Fear of Water

Recommended Grade Level(s):

Appropriate for: Middle school and High school

Time Requirements:

Activity Time: 20 minutes

Teaching Topics & Concepts:

- Hydrogen bonding, hydrophobic bonding, surface tension
- Properties of water molecules
- Observation skills

Background:

This activity is no day at the beach. Normal beach sand is polar, which makes it hydrophilic (water-loving). When regular beach sand comes in contact with water, the water's polarity causes it to stick the sand together. That's how we can build those incredible sandcastles. When individual grains of sand are treated with a hydrophobic monolayer, it becomes hydrophobic sand. This process creates a non-polar (hydrophobic) layer on the surface of the sand grain. The hydrophobic layer repels water from the surfaces of individual grains of sand. Now instead of causing the grains of sand to stick together, water either repels or completely envelops the non-polar sand, so it bonds with itself. It never gets wet, so students can build their sandcastles, coral reefs (or other works of art) under water!

Materials:

- Hydrophobic sand
- Ethanol
- Water
- Filter paper
- Funnel
- (2) 400 mL beakers

Safety

- Read the SDS sheet for ethanol.
- Wear safety glasses and gloves.
- Alcohol is highly volatile and flammable. Ensure no open flames are present (candle, Bunsen burner).
- Avoid inhalation of alcohol vapors.

Procedure:

1. Pour 200 mL of water into a 400 mL beaker.
2. Sprinkle some hydrophobic sand onto the water.
3. Try to push the sand down with your finger.
4. Sprinkle more sand into the beaker so that some falls to the bottom.
5. Pour 200 mL of ethanol into a second 400 mL beaker.
6. Sprinkle hydrophobic sand into this second beaker and observe.

Expected Results:

When hydrophobic sand is sprinkled on the water's surface, the water molecules bond with other water molecules instead of with the non-polar sand. This prevents the grains of sand from breaking through the surface. The sand appears to stick to the finger when submerged. The sand then stays on the water's surface until enough sand collects to break the surface tension. When large amounts of sand are added, intestinal shapes form at the bottom of the beaker.

Follow up:

- Explore the effects of detergents on the surface tension of water.
- Predict how normal beach sand and hydrophobic sand would behave in methanol (CH_3OH). Explain.
- Explore how nanotechnology is changing products that we use in everyday life, mostly through surface treatments (like hydrophobic sand).

Teaching notes:

- The non-polar sand does not mix with the polar water molecules.
- The sand appears to bond together in water, giving rise to the concept of hydrophobic bonding.
- The effect disappears with ethanol or if regular sand is used in water.

Questions and observations for students:

1. Predict what will happen when you put a drop of water on a pile of hydrophobic sand. Explain.
2. Predict what will happen when you put regular beach sand and hydrophobic sand in oil. Explain.
3. How could hydrophobic sand be used to help clean up oil spills in the ocean?
4. Can you think of how mixing some hydrophobic sand in soil can keep plants healthy?
5. Can you find examples of the hydrophobic effect in nature?

Disposal/Clean-Up:

- Recollect the sand for reuse by filtration.
- The used water can be washed down the drain.
- The used alcohol can be washed down the drain with lots of water.