Maintaining an Oil Spill Disaster: Free Volume, Solubility and Crosslinking Explained

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Total Time: 220 minutes

Engage (20 minutes)

Address the class: Have you ever experienced a nasty spill that inconveniences you? What kind of discomfort did it cause you? Did you know how to clean the spill? If so what was the spill and how did you clean it up?

Students: Write down and draw a picture of the spill. Identify the components of the spill and the components of the clean-up process.

Ask students to explain what they know or can recall regarding the Deepwater Horizon Oil Spill in 2010. Present information (most pictures) regarding the oil spill via PowerPoint. Ask students to note salient problems and solutions they see in the presentation. After the presentation go around the room and ask students to share at least one thing they wrote down.

Take-Home Message: In order to preserve human lives during disasters like oil spills, flooding, and contamination we need to understand the rules of solubility, absorption, free volume and chemical compatibility to effectively clean up the spillage.

Elaborate (20 minutes)

Students will perform a computer search using specified websites or print-outs with prompts to discover the strategies that were used for large scale cleanup on the coast. Ask them include at least one interesting thing they learned from this search in their final PowerPoint presentation.

Example Websites:
http://science.howstuffworks.com/environmental/green-science/cleaning-oil-spill.htm
http://en.wikipedia.org/wiki/Oil_spill
http://www.ceoe.udel.edu/oilspill/cleanup.html
http://www.cnbc.com/id/37593652/17_Ways_To_Clean_Up_The_Gulf_Oil_Spill

Internet Keywords

Oil spill
Hydrophobic Polymer
Methods of cleaning the oil spill
Kevin Costner
Burning
Polyethylene
pads
Booms

Explore (45 minutes)

Give the students a *pre-test* with the following questions:

1. Give a brief description of the concept of *absorption*.
2. Do you think smaller molecules or larger molecules (such as polymers) are better for absorbing materials?
3. What is oil made up of?
4. Do oil and water mix? Why or why not?
5. How do you think free volume (or free space) influences absorption?
6. What property determines which layer will go on top?
7. What is a polymer?
8. What is a cross-linked polymer? Draw a picture with labels if you'd like.
9. What is a micelle?
10. What is the general rule for solubility?

Use the answers from their pre-test to explain the concepts to them later.

Experimental

Divide students into groups of 4. Assign a group leader. The group leader should assign roles to every student in the group.

Roles:

1. Procedure reader (read the procedure out loud and direct the other students what to do)
2. Measurer (someone who weighs everything)
3. Recorder (someone who writes down the weight of everything)
4. Materials Collector (collect the material that your group needs for the experiment)

What will the students do? Perform an experiment testing the efficacy of various materials in cleaning a small-scale oil spill.

1. Determine which material works the best to clean up the oil spill and why.
2. Draw and know the structure of each oil cleaner.
3. Describe how each material interacts with the water and oil.
4. Calculate the absorbing power of the hydrophobic polymer, the cross-linked hydrophobic polymer, the hydrophilic polymer and the cotton. (Detergent will only be qualitatively observed.)

$$\text{Absorbing Power (\%)} = \frac{\text{Weight of oil} + \text{Weight of polymer}}{\text{Weight of polymer}} \times 100$$

Materials:

- Salt water (tap water works as well)
- Clear plastic cup or beaker
- Oil (Vegetable oil and/or Marvel Crude Oil)
- Oil Cleaners:
    - Detergent (Soap)
    - Oil Absorb (Gas Station)
    - Cross-linked hydrophobic polymer (supplied by Steve-Spangler Science)
    - Cotton
    - Other oil cleaners and can be used and substituted as well.

Procedure:

1. Fill a clear glass beaker with approximately 100 mL of salt water.
2. Measure 25 mL of crude oil in a graduated cylinder and pour this into the beaker with the water.
3. Measure a known amount of hydrophobic powder onto the top of the oil water beaker (record this as "Weight of Cleaner" in your table).
4. You and your group member should decide what to do next. You can either stir the mixture or let it stand still. Once you think the powder has absorbed the oil, scoop it out of the beaker and record its weight (record this as "Weight of Oil+Cleaner" in your table).
5. Mark down your observations. (For example, did the cleaner remove ALL of the oil or just some of it? Did the color of the water change, etc. Be creative and descriptive!)
6. Create a Table recording your results (see below).
7. Make a bar graph of your results using Microsoft Excel
    a. x-axis: Cleaner name
    b. y-axis: Absorbing power (%)

Results Table

	Weight of Cleaner (g)	Weight of Oil +Cleaner (g)	Absorbing Power (%)
Oil Absorb (Gas Station)			
Crosslinked Hydrophobic Polymer			
Cotton			

Explain (45 minutes)

Use either a PowerPoint presentation of some sort of interactive media to discuss the main concepts and keywords.

Keywords:

- Density
- Free Volume
- Solubility
- Absorption
- Cross-linking Polymer
- Hydrophillic
- Hydrophobic
- Micelle

Concepts:

- Like dissolves Like—Solubility
    - Oil is hydrophobic and water is hydrophilic so they don't like each other and don't mix
    - A hydrophobic substance will attract a hydrophobic substance
    - A hydrophillic substance will attract a hydrophillic substance
- Crosslinking helps in absorbing substances—have a demonstration for this. Use elastic to make a polymer and a cross-linked polymer. Then show what happens to each of these when they are submerged in a substance. The noncrosslinked polymer chains will just move further apart from each other but the crosslinked polymer will stay in tact and stretch to fill its voids with solution.
- Discuss free volume and how it aids in absorption
- Introduce micelles (structure and components) and explain how they can disperse two non-mixable substances (oil and water).

Evaluate (1.5 hours)

The students should be given at least 1 hour to prepare their PowerPoint presentations either in class or outside of class and 10 minutes per group to present. They should summarize what they've learned. Ask them to prepare a creative presentation (PowerPoint, oral, skit) of the problem and the solution. Incorporate ALL relevant scientific information from the pre-test. Students will also perform a peer-evaluation of each presentation including their own. Grading rubric is provided.

Power Point should be 10 minutes long.
Students should answer the following questions in their presentations:

1. Which material absorbed the most oil and why? (Use results table and graph to support answer.)
2. Which material absorbed the *least* oil and why? (Use results table and graph to support answer.)
3. What did the soap do to oil? Was it easy to remove the oil by adding soap?
4. Present something you discovered during your Internet search about the oil spill.

The mastery of the following objectives should be demonstrated in the PowerPoint:

1. Identify and understand hydrophillic versus hydrophobic molecules.
2. Describe what oil is made of.
3. Explain the two tenants of the absorption process
    a. Chemical: like dissolves like
    b. Physical: Free volume aids in absorption
4. Understand how cross-linked polymers can be used to absorb large amounts of substances.
5. Understand how a micelle can be used to disperse (evenly mix) oil and water.

Each keyword should be mentioned at least once during the presentation:

- Density
- Free Volume
- Solubility
- Absorption
- Cross-linking Polymer
- Hydrophillic
- Hydrophobic
- Micelle

Grading Rubric for PowerPoint

	1	2	3	4	5
	Poor	Needs Improvement	Satisfactory	Good	Excellent
Answered all the Objectives					
Used all Keywords and Concepts					
Provided Clear Results and Conclusions					
Organization					
Eye contact, good language, good enunciation					
Creativity of presentation					
				Total Points	