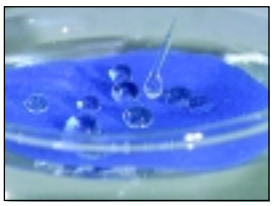
Magic Sand



by the *Journal*'s Editorial Staff

Background

Sand is largely silica that has broken into small grains. At the atomic scale, silica consists of a three-dimensional network of covalently bonded silicon and oxygen atoms. Typically, silica surfaces contain mostly oxygen atoms, many of which are covalently bonded to hydrogen atoms. The surface contains many polar bonds and can hydrogen-bond to water molecules. Therefore water is attracted to silica surfaces, which are said to be *hydrophilic* (water loving).

Magic Sand also consists of silica grains, but the grains have been specially treated in a way that greatly reduces the attraction of water molecules to their surfaces (*1*, *4*). In addition, the grains are usually dyed a distinctive color. Water does not wet the surfaces of Magic Sand grains, which are said to be *hydrophobic* (water fearing).

fold here and tear out

Integrating the Activity into Your Curriculum

This Activity takes a toy from the realm of play into the realm of scientific application and explanation. The use of a toy in the classroom can stimulate student interest in the topics being studied. Applications of Magic Sand to the chemistry curriculum are outlined by Hoffman (*2*). These include using it to illustrate various solubility principles and as a model for a nonpolar molecular material. The Activity allows students to predict and observe how new substances will interact with Magic Sand after observing the interactions of Magic Sand with water. It also allows for extension into the practical realm, where students formulate real-world uses for Magic Sand.

About the Activity

This Activity was inspired by the work of a high school student, Kara Bruce. In the summer of 1999, she and Jerrold Jacobsen of the *JCE* staff created a video sequence that compares the properties of ordinary sand and Magic Sand. This video sequence is available for viewing as supplemental material on *JCE Online*. The Web address is on the student side of this Activity. This Activity is also based on a more complex experiment done with Magic Sand (*1*). This issue of *JCE* includes a Tested Demonstration that uses an overhead projector to make initial comparisons between ordinary sand and Magic Sand (*3*). Instructors may wish to have students make initial observations during such a demonstration and then move on to the extended work of the Activity. The Activity can be done in the lab or at home, if instructors provide students with materials not readily available in a kitchen.

perforated

Magic Sand is available in some toy stores and can be ordered from Flinn Scientific (800/452-1261) and Educational Innovations (888/912-7474). Students can make homemade Magic Sand by spraying dry sand with ScotchGard and allowing it to dry overnight (*1*). To ensure consistent results in this Activity, commercial Magic Sand is recommended.

A little Magic Sand may be lost during the Activity. Some Magic Sand will float on the water surface and is difficult to save when decanting. Students may wish to use coffee filters to separate the Magic Sand from water. Mixing the Magic Sand with soapy water or cooking oil destroys its nonwettability.

Answers to Questions

__1. Both dry ordinary sand and dry Magic Sand are free-flowing and neither can form a structure that holds its shape. Ordinary sand becomes wet in water, does not mold into structures that hold their shape under water, and remains wet when the water is poured off. When Magic Sand is poured into water, it has a silvery sheen and doesn't become wet. It can be molded into structures that hold their shape under water and is dry when the water is poured off.

__2. Hydrophobic means "water fearing" or "having an aversion to water". The surface of Magic Sand particles is hydrophobic, and the Magic Sand is not wetted by water. Hydrophilic means "water loving". The surface of ordinary sand particles is hydrophilic, and ordinary sand is wetted by water.

__3. Both cooking oil and Magic Sand are hydrophobic. This allows the oil to wet the Magic Sand.

__4. Liquid dishwashing detergent lowers the surface tension of water. The soapy water wets the Magic Sand. This might be explained by several factors: the soap might remove the hydrophobic surface, water molecules might be able to slide between the hydrophobic grains owing to the reduced surface tension, the detergent may be attracted to the Magic Sand's surface, etc. You may wish to have students test some of these ideas.

__5. In the Arctic, utility companies can bury junction boxes in Magic Sand. The box can be serviced when the ground freezes because the Magic Sand remains dry and loose year-round. This and other uses are in *ChemMatters* (*4*, *5*).

