**VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE**

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**MAGIC SAND (Mini-Lesson)**

**Fall 2013**

**GOAL:** To learn about "water-loving” (hydrophilic) and "water-hating” (hydrophobic) substances by using sand and coated sand (Magic Sand). To introduce students to nanotechnology.

**Materials**

1 oil and water bottle for demonstration

15 teaspoons coated with magic sand

1. teaspoons coated with regular sand

16 “How Big Is Your Hand?” worksheets

2 2-oz. container of magic sand

32 1oz plastic cups

4 plastic taster spoons

16 1-oz dropper bottles of water

16 popsicle sticks

1 dropper bottle mineral oil

Scotch guarded fabric sample

2 16-oz water bottles (filled with water)

1 16 oz cup for waste collection

1 large waste container.

16 aluminum pie pans or plates

10 sheets of paper towels

1 trash bag

**Complete teacher/school information on first page of manual.**

1. Make sure the teacher knows PatTellinghuisen’s home and office numbers (in front of manual).
2. Exchange/agree on lesson dates and lesson order (**any changes from the given schedule need to be given to Pat in writing (email)**).

Since this is your first visit to the class, take a few minutes to introduce yourselves. Mention you will be coming three more times to teach them a science lesson. Then tell students today's activity involves comparing the properties of a coated sand (magic sand) with regular sand.

**Pre-lesson Preparation:**

* Count number of students and prepare cups of magic sand and cups of water so that students can share in pairs.
* Put 1 tasterspoonful of the Magic Sand into 1oz cups,
* Pour water into 1oz cups, about half full.
* Write the vocabulary words on the board: **hydrophobic and hydrophilic, nanotechnology**

**I. Background**

For VSVS members only: The surface of sand grains is wetted by water, which means that water molecules are attracted to sand grains. This water-loving property of sand is called a hydrophilic (water-loving) property. Magic Sand is regular sand that has been coated with an oil-like substance that is water-hating or hydrophobic.

**II. Activities with Magic Sand**

**A. Demonstration:** to show students that oil and water don’t mix.

* Tell students that the bottle contains oil and water. Tell them that the water has blue food coloring added to it.
* Shake the soda bottle and allow the mixture to settle out again into the 2 layers.
* Explain to the students that oil is **hydrophobic (water-hating).** Hydrophobic substances do

not mix with water.

* Ask the students why the blue food coloring is in the water only, and not the oil?

*The oil is* ***hydrophobic*** *and will not mix with the food coloring which is 99.7% water.*

Ask: What are other examples of hydrophobic materials?

* *A newly waxed car will make water form beads on its surface.*
* *Oil from cars will float on top of puddles.*
* *Oil and vinegar salad dressings need to be shaken up before using.*

Ask students to give examples of **hydrophilic (water loving)** substances.

* *Vinegar and water mix together*
* *Lemon juice and Iced tea*
* *Chocolate syrup and milk*

**Students should work in pairs for the following activities.**

1. **Activity: Investigating Hydrophobic and Hydrophilic properties.**

**Distribute materials per pair:**

1 spoon coated with Magic sand

1 spoon coated with regular sand

1 plate

1oz dropper bottle of water

1. Tell the students to use the 1-oz dropping bottle of water to carefully add two drops onto the Magic

Sand coated spoon. Tilt the spoon left and right and watch what happens to the bead of water.

Ask: what happens when water is added?

*The water drops sit on the Magic Sand’s surface, and are separated. Like the oil, the surface of*

*Magic Sand is* ***hydrophobic (water-hating).***

Tell students to shake the water off onto the plate, and look at the magic sand again (it is dry).

3. Repeat the experiment with the regular sand coated spoon, and make observations.

*The surface of regular sand is* ***hydrophilic (water-loving).*** *The water drops are attracted to the sand and soak into it.*

**Collect sand–covered spoons and put back into the kit.**

**III. Introducing Nanotechnology**

**Ask students if they know what Nanoscience is?**

**Nanoscale science** focuses on things that are measured in nanometers, including atoms and molecules.

In the field of nanotechnology, scientists and engineers make new materials and tiny devices.

**Important Idea: At the nanoscale, many ordinary materials have different and unusual properties, compared with the same material at the macro level.**

Hand out the “How Big Is Your Hand?” worksheets (1 per pair).

Tell students to:

1. Look at the scale.
2. Place your hand against the ruler and read off how many nanometers your hand measures.
3. How many nanometers long is it?

One meter is a billion nanometers. (A meter is a little longer than a yard.)

