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Soap: Clean for the Environment or Just Us?

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Introduction

Overall, middle school students are social beings trying their best to fit in and belong. As they begin transitioning to high school, their social awareness increases, and they begin to seek relevancy for their present learning. They demonstrate this emerging sense of consciousness by enrolling in social, political and academic clubs/activities that promote these concepts. At home, their roles and responsibilities, (care-taking, cleaning), becomes more demanding, leading from dishes, to laundry, to washing cars. At this point, if not before, personal hygiene becomes a major issue, as they are bombarded with advertisements in the media and literature. This is where the relevancy of science as a subject to science as life-long practical learning is put into place.

Goals & Objectives

Common household and personal cleaning products are a norm in today's advanced society. When one considers the historical development in the Western world of cleanliness as it relates to diseases, especially the outbreak of the H1N1 virus (swine flu), one can see that a widespread social awareness of hygienic practices and protocols has developed. Middle school students especially became more self-conscious when they were coughing, or greeting each other. Aerosol disinfectant sprays, hand sanitizers and anti-bacterial hand soaps suddenly became must-have items for everyone.

I teach Physical Science at Chapel Hill Middle School in DeKalb County, Georgia. The annual enrollment for 2010-2011 school year was 1,080 students, with 858 economically disadvantaged, 110 were students with disabilities, and 934 were on the free and reduced lunch program. The school has a population of 98% African-American, 1% Hispanic, and 1% multiracial. My target audience will be 8th grade students in the gifted and high achiever program. [1] However, this unit can be modified for any learning modalities.

In this curriculum unit, I plan to combine students' self and social awareness with science relevancy. We will first compare and contrast detergents and soaps in the forms of research and in observing their properties.

Then we will investigate the chemical components of soaps and detergents, to see how effective these chemical components will be to move and get rid of dirt. Then we will compare and contrast the differences between environmentally friendly and conventionally produced soaps and detergents. According to Marzano et al., there are nine categories of strategies that have a strong effect on student achievement. Those strategies are: identifying similarities and differences, summarizing and note taking, reinforcing effort and providing recognition, homework and practice, nonlinguistic representations, cooperative learning, setting objectives and providing feedback, generating and testing hypothesis, questions, cues, and advance organizers. [2] This research will encompass these strategies as well as encourage the students to become more personally aware of hygienic practices as well as socially aware of products harmful to the environment. Their cumulative project will be to create their own eco-friendly soaps, shampoos and other personal care products, with an emphasis on global consciousness as well as maintaining good personal hygiene.

Background Research

Where did soap originate?

The origin of the word soap is suggested to come from the Latin word *sapo*[3] stemming from a story about 3,000 years ago on Mount Sapo, near Rome, where the fat from the burnt sacrificial animals, mixed with the ashes from the altar, ran downhill over the clay soil, forming a slippery mixture. The women discovered that this actually helped to wash and clean their clothes, and so the story goes. The term *sapo* is a common derivative that is depicted in different languages, for example in Greek it is *sapon*, Hindi- *Saban*, French- *Savon*, Hebrew-*Sabon*, and Icelandic-*Sapa*. [3] On the other hand, the word "detergent" is derived from the Latin word *detergee*, which means to wipe or clean, hence the Latin *de* meaning off, and *tarsus*, meaning cleansing or heat, referring in modern times to synthetic soap. [3]

Historians have traced the use of soap back to the 3 rd millennium B.C.E. to a Sumerian clay tablet discovered in the ancient city of Babylon from the Ur dynasty, with an inscription that stated, "With water I bathed myself, with soda I cleansed myself, with oil from the basin I beautified myself." [3] This marked humankind's history of using soap. The Celts called their combination of animal fat and plant ashes *saipo*, the Romans used mutton tallow and wood ashes to make their soap. [4] This process was officially named saponification, which is a reaction in which an ester is heated with an alkali, such as sodium hydroxide, producing a free alcohol and an acid salt, especially alkaline hydrolysis of a fat, or oil to make soap. [5] The process to make soap underwent various trials and errors from LeBlanc's soda ash, to Berthollet's use of chlorine to Tennant's concept using lime to form bleaching powder, to Gunther's synthetic detergent using castor oil. [4] The Crimean War of 1854-1857 resulted in Britain losing most of the military to infectious diseases. Florence Nightingale's rise to fame was attributed to helping Britain with the use of soap and instituting hygienic practices in nursing. This concept aided the Americans in their Civil War, which later propelled the manufacturing of soap into an industry. [4] The uses of soap varied depending on culture, location, and era, but mainly it was for agricultural, cleaning, washing, ceremonial rites, industrial, medicinal and personal uses.

