Penn State RET in Interdisciplinary Materials

Teacher's Preparatory Guide

"The Science of Sunscreen"

Purpose:

This lab is designed to teach basic laboratory safety practices and understand how nano-sized active ingredients in sunscreens (such as zinc oxide) help protect skin cells from UVA and UVB radiation that can lead to skin cell damage, aging, and potentially forms of skin cancer.

Objectives:

1. Students will be introduced to laboratory safety practices/procedures.
2. Students will convert between the U.S. measurement system and the Metric system.
3. Students will create an emulsion (sunscreen).
4. Students will compare and contrast commercial and homemade sunscreens describing their observations and analyzing results.
5. Students will work in collaboration to design an experiment to test the homemade sunscreen against commercial sunscreen.

Time required: 3-5 40-minute class periods
Level: Middle School

National Science Education Standards (NGSS Grade 8)

MS-PS1-2 – Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

MS-ETS-2 - Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

MS-ETS-4.2 - Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.

MS-ETS-3.2 - Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.

MS-ETS-3.3 - Evaluate the accuracy of various methods for collecting data.

Teacher Background:

This is meant to follow classroom instruction on the electromagnetic spectrum, ultraviolet radiation, and an introduction into nanoscale science (since both the ultraviolet radiation and particles in sunscreen are measured in

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nanometers).

Materials

- Hotplate
- (1) 500 mL/(1)1000 mL beakers per lab group (to create a double boiler system)
- Magnetic stir bar (optional) or spatula or popsicle sticks (stirring instrument)
- Dust masks (for working with ZnO)
- Gloves (for working with ZnO)
- Safety glasses
- Tongs or heat resistant gloves
- Trivet or hot pad (for placing hot beakers)
- Measuring cups or 250-500 mL beakers to measure ingredients
- Coconut oil
- Almond oil
- "Raw" shea butter (not processed with hexane derived chemicals)
- Non-nano zinc oxide powder (micronized)
- Carrot seed oil or Raspberry seed oil or Wheat germ oil
- Sunscreen(s) with a low SPF (5-15)
- Sunscreen(s) with a high SPF (30-70)
- Sunscreen recommended for babies or children. Make sure this contains ZnO

Advance Preparation

All materials can be purchased at stores such as Wegmans, Wal-Mart, Target etc, with the exception of beeswax pellets, seed oils and zinc oxide powder. These items can be found on Amazon in varying sizes and prices so adjustments can be made where needed to accommodate class sizes. No real prep work is required, this will allow the students to measure proper quantities on their own.

Safety Information

Safety glasses must be worn at all times. Materials will be hot and could injure a student if splashed into eyes. Gloves and dust mask must be worn when working with zinc oxide powder (ZnO can be an irritant if inhaled or overexposure to the skin) (MSDS link: http://www.sciencelab.com/msds.php?msdsId=9927329). Heat resistant gloves should be worn when using the double boiler system, while stirring or touching beakers associated with the double boiler system.

Teaching Strategies

This laboratory activity is a great introduction into safe laboratory practices because students are required to work with hot materials and a mild irritant (ZnO). A review of the MSDS or SDS symbols and responsible laboratory practices should be conducted before beginning. The lab will work best with small groups (3 or less) to give enough responsibility to each student to limit free time.

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Procedure

- Fill 1000 mL beaker with ~500 mL of water and place on a hotplate.
- Bring to a slow rolling boil
- While the water is heating up, in a separate 500 mL beaker, add (1/3 cup) coconut oil, (1/4 cup) beeswax pellets, and (2 Tbs) "raw" shea butter
- Place 500 mL beaker inside 1000 mL beaker to create a double boiler system
- Stir mixture frequently
- Once all is melted, remove from heat and add (1/4 cup) almond oil, (20-25 drops) carrot seed oil or raspberry seed oil, or wheat germ oil, and **slowly** add (4 heaping Tbs/ 54.4g) ZnO powder, stirring constantly
- Once added, you may want to transfer back to low heat to help dissolve the ZnO powder. This may take 10-15 minutes
- Using a magnetic stir bar helps with consistency

*As a math extension, students can convert U.S. units to metric units before making emulsion

Cleanup: Large safety container for any zinc oxide remnants left in beakers. Anything else (non ZnO) can be cleaned up using Alconox powder and warm water and disposed of normally.

Student Worksheets and Guidelines

Accompanying this laboratory exercise, there are handouts and a quiz pertaining to the old and new hazard symbols (pg. 5-7). This is NOT an all-inclusive laboratory safety lesson. Teachers should use their best judgement to fulfill the needs of safety in the classroom/laboratory. Safety handouts, and quiz are modified versions of original documents found at https://www.tes.co.uk/teaching-resource/new-hazard-symbols-6361473. The safety section is meant to precede the sunscreen emulsion lab.

Work and additional lab experiment related to the sunscreen emulsion lab can be found on pg. 8-12 .

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Hazard Symbols Old and New

Old Symbol	New Symbol	Meaning
		**Toxic** Can cause death if swallowed, breathed in or absorbed by skin
		**Corrosive** Attacks and destroys living tissues, such as skin and eyes.
		**Oxidizing** Provides oxygen to make other substances burn more fiercely
		**Radiation** Damaging to living tissue, possibly causing DNA damage and mutations.
		**Highly flammable** Catches fire easily.

