TEAM CLASSROOM IMPLEMENTATION PLAN REPORT

Project # 6: Applications of Nanotechnology in Health and Beauty Products

Get Rich Quick: A Nanoscale Production

Lesson # 1: Too Small To See?

Lesson # 2: What Color Is Gold?

Submitted To

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ABSTRACT

Nanotechnology has become the new cutting edge science. Yet, students have trouble understanding size and scale to the nano level. These lessons provide an introduction to nanoscience, focusing on concepts related to the size and scale, unique properties of nanoscale materials using green chemistry methods, and example applications of nanoscience.. The activity begins with the synthesis of gold nanoparticles by reduction of a gold salt using plant material. Green chemistry of plants results in safer products and reduced use of energy and resources. The students use the resulting nanoparticles solution to explore size scale and the size-dependent optical properties of gold nanoparticles. Aggregation of gold nanoparticles results in a dramatic color change. Students will have a better appreciation of the nanoparticles and the implications it has in every aspect of their lives.

KEY WORDS: Nanotechnology, Nanoparticles, Gold, Scale, Green Chemistry ,

1. INTRODUCTION

Students will participate in learning activities that are designed to help them establish an understanding of the relative size of nano, unique properties of nanosized particles and applications of nanoscience. They will conduct laboratory investigations, and create a visual demonstrating scale and nanoparticle properties. Extension activities are available utilizing microscopy advancements in nanotechnology, field trip suggestions, and antimicrobial lab utilizing the synthesized nanoparticles.

Nanotechnology has become one of the most popular areas of scientific research, from manufacturing to medicine. Nanotechnology deals with anything measuring between 1 and 100 nm. To understand 1 nanoparticle (1 nm), I needed to grasp the unit of measure. For example, one millimeter is one thousands of a meter, and a micrometer is one thousands of a millimeter, another thousands of an um is a nanometer.

One nanometer is 10,000 times smaller than the diameter of a human hair. Nanoscience investigates the properties of these materials. By understanding these properties and learning how to utilize them, scientists and engineers can develop new types of sensors and devices. This technology has a huge impact on diagnosing diseases, processing and storing information, and other areas. Physical and chemical properties are size-dependent over a certain size range specific to the material and property. The color of a gold nanoparticle solution depends on the size and shape of the nanoparticles. The volume and shape of a nanoparticle determines how it interacts with light. Accordingly, this determines the color of a nanoparticle solution. For example, while a large sample of gold, such as in jewelry, appears yellow, a solution of nano-sized particles of gold can appear to be a wide variety of colors, depending on the size of the nanoparticles. In Lesson 2, students will explore these size-dependent properties of gold nanoparticles and investigate the effect of adding different substances.

Nanoparticles' small size allows them to infiltrate almost anywhere. Learning about nanoparticles and their applications in today’s society will opened students to the numerous career connections available to pursue once they become knowledgeable of nanoparticles

including some hands on lessons demonstrating nano properties and the impact on society. At the conclusion of these lessons students will try to imagine producing and using nanometer-sized materials.

2. LESSON OVERVIEW

Get Rich Quick: Lesson 1 What Color Is Gold?

Nanoparticles (1-100 nm) have become the preeminent ideal building block for the synthesis of a variety of nanomaterials engineered for multiple applications. The preparation of gold nanoparticles is a major research area for nanoscale scientist and engineers due to their extraordinary chemical and physical properties; such as catalytic activity, novel electronic, optic and magnetic properties. The properties observed in gold nanoparticles also show significant potential in biotechnology applications.

Gold nanoparticles have garnered much attention in the past few years for potential in biological and medical applications such as drug delivery, biosensors, and molecular imaging. Specifically, gold shows promise in enhancing the effectiveness of various cancer treatments such as radiotherapy (radiation therapy) and photothermal therapy (heat/vibrational energy therapy). Also, drug carrier capabilities of gold nanoparticles are being considered along with therapy and early diagnosis of explicit tumors.

This lesson is a simple, cost effective, and environmentally benign biological method to fabricate stable and reproducible gold nanoparticles at room temperature. Various reducing/stabilizing agents will be added to aqueous solution of $HAuCl_4 \cdot 3H_2O$ and vigorously stirred until complete reduction observed. The sample preparation for each characterization technique is described in detail below.

BACKGROUND KNOWLEDGE

Properties of matter, Human impact on environment, Experimental procedures, Familiarity with atoms.

This lesson are intended for a 10th grade biology class. These students should have completed a physical science class with a unit on atoms and properties of matter.

Lesson 1 is a approximately two 55 min class periods. (not including pretest)

3. GOALS AND OBJECTIVES

1. Nanosized particles of any given substance exhibit different properties than larger particles of the same substance.
2. Understand nanoparticles influence substrate
3. Describe an application (or potential application) of nanoscience and its possible effects on society.