Or, **a nanometer is a billionth of a meter.** That’s really tiny! Nanometers are used to measure things that are too small to see.

So a person who is a little over three feet tall measures one billion nanometers. A person 6 feet tall is nearly 2 billion nanometers.

Here are some other ways to think about how small a nanometer is:

* The ridges in your fingerprints are around 250,000 nanometers wide.
* A sheet of paper is about 100,000 nanometers thick,
* A strand of your hair is around 75,000 nanometers wide.
* Your fingernails grow one nanometer every second.
* 10 hydrogen atoms are about 1nm.

**Why is Nanoscience important?**

Nanotechnology has begun changing products that we use in everyday life.

**How does this relate to Magic Sand?**

* Would you like to have shirts that don’t get dirty? What if the milk that spilled in your minivan never smelled? Imagine the value of a surgical mask that actually kills germs, rather than simply preventing them from being inhaled.
* Scientists have manipulated particles at the molecular level to enhance the performance of a fabric without compromising the fabric’s original properties—durability, softness, flexibility, and so on.

Ask students if they have heard of **stain-resistant Nano-TexR fabric**? Show students the piece of fabric.

Tell them that an advertisement states:

“Traditional coatings make garments feel stiff and clog the weave of the fabric preventing breathability. Using nanotechnology, our treatments are small enough to attach to individual fibers, delivering superior performance characteristics without compromising the look, feel or comfort of the fabric.

“Old techniques encase fabric in thick layers of chemicals. Nano-Tex is the first high performance nanotechnology that builds **permanent spill and stain resistance into the fiber structure of the fabric.** It bonds with the fibers, protecting the material at the atomic level from dirt without depriving it of air.   
**“Spills just stop, bead and roll.**  The performance design of nanotechnology bonds with fabrics rather than coats them, creating a huge new universe of fabric choices that are almost impossible to stain. “

**IV. More Activities with Magic Sand**

**Materials for each pair**

1 1-oz. cup containing one tasterspoon of magic sand

1 1-oz plastic cup half filled with water

1 popsicle stick

Tell the students to:

1. Sprinkle the Magic Sand from their 1 oz cups onto the surface of the water.

Ask: why does the Magic Sand float on the surface?

*Magic Sand is regular sand that has been coated with an oil-like substance so it is*

*water-hating. The Magic Sand grains like to stay in contact with each other. Also,*

*the surface tension of the water makes the Magic Sand float.*

1. Take a wooden popsicle stick and slowly push it through the Magic Sand layer, and into the water about a quarter of an inch. The Magic Sand will coat the popsicle stick. Now pull the stick out.

Ask: Why is the popsicle stick dry?

*Since Magic Sand is not wetted by water, the wooden stick is only in contact with Magic*

*Sand and doesn’t get wet.*

1. Add 2 drops of water onto the floating magic sand. Keep adding water so that a large drop forms.

Look under the Magic Sand surface. What do you see and why?

Tell the students to keep adding drops of water until the water falls through the sand layer.

*The drop eventually gets heavy enough to break through the layer.) Some of the Magic Sand will fall through with the water.*

1. Use the popsicle stick to mix the Magic Sand and water. What happens?

Ask: What shape does the Magic Sand form under the water? What does the surface of the Magic Sand look like underwater?

*The Magic Sand has a silvery sheen and doesn’t become wet. It can be molded into a*

*structure that holds its shape under water.*

1. Have VSVS students carefully pour off the water from the sands back into the waste

container, leaving the sand behind.

Make observations of the remaining sand. Feel the sands with your fingers.

Ask: What happens when the water is removed?

*Since the Magic Sand was not wetted by water, it is now dry and cannot form shapes.*

**Magic sand and Oil**

Ask students to predict what will happen when oil is added to magic sand? Remind students that oil and water do not mix, because oil is **hydrophobic (water-hating).**

VSVS members willuse the 1-oz dropping bottle of mineral oil to carefully add two drops of oil on the Magic Sand.

Ask: What happens when the oil is added?

*The oil sinks through the Magic Sand.*

*Both mineral oil and Magic Sand are hydrophobic (water-hating). Since they have this* ***same*** *property, the oil is not repelled by the Magic Sand and sinks through it.*

**Collect the 1oz cups and put in the small trash bag. PLEASE DISCARD AT SCHOOL. (Oil may leak out into the VSVS box and make it unusable.)**

**V. Other Practical Applications**

A. Magic Sand was originally developed as a way to trap oil spilled from oil tankers near the shore. The idea was that when Magic Sand was sprinkled on floating petroleum, it would mix with the oil and make it heavy enough to sink. This would prevent the oil from contaminating beaches. However, it is not being used for this purpose, perhaps because of the expense of making Magic Sand.