What properties do soaps and detergents have? (similarities and differences)

Both soaps and detergents are used as cleaning agents. They are both surfactants; that is, they are surface active agents that change the surface or interface. For instance, if water touches a counter top, then both the water and the counter top are surfaces and the point where they touch is call the interface. Surfactants are classified according to their properties in water which can be ionic (electrical charge), anionic (negative charge), nonionic (no charge), cationic (positive charge) and amphoteric (either positive or negative charge) properties in water. Soap is an anionic (negative charge) surfactant. [7] One of the main differences between soaps and detergents is their behavior in water. A soap molecule is shaped like a tadpole with a head and a tail. The head mixes well with water, whereas the tail mixes well with grease and dirt. So, when you are washing, the soap molecules surround the dirt and break it up into smaller pieces so that the water can now wash it away. In hard water, minerals such as, calcium, magnesium and iron are dissolved in it, and form deposits called scum. Scum does not wash away easily because it is difficult to dissolve. Hard water does not allow for soap to lather well, and it will leave hair dull after washing. Hard water does not affect the cleaning action of detergent.

Table 1: Comparison of Soap and Detergent

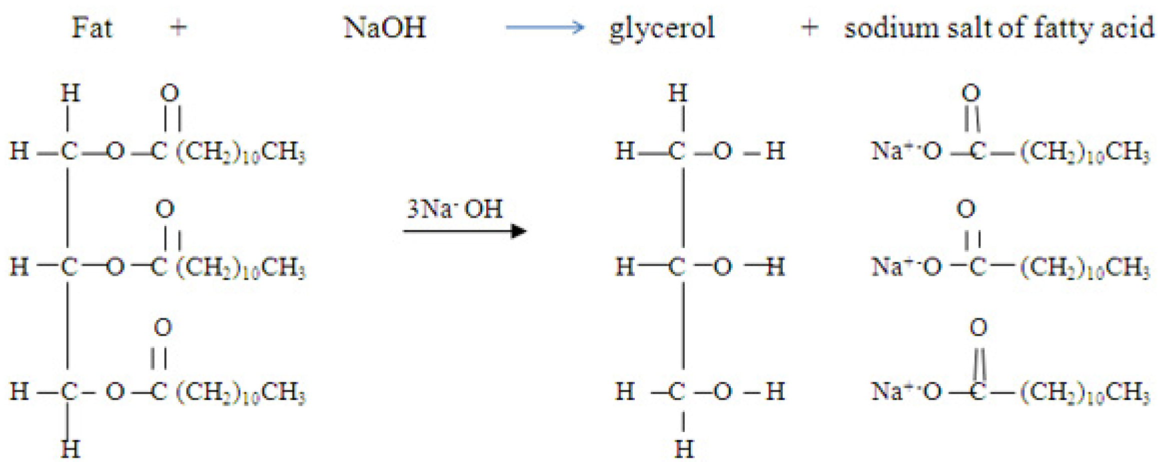
Soaps	Detergents
Are sodium salts of long chain carboxylic acids	Are sodium salts of long chain benzene sulphonic acids or alkyl sulfate
Obtain by natural resources from plants and animals (fats, oils)	Synthetic materials, hydrocarbon of petroleum or coal
Calcium and magnesium salts are insoluble in water	Calcium and magnesium salts are soluble in water
Produces scum in hard water which affects it's cleaning action	Hard water does not affect it's cleaning action
Biodegradable	Not too biodegradable

Acids, Bases and Salts

Another difference between soap and detergent is their sensitivity to acidic conditions. To understand the action of soap and detergent, we will review the pH scale to describe the characteristics of acids, bases and salts. Acids are substances that donate hydrogen ions, H^{+}, to form hydronium ions, H_3O^{+}, when dissolved in water. Acids taste sour and will turn blue litmus paper red. Acids can be very dangerous if not diluted with water. All acids conduct electricity, some more than others. Strong acids fully ionize when dissolved in water. This means their solutions have as many hydronium ions as the acid can possibly form. Acids range from 0 to 7, on the pH scale. Bases are substances that either contain hydroxide ions, OH – , or react with water to form hydroxide ions. Bases taste bitter, are slippery and turn red litmus paper blue. Bases are also dangerous if not diluted with water. Potassium hydroxide, KOH, is a strong base and conducts electricity well. Potassium hydroxide will disassociate completely to form ions, when in water, KOH —> K^{+} + OH^{-} . Bases are from 7-14 on the pH scale. Potassium hydroxide (KOH) or potash is a very strong base, and is used in the manufacturing of soap, drain cleaners and bleach. Sodium hydroxide (NaOH) or lye is also a very strong base and is used to manufacture soap, drain cleaner, paper, and textiles. pH measures the concentrations of hydronium ion and hydroxide ion in a solution. A pH number or value will indicate how acidic or basic a solution is. In a solution with water, the more hydronium ions there are, the more acidic will be the solution, and the fewer hydroxide ions indicate the less basic the solution will be. A pH of 7 will indicate that the solution is neutral and is neither acidic or basic. [8] Neutralization is a reaction between an acid and a base leaving it neutral; so, it is neither an acid nor a base. Neutralization depends on concentration, volume, and the identity of the reactants. Sometimes the acids and bases react to form an acidic solution because the acid was the larger amount. The common product of neutralization is a salt, which is an ionic compound formed from the reaction of a positive counterion of a base and the negative counterion of an acid.

