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IEEE Lesson Plan:

Fizzy Nano Challenge

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Lesson Focus

Lesson focuses on how materials behave differently as their surface area increases. Students learn about nanotechnology and how engineers can harness the differences in how materials behave when small to solutions for challenges in many industries. Students work in teams to explore examples of how surface area impacts functionality. They hypothesize how surface area will impact the performance of antacid tablets, conduct an experiment using whole and crushed tablets to see how they behave when introduced to water, observe what they see, extrapolate to other examples, compare their hypotheses and the results with those of other student teams, reflect on the experience, and share observations with the class.

Lesson Synopsis

The "Fizzy Nano Challenge" lesson explores how some materials behave differently as their surface area increases. Students work in teams to develop hypotheses and then test how whole and crushed antacid tablets will behave in water. Teams evaluate the results against their hypotheses, compare their team's results with those of other student teams, reflect on the experience, and share observations with the class.

Age Levels

8-14.

Objectives

- Learn about nanotechnology.
- Learn about surface area.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- nanotechnology
- surface area
- teamwork

Lesson Activities

Students explore how the surface area of some materials impacts how they behave, and how engineers use this change in behavior to develop solutions to societal challenges in many industries. Students develop hypotheses and then test how whole and crushed

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antacid tablets will behave in water. Teams evaluate the results against their hypotheses, compare their team's results with those of other student teams, reflect on the experience, and share observations with the class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Resource Sheet (attached)
- Student Worksheet (attached)

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- TryNano (www.trynano.org)
- National Nanotechnology Initiative (www.nano.gov)

Recommended Reading

- Nanotechnology For Dummies (ISBN: 978-0470891919)
- Science at the Nanoscale: An Introductory Textbook (ISBN: 978-9814241038)

Optional Writing Activity

- Write an essay or a paragraph about how advances through nanotechnology have changed how materials are waterproofed.

Safety Notice

- Students should not eat the antacid tablets used in this lesson. If you like, you can substitute these for other fizzy materials such as vitamin C tables, or others you can purchase locally.

For Teachers:
Teacher Resource

Lesson Goal
The "Fizzy Nano Challenge" lesson focuses on how materials behave differently as their surface area increases. Students learn about nanotechnology and how engineers can harness the differences in how materials behave when small to solutions for challenges in many industries. Students work in teams to explore examples of how surface area impacts functionality. They hypothesize how surface area will impact the performance of antacid tablets, conduct an experiment using whole and crushed tablets to see how they behave when introduced to water, observe what they see, extrapolate to other examples, compare their hypotheses and the results with those of other student teams, reflect on the experience, and share observations with the class.

Lesson Objectives
- Learn about nanotechnology.
- Learn about surface area.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Materials
- Student Resource Sheets
- Student Worksheets
- Class Materials: clear cups (can be plastic or test tubes/beakers), antacid tablets (handled by teacher only for younger students), water.
- Student Team Materials: envelope (for crushing tablet in) paper, pencil; access to the internet (optional).
- Note: Instead of antacid tablets, you may try using fizzy vitamin C tablets or other fizzy substances.

Procedure
1. Show students the student reference sheets. These may be read in class or provided as reading material for the prior night's homework.
2. To introduce the lesson, consider asking the students whether they think that the size of a material such as the active ingredient in sunblock impacts how it performs.
3. If internet access is available, have students review the resources at www.trynano.org. The site will provide additional background information about nanotechnology and the industries where it is having great impact.
4. Teams of 3-4 students will consider their challenge, and as a team decide what impact crushing the antacid tablets will have on how they behave in water.
5. Teams crush one tablet, and leave one tablet whole, and add 5 oz./150 ml water.
6. Teams observe what happened, compare their hypotheses to the actual results, complete a reflection sheet, and present their experiences to the class.

Time Needed
One to two 45 minute sessions.

Student Resource:
What is Nanotechnology?