B. Another potential use of Magic Sand is to bury junction boxes for electric and telephone wires in the Arctic in order to protect the utilities from the extreme cold temperatures but make it easy to dig up for repairs. Normal earth is frozen so hard because of moisture content that it is difficult to dig. However, Magic Sand remains dry and is easy to dig, regardless of how cold it is.

**VI. Clean-up**

If magic sand has not been contaminated with oil, the teacher can keep it.

Put 1oz cups with **contaminated sands** into plastic trash bag and dispose of at school.

Lesson written by Dr. Melvin Joesten, Faculty Advisor of VSVS, Vanderbilt University

Pat Tellinghuisen, Coordinator of VSVS, Vanderbilt University

This lesson is based on information found in the following references.

1. J. Chem. Educ. editorial staff, J. Chem. Educ. **2000**, *77*, 40A.

2. Black, H. *ChemMatters* **1995**, 13(1), 14-15.

3. Institute for Chemical Education, *Super Science Connections*, 187-

**Magic Sand Instruction Sheet**

**I. Introduction**

The chemical name of sand is silica and grains of sand are made up of silicon and oxygen bonded together in a three-dimensional network of billions of atoms. The chemical formula, SiO2, illustrates the ratio of oxygen to silicon atoms is 2 to 1. The surface of sand grains is wetted by water, which means that water molecules are attracted to sand grains. This water-loving property of sand is called a hydrophilic (water-loving) property. Magic Sand is regular sand that has been coated with an oil-like substance that is water-hating or hydrophobic.

**II. Activities with Magic Sand**

**Demonstration:**

To show that oil and water don’t mix.

Oil is **hydrophobic (water-hating).** Hydrophobic substances do not mix with water.

**Activities**

1). Put 1 teaspoon of Magic Sand into a 1oz cup and 1 teaspoon of regular sand into the other 1oz cup (just enough to cover the bottom) and make observations. Are there any differences in the shape of Magic Sand and regular sand?

2). Use the 1-oz dropping bottle of blue food coloring to carefully add two drops of blue food coloring

on the Magic Sand. What happens when colored water is added?

Repeat the experiment with the regular sand and make observations. Which sand is **hydrophobic** and

which is **hydrophilic?**

3). Use the 1-oz dropping bottle of mineral oil to carefully add two drops of oil on the Magic Sand and

on the regular sand. What happens when the oil is added? Why?

4). Fill cups about one-third with water.

Use 1 teaspoon of the regular sand and sprinkle a thin layer on the surface of the water in one of the

cups. What happens?

Now use 1 teaspoon of the Magic Sand and sprinkle a thin layer on the surface of the water in one of

the cups. Why does the Magic Sand float on the surface whereas the regular sand sinks?

a.) Take a Popsicle stick and slowly push it through the Magic Sand layer, and into the water about a

quarter of an inch. The Magic Sand will coat the pencil. Now pull the pencil out. Why is the

pencil dry?

(b). Add a few drops of the blue water on the surface. Keep adding water so that a large drop forms.

Look under the Magic Sand surface. What do you see and why? Keep adding drops until the

water falls through the sand layer.

**Have a VSVS member pour all the water off the Magic Sand, keeping as much sand as possible in the cup. (Use a sink or the large “waste” container.) The remaining Magic Sand should be DRY. If it is not, it has been contaminated with oil, and you will need to start over in the next section with fresh Magic Sand**

5). Now pour a teaspoon of regular sand into the other 9 oz cup.

Tilt both cups until the sands form a “pile” to one side of the cup. Carefully pour water down the side

of the cups, to about the 50 mL mark.

Observe what happens to the two sands.

What shape does the Magic Sand form?

What does the surface of the Magic Sand look like underwater?

Compare your observations with those for regular sand.

Are their any differences?

Use the plastic spoon to mix the Magic Sand and water. What happens?

**Have VSVS members carefully pour off the water from the sands back into the waste container, leaving the sands behind**.

6). Make observations of the remaining sands:

Feel the sands with your fingers.

What happens when the water is removed?

7). Use the dry Magic Sand from above and add 10 drops of liquid detergent and add water to the

50ml line. Stir with a teaspoon and observe what happens.

What happened?

How does the addition of liquid dishwashing detergent affect the water’s interaction with

Magic Sand?