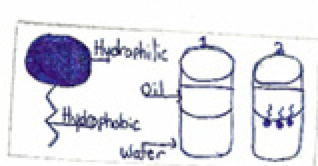
How is soap formed?

Figure 1: Chemical equation of soap[9]



Soap is formed from the sodium salt of fatty acids in the hydrolysis of a fat as indicated in the equation above. We observe that the glycerol turns back into an alcohol and the fatty acid is turned into a salt due to the presence of the NaOH or (KOH). The properties of the soaps vary according to the type of fatty acids and the length of the carbon chain. Tallow or animal fats with 18 carbons will make a very hard, insoluble soap, whereas fatty acids with longer chains will be more insoluble. Coconut oils, on the other hand, have 12 carbons, which makes the resulting soap more soluble. [10] The common lipids for soaps are coconut oil, sunflower oil, palm oil, tallow, and olive oil. There are two types of soaps based on the action of saponification; they are sodium soaps, which are hard and used as hand soaps, and potassium soaps, which are soft and used as bath soaps. [10] Solubility is not the only characteristic of soaps. The polar and non-polar structure will determine how the soap gets rid of dirt. The long hydro-carbon chain is non- polar and hydrophobic (repelled by water), whereas the salt part of the soap molecule is ionic and hydrophilic (soluble in water). [7] Therefore, when soap is added to water, then the ionic-salt end of the molecule is attracted to the water and the non-polar end is repelled by the water as illustrated in Figure 2 below.

Figure 2: Hydrophilic and Hydrophobic[11]

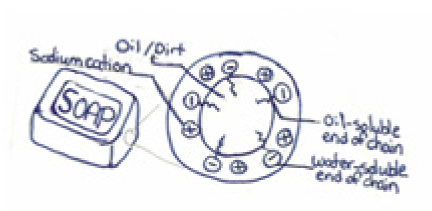


Drops of soap in water will then form a monolayer on the surface of the water, and the soap molecules will stand up. Surfactants are both lipophilic and hydrophilic, having dual affinity. They are classified according to the charge of the hydrophilic head. Most soaps, shampoos and personal cleansing bars contain an anionic surfactant.

How do soap and detergents clean?

Soaps are emulsifiers; this allows the oil and the water to mix, and keeps them from separating. Soap can dissolve in both oil and water. This makes soap a good cleaner. As an example, when someone washes their face with soap, the oil on the face is suspended in soapy water. Then by rinsing the face with water, the soap and unwanted oil is carried away and the face is now clean. So, when soap molecules are added to water, they clump together to form micelles, as illustrated in figure 3. These micelles are important to the cleaning properties of soaps and detergents. The negative ion in soap is made of long fatty acid chains and the positive ion is made of potassium or sodium ion. Because the soap acts as an emulsifier it will surround the droplets of oily dirt and the fatty acids will mix with the oil and the negative and positive ions will mix with the water. The resulting droplets of oil and dirt are surrounded by soap and are suspended in the water, and can now be rinsed away. [8] Figure 3, below, illustrates the action of the micelles as they clump and so a droplet of oil that can stay suspended in water because the charged ends of the soap dissolve in water and the uncharged ends dissolve in oil. [8]

Figure 3: How soap cleans[12]



What environmental concerns are there with soaps and detergents?

There are some environmental concerns in the manufacturing of soaps and detergents. In the case of soap, the main idea is to arrange for safe transportation and containment of the raw material, as well as, keeping loss to a minimum. The oils and perfumes for soaps can spill but the drums are kept tightly sealed, and can be readily cleaned up. The perfumes are not flammable so that is not a concern. The acidity and alkalinity of the waste byproduct of soap manufacturing is constantly being checked to meet requirements. Loss is kept at a minimum and there are interceptors in place for emergency situations. In the manufacturing of detergents, there are two things to constantly monitor, that is dust control and volatile organic emissions. Dust is present with the transporting of powdered raw and complete detergents, and this can be dangerous. The dust level emissions should be below 50 mg m^{-3} . [13]

So, what are environmentally friendly cleaning products?

