CRISP Kit Teacher Module

Title of Module:

Oil Spills Cleanup

Subject(s) or Unit of Study:

Hydrophobicity, Biology, Properties of materials

Grade Level(s):

Suggested Grades

Est. Length of Activity:

Est. length of activity

Student Objectives:

Students will understand:

- The way a material behaves on the macroscale is affected by its structure on the nanoscale.
- Work with a complex real-world problem and possible solutions while considering the cost, safety, and effectiveness, as well as possible social, cultural, and environmental impacts.

Vocabulary:

Hydrophobic, Hydrogel (Sodium Polyacrylate), polymer

Materials:

- Hydrogel
- Hydrophobic sand
- Sand
- Corn oil
- Water
- Plastic spoon
- ½ Teaspoon
- Plastic cups
- Coffee filter

Additional hydrogel and hydrophobic sand may be purchased at:
https://www.teachersource.com/product/magic-sand/chemistry
https://www.teachersource.com/product/sodium-polyacrylate-diaper-polymer/chemistry

Learner Background:

Hydrogel (sodium polyacrylate): Hydrogels are polymeric materials that can absorb large quantities of water. They can absorb up to 1000 times its own weight in pure water. Hydrogels are cross-linked polymers that are hydrophilic. The polymer chains are arranged in the shape of randomly coiled molecules. However, when sodium ions are removed the negative charges along the polymer chain all repel each other.

When this occurs, the polymer chains that were once coiled begin to uncoil. Water molecules are attracted to the negative charges by hydrogen bonding and so when the hydrogel is in this state it is able to attract and absorb large amounts of pure water.

Hydrogels mostly are used in the linings of baby diapers to absorb liquid and in the soil to help plants retain water. However, there are specially synthesized hydrogels used to clean up oil spills. These hydrogels, instead of containing hydrophilic polymers contain hydrocarbon polymers. This hydrogel contains the same major components that oil possess, this is why oil is attracted to this type of hydrogel. The polymers attracts the oil and contains it within its pores preventing it from being released again. This special type of hydrogel is hydrophobic, it will not absorb water, only oil.

Hydrophobic sand: Hydrophobic sand is sand that is coated with a hydrophobic compound. As a result of the hydrophobic compound layer, the grains in the sand adhere to one another and form cylinders to minimize surface area when exposed to water. When the sand is removed from the water it is dry and free flowing. Hydrophobic sand was originally created to clean up oil spills. The sand mixes and traps the oil but does not mix with water. The sand mixed with oil would then sink to the bottom of the ocean where removal can then take place.

When oil-contaminated water is exposed to the hydrophobic sand, the oil is pulled through, leaving clean water behind. Putting the hydrophobic sand on top of oil spills (sprinkling it on top of the actual oil) allows the sand to bind with the oil forming clumps of oily sand which will fall to the bottom of an ocean or lake, allowing for easier cleanup.

Learning Activity or Procedure:

Students will work through 4 stations in groups of 2-3. *if you have students add the oil to the cups at each station, be sure each station has a designated oil (½) teaspoon. Be sure to have plenty of paper towels on hand!

Station 1: Hydrogel

Advanced Prep
Set up plastic cups filled half way with water (enough for each group to use 1 cup).
Pour ½ teaspoon of oil into each cup (there should be a total layer of oil over the water. Add more oil if needed.)

Each group should have available: *½ teaspoon, 1 plastic spoon, and 1 empty plastic cup*

Student activity
Tell students to make observations about the oily water. Students should make a prediction about what will happen when they add Hydrogel to the oil layer on the water.

After they make their predictions, have the students sprinkle a *½ teaspoon* of hydrogel on the oil layer. Wait a few minutes and then have students try to scoop out the oil with a spoon and put it into a plastic cup. Record observations.

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Station 2: Scooping with a spoon

Advanced Prep
Set up plastic cups filled half way with water (enough for each group to use 1 cup).
Pour ½ teaspoon of oil into each cup (there should be a total layer of oil over the water. Add more oil if needed.)

Each group should have available: *1 plastic spoon and 1 empty plastic cup*

Student activity
Students should make a prediction about what will happen when they try to scoop out the oil with a spoon (can they scoop just oil, or will water be removed as well)

After they make their predictions, have the students try to scoop only oil from the cup of oily water and put it into the empty cup. Students should think about the level of difficulty and efficiency when recording their observations.

Station 3: Sand (regular vs hydrophobic)

Advanced Prep
Set up plastic cups filled half way with water (enough for each group to use 2 cups).
Pour ½ teaspoon of oil into each cup (does not need to be a full layer across the water) *if you leave the oil in "bubbles" rather a layer, students can see the sand pull the oil through the water*

Each group should have available: *½ teaspoon, 2 plastic spoons and 2 empty plastic cups*

Student activity
Tell students to make observations about the two different kinds of sand, how are they alike? How are they different? Students should make a prediction about what will happen when they sprinkle each of the different sands into a cup of oil.

After they make their predictions, have the students first sprinkle a *½ teaspoon* of the regular sand onto the water area of the cup, observe and record results. Now sprinkle a *½ teaspoon* of regular sand onto the oil areas of the cup and record any observations. Continue to sprinkle sand ½ teaspoon at a time until all the oil is covered.

Next have the students sprinkle a *½ teaspoon* of the nanosand onto the water area in the cup. Observe and record results. Now sprinkle a *½ teaspoon* of nanosand onto the oil areas of the cup and record any observations. Continue to sprinkle sand ½ teaspoon at a time until all the oil is covered.

