Graphene oxide and Nanotechnology

Subject Area(s)
Measurement, Number and Operations, Physical Science, Science and Technology, Chemistry, and Physics

Image 1
Image file: graphics1.jpg
ADA Description: Oxidized sheet of Graphene (Graphene Oxide)
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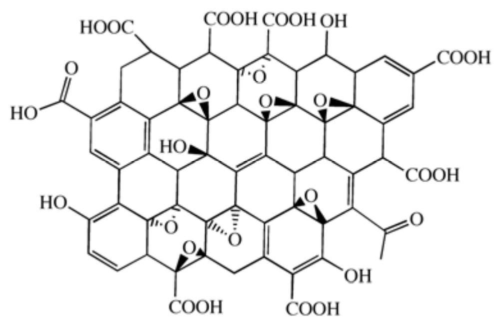
Adapted from C.E. Hamilton, PhD Thesis, Rice University (2009).
Caption: Idealized structure of proposed for Graphene Oxide (GO).

Associated Unit
Measurement and Scientific Notation

Lesson Title
Graphene Oxide and Nanotechnology



Grade Level
11 (9-12)

Time Required
100 minutes

Summary

Students learn about one of many possible applications of nanotechnology in the field of engineering. They learn about the chemical process used to remove a thin layer of graphite to make Graphene and then how it can be oxidized to form Graphene oxide. They also hear about the advanced research being done using Graphene oxide as a possible solution to removing carcinogenic toxins, polychlorinated biphenyls (PCB), from the Houston Ship Channel. Students compare the size of nanoparticles to other objects of known length to get an idea of the size of Graphene oxide particles. Students practice using and reading metric rulers and meter sticks. They also use dimensional analysis as a method to convert from one unit to another as well as realize the importance of scientific notation when dealing with very large or small numbers.

Engineering Connection
Students learn the application of nanotechnology in the field of environmental engineering as well as in other fields of engineering. Through this introduction to nanotechnology and engineering students learn that engineers use and convert between many different units of measurement on a daily basis. They also learn that it is critical for engineers to be able to use multiple types of measuring devices and understand which unit and value is appropriate for precise and accurate representation of that measurement. I.e. When is it appropriate to write a number in scientific notation? Should I use meters or micrometers?

Engineering Category = #1
Choose the category that best describes this lesson's amount/depth of engineering content:
1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords
Dimensional Analysis, Measurement, Scientific Notation, Significant Figures, Units, Unit Conversion

Educational Standards

National and State

Texas Science(Chemistry): 2010-2011, grades 10-12: 3E

3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

(E) describe the connection between chemistry and future careers; and

Texas Science(Environmental Science): 2010-2011, grades 11-12: 3D-E, 5B, 9A-C

(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

(D) evaluate the impact of research on scientific thought, society, and the environment;

(E) describe the connection between environmental science and future careers

5) Science concepts. The student knows the interrelationships among the resources within the local environmental system. The student is expected to:

B) identify source, use, quality, management, and conservation of water;

(9) Science concepts. The student knows the impact of human activities on the environment. The student is expected to:

(A) identify causes of air, soil, and water pollution, including point and nonpoint sources;

(B) investigate the types of air, soil, and water pollution such as chlorofluorocarbons, carbon dioxide, pH, pesticide runoff, thermal variations, metallic ions, heavy metals, and nuclear waste;

(C) examine the concentrations of air, soil, and water pollutants using appropriate units;

Texas Science(Physics): 2010-2011, grades 9-12: 2H, 3E, 8A-B

2) Scientific processes. The student uses a systematic approach to answer scientific laboratory and field investigative questions. The student is expected to:

(H) make measurements with accuracy and precision and record data using scientific notation and International System (SI) units;

3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

(E) research and describe the connections between physics and future careers

8) Science concepts. The student knows simple examples of atomic, nuclear, and quantum phenomena. The student is expected to:

(A) describe the photoelectric effect and the dual nature of light;

(B) compare and explain the emission spectra produced by various atoms;

Texas Science(Principles of Technology): 2010-2011, grades 10-12: 2H, 4D-F

(2) The student uses a systematic approach to answer scientific laboratory and field investigative questions. The student is expected to:

(H) make measurements with accuracy and precision and record data using scientific notation and International System (SI) units;

4) The student uses the scientific process to investigate physical concepts. The student is expected to:

(D) demonstrate the appropriate use and care of laboratory equipment;

(E) demonstrate accurate measurement techniques using precision instruments;

(F) record data using scientific notation and International System (SI) of units;

ITEEA Educational Standard(s): Grades 9-12

Standard 3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

J. Technological progress promotes the advancement of science and mathematics.

Standard 5. Students will develop an understanding of the effects of technology on the environment.

