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Theme Based Lesson

Topic: The Evaluation of Sunscreen Formulation and Effectiveness

National Science Education Standards: Science as inquiry/ Physical Science

MS Science Frameworks: Properties of Matter/Atomic Structure

Objectives:

- Compare the properties of compounds according to their type of bonding. (DOK 1)
  - Covalent and ionic bonding, polar and non-polar interactions
- Analyze the relationship between microscopic and macroscopic models of matter.

(DOK 2)

  - Particle size and nanoparticles

- Compare and contrast the physical states of all 3 states of matter. (DOK 2)
  - Liquid, solid, and gas
- Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
  - Comparison of commercial sunscreen vs. formulated sunscreen

Engage

Students were shown a PowerPoint presentation regarding sunscreen, its history, and effectiveness. Following the sunscreen presentation, students were assigned a specific sunscreen formulation. The lab was set up for the students to weigh out products in a round-robin fashion prior to their arrival. During this time the students were asked the following questions.

What are the effects of sunlight on skin? What at the molecular level allows one person to tan while anther may burn? Does it matter whether the sunscreen is a gel, cream, or spray? Should the sunscreen be water-resistant or water-proof? Is a tanning bed a safe alternative to the beach? How is exposure to sunlight beneficial? If too much exposure to the sun can cause cancer, why doesn’t it affect plants and animals?

Article:

Ms. Green provided recent literature regarding a person catching on fire after using a popular type of sunscreen.

Explore

Student groups will prepare a single formulation of a sunscreen lotion assigned from Table 1. Data and results from all individuals and/or lab groups will be combined for comparison.
Place a 150-mL beaker on a balance and weigh it. Weigh the quantities of cetyl alcohol, benzophenone-3, ethylhexylmethoxycinnamate, stearic acid, glycerin, and stearyl dimethicone silicate crosspolymer called for in your assigned formulation from Table 1 into the 150-mL beaker. Heat the beaker with the organic mixture in a water bath until all the ingredients have melted.
Note: Cosmetic ingredients should not be melted over a direct flame or high heat because they may scorch or decompose if they are heated much above the boiling point of water.

Measure 78 g of water into a 400-mL beaker. Add 1.0 g of triethanolamine to the water. Stir. Heat the water solution to a temperature of 80° to 85°C.
After the water solution has reached a temperature between 80° and 85°C, remove it from the heat and slowly pour the melted cetyl alcohol, benzophenone-3, ethylhexylmethoxycinnamate, stearic acid, glycerin, and stearyl dimethicone silicate crosspolymer mixture into the water a little at a time, stirring constantly. It may be helpful to hold the 400-mL beaker using a pair of beaker tongs. (Note: If the “organic mixture” has solidified, heat briefly in the water bath to remelt it.) If you pour too fast or if you do not stir, your emulsion will be lumpy or the mixture may not fom an emulsion. Continue stirring until you have a smooth, uniform paste. Label the beaker and set the sunscreen cream aside to cool. You will need this sunscreen mixture for Part II of this experiment.

Explain

Some active ingredients in sunscreens are:

Benzyl salicylate and salicylate derivitaves. One of the first sunscreen agents. It provides UVB protection, but not UVA. It is not soluble in water and can be used in waterproof formulations. It is often used in combination with other ingredients. One of the derivative compounds is known as homosalate.
Benzyl cinnamate and cinnamate derivatives. Another early sunscreen agent. It is an effective UVB blocker, but is not waterproof. Often found in combination with other ingredients.
PABA (p-aminobenzoic acid). This compound was extensively used in many formulations, however, it was not water soluble and needed to be used in alcohol-based solutions, it would discolor fabrics, and many individuals experienced or developed allergic reactions to it. Most sunscreen lotions are now PABA free.

Butyl methoxydibenzoylmethane and related compounds. Also known as Parsol 1789 and Parsol A is an effective UVA blocker. Oxybenzone is a related compound.
Zinc oxide and titanium dioxide are two inorganic compounds that are insoluble in most liquids. These block the UV radiation because their preparations are opaque to light. Sunscreen lotions containing these are normally white opaque ointments on the skin.
Each of the active ingredients provides an SPF factor related to its concentration in the sunscreen.
Increasing the concentration of the ingredient should also increase the SPF rating of the sunscreen.
In Part I of this experiment, we will prepare a sunscreen lotion varying the concentration of some of the active ingredients in the formulations (Table 1).

Elaboration

After the sunscreen mixture has cooled, rub a small amount onto your forearm. Describe the texture, and spreadability of the lotion. Does it dissolve into the skin in a reasonable amount of time? Does it leave the skin feeling oily or greasy? Using tap water, wet the area of your skin where you applied the sunscreen lotion. Does it appear to wash off?
How does the sunscreen lotion you prepared compare with a commercial sunscreen lotion?

Evaluation

Worksheet attached_ Evaluation of Sunscreens

Following the previous, we used *Saccharomyces cerevisiae* to determine the effectiveness of the formulated sunscreen and the commercial sunscreen. In order to evaluate the effectiveness of the formulated sunscreen and the commercial sunscreen, the students were divided into groups and given a plate that was previously streaked with UV sensitive yeast. The plates were sealed to prevent exposure to outside bacteria. Students labeled each half of the plate to compare their formulated sunscreen against their specific commercial sunscreen. The amount of yeast growth is expected to reveal the effectiveness of the sunscreen applied. A lot of growth signifies a good sunscreen protectant. This activity allows students to identify how science is used to evaluate how composition affects the performance of the product.

Table 1. Components of a Sunscreen Lotion

Ingredient	Formulation 1	Formulation 2	Formulation 3	Formulation 4	Formulation 5	Formulation 6	Formulation 7	Formulation 8
Cetyl alcohol	2.0 g	2.0 g	2.0 g	2.0 g	2.0 g	2.0 g	2.0 g	2.0 g
Benzophenone-3	1.5 g	1.5 g	1.5 g	1.5 g	—	3.0 g	4.5 g	4.5 g
Ethylhexylmethoxy-cinnamate	1.5 g	—-	3.0 g	4.5 g	1.5 g	1.5 g	1.5 g	4.5 g
Stearic acid	4.0 g	4.0 g	4.0 g	4.0 g	4.0 g	4.0 g	4.0 g	4.0 g
Glycerin	2.0 g	2.0 g	2.0 g	2.0 g	2.0 g	2.0 g	2.0 g	2.0 g
Stearyl dimethicone silicate crosspolymer	10.0 g	10.0 g	10.0 g	10.0 g	10.0 g	10.0 g	10.0 g	10.0 g
Triethanolamine	1.0 g	1.0 g	1.0 g	1.0 g	1.0 g	1.0 g	1.0 g	1.0 g
Water, distilled or deionized	78.0 g	78.0 g	78.0 g	78.0 g	78.0 g	78.0 g	78.0 g	78.0 g

Note: Concentrations of ethylhexylmethoxycinnamate are limited to a maximum level of 7.5% in a sunscreen formulation.

References:

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2. Rocha, L.K. (2005). The Science Teacher, Vol. 72, No. 6. Retrieved January 07, 2013, from http://www.questia.com/read/1G1-136199789/to-tan-or-not-to-tan-students

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4. Nanosense. (2012) http://www.nanosense.org/activities/clearsunscreen/.../CS_Lesson3Teacher.pdf

5. CK-12 (2012)www.ck12.org/tebook/NanoSense-Teacher-Materials/r1/section/2.0/