SCSU CRISP CCSA Kit Pages 2016

Title of Module: Exploring Products: Nanosand

Subject or Unit of Study: Hydrophobia, properties at the nanoscale, structure-property relationships,

GRADE LEVEL 5 – 12+ **LENGTH OF DEMO/LESSON**: ___________________

STUDENT OBJECTIVES

Students will...

- The way a material behaves on the macroscale is affected by its structure on the nanoscale.
- Hydrophobic sand is coated with a nanometer-thick layer of a silicon compound, which makes it repel water

NEXT GENERATION SCIENCE STANDARDS

NGSS Performance Tasks	**5-PS1-1** • Develop a model to describe that matter is made of particles too small to be seen **MS-ETS1-1 Engineering Design** • Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **HS-ETS1-1 Engineering Design** • Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
NGSS Disciplinary Core Ideas (DSI)	**MS - ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. **HS - ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • 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.
NGSS Cross Cutting Concepts (CCC)	**Interdependence of Science, Engineering, and Technology** • 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) • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS)

	• 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)
NGSS Science and Engineering Practices (SEP)	**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.

COMMON CORE STANDARDS

CC-ELA/Literacy Standards	**RST.6-8.1** • Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-1) **WHST.6-8.8** • Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1) **RST.11-12.7** • Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1) **RST.11-12.9** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1)
CC-Math	**MP.4** • Model with mathematics. (5-PS1-1)

MATERIALS

- Ordinary, colored sand (green, or another color)
- Hydrophobic sand (purple, or another color)
- Trays
- Dropper bottles
- Small portion cups
- Drinking cups
- Spoons
- “Nano Sand” sheet

SAFETY

Do not ingest sand

LEARNER BACKGROUND

Students should know what a nanometer is. They should also know what Hydrophobic means.

LEARNING ACTIVITY OR PROCEDURE:

Explicitly layout the lesson or demonstration

See below for background info

TEACHER NOTES:

Describe any tips/tricks for implementing this lesson/demonstration that might be helpful to future educators. Provide answer keys if applicable.

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

ADDITIONAL BACKGROUND INFO

To understand how hydrophobic sand works, we first must understand some basic principles of water.
Water molecules are highly polar, which means that the molecules have slightly positive and slightly negatively charged ends. Polarity arises when the electrons in the molecule's bonds are not shared equally between the atoms, creating slightly positive or slightly negative charges on different atoms within the molecule. In water, these charges on the atoms are arranged uniquely, causing the molecule to have a positively charged end and a negatively charged end. The positively charged ends of the one water molecule strongly interact with the negatively charged end of another molecule, much like how the poles of a magnet interact. These interactions are called "hydrogen bonds", and are directly responsible for some of water's unique properties (high boiling point, high surface tension, low freezing point, etc.).

The interactions between the water molecules are so strong that substances made up of non-polar molecules (which cannot form hydrogen bonds) cannot mix with water. Vegetable oil, for example, is made up of non-polar molecules. When the oil comes in contact with water it does not mix with the water. Water either repels or completely envelops nonpolar substances so it can continue to bond with itself. **Hydrophobic**, or water hating, molecules are always non-polar, and include greasy substances like oils, fats.

Natural sand is **hydrophilic**, or attracted to water. At the beach, natural sand surface readily absorbs water when waves crash upon the shore. The atoms on the surface of natural sand particles have positive and negative charges. The charges on the surface of the sand are attracted to the positively and negatively charged ends of the water molecules. Therefore, the water and the sand are attracted to each other. Treating the surface of individual grains of the sand makes a new type of sand that behaves very differently from regular beach sand.

Using nanotechnology, scientists have created a way change the way sand and water interact. Natural sand grains are coated with a special silicon-based compound. One end of the compound is hydrophilic—therefore it is attracted to the sand particle. However, the other end of the compound is hydrophobic, so it *sticks out away from the grain of 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. When nanosand is sprinkled on the surface of water, the grains of nanosand do not break through the surface – this is due to the fact that water molecules prefer to bond with other water molecules rather the nanosand. The nanosand will lay on top of the water's surface until enough sand accumulates to overcome the surface tension, and the weight of the sand will allow it to fall into the water. This same effect keeps the nanosand dry once it falls into the water. Water molecules will not attach to individual grains of nanosand or flow between them. The nonpolar properties of oil allows nanosand to be attracted to it which means that nanosand can **absorb large quantities of oil.**

Scientists have found ways to take advantage of the hydrophobic properties of materials such as nanosand. This sand was originally developed for use in cleaning up petroleum oil spills in water. The sand will bond with petroleum oil floating on the surface of water (remember the nonpolar properties of oil), eventually adding enough weight to make the mixture sink to the bottom. The petroleum oil could then be dredged up from the bottom of the body of water and removed for treatment. Unfortunately, this process requires large amounts of the hydrophobic sand, making it too expensive for current use.