J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.
K. Humans devise technologies to reduce the negative consequences of other technologies.

Standard 17. Students will develop an understanding of and be able to select and use information and communication technologies.

Q. Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.

Pre-Requisite Knowledge

Collect data and make measurements with accuracy and precision.

Express and manipulate chemical quantities using scientific conventions and mathematical procedures, including dimensional analysis, scientific notation, and significant figures.

Learning Objectives

After this lesson, students should be able to:

- Use scientific notation in writing very large or small numbers.
- Convert units of measurement and use scientific notation to write their answers when appropriate.
- Apply basic math skills for precision and accuracy when taking measurements and making conversions.

Introduction / Motivation

(Nanotechnology PowerPoint [See *Associated Activities*] set up on the projector when students enter the room.)

Teacher:

Have you heard of Nanotechnology?

Expected Student Response:

No, what's nanotechnology? Various goofy responses.

Teacher:

How many of you have heard of an iPod Nano?

Expected Student Response:

Most all students will say they have heard of an iPod Nano. Some students may actually get their iPod out to show it off.

Teacher:

What is the difference between the iPod Nano and almost all the other iPod models?

Expected Student Response:

It cannot perform as many functions, other comparisons, etc. It is smaller than most of the other iPods – This should be the response the teacher is waiting to hear.

Teacher:

Assuming the name is describing the product; what do you think nanotechnology is?

Expected Student Response:

Technology used to make something smaller, or some answer incorporating this idea.

(5 min)- Dialogue between student and teacher should be quick; this is to get the kids thinking.

Teachers will then go through the PowerPoint and introduce students to the idea of nanotechnology and how engineers use it in various different fields. The PowerPoint highlights one specific Environmental Engineering group which has been focusing on using Graphene Oxide to sequester specific contaminants (Polychlorinated Biphenyls) from the Houston Ship Channel and Galveston Bay.

The PowerPoint will focus on how Graphene Oxide, a nano-particle, is produced and why it is considered a nano-particle. It will introduce units and scientific notations used to measure and record particles of this size as well as specify the meaning of the prefix nano- in the context of measurement.

(30 min)- Students will take guided notes over PowerPoint [See *Associated Activities*].

Show students the Power of Ten Animation [See *Additional Multimedia Support*].

(10 min)- Spend approximately 10 minutes browsing the animation.

Exit Ticket-Students will be given the following prompt:

Why is it important for engineers to be accurate in measurement? When is it appropriate to write a number in scientific notation? What happens to the decimal every time a number is magnified by ten?

Students will be asked to respond to the questions above in at least three sentences in the space provided on their guided notes.

(5 min)- This will be used as an informal assessment [See *Assessment*].

Lesson is structured around ***50 min.*** *periods* ***(End of Day 1).***

<u>Introduction</u>- Day 2

The students will participate in the Graphene Oxide Activity [See *Associated Activities*].

The Graphene Oxide Activity allows students to compare the size of objects they can see to the thickness of a particle of Graphene Oxide. They will make simple conversions between larger and smaller units and practice writing numbers in scientific notation. This will be guided practice: The teacher will be actively monitoring and go over the answers at the end of the allotted time.

(30 min)- The activity gives the students practice in using scientific notation and simple dimensional analysis to record measurements and convert from one unit to another. The teacher will work each problem on the board, overhead, or digital projector in order to provide instant feedback to the students.

The students will be asked to complete the remaining portion of the guided notes and submit for grading [See *Associated Activities*].

(20 min)- The practice portion of the notes will be submitted as a formal assessment to the lesson [See *Assessment*].

Lesson Background & Concepts for Teachers

This lesson is based on recent experiments being conducted by Environmental Engineers on the effectiveness of Graphene Oxide, a nano-particle, at removing carcinogenic contaminants from water sources.

Graphite is a very common and available resource made of Carbon atoms which bond together in a layered arrangement similar to a stack of sticky notes. Through chemical processes we have been able to peel a single layer, one atom thick, from the graphite molecule called Graphene.

Graphene, a nano-particle, yields incredible properties including the ability to kill multiple forms of bacteria, increased conductivity of heat and electricity, and extreme strength. This material is being tested in a wide range of applications ranging from computer circuitry and antimicrobial filters to building materials due to its incredible strength. Graphene is actually 200 times stronger than steel and the best conductor of heat known to man.