4. MATERIALS

Supplies need for class

1. Varying plants
2. 1mM Gold Chloride Solution
3. 1mM Silver Nitrate Solution
4. 1M NaCl solution
5. 250ml Brown bottle (for storage)
6. 2-400ml beaker
7. Balance
8. DI water

Supplies needed per group

1. 200 ml beaker of Ag or Au solution
2. 50 ml 1M NaCl solution
3. Blade/scissors to finely cut plant
4. 50 and 1000 ml graduated cylinder
5. 4- 100ml beakers (labeled A-D)
6. 2- 250 ml beaker
7. Filter paper
8. Spatulas
9. 4 Magnetic stir bars
10. Stir plate
11. 4- Pasteur pipits

5. INSTRUCTIONAL STRATEGY

Whole class discussion, cooperative group work, power point, worksheets**,** experimental procedures

6. TECHNOLOGY

Internet, power point, optional: TEM, AFM, SEM, light microscope**,** used in the lesson and the benefits associated with it

7. PRE/POST ASSESSMENT QUESTIONS

For the lesson ask 4 to 6 questions, including:

1. How big is a nanometer compared to a meter? List one object that is nanosized, one that is smaller, and one that is larger but still not visible to the naked eye.
2. Name two properties that can differ for nanosized objects and much larger objects of the same substance. For each property, give a specific example.
3. Describe two reasons why properties of nanosized objects are sometimes different than those of the same substance at the bulk scale.
4. What do we mean when we talk about “seeing” at the nanoscale?

5. Choose one technology for seeing at the nanoscale and briefly explain how it works.

8. LEARNER PARTICIPATION/ACTIVITY

Nanotechnology is an interdisciplinary field and can be taught in any science classroom. I designed an engagement lesson to hook my students in wanting to learn of a world so small they cannot see with the technology available in our classroom. So how do you get a bunch of high school students interested in particles they cannot manipulate unaided? By using the students' innate desire to get rich quick. They see the propaganda ads everywhere: sell real estate, become a Pro athlete, sell unwanted jewelry. Precious metals are advertised to be at an all time high in cost. . Use these ads to entice the students on how to get rich quick, by using a new technology read and researched about this past summer. But to become undetected, the class will want to use green chemistry methods as an alternative to the published chemical synthesis methods. Holding up a published article, the teacher can quote how they can make million upon billions of pieces of the desired precious metals. Yes they can synthesize billions of pieces of Gold and Silver combining a tiny bit of purchased salt and the sugar made by plants! Each group will sell all the synthesized pieces for profit.

Using plants, students can be introduced to the topic of Green Chemistry., also known as sustainable chemistry. The Environmental Protection Agency defines green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry technologies provide a number of benefits, including:

- reduced waste, eliminating costly end-of-the-pipe treatments
- safer products
- reduced use of energy and resources
- improved competitiveness of chemical manufacturers and their customer

Students will be using all four green chemistry technologies while producing precious metals. Students assume they are synthesizing particles large enough to see unaided, but will soon discover they have synthesized particles on the nanoscale which behave differently than in bulk. This procedure is a simple, cost effective, and environmentally benign biological method to fabricate stable and reproducible gold nanoparticles at room temperature

Various reducing/stabilizing agents will be added to aqueous gold or silver salt solution and vigorously stirred until complete reduction observed. The sample preparation for each characterization technique is described in detail below

Safety: Gold Chloride solution will turn skin purple. The proteins in skin reduce the gold ions to a metallic purple state. Over time, the skin will return to its normal color. Safety goggles and latex gloves are required.

Procedure:

Teacher Prep:

- 1mM hydrogen tetrachloroaurate: The solid is hygroscopic so purchase $HAuCl_4 \cdot 3H_2O$ (Aldrich 244597 or 520918) in 1.0 g quantities and use the entire bottle. Dissolve 1.0 g $HAuCl_4 \cdot 3H_2O$ in 250 mL distilled water to make a 10.0 mM stock solution of gold(III) ions that can be kept for years if stored in a brown bottle. Dilute 25 mL of stock to 250 mL to make the 1.0 mM concentration for this experiment.
- 1mM Silver Nitrate- Dissolve 0.0424 g AgNo3 in 250 of DI water in 400 ml beaker. (Aldrich 10220)
- 1 M NaCl: Dissolve 0.5 g of NaCl in 10 mL distilled water

Procedure:

Plant Citrate Synthesis- Published research used the leaves, we were successful using flowers.