They are products that contain ingredients with less contaminants, carcinogens, phosphates, and petroleum. These are not biodegradable or if they are, they are slow, and therein become harmful to the environment, and other organisms, especially marine life. The sulphonic acid and nonionic detergents that are found in powder and liquid detergents are biodegradable. It is suggested that we choose cleaning products that are completely phosphorous and phosphate free (these are added to make water soft and more alkaline), and to avoid chlorine-based bleach, which produces dioxins, harmful to the inner body, and the environment. [13] Sodium citrate and sodium bicarbonate can be used to replace builders like phosphates. Another ingredient in cleaning products to avoid is surfactants that are made from petrochemicals (petroleum), because these are nonrenewable and slow to biodegrade. Surfactants like plant oil, preferably coconut, palm kernel and corn oil, are natural and easier on the environment. Antibacterial cleaning agents create anti-biotic resistant super germs and are to be avoided for health purposes. [13] Manufacturing plants suggest that eco-friendly soaps and detergents can make lesser use of chemical ingredients, non addition of additives like perfumes, color, brightening agents to decrease toxicity, minimal packing, and reduce or eliminate dyes and fragrances. Lastly, we are encouraged to carefully consume from companies who specialize in being respectful to the environment producing healthy, green products, as well as continuing to be respectfully vocal and assertive on the legislative level.

Teaching Strategies

For this curriculum unit, students will demonstrate the properties of soaps and detergents with a surfactant activity, polarity demonstration, and pH testing. Students will focus on balancing the chemical components/equations, in order to construct a chemical framework illustrating how soap cleans. The students will research to compare and contrast cleaning product labels and use their green knowledge to draw conclusions based on research findings. They will then create their own soap and personal care package with emphasis on creating eco-friendly products. These teaching strategies are aligned with Marzano et al.'s nonlinguistic representations, which encourage creating graphic representations, making physical models, and generating mental pictures, drawing pictures and pictographs, and engaging in kinesthetic activity. [2] These teaching strategies will also utilize differentiated learning and grouping as well as thinking maps, which are practices adapted by the school's professional learning community.

Classroom Activities

Day 1 & 2: Bubble Formulas

In the opening session, the teacher will have various small samples of soaps, and liquid detergents in wells. In small differentiated groups, the students will investigate the physical properties and record their observations. The work session will continue with students working in their groups, testing the pH, and comparing the viscosity of the samples. The teacher will engage the students to brainstorm the different properties that soaps and detergents have that make them unique. For this activity, the students may create a Venn diagram or a double bubble map with poster paper. Students will discuss their findings, and will complete brief note-taking corrections in their science interactive notebook. Following this, students will demonstrate the properties of soap and detergents by investigating different formulas for making bubbles. Students will test and record the pH as well as blow bubbles to see which formula created the longest lasting bubbles. In the closing session, they will analyze their results and draw conclusions as to what physical properties gave evidence to their conclusion. They will write their lab report in their science interactive notebook. (See Appendix 2, adapted from Prentice Hall Science Explorer Physical Science Interdisciplinary Explorations, pg. 8)

Day 3 & 4: Marble Lather Picture

In the opening session, the teacher will discuss the actions of surfactants, explain polarity, and differentiate the states of matter, emphasizing colloids in this activity. For the work session, the students will be in differentiated groups and will create designs in the shaving cream and the foamy soap to illustrate movement of liquid through various states of matter, polarity, and the actions of surfactants. Students will conclude the session by answering the analyzing questions in essay format. Selected students/groups will be called on to present their findings. (Teacher will look for groups with different designs) (See Appendix 3, adapted from Journal of Chemical Education, Classroom Activity, #89).

Day 5 & 6: How does soap remove dirt?

In the opening session, the teacher will conduct a whole group discussion on chemical bonds, i.e., ionic and covalent bonds. The discussion will continue to expand on properties of ionic and covalent compounds with an emphasis on attraction between polar and nonpolar molecules. Students will individually create a two-tab foldable book that will compare and contrast covalent and ionic bonding. They will glue the foldable in their science interactive notebook. The work session will include an activity entitled, "How does soap remove dirt?" This activity will explore how the surface tension (attraction between molecules of water) changes when soap is added enabling the soap to remove dirt. The students will observe that the surface of water has a very thin layer of water molecules bonded together. In the closing session, the students will answer the analyze questions using the vocabulary words for this lesson to explain their answers. (See Appendix 4, adapted from Prentice Hall Science Explorer, Interdisciplinary Explorations, 2001)

Day 7 & 8: What is the claim to this soap's fame?