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		**Biohazard** Biological substances that pose a threat to human health.

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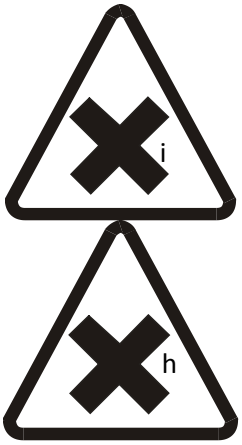
Hazard Symbols Old and New

Old Symbol	New Symbol	Meaning
		**Irritant** Not corrosive but will make the skin red or blister. Not as dangerous as Toxic
		**Environmental Toxicity** Substances that can damage the environment if released
		**Compressed Gas** Gas cylinders under high pressure
		**Explosive** Substances that can self-react or detonate easily
NONE		**Aspiration Hazard** Respiratory sensitizer Substances that can attack organs in the body. Cancer causing substances.

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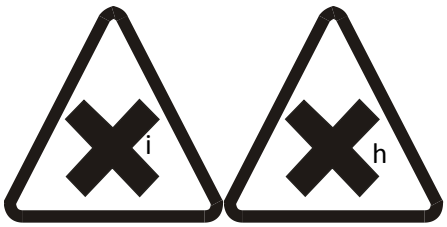
Hazard Symbols Quiz

Old Symbol	New Symbol	Meaning
		
		
None		
		
		
		

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Sunscreen Emulsion Lab Worksheet(s)

Brand Name	Price	Active Ingredients	Chemical or Mineral	SPF	Broad Spectrum?

(http://nanosense.sri.com/activities/clearsunscreen/allaboutsunscreens/CS_Lesson2Teacher.pdf)

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Additional Lab Activity

If the students are unable to propose an experiment to compare the homemade sunscreen with the commercial sunscreens (that is able to be completed due to time constraints or health/safety issues etc), follow instructions below for a quick and simple experiment.

Materials

- UV sensitive beads (multi-colored or homogeneous colors)
- Several 8”x10” (or other similar sizes) sheets of Plexiglas
- Double-sided tape or glue sticks
- Black construction paper
- Dry erase or permanent marker
- Black garbage bags/boxes (optional)

Procedure

*This experiment is also meant to be done in small groups

- Distribute black construction paper
- Instruct students to draw six (6) squares on the sheet that are approximately 5 cm^2
- Distribute the 8”x10” Plexiglas sheets
- Place Plexiglas over the construction paper and instruct students to trace (with marker) the previously drawn squares (from construction paper)
- Label each box with the SPF or name of sunscreen that will be smeared on surface
- In appropriate boxes, place a pea-sized drop of sunscreen and distribute as evenly as possible, covering all portions of the box (Figure 1)
- Select a consistent number of UV beads to use for each box (~10 works well)
- Using either the tape or glue, fix them to the construction paper inside the lines of the box
- Place Plexiglas over the fixed beads and construction paper
- Cover with construction paper, garbage bag, or box in order to keep the UV rays from hitting beads until you are ready for exposure
- Unveil to the Sun (Figure 2)

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Figure 1.

Figure 2.

Observational Worksheet and Discussion Questions

*To be completed before going outside with beads

1. Does the opacity of a substance (its appearance) relate to its ability to block UV light from hitting an object?

2. With your partner(s), record your hypothesis/hypotheses in the table below.
    a. Find the row that corresponds to its opacity
    b. Find the column that corresponds to its UV blocking ability
    c. Draw a large dot (●) in the box where this row and column intersect
    d. Label the dot with the name of the substance

Hypothesis Chart		UV Blocking Ability				
		No Blocking	Low Blocking	Medium Blocking	High Blocking	Total Blocking
Opacity	5 Fully Transparent					
	4					
	3					
	2					
	1 Fully Opaque					

(http://nanosense.sri.com/activities/clearsunscreen/introduction/CS_Lesson1Teacher.pdf)

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Example Key		UV Blocking Ability				
		No Blocking	Low Blocking	Medium Blocking	High Blocking	Total Blocking
Opacity	5 Fully Transparent	●	●			
	4	●	●	●		
	3		●	●	●	
	2			●	●	●
	1 Fully Opaque					●

(http://nanosense.sri.com/activities/clearsunscreen/introduction/CS_Lesson1Teacher.pdf)

3. Does your hypothesis chart pattern match what you observed in the outdoor experiment? Compare and contrast and explain what you are seeing.
4. What does this mean in practical terms? What does it tell you about how well you can judge the effectiveness of sun protection by looking at the appearance of a sunscreen? (Explain)
5. How might this activity affect your sun protection activities?(Explain)
6. Would increasing or decreasing the number of substances you test change your answer(s)? Explain
7. How confident are you that the answer(s) that you came up with are correct? Would increasing or decreasing the number of substances tested change how sure you are of your answer(s)? Explain

(http://nanosense.sri.com/activities/clearsunscreen/introduction/CS_Lesson1Teacher.pdf)

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