1. Wash plant pieces several times with DI water
2. Finely cut 20 g of plant and stir with 200 mL of DI water. Stir for two (2) minutes and filter into clean 250 ml beaker. .
3. Pour 30 ml aliquots of gold or silver solution into beakers A-D. Add 1 stir bar in each beaker.
4. Add 5, 10, 20, 30 ml plant extract to beakers A-D.
5. Vigorous stirring is continued for 10 minutes. The gold solution gradually forms as the citrate reduces the gold(III). The solution turns a deep red. The silver solution gradually forms as the citrate reduces the silver. The solution will be a greenish brown.
6. Each group will have four beakers of differing concentrations. The color of the solutions will demonstrate the amount of gold particles synthesized as seen below.
7. Label solutions appropriately and the colloids are stable for 2 months.

Looking at the solutions the students will believe they have done something incorrectly. Ensure them they have not. Why is the solution of gold particles red?? Why is the solution of silver particles green?? Act in disbelief. Comment that you read millions of millions of silver and gold is synthesized in this same reaction. Recall an experiment that you know of that will test for the presence of gold and silver. Pass out copies of the published paper. Students will note the pictures in the published papers use nano as the size scale for the gold particles made. The students use the resulting nanoparticle solution to explore the size-dependent optical properties of gold nanoparticles. Specifically, they determine that the nanoparticle solution functions as an electrolyte sensor because electrolyte-induced aggregation of the nanoparticles results in a dramatic color change.

1. Have the students record the color of their initial solution.
2. Place 5-10 drops of the 1M NaCl solution into their beaker.
3. Record color changes as students continue to add 1M NaCl

The formation of gold nanoparticles can be observed by this change in color since small nanoparticles of gold are red. A layer of absorbed citrate anions on the surface of the nanoparticles keep the nanoparticles separated. Switching to a smaller anion by the addition of

the 1M NaCl allows the particles to approach more closely and another color change is observed. (the color will change from a red, pink, maroon, purple, blue).

The teacher can also use this disbelief and student's competitive nature of become richer than their peers to have students design experiments. Each group of students could use their prior knowledge of photosynthesis to design an experiment using either different plants or different parts of plants to reduce the Gold or Silver salt solution to produce countless particles of the metal. Also students with a background in chemistry can use stoichiometry to determine limiting reagents in producing the largest yield of Au and Ag. As a guideline, the teacher can give the class the general technique and then the students can manipulate the design. Also microbial activities can be demonstrated using yeast grown in a petri plates being exposed to disks soaked with the nanoparticle solution. This has real life applications for antimicrobial clothing, medical apparatus's, and food storage.

So what does this all mean? Right now, it means that scientists are experimenting with substances at the nanoscale to learn about their properties and how we might be able to take advantage of them in various applications. Engineers are trying to use nano-size wires to create smaller, more powerful microprocessors. Doctors are searching for ways to use nanoparticles in medical applications. A recent application of this technology is in cancer treatment. Doctors can embed gold nanoparticles that are tuned to absorb infrared light in cancer cells. Then, the doctor shines infrared light upon the tissue. As the nanoparticles absorb the infrared light, they heat up. Eventually they heat up enough to destroy the cancerous cells.

Still, we've got a long way to go before nanotechnology dominates the technology and medical markets. Nanotechnology is so new; no one is really sure what will come of it. Even so, predictions range from the ability to reproduce things like diamonds and food to the world being devoured by self-replicating nanorobots.

Extension:

Lesson 3- Field trip to University SEM/TEM/AFM/DLS/UV-Vis for data collection of designed experiment.

Lesson 4- Antimicrobial property of Au using E. Coli

9. ESSENTIAL QUESTIONS AND REVIEW

List the essential questions that will be asked and explain the review before or after these questions

10. POSSIBLE CHALLENGES:

Gold Chloride may not be found in the typical chemistry classroom. Silver Nitrate can be substituted. The color change will be different but still noticeable.

Misconceptions

Material properties do not change with size.
People are not affected by Nanoparticles

11. ACKNOWLEDGEMENTS

This project was funded by the NSF RET Grant Research Experiences for Teachers Site for "Civil Infrastructure Renewal and Rehabilitation". The Grant ID No. is EEC-0808696. This opportunity could not be possible without the time and effort of Ms. Kelly J. Cross, Dr. Doug Kohls, Ms. Andrea Burrows, and Dr. Anant Kukreti.

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12. **APPENDIX I: LESSON PLAN TEMPLATE**

13. APPENDIX II: WORKSHEETS, POWERPOINTS, ETC… – for each lesson

14. APPENDIX III: LESSON PLAN DEVELOPMENT SCHEDULE This unit will be taught as the conclusion of the Environmental unit 1st quarter and the cell unit taught 2nd quarter. Using the Green Chemistry as the environmental transition and the size and scale for the cell transition.