Have students use the plastic spoons (1 for the nanosand, and 1 for the regular sand) to try and scoop out the oil, putting it into the 2 empty cups

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Station 4: Filter paper

Advanced Prep
Set up plastic cups filled half way with water (enough for each group to use 1 cup).
Pour ½ teaspoon of oil into each cup (there should be a total layer of oil over the water. Add more oil if needed.)

Each group should have available: *1 filter and 1 empty plastic cup*

Student activity
Students should make a prediction about what will happen when they try to filter out the oil into the empty cup

After they make their predictions, have the students try to separate the oil from the water using the filter. Students should think about the level of difficulty and efficiency when recording their observations.

Assessment:

Student worksheet at end of document

Additional Resources:

https://www.cmu.edu/gelfand/k12-teachers/polymers/polymer-and-absorption/oil-spill-cleanup.html
https://www.flinnsci.com/enviro-bond-403-hydrocarbon-encapsulant-100-g/e0058/

Teacher Notes:

- **Hydrogel** | Students should try a ½ teaspoon of the hydrogel initially but they can add more after if there is oil remaining (to cover the layer of oil entirely).
- **Hydrophobic Sand** | Use a small amount of oil in the cup so that it forms bubbles instead of a full coating of oil. A small amount of the hydrophobic sand on the water and you can show students how the sand moves from the water into the oil.

Safety:

Do not consume the sodium polyacrylate powder or gel
Do not consume the oil
Do not consume the hydrophobic, or non-hydrophobic sand

STEM Careers:

Environmental Technician
Manufacturing Technician
Materials Scientist
Researcher
Conservation Scientists
Environmental Scientists
Health and Safety Engineers
Industrial Engineering Technicians
Industrial Engineering Technologist
Materials Engineers

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Standards:

Next Generation Science Standards:

NGSS Performance Tasks	**MS-ETS1-3** • Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. **MS-ETS1-4** • Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. **HS-ETS1-1** • Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. **HS-ETS1-3** • Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
NGSS - (DCI) Disciplinary Core Ideas	**MS-ETS1.B: Developing possible solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4) **MS-ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) **HS-ETS1.A: Defining and Delimiting Engineering Problems** • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)
NGSS - (CC) Cross-Cutting Concepts	**Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1) • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1)
NGSS - (SEP) Science and Engineering Practices	**SEP 1 - Asking Questions and Defining Problems** • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS) • Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS) **SEP 2 – Developing and Using Models** • Use models to describe phenomena

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Student Worksheet

Station 1: Hydrogel

Advanced Prep

Each group should have available: *½ teaspoon, 1 plastic spoon, 1 cup of oily water, and 1 empty plastic cup*

Student activity

Look at the oily water. Try to stir it around with the plastic spoon. What can you describe about the oil and water?

What do you think will happen when you sprinkle on a *½ teaspoon* oh hydrogel (sodium polyacrylate) over the oily water?

Sprinkle on a *½ teaspoon* of hydrogel (sodium polyacrylate) over the oily water and wait a few minutes. What happened when you first added the powder? What happened after a few minutes? Add ½ teaspoon at a time until the oil is covered in a light layer of the powder.

Using the plastic spoon, try to scoop out the oil with a spoon and put it into an empty plastic cup. Was this easy or difficult and why?

Station 2: Scooping with a spoon

Advanced Prep

Each group should have available: *1 plastic spoon, 1 cup of oily water, and 1 empty plastic cup*

Student activity

Do you think that using a scoop (in our activity a plastic spoon) would be a good way to clean up an oil spill in a large body of water? Why or why not?

What do you think will happen when you try to scoop out the oil with a spoon (can you scoop just oil, or will water be removed as well)?

Using the plastic spoon, try to scoop out ***just*** the oil from the water and put it into an empty cup. Were you able to scoop out only oil?

What are some factors that might get in the way of using a giant scoop in the ocean to clean up an oil spill? Think about the ocean wildlife and what might happen to them.

Do you think this is an effective and safe way to clean up an oil spill? Why or why not?

Station 3: Sand (regular and hydrophobic)

Advanced Prep

Each group should have available: *2 - ½ teaspoons, 2 plastic spoons, 2 cups of oily water, and 2 empty plastic cups*

Student activity

Looking at the two different kinds of sand, how are they alike? How are they different?

Using what you know about regular, everyday sand and what you have learned about the Nanosand (hydrophobic sand), what do you think will happen when you sprinkle the regular sand onto the oily water? What about when you sprinkle the nanosand?

First you will test the regular sand. Sprinkle a *½ teaspoon* of the **regular sand** onto **the water area of the cup**, write down what you see.

Now sprinkle a *½ teaspoon* of **regular sand** onto **the oil areas of the cup**. Continue to sprinkle the sand until the oil is covered in a light layer of the sand and write down what you see.

Station 3: Sand (regular and hydrophobic) CONT.

Now you will test the nanosand. Using a new *½ teaspoon*, sprinkle the **nanosand** onto **the water area in the cup**. Write down what you observe.

Next, sprinkle a *½ teaspoon* of **nanosand** **onto the oil areas of the cup**. Continue to sprinkle the sand until the oil is covered in a light layer of the sand and record your observations.

Use a plastic spoon (1 for the nanosand, and 1 for the regular sand) to try and scoop out the oil, putting it into the 2 empty cups. Was this easy or difficult?

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Station 4: Filter paper

Advanced Prep

Each group should have available: *1 filter and 1 empty plastic cup*

Student activity

What do you think will happen when they try to filter out the oil into the empty cup, will it be easy? Will you be able to filter out just the oil or will you have water also?

Have one person hold the filter over the top of the empty cup while another person slowly pours the oily water over it. What happened?

Do you think this is an effective way to clean up an oil spill?

What are some other things we might be able to do/use to help clean up oil spills?