In the opening session, students will investigate the claims of various brands of soap. The whole group discussion will explore variables that make the soap and laundry detergent effective. For the work session, students will be in small groups, and will have several labels from a variety of soaps and detergents available to compare and contrast. First, they will list the ingredients on the label, and compare the oils. Then, they will write and analyze the language of the claim that the company used to describe how their product works. Third, they will note how many kinds of surfaces the product claims to clean. For the closing, the students will create a graphic organizer to illustrate their label investigation, and group leaders will present the information. (Adapted from Prentice Hall, Science Explorer Physical Science, pg. 141)

Homework: Students will survey about 10-20 people in their community to gather data on soaps (brand, color, fragrance, uses, size, etc.) and will bring these data to class. They will create a bar graph based on this information. Students will be grouped according to their multiple-intelligence profile.

Day 9 & 10:

Lab Activity: Creating Soap

In this lab activity, the teacher will demonstrate how to make soaps using two different formulas. Emphasis will be placed on lab safety practices. On the tenth day, the teacher will introduce soap making as a lab activity. The rules and procedures will be a whole group delivery, in the opening session. Then, the students will prepare and complete their labs in their differentiated learning groups. Students will analyze and conclude their results as well as present and communicate their findings.

(See Appendix 5: How to make soap)

Day 11-15: The Culminating Activity: The Soap Company

In this activity, students will start creating their soaps, based on data gathered from their survey. Students will designate roles and responsibilities to each person in their group. They will complete a checklist of items brought and the cost. The students will divide the cost of their materials, as well as their profits, evenly. Students will use the days to create about 10 soaps for marketing purposes. They will package and market their soaps with an advertisement/jingle. This can be performed live, audio, or video. It must be appropriate for age, lyrics, music, and clothing. The students will also complete a tri-fold board display. Students will create and distribute the invitations to their presentations to the learning community. They will be able to market their product after assessment is completed. Parents are very helpful in this activity. (See Appendix 6: Tri-fold board display)

Annotated Bibliography

Elsner, P. and Howard, I. *Cosmeceuticals: Drugs vs Cosmetics*. New York: Marcel Dekker, 2000. Some legalities and a look at cosmetic industry.

Fawcett, W.R. *Liquids, Solutions & Interfaces: From Classical Macroscopic Descriptionsto Modern Microscopic Details*. North Carolina: Oxford University Press, 2004. Discusses chemical aspects of liquids.

Goddard, E.D. and Gruber, J.V. *Principles of Polymer Science and Technology inCosmetics and Personal Care.* New York: Marcel Dekker, 1999. Interesting writings about the chemistry of surfactants.

Goodwin, J . *Colloids & Interfaces with Surfactants and Polymers: An Introduction.* New Jersey: Wiley, (2ed) 2009. Very detailed and higher level writings on the action of surfactants.

Hershberger, S., Nance, M., Sarquis, A. "Colorful Lather Printing." *Journal of ChemicalEducation*, 84(4) 608A-608B, 2007. Interesting activity may be included in art classes.

Ho, T. *Australian Green Consumer Guide: Choosing Products for a Healthier Home,Planet, and Bank Balance.* Sydney, Australia: UNSW Press, 2007. Awesome and detailed ideas to go green.

Indira, L., Nagaraju, K., Zameer, A. *College BioChemistry-V*. Mumbai, India: Global Media/Himalaya Publishing House. 2010. Very well research book.

Katz, D. *The Chemistry (and a little Physics) of soap bubbles*. www.chymist.com (accessed: June 20, 2011) Has wonderful activities with bubbles. Students would love this. Can be incorporated in a physical education class.

Kostka, K. Chemists clean up: a history and exploration of the craft of soap-making-how soap came to be common in America. *Journal of Chemical Education*, 79 (10) 1172-1175, 2002. Great historical aspect of the time line of soap.

Marzano, R., Pickering, D., Pollock, J. *Classroom Instruction that works*. Virginia: Association for Supervision and Curriculum Development. 2001. Instructional strategies that are effective.

Ophardt, C.E. Virtual ChemBook. Elmhurst College. 2003.http://www.elmhurst.edu/~chm/vchembook/554soap.html (accessed: June 20, 2011) This virtual chemistry book has great labs and great graphics.

Routh, H.B., Bhowmik, K.R., Parish, L.C., Witkowski, J.A. "Soaps: From the Phoenicians to the 20 th Century-A Historical Review." *Clinics in Dermatology* 14 (1): 3-6. 1996. Neat history, students can create timeline with this information.