Additional Activities and Demonstrations

1. Vitz, E. *J. Chem. Educ.* 1990, *67*, 512–515. • 2. Hoffman, A. B. *J. Chem. Educ.* 1982, *59*, 155. • 3. Goldsmith, R. H. *J. Chem. Educ.* 2000, *77*, 41. • 4. Robson, D. P. *ChemMatters* 1994, *12*(2), 8–9. • 5. Black, H. *ChemMatters* 1995, *13*(1), 14–15.

Magic Sand

by the *Journal*'s Editorial Staff

You've probably played with sand at the beach or in a playground sandbox. Toy manufacturers sell another kind of sand. You may have seen this colored sand in stores under the name "Magic Sand". The name suggests that something magic is going on to give this sand its unusual properties, but it's not magic at all, it's simply chemistry. In this Activity, you will investigate the properties of both ordinary sand and Magic Sand.

Sand is largely silica that has broken into small grains. Typically, silica surfaces contain oxygen atoms, are polar, and can hydrogen-bond to water molecules. Therefore water molecules are attracted to them. Magic Sand also consists of silica grains, but the grains have been specially treated in a way that greatly reduces the attraction of water molecules to their surfaces. Water wets ordinary sand, but not Magic Sand.

Try This

You will need: 10 mL of Magic Sand, 10 mL of ordinary sand, four 250-mL beakers or small plastic cups, stirring rod, water, food coloring that is a different color from the Magic Sand, dropper, liquid dishwashing detergent, and cooking oil. In each step, record your observations.

__1. Pour 10 mL of Magic Sand into a dry 250-mL beaker or small plastic cup. What shapes does the Magic Sand form? What does the surface of the Magic Sand look like? Repeat with ordinary sand and compare.

__2. Pour 150 mL of water into a second 250-mL beaker or small plastic cup. Pour 10 mL of Magic Sand into the water all at once. What shapes does the Magic Sand form? What does the surface of the Magic Sand look like underwater? With your finger, try to press the Magic Sand into different shapes and against the side of the beaker. With a stirring rod, mix the Magic Sand and water. Repeat with ordinary sand and compare.

__3. Decant (pour off) the water from the beaker in step 2. Lay a stirring rod across the diameter of the beaker, with one end of the stirring rod resting in the pouring spout. Then, carefully pour just the water into another 250-mL beaker, leaving the Magic Sand behind. When the water is removed from the Magic Sand, what shapes does it form? What does the surface of the Magic Sand look like? Repeat with ordinary sand and compare.

__4. Pour 150 mL of water into a 250-mL beaker. Sprinkle a thin layer of Magic Sand onto the surface of the water. In a small cup, mix 25 mL of water and one drop of food coloring. Choose a color of food coloring that is not the same as the Magic Sand. Using a dropper, carefully place a few drops of the colored water on the surface of the Magic Sand and observe what happens. Using the tip of the dropper, one by one bring the drops together into a single large drop. Is there a maximum number of drops that can be brought together into one large droplet on the surface?

__5. Label two 250-mL beakers. Into the first beaker, pour 100 mL of water and add several drops of liquid dishwashing detergent. Stir gently with a stirring rod. Into the second beaker, pour 100 mL of cooking oil.

__6. Predict what will happen if you pour Magic Sand into the beakers.

__7. Pour small amounts (about 5 mL) of Magic Sand into each of the beakers. Stir the Magic Sand and each liquid with a stirring rod, cleaning it off between beakers. Decant (pour off) the liquid from each beaker with a stirring rod, cleaning it off between beakers. Do your observations match your step 6 predictions? The oil should go into an appropriate waste container, not down the drain.

Questions

__1. Compare and contrast the properties of ordinary sand and Magic Sand when they are dry, when water is added to them, and when the water is poured off.

__2. What do the terms *hydrophobic* and *hydrophilic* mean? How do these terms apply to the interaction of ordinary sand with water? To the interaction of Magic Sand with water?

__3. Describe the major type of bonding present in cooking oil. How does the type of bonding affect the interaction of the substance with Magic Sand?

__4. How does the addition of liquid dishwashing detergent to water affect the surface tension of water? How does the addition of the detergent affect the water's interaction with Magic Sand?

__5. Suggest another use for Magic Sand (other than for a toy or science experiment).

Information from the World Wide Web *(accessed Nov 1999)*

Magic Sand video sequence: *http://jchemed.chem.wisc.edu/Journal/issues/2000/Jan/abs40A.html*

Electronegativity and bond polarity. *http://www.chemistry.ohio-state.edu/~grandinetti/teaching/Chem121/lectures/Electronegativity/ENBondPolarity.html*