Imagine being able to observe the motion of a red blood cell as it moves through your vein. What would it be like to observe the sodium and chlorine atoms as they get close enough to actually transfer electrons and form a salt crystal or observe the vibration of molecules as the temperature rises in a pan of water? Because of tools or 'scopes' that have been developed and improved over the last few decades we can observe situations like many of the examples at the start of this paragraph. This ability to observe, measure and even manipulate materials at the molecular or atomic scale is called nanotechnology or nanoscience. If we have a nano "something" we have one billionth of that something. Scientists and engineers apply the nano prefix to many "somethings" including meters (length), seconds (time), liters (volume) and grams (mass) to represent what is understandably a very small quantity. Most often nano is applied to the length scale and we measure and talk about nanometers (nm). Individual atoms are smaller than 1 nm in diameter, with it taking about 10 hydrogen atoms in a row to create a line 1 nm in length. Other atoms are larger than hydrogen but still have diameters less than a nanometer. A typical virus is about 100 nm in diameter and a bacterium is about 1000 nm head to tail. The tools that have allowed us to observe the previously invisible world of the nanoscale are the Atomic Force Microscope and the Scanning Electron Microscope.

◆ How Big is Small?

It can be hard to visualize how small things are at the nanoscale. The following exercise can help you visualize how big small can be! Consider a bowling ball, a billiard ball, a tennis ball, a golf ball, a marble, and a pea. Think about the relative size of these items.

◆ Scanning Electron Microscope

The scanning electron microscope is a special type of electron microscope that creates images of a sample surface by scanning it with a high-energy beam of electrons in a raster scan pattern. In a raster scan, an image is cut up into a sequence of (usually horizontal) strips known as "scan lines." The electrons interact with the atoms that make up the sample and produce signals that provide data about the surface's shape, composition, and even whether it can conduct electricity. Many images taken with scanning electron microscopes maybe viewed at www.dartmouth.edu/~emlab/gallery.

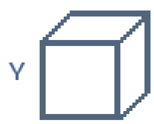
Student Resource:
What is Surface Area?

Surface area is the measure of how much exposed area an object has. It is expressed in square units. If an object has flat faces, its surface area can be calculated by adding together the areas of its faces. Even objects such as spheres, have surface area.

◆ Square Surface Area Formulas

The surface area of a cube may be expressed by the formula:

x = 6 times Y times Y

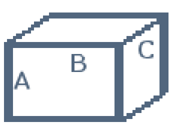


The drawing to the left shows a cube, where Y equals the length of each side. Because it is a square, all sides are equal in length. To determine the surface area of the cube, you first have to find out the area of one side. The area of one side is Y x Y or Y^2. To find the surface area of the cube, you need to multiply the area of one side by 6. If, for example, the length of Y equalled 10 mm, then the area of one side would be 100 square mm and the area of the cube would be 600 square mm.

◆ Rectangular Surface Area Formulas

The surface area of a rectangle may be expressed by the formula:

x = 4AB + 2AC



With a rectangle, all the sides are not equal…but there are three different lengths to be measured. If the drawing above, these are represented by A, B, and C. To determine the area of the front of the rectangle, we'll need to multiply A x B. Since there are four surfaces on the rectangle that are equal in size, we need 4 x A x B as one part of our formula to determine the surface area of the dimensional rectangle. We'll also need to determine the area of the two smaller surfaces. In this case, we'll need to multiply A x C. And, because there are two of these "faces" to the rectangle, we need 2 X A X C for the full surface area formula. If, for example, the length of A equalled 10mm, and B equalled 30mm and C equalled 15mm then:

A times B = 300mm, so 4AB= 1200 square mm

A times C = 150mm, so 2AC= 300 square mm

So the surface area of the dimensional rectangle is 1500 square mm

◆ Why Surface Area Matters

At the nanoscale basic properties of particles may vary significantly from larger particles. This might include mechanical properties, whether the particle conducts electricity, how it reacts to temperature changes, and even how chemical reactions occur. Surface area is one of the factors that changes as particles are smaller. Because chemical reactions usually take place on the surface of a particle, if there is an increased surface area available for reactions, the reaction can be very different.

