

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

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Note: This file contains the 5 E formatted lesson plan for instructors and then a student handout version of the lesson plan.

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.cnn.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)

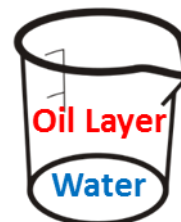
What will the students do? Perform an experiment testing the efficacy of various materials in cleaning a small-scale oil spill.

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
- Hydrophilic
- 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 hydrophilic substance will attract a hydrophilic 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 hydrophilic 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
- Hydrophilic
- 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	

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Student Handout

The scientific method will be employed to discover the best way to clean up an oil spill. All the objectives and keywords should be discussed in the final presentation.

Take-Home Message:

Main Goal:

What are the steps of the scientific method? Write out each step on a separate piece of paper.

Objectives

6. Identify and understand hydrophilic versus hydrophobic molecules.
7. Describe what oil is made of.
8. Explain the two tenants of the absorption process
 - c. Chemical: like dissolves like
 - d. Physical: Free volume aids in absorption
9. Understand how cross-linked polymers can be used to absorb large amounts of substances.
10. Understand how a micelle can be used to disperse (evenly mix) oil and water.

Concepts and Keywords

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

Elaborate/Internet Search

Perform an Internet search to answer any of the following questions and include something interesting you learned in your final PowerPoint presentation:

1. What happens or causes an oil spill?
2. What are popular and common methods that are used to clean up an oil spill? (State two methods)
3. How are polymers involved in cleaning up oil spill?
4. What are some bad outcomes or repercussions of an oil spill on the environment or other?

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.cnn.com/id/37593652/17 Ways To Clean Up The Gulf Oil Spill](http://www.cnn.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
- Hair
- Straw
- Burning
- Polyethylene pads
- Booms
- Other methods used to clean up the oil spill

Procedure

Roles:

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

Materials required:

- Water
- Clear plastic cup or beaker
- Oil (Vegetable Oil and Marvel Crude Oil)
- Calculator
- Wooden sticks
- Oil Cleaners:
 1. Detergent (Soap)
 2. Oil Absorb (Gas Station)
 3. Cross-linked hydrophobic polymer (Steve Spangler Science)
 4. Cotton

Procedure:

8. Fill a clear glass beaker or plastic cup with approximately 100 mL of water.
9. Measure 20 mL of motor oil in a graduated cylinder and pour this into the beaker (or plastic cup) with the water. (Which layer is on top?)
10. Measure a small amount of each **oil cleaner** and record this as “weight of cleaner” in your table.
11. Next, place this oil cleaner onto the surface of the oil in the beaker.
12. You and your group members should decide what to do next. You can either stir the mixture or let it stand still (or something else). 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+ weight of cleaner” in your table).
13. 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!)
14. Create a Table recording your results (see below).
15. Pick **the best oil absorber** and test it on Vegetable Oil using the same procedure as above. Did it work just as well as it did on the motor oil? (Hint: Compare the Absorbing Power)
16. Make a bar graph of your results using Microsoft Excel
 - a. x-axis: Cleaner name
 - b. y-axis: Absorbing power (%)

$$\text{Absorbing Power} = \frac{\text{weight of oil} + \text{weight of cleaner}}{\text{weight of cleaner}} \times 100$$

Results Tables

Motor Oil

	Weight of Cleaner (g)	Weight of Oil +Cleaner (g)	Absorbing Power (%)
Oil Absorb			
Cross-linked Hydrophobic Polymer			
Cotton			

Vegetable Oil

Cleaner Name	Weight of Cleaner (g)	Weight of Oil +Cleaner (g)	Absorbing Power (%)

Final Presentation

Summarize what you've learned! Prepare a creative presentation (PowerPoint, oral presentation, skit) of the problem and the solution. Below you will find a grading rubric with the requirements for a perfect score. You will also be grading each group as they present.

Time requirements: 10-15 minutes

Answer the following questions in your presentation:

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

Address all keywords and concepts in your presentation (see page 1).

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	