Saponification. Dictionary.com. *The American Heritage® Stedman's Medical Dictionary*. Houghton Mifflin Company. http://dictionary.reference.com/browse/saponification (accessed: June 20, 2011).

Schulz, P. and Clausse, D. "An undergraduate Physical Chemistry experiment on surfactants: electrochemical study of a commercial soap." *Journal of Chemical Education*, 80 (9), 1053-1056, 2003.

Science Explorer, Physical Science. New Jersey: Prentice Hall, 2002. A physical science textbook.

Science Spectrum, Interactive Reader. Physical Science with Earth and Space Science. Florida: Holt Rinehart and Winston, 2008. A physical science textbook.

Science Spectrum, A Physical Approach. Holt Rinehart and Wilson, 2001. A physical science textbook.

Soaps and detergents. http://www.soapsanddetergents.com (accessed: July 12, 2011)

Stein, D. *How to make monstrous, huge, unbelievably big bubbles*. California: Klutz. 2005. Great book, students would love the bubble activities.

Surfactants.http://www.princeton.edu/~pccm/outreach/scsp/mixturesandsolutions/milk/surfactant.html. (Accessed: June 20, 2011) Great information and graphics.

Tareila, J. "Clean up on Aisle 5: The chemistry or soaps, detergents, and bleach." Thesis, University of Pennsylvania. 2004. Thesis paper with similar concepts as the unit.

Wolf, R. "Soaps, Shampoos, and Detergents." *Clinics in Dermatology* 14(1): 1–32. 1996. Very informal and informative writing.

Student Reading List

Crissey, P. "Personal Hygiene? What's that got to do with me? Philadelphia: Jessica Kingsley Publishers. 2005

Sarquis, M. "Lather up, hand washing activity handbook." Ohio: Terrific Science Press.2007

Stein, D. "How to make monstrous, huge, unbelievably big bubbles". California: Klutz. 2005.

End Notes

[1] http://www.doe.k12.ga.us. (Accessed July 25, 2011)

[2] Marzano, R., Pickering, D., Pollock, J. Classroom instruction that works. Virginia: Association for Supervision and Curriculum Development. 2001.

[3] Routh, H.B., Bhowmik, K.R., Parish, L.C., Witkowski, J.A. "Soaps: From the Phoenicians to the 20 th Century-A Historical Review." *Clinics in Dermatology* 14 (1): 3-6. 1996. Neat history, students can create timeline with this info.

[4] Kostka, K and McKay, D. Chemists clean up: a history and exploration of the craft of soap making. Journal of Chemical Education, 79 (10) 1172-1175, 2002.

[5] Saponification. Dictionary.com. *The American Heritage® Stedman's Medical Dictionary*. Houghton Mifflin Company. http://dictionary.reference.com/browse/saponification (accessed: June 20, 2011).

[6] Surfactants.http://www.princeton.edu/~pccm/outreach/scsp/mixturesandsolutions/milk/surfactant.html. (Accessed: June 20, 2011) Nice activities too

[7] Soaps and detergents. http://www.soapsanddetergents.com/soap-detergent-chemistry.html (accessed: July 12, 2011)

[8] Science Spectrum, A Physical Approach. Holt Rinehart and Wilson, 2001

[9] Tareila, J. Clean up on aisle 5: The chemistry of soaps, detergents, and bleach. University of Pennsylvania, 2001.

[10] Indira, L., Nagaraju, K., Zameer, A. College BioChemistry-V. Mumbai, India: Global Media/Himalaya Publishing House. 2010. Nice research, little skimpy.

[11] Ophardt, C.E. Virtual ChemBook. Elmhurst College. 2003.http://www.elmhurst.edu/~chm/vchembook/554soap.html (accessed: June 20, 2011) Love their virtual chembook, I use a lot in teaching, esp. labs, great graphics

[12] Science Spectrum, Interactive Reader. Physical Science with Earth and Space Science. Florida: Holt Rinehart and Winston, 2008.

[13] Ho, T. Australian Green Consumer Guide: Choosing Products for a Healthier Home, Planet, and Bank Balance. Sydney, Australia: UNSW Press, 2007. Awesome ideas to go green, will use with the students for their research.

Appendix 1: Implementing State Standards

Standard: S8P1 Students will examine the scientific view of the nature of matter.

Element a. Distinguish between atoms and molecules.

Students will discuss the formation of ionic and covalent compounds.

Element b. Describe the difference between pure substances (elements and compounds) and mixtures.

Students will investigate different types of substances.