For Students:
Nanoscale Properties

Properties of materials at the nanoscale are different in many cases from the properties of materials observed in other scales. Consider, for example, the melting point of metals. Nanoparticles often exhibit a lower melting point than the corresponding metals in bulk, and these melting points depend on size. For example, bulk Gold melts at 1064 degrees Celsius, but a 4nm Gold particle melts at roughly 850 degrees Celsius.

The color of a material can also be size dependent. The appearance of color is caused by the partial absorption of light by electrons in that material; the unabsorbed part of the light remains visible.

On most smooth metal surfaces, light is entirely reflected by the very high density of electrons; this is why the surfaces of slabs of metal have mirror-like appearance. In contrast, small particles absorb some of the light, leading to the appearance of color. This property depends on size.

For example, Gold exhibits a different color depending on its particle size. Extremely tiny particles of Gold have been used to color glasses since the very early days of glass making. Ruby vases (with color that is pink to blood-red) were made using finely dispersed Gold particles for centuries. Many stained glass windows exhibit red color because of doping with gold Nanoparticles.

Nanosystems are not large enough for many classical laws of physics to apply. For example, Ohm's law, which describes the relation between current and voltage in a conductor, does not describe current conduction through a tiny nanowire. Here other effects, known as quantum mechanical effects are more important.

Student Worksheet: Surface Area Challenge

◆ Research Phase
Read the materials provided to you by your teacher. If you have access to the internet, also explore resources at www.trynano.org.

◆ Hypothesis
As a team, decide what if anything you think might happen differently when water is added to a whole antiacid tablet or when water is added to a crushed or crumbled up antacid tablet. In the box below, write a sentence or two describing your team's hypothesis.

◆ Test
Now, test your hypothesis! Place one whole tablet in one of the two cups provided to you, and crush another tablet inside an envelope to help contain the crumbled parts. You may also simply crack the whole tablet into ten to fifteen smaller pieces if you like. Drop the crumbled tablet into the second cup. Then add about 5 oz. or 150 ml of water to each one.

◆ Observation and Results
Observe and discuss what happened -- if anything -- and compare the results with your team's hypothesis.

◆ Presentation and Reflection Phase
Present your original hypothesis and experiment observations to the class, and listen to the presentations of the other teams. Then complete the reflection sheet.

Student Worksheet:
Surface Area Challenge (Continued)

◆ **Reflection**

Complete the reflection questions below:

1. How accurate was your hypothesis compared to what happened?

2. What surprised you about what you saw?

3. What other hypotheses were developed by other student teams?

4. What do you think might have happened if you used a larger whole tablet instead? What about if you were able to crush the tablet into a powder?

5. Did you think that working as a team made this project easier or harder? Why?

6. Give an example of how surface area impacts another material.

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4-9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- Properties of objects and materials

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Understanding about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

◆National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- Properties and changes of properties in matter

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Personal health
- Risks and benefits
- Science and technology in society

For Teachers:
Alignment to Curriculum Frameworks

◆**National Science Education Standards Grades 5-8 (ages 10-14)**

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor
- Nature of science
- History of science

◆**National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- Structure and properties of matter
- Chemical reactions

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

◆**Next Generation Science Standards – Grades 2-5 (Ages 7-11)**

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

◆**Next Generation Science Standards - Grades 6-8 (Ages 11-14)**

Matter and its Interactions

- MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

For Teachers:
Alignment to Curriculum Frameworks

◆**Standards for Technological Literacy - All Ages**

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 2: Students will develop an understanding of the core concepts of technology.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- Standard 5: Students will develop an understanding of the effects of technology on the environment.
- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.

Design

- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 13: Students will develop abilities to assess the impact of products and systems.