Graphene has many impressive properties and seems to have almost unlimited potential in a huge variety of engineering fields. A group of Environmental Engineers have been testing Graphene Oxide, Graphene that has been oxidized, for its ability to remove contaminants called polychlorinated biphenyls (PCB's) from the Houston Ship Channel and Galveston Bay area.

Graphene is not naturally a very reactive material but when oxidized it becomes more stable and reactive with other molecules. Graphene oxide is also a nano-sized particle which gives it an extremely high surface area so when it is dispersed in water the chances of the contaminant coming in contact and adsorbing to the Graphene Oxide particle is high. These properties make Graphene Oxide an excellent candidate for removing large amounts of PCB's from our water sources.

The lesson is designed to inspire interest in engineering and nanotechnology by using relevant research with Graphene Oxide to introduce the topics of measurement, scientific notation, and unit conversion. Using the molecule Graphene Oxide and comparing it to the size of several known objects will help the students to visualize the size of a nano-particle as well as practice measurement techniques, scientific notation, and unit conversions.

Image 1

Image file: nanoscale7_0.jpg

ADA Description: Pictures and sizes of different objects from nanoscale to meter size objects.

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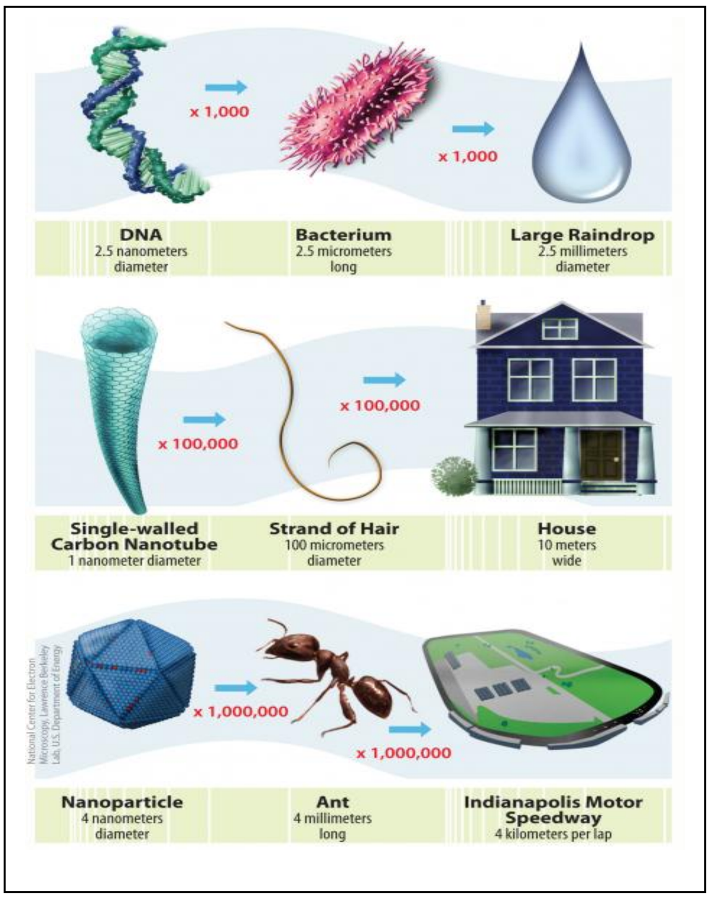
White House Office of Science and Technology Policy

Caption: Comparing normal size objects to nanosize objects.



Vocabulary / Definitions

Word	Definition
Atom	The smallest component of an element which still retains the properties of that element.
Celsius Thermometer	Instrument used to measure temperature.
Dimensional Analysis	Problem solving method that can be used to convert measurements from one unit to another.
Engineer	Problem based innovators that find answers to how things work.
Graduated Cylinder	Instrument used to measure volume.
Metric Ruler	Instrument used to measure length.
Micrometer	A metric measurement of length equal to one millionth of a meter.
Millimeter	A metric measurement of length equal to one thousandth of a meter.
Molecule	The smallest part of a substance that retains all the properties of the substance and is composed of two or more atoms.
Nanometer	A metric measurement of length equal to one billionth of a meter.
Nanotechnology	The engineering of materials at the molecular scale.
Oxidation	The interaction between oxygen molecules and all the substances they may come in contact with; The loss of electrons during a reaction.
Protractor	Instrument used to measure angles.
Scientific Notation	A way of writing numbers which are too large or too small to be conveniently written in standard decimal notation.
Triple Beam Balance	Instrument used to measure mass.
Unit	Specific standards for measurement.

Associated Activities
Making Nano-Comparisons Activity

Assessment
Scientific Notation and Measurement Test

Contributors
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Supporting Program

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