Oil Spill Polymer Clean-up

Objective:

Students will:

Experience how a hazmat crew might handle an oil spill cleanup using a super absorbent polymer.

Introduction:

Imagine a simple way to clean up an oil spill: A small amount of a non-toxic polymer owder is sprinkled onto the spreading oil. In seconds, the polymer powder collects the oil and forms a sponge-like layer that can be easily skimmed off of the water. It's more than just a dream! It's a new way of using super-absorbent polymers to change the way cleanup teams control oil spills and manage other waste problems. The results are amazing! (1).

Remind students that the word polymer comes form the two root words *poly* – many and *mere* – parts. So a polymer is a chemical compound that has many repeating parts. Polymer chains can be long and they can become entangled. The degree of the entanglement helps to determine some of the properties of the polymer material such as its density and ability to absorb other materials, (2).

Materials that easily dissolve in water, like NaCl or sugar are said to be hydrophilic (water-loving). Other materials that do not dissolve in water, like oil and grease, are said to be hydrophobic (water-fearing). The ability to dissolve in water has to do with having polar or charged chemical groups on the molecules of the material. Oil molecules do not have these types of polar groups and can not interact individually with water molecules. So when oil and water are mixed they eventually separate.

Figure 1. Marvel Mystery Oil® is hydrophobic and separates on top of water.

Materials:

- Clear plastic cup.
- Plastic spoon and fork.
- Water
- Marvel Mystery Oil® (available from Flinn Scientic Inc.) or kerosene. Marvel Mystery Oil®is a registered trademark of Turtle Wax, Inc., Chicago, USA. All Rights Reserved.
- Small contain to weigh Marvel Mystery Oil®.
- Enviro-Bond® 403 polymer powder (available from Flinn Scientic Inc.)
- Paper towel or napkin.
- Paper plate
- Centigram Balance – to weigh polymer, and oil.

Procedure:

- Fill the clear cup 2/3-full with room temperature tap water.
- Weigh a second, empty plastic cup. Record the weight.
- Pour a thin layer of Marvel Mystery oil in a second plastic cup.
- Weigh the cup again. Record the second weight.
- Subtract the two weight values to find the weight of the oil. Record on lab sheet.
- Pour the Marvel Mystery Oil into the cup of water to make a thin, but obvious, oil slick on the water. Notice the oil and the water separate. Since the oil (petroleum) is less dense than water, it floats on top of the water. Its bright color reveals it clearly.

- Weigh the paper towel or napkin on the balance. Record the weight.
- Use the spoon to scoop a small amount of Enviro-Bond 403 on to the paper towel or napkin. Record the second weight.
- Subtract the two weight values to find the weight of Enviro-Bond. Record on lab sheet.
- Sprinkle the Enviro-Bond on top of the oil in the water cup. Spread the polymer evenly over the surface of the oil. Watch the polymer particles absorb all the oil. The polymer immediately bonds to the oil and forms a sponge-like disk that floats on the water.
- Wait about 3-5 minutes or until the oil has been absorbed.
- While student are waiting, they will want to watch this process closely. Students should be recording their observations on the lab report sheets.

- Before removing the sponge-like, polymer-oil glob, students should press down on the edges of the polymer where it touches the cup to prevent sticking to the plastic cup.
- Lift the polymer-oil glob mixture from the surface of the water using the fork and place it on the paper plate to “cure” for 10 minutes.
- Weigh the polymer-oil glob and record on the lab sheet.

- Repeat with ice water after removing ice in another trial.
- Repeat with hot water about 80 °C.

Figure 2. Adding Enviro-Bond 403 polymer powder to the Marvel Mystery Oil® (left). Then removing the polymer-oil mixture from the surface of the water (right).

Discussion:

The chemical formulation of the polymer is a carefully guarded trade secret and a patent application has been made. However, the inventor agreed to share some limited information about the polymer for educational purposes. The hydrocarbon source (crude oil, diesel fuel, gasoline, Mystery Oil, etc.) consists of three basic petroleum components: paraffinics, naptinics, and aromatics. The polymer is formulated to specifically bond to these components. The bonding mechanism involves three-dimensional cross-linking so as many as possible are captured. According to the manufacturer, the polymer structures are referred to as dieblock, triblock, branched, radial, and liner.

When the polymer comes in contact with a liquid hydrocarbon, the free hydrocarbons bond to the polymer forming a solid mass. The hydrophobic (water avoiding) properties of the polymer cause it to float on water. However, the structure of the polymer allows it to sink through the hydrocarbon material to maximize its bonding potential. There is no need for mixing since the polymer automatically bonds to free hydrocarbons but not to water. As the water dries out of the disk, the polymer becomes firm and rubbery. The oil is actually absorbed by the polymer because both materials have similar types of hydrophobic interactions. The petroleum molecules in the oil become entangled in the three-dimension structure of the polymer and hide away from the water.

The polymer is also used in treating oily sludges. It can effectively filter oil field drilling fluids as well. It's good for stabilizing any other spilled or leaked liquid hydrocarbons that pose a threat to the environment. It's truly amazing – and *timely* – chemistry!, (1)

References:

1) Oil Spill Polymer, Steve Spangler, Website active August 2017, https://www.stevespanglerscience.com/lab/experiments/oil-spill-polymer/

2) How Polymers are Used, The Works, Ohio Center for History, Arts & Technology, 2014, supported by Battelle STEM Grant Program 2014, Website active August, 2017, http://195.189.206.177/theworks/files/wp-content/uploads/2017/01/Polymer-Lesson-Plan-4th-grade.pdf

Name _____ Date _____

Oil Spill Polymer Clean-Up

Material	Mass of container (g)	Mass of material and container (g)	Mass of Material (g)
Room Temp			
Marvel Mystery Oil			
Enviro-Bond polymer			
Polymer –Oil mix			
Observations	Was the mass of the Polymer-Oil mix the sum of the mass of polymer and oil? _____ (Yes/No) Why do you think your answer is correct:		
Ice Water Temp			
Marvel Mystery Oil			
Enviro-Bond polymer			
Polymer – Oil mix			
Observations	Was the formation speed of the f the Polymer-Oil mix the same as the formation speed at room temperature? _____ (Yes/No) Why do you think your answer is correct:		
Hot Water Temp			
Marvel Mystery Oil			
Enviro-Bond polymer			
Polymer – Oil mix			
Observations	Was the formation speed of the f the Polymer-Oil mix the same as the formation speed at room temperature? _____ (Yes/No) Why do you think your answer is correct:		

Name _____ Date _____

Lab Questions:

1. How did the water in the cup look after the polymer-oil mixture was removed; was it clean?

2. Which temperature removed the most oil?

3. Do you think more oil would have been removed is more Enviro-Bond polymer was used?

4. Do you think the Enviro-Bond is hydrophilic or hydrophobic and what make you think that way?

5. What do you thing we could do with the Polymer-oil mixture in the case of a real Oil spill? Leave it in the ocean, bury it, burn it. Squeeze it to remove the oil. Some thing else,? What would you do with the Polymer-oil mixture.?

6. Do you think that this method of clean oil spilled on water would be useful in cleaning a hydrophobic liquid that is heavier than water like chloroform (Why or Why not)?