Name: ______________________________________ Date: __________________ Class: ______________________

Soap vs. Shampoo Lab Worksheet Answer Key

Challenge

In this activity, you will work as chemical engineers as you:

1. Investigate surfactant behavior in tap water, hard water, salt water and acidic water.
2. Explore the difference between soap and shampoo. (pH)
3. Explore how surface tension and viscosity are related. (low surface tension = low viscosity)

Pre-Lab Discussion

Observe a drop of alcohol and a drop of water, side by side. How does the surface tension of each relate to its droplet shape?

A drop of water makes a dome shape because water is a bent polar molecule so the water molecules are attracted to one another; since this attraction is strong, the shape bends. The alcohol drop has a flat shape because alcohol's polarity and shape are different from those of water and they break the surface tension.

How do soaps or shampoos "clean?"

Cleaning products form micelles, lipid molecules that take a spherical shape around molecules they are attracted to, such as dirt. These micelles also break the surface tension of water and form suds.

What makes soap and shampoo different from each another? What would happen if you washed your hair with soap instead of shampoo?

Soap has a higher pH than shampoo; it would dry out your hair. This example shows how it is important that chemical engineers in the soap industry design shampoo and soap with the appropriate pH levels.

Materials

250-ml beakers
thermometer
glass stirring rod
hot plate
pH meter
graduated cylinder
pipette
test tubes
penny
olive oil
KOH
DI water
tap water
vinegar
salt
calcium chloride
phenolphthalein
5% triethanolamine
5% oleic acid in ethanol
polypropylene sheet

Procedure

Part 1: Making Liquid Soap (skip this part if you have purchased liquid soap)

1. Weigh out 50 g of olive oil and pour it into a 250-ml beaker.
2. Place the beaker with oil onto a hot plate and keep the temperature between 33-43 °C. (Monitor it closely! When dealing with oils, a slow rise in temperature is better than a fast one. BE PATIENT!!)
3. Pour 17.5 ml of water in a different 250-ml beaker.
4. In the same beaker, slowly add 6.7 g of KOH while stirring with a stirring rod until completely dissolved. This is the “base solution.” (Upon mixing the KOH in water, the solution might feel warmer. After it has dissolved, check the temperature. The temperature should also be between 33-43 °C. If not, place on the hot plate as well and monitor it.)
5. Once both solutions are at the same temperature, slowly pour and stir the base solution into the olive oil. Continue to stir for 10 minutes or until the solution has traced (a term for the thickening of the soap/lye solution). The mixture should stick slightly to the stirring rod when lifted. (NOTE: Once the soap mixture has reached the tracing stage, you may add fragrance or additives if you wish.)
6. Let the soap sit for 24-48 hours. (NOTE: Do not use the soap until the pH has been tested!)

Part 2: Making Shampoo (skip this part if you have purchased shampoo)

1. Pour 50 ml of 5% triethanolamine in water into a 250-ml beaker.
2. Add 1 drop of phenolphthalein to the solution and gently stir. The solution should have a pink color.
3. Add dropwise the 5% oleic acid in ethanol solution until the solution becomes colorless (5 to 10 drops). Be sure you are stirring while you add the solution.

Part 3: Testing the Surfactants

Interactions with Ions Test: “Shake Test”

1. Make 100 ml of a 5 % solution of your liquid soap in 1 beaker and a 100 ml of a 5 % solution of shampoo in a separate beaker. In a third 250-ml beaker, pour 100 ml of deionized (DI) water. These are your stock solutions, so label each beaker. Be sure these are mixed well!
2. Place 2 ml of DI water in each of 4 test tubes. In the first test tube, add 1 ml of tap water; in the second test tube, add 1 ml of acidic water; in the third test tube, add 1 ml of hard water; in the fourth test tube, add 1 ml of seawater.
3. Stopper the end of each test tube and shake each for 5 seconds. Using a ruler, measure the height of bubbles produced; record your results. (NOTE: Start measurement from the top of the solution.)
4. Rinse out each test tube and repeat steps 2 and 3 with liquid soap solution
5. Rinse out each test tube and repeat steps 2 and 3 with shampoo solution.

Surface Tension Test: “Penny Test”

6. Place a clean penny on a flat surface.
7. Using a dropper filled with DI water, count the number of drops the surface of the penny can hold before they spill over. Record your data.
8. Repeat with liquid soap and shampoo solutions.

Viscosity Test

9. Prop a polypropylene sheet at a 45° angle over a drain or bucket.
10. Using a pipette, obtain some DI water.
11. From the top of the sheet, record how many seconds it takes for a drop to get to the bottom. Repeat the test two more times and average the times together before putting it on the chart.
12. Repeat with liquid soap and shampoo solutions.

pH Test

13. Using a pH meter (or pH paper), test the pH of each of the stock solutions and record your data. NOTE: The pH paper may not be as accurate. A pH meter yields more accurate results.

Data Table	DI Water	Liquid Soap	Shampoo
Tap water(cm)			
Acid rain (cm)			
Hard water (cm)			
Seawater (cm)			
Surface tension (drops)			
Viscosity (drop/s)			
pH			

Name: **Date:** **Class:**

Part 4: Results Analysis and Recommendation

1. Compare tap water, acid rain, hard water and seawater's results in the shake test. What do you notice about your results? What is it about each of the four samples of water that is causing your results?

   Solutions with ions in it were lower in suds than the distilled water. Water from the sink (tap water) varies, depending on your location and filtration. Acid rain has hydrogen ions, hard water has calcium ions and seawater has sodium ions. Expect the impure solutions to have the lowest values.

2. Compare the results of your penny test with the DI water, liquid soap and shampoo. Which sample was able to hold the most drops? How does this relate to surface tension? How does viscosity compare? Explain.

   Solutions with no soap or shampoo were able to hold the most drops. Since the soap and shampoo solutions contain surfactants, they were able to break the surface tension causing those tests to hold fewer drops. Viscosity relates to surface tension because the higher the surface tension, the slower the drops flowed on the polypropylene sheet. High surface tension correlates with high viscosity.

3. Compare and contrast the results for liquid soap and shampoo. What results were different? Why would those results be different for cleaning your hair versus your hands? Explain.

   The main results showed a difference in the pH of soap and shampoo. I would make the pH of shampoo lower so it does not dry out your hair. High pH soap would denature the roots of hair causing it to fall out and resulting in dry scalps.

4. ***Recommendation***: If you were given the responsibility to engineer the ideal soap and shampoo solutions, what would you make the pH of each? How would you propose making the solutions?

   Ideal pH of shampoo ~5.5 and liquid soap ~7-10