Element c. Describe the movement of particles in solids, liquids gases, and plasma states.

Discuss soap and food coloring action on water, foam and shaving cream in respect to surface tension.

Element d. Distinguish between physical and chemical properties of matter as physical (i.e. density, melting point, boiling point) or chemical (i.e., reactivity, combustibility)

Students will demonstrate physical properties by investigating mixtures with different bubble formulas; pH, density, viscosity, surface tension, temperature.

Students will investigate the action of how soap removes dirt.

Element e. Distinguish between changes in matter as physical (i.e., physical change) or chemical (i.e. development of a gas, formation of precipitate, and change in color).

Students will investigate the action of how soap removes dirt.

Element f. Recognize that there are more than 100 elements and some have similar properties as shown on the Periodic Table of Elements.

Students will identify the elements and molecules needed to create soap.

Element g. Identify and demonstrate the Law of Conservation of Matter.

Student will give evidence to the law when they create their soap and employ the chemical equation.

Appendix 2: Bubble Formulas

Have you ever blown bubbles, and noticed that some burst too quickly, while others floated along for a while? In this activity, you will compare different bubble formulas and see if you can create a better formula.

Materials: dishwashing soap, glycerine, bubble solution, corn syrup, water, petri dish, blue and red litmus paper.

Formula 1: 2/3 cup clear dishwashing soap, 1 gallon water, 2-3 tablespoon glycerine.

Formula 2: 1/3 cup commercial bubble solution, 1/3 cup water, 1/3 cup glycerine.

Formula 3: 2/3 cup clear dishwashing soap, ¼ cup corn syrup, 2 cups water.

Procedure: Place each formula in a dish and label the dish. Carefully take a blue and red litmus paper and dip them in each dish. Record the color change. Using the bubble wands provided, blow bubbles in order to compare and contrast the formulas. Answer these questions as you are working:

1) How difficult is it to form bubbles?

2) How long do the bubbles last?

3) How large can you make your bubbles?

4) What colors do you see in your bubbles?

5) Can you catch your bubble on a ring such as the open top of a glass jar?

6) Does the formula behave differently after it has sat overnight?

If you can, catch a bubble and put it somewhere where it won't be touched or vibrated. See how long the bubble lasts. Some bubbles are alleged to have stayed whole for over 300 days! They do not pop but they gradually shrink as air escapes through the film of soap.

What do you think makes a good bubble formula? Modify one of the formulas above. Measure your ingredients carefully and record what formula you tried. Record how your new solution performed. Continue experimenting with different formulas and see if you can find a formula that makes exceptional bubbles. An exceptional bubble is very large or lasts a long time.

Adapted from Prentice Hall Science Explorer, Interdisciplinary Explorations, 2001.

Extended Activity: To create large monstrous bubbles, use thin, hula hoops, or combine wire hangers to form a large circle (may be dangerous for the students, so I would have 2 pre-made). Place the bubble formula in a large plastic tub. We take this activity in the school yard, behind the school, and have the students dip the circle object in the tub, and run around the yard to see who makes the biggest bubble. *(Adapted from, How to make monstrous, huge, unbelievably big bubbles, David Stein and Klutz, Palo Alto, 2005).*

Appendix 3: Marble Lather Picture

Purpose: To investigate water polarity, surfactants in action and states of matter, using shaving cream and foamy soap. Students will also observe the movement of food coloring (wetting agent) on different states of matter.

Materials: aerosol shaving cream (white), foam pump soap, paper plate, popsicle craft stick, tooth pick, food coloring, index card (unlined), white printer paper (cut in half).

Procedure: 1) Read the label of the shaving cream and the foamy soap and create a chart with the data from the labels. What are the common ingredients?

2. Place a drop of food coloring in the middle of the index card, observe and record how the drop spreads.

3. Place a drop of food coloring in a small transparent plastic cup with 50 ml of water. Observe and record how the drop spreads.

4. Spray 4 dollops of shaving cream on the paper plate, use the popsicle stick to shape and create a flat surface. Add 5-6 drops of food coloring to the top of the shaving cream. Record how the drop spreads.

5. Take the toothpick and create swirling patterns on the surface of the shaving cream. Press the printer paper on the design you

created. What do you observe from the back of the paper?

6. Gently lift the paper off the shaving cream and scrape off the excess as close to the paper as possible. Return the excess to the plate. Observe the front of the paper. Explain.

7. Mix the shaving cream on the plate with the popsicle stick until it is one uniform color. You can add 4 more drops if all the color was absorbed by the paper.

