note of the predictions that were not the same so that at a later time you can develop an explanation of why they were different.
2. Make drawings for each of the mixtures you have just made.
3. Make drawings/representations on the particulate level for each of the mixtures you have just made.
4. In your group, compare your drawings. Discuss each of the drawings and decide which ones best represent the particulate nature of each of these substances. Be able to give reasons for your choices.

ChemSense Instructions

Now, as a group, use the ChemSense tools to make a good representation on the computer of what has happened on the particulate level in this lab. Also use the tools to explain in words why you think this is a good representation. Why did you decide to make it look this way?

In general, what makes something a good (as opposed to a bad) representation/drawing? How can you judge whether one explanation is better than another? Write down the ideas that your group discusses.

Appendix C

MISCIBILITY LAB

Purpose: to investigate what substances do or do not form solutions.

Introduction

In the previous lab you worked with drew representations of three different types of substances and drew representations. You learned that some substances do not make solutions when put together while other substances do. You will extend that idea in this lab as you will test the **miscibility** of two different liquids. Miscibility is the ability of two liquids to make a solution. **Immiscibility** is term that describes two liquids that do not make a solution.

As in the previous lab, you will make predictions about your results. In addition, you need to state the reason for each prediction. You also need to write a procedure for that will allow you to get to achieve the purpose.

When you have completed the lab activity, you will be asked to explain why the substances that you tested did, or did not, make a solution. Be sure to be thinking of this while you are doing the lab.

Materials

Various liquids, water, oil, test tubes.

Prelab

Prepare a data chart in ChemSense that will provide space for you to make observations for many different liquids as you mix each of them with water and then with oil. Note - you will not know the exact identity of each liquid until you are in lab so you need to come prepared with a blank chart.

Also, be sure to write a procedure for the lab using the ChemSense tools.

Analysis

1. Clearly state any patterns you can find in your data. Did the patterns match your predictions? Why or why not? Write up an explanation for the patterns that you found.
2. Are there any liquids you tested that do not follow the patterns you stated in #1? Explain.
3. Use your drawings from the first lab to explain what has to be true for a liquid to be miscible in both water and oil. Make a new set of drawings in ChemSense to include any new ideas or information you now have after doing this lab.
4. Draw a representation of a soap molecule in ChemSense. Write an explanation about what your drawing shows. For example, why are you drawing the soap molecule in this way? What is not shown?