15. APPENDIX IV:

Ohio Science Standards- 10th Grade

Science and Technology

Understanding Technology	Cite examples of ways that scientific inquiry is driven by the desire to understand the natural world and how technology is driven by the need to meet human needs and solve human problems. Describe examples of scientific advances and emerging technologies and how they may impact society.
Abilities To Do Technological Design	Explain that when evaluating a design for a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced and disposed of in addition to who will sell, operate and take care of it. Explain how the costs associated with these considerations may introduce additional constraints on the design.
Science and Society	Investigate how the knowledge, skills and interests learned in science classes apply to the careers students plan to pursue.

Scientific Inquiry

Doing Scientific Inquiry	Research and apply appropriate safety precautions when designing and conducting scientific investigations (e.g. OSHA, MSDS, eyewash, goggles and ventilation). Present scientific findings using clear language, accurate data, appropriate graphs, tables, maps and available technology. Use mathematical models to predict and analyze natural phenomena.

Draw conclusions from inquiries based on scientific knowledge and principles, the use of logic and evidence (data) from investigations.

Explain how new scientific data can cause any existing scientific explanation to be supported, revised or rejected.

Scientific Ways of Knowing

Nature of Science

Discuss science as a dynamic body of knowledge that can lead to the development of entirely new disciplines.

Describe that scientists may disagree about explanations of phenomena, about interpretation of data or about the value of rival theories, but they do agree that questioning, response to criticism and open communication are integral to the process of science.

Lesson 2: Too Small To See

1. See Lesson #1

2. **Get Rich Quick LESSON 2: Too Small To See? OVERVIEW**

   BACKGROUND KNOWLEDGE

   Experimental procedures, Familiarity with atoms. Knowledge of basic units of the metric system.

   This lesson are intended for a 10th grade biology class. These students should have completed a physical science class with a unit on atoms and properties of matter. Lesson 2 is a class period using 55 minute classes.

3. **GOALS AND OBJECTIVES**

   There are enormous scale differences in our universe, and at different scales, different forces dominate and different models better explain phenomena.

   New tools for seeing and manipulating increase our ability to investigate and innovate.

   Describe, using the conventional language of science, the size of a nanometer. Make size comparisons of nanosized objects with other small objects.

4. **MATERIALS**

   Student handout, visual demonstration, optional access to internet

5. **INSTRUCTIONAL STRATEGY**

   Whole class discussion, cooperative group work, power point, worksheets**,** experimental procedures

6. **TECHNOLOGY**

   Internet, power point, optional: TEM, AFM, SEM, light microscope**,** used in the lesson and the benefits associated with it

7. **Pre/Post ASSESSMENT QUESTIONS** for the lesson – 4 to 6 questions

   1. How big is a nanometer compared to a meter? List one object that is nanosized, one that is smaller, and one that is larger but still not visible to the naked eye.
   2. Name two properties that can differ for nanosized objects and much larger objects of the same substance. For each property, give a specific example.

3. Describe two reasons why properties of nanosized objects are sometimes different than those of the same substance at the bulk scale.
4. What do we mean when we talk about "seeing" at the nanoscale?
5. Choose one technology for seeing at the nanoscale and briefly explain how it works.

8. LEARNER PARTICIPATION/ACTIVITY – explain the procedure of the activity in words and then with bulleted details

Activity with paper cutting

1. Students will begin by reviewing scale and the importance of scale in STEM. Open ended questions about how big students believe things are. How big is the school building, your locker, your textbook, an organ in your body, a cell, a nucleus in a cell, DNA, and a water molecule in your cell?

They have come to understand the characteristics and properties of atoms and molecules by studying a pure sample of the substance in quantities big enough to measure under normal laboratory conditions. Because atoms and molecules are so extremely small, we need a huge amount in order to see them, measure their mass on a typical laboratory scale and mix specific amounts together (remember just 18 grams of water (1 mole) contains 6.022 x 1023 molecules). So when scientists make measurements of the different properties of gold, they are actually measuring the average properties based on the behavior of billions and billions of particles and not looking at the behavior of individual atoms or molecules. We have always assumed that these properties. So how small is billion and billions of particles?

- Students will measure a piece of paper.
- Challenge the students to cut a piece of paper in half until they reach a nano particle
- Students will realize they cannot cut that small. These limitations are due to Either to being able to see the paper or limitations of the scissors. Hence why certain technology is invented (lens, light microscope, electron microscopes etc)
- The video "Power of Ten" will be shown to give students a visual of the Macro to Nano scale.

9. ESSENTIAL QUESTIONS AND REVIEW

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10. POSSIBLE CHALLENGES

Misconceptions

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