8. Apply a drop of water to the tinted shaving cream, with the dropper. Observe/record.

9. Repeat steps 1-8 with the foamy soap.

Analyze: 1. Compare and contrast the spreading of the food coloring onto clean paper, water, and shaving cream. Explain about the polarity of the food color and the paper.

2. Shaving cream is lather, similar to foam. A foam is a colloid consisting of a gas dispersed within a liquid. (The liquid in shaving cream is water and soap, with larger sized soap particles dispersed in water.) What other common products are foam or lather colloids?

3. Artists have created beautiful marble papers since the middle ages. How do you think an artist's understanding of materials influences his or her work? Explain your answer

(Adapted from Journal of Chemical Education, Classroom Activity #89)

Appendix 4: How Soap Removes Dirt

Purpose: To observe the action of soap on the surface of water.

Materials: shallow container with cold water (jar lid, small plastic bowl, petri dish), dropper, paper clip, and a bar of soap.

Procedure: 1) Fill a clean shallow container with cold water. The container should be 5-10 cm in diameter and 1-2 cm deep, preferably a lid from a jar, or plastic bowl. Ensure that the container is clean and does not have any soapy residue. Make sure you are eye level with the top surface of the container. Fill the container slowly to the top using a small graduated cylinder or dropper.

2) Take a clean paper clip about 3 cm long and gently place ease it onto the rim of the container and slowly level it on the surface of the water to make it float. It must be done slowly and gently, or else the paper clip will sink. Surface tension will hold the paper clip on the surface of the water.

3) Gently dip one end of a bar of soap into the water, in a spot that is farthest away from the paper clip. Try not to make any waves because then you will break the surface tension. Notice as the soap dissolves that the surface tension will also change and eventually the paper clip will drop to the bottom of the container.

Analyze Questions:

1) What effect did soap have on the surface tension? Explain.

2) Water alone is not good at removing dirt because surface tension prevents water molecules from surrounding dirt particles. How do you think soap improves the ability of water to remove dirt?

3) Temperature is the measure of the amount of energy of a substance. What effect would you expect a high temperature to have on the water molecules and therefore on the surface tension of the water?

Extension: Use warm water or even hot water and repeat the procedure, observing the difference, if any in the surface tension. Use caution with the hot water, and remember slowly and gently.

Vocabulary: surfactant, surface tension, polar, nonpolar, hydrophilic, hydrophobic, attract, repel.

(Adapted from Prentice Hall Science Explorer, Interdisciplinary Explorations, 2001)

Appendix 5: How to Make Soap

Soap A: Teacher will demonstrate this soap making activity.

Purpose: To demonstrate how to make soap.

Materials: 20 grams lard or vegetable shortening (solid), 5 grams baking soda, water, hot plate, 20 grams of salt, cheesecloth, beakers, containers, molds.

Procedure: 1.Dissolve 5 grams of baking soda in 10ml of water.

2. Add 20 grams of lard to this solution.

3. Boil gently on a hot plate for 20 minutes. Can demonstrate temperature change here. Stir continuously while the mixture is boiling (stir so substance can mix thoroughly for saponification to occur). Can also illustrate the law of conservation of matter, based on the chemical equation.

4. Let the mixture cool, then pour into a plastic container and place on an ice bath for 5-10 minutes, stirring continously. (temperature change)

5. Dissolve 20 grams of salt in 25 ml of water to make a saturated solution. Add to the cooling mixture and stir. (this solution should be curdling now)

6. Gently take the container and pour through a cheesecloth until the container is empty. Drain any excess liquid. Pour the soap curdles in a mold and leave to set.

7. Test with litmus paper to determine acidity or alkalinity.

Explain saponification, solutions/saturated, temperature changes.

(Adapted from Prentice Hall, Science Explorer, Physical Science, pg. 138-139, 2002)

Soap B: Student's Soap

Purpose: To demonstrate how to make eco-friendly soaps

Materials: double boiler, glycerine soap base, essential oils, cocoa butter, fragrances, soap colorant, molds.

Procedure:1. Place the glycerine soap base into the top container of the double boiler and set the temperature on high to melt the glycerine until the moisture is remove, but not so that it forms bubbles.

2. Add the coloring to it, ensuring that the glycerine is evenly coated and absorbed the color.

3. Slowly stir in essential oils and fragrances.

4. Add melter cocoa butter, stir until the mixture is very smooth and even.

5. When it is completely bound together, slowly pour into molds and allow to set & harden.

For softer texture; add goat milk, whole milk, almond milk, etc. Students will use different oils and fragrances based on the results of their survey. Students will be required to measure and chart the temperature change every 3 minutes. Students will also illustrate using a chemical equation to indicate law of conservation of matter.

Appendix 6: Tri-fold Board Display