Clean Water for the World; Nanotechnology to the Rescue

Subject Area(s) Chemistry

Activity Title **Clean Water for the World; Nanotechnology to the Rescue**

Image 1

Image file: worldwide water crisi.jpeg

ADA Description: This picture shows the worldwide need of safe and clean water

Source/Rights:

http://previews.123rf.com/images/koya79/koya791202/koya79120200760/12558291-drinking-water-crisis-eco-concept--Stock-Photo-water-pollution-shortage.jpg

Image 2

Image file: water treatment process.jpeg

ADA Description: This picture shows the need of treatment processes for safe and clean water

Source/Rights:

http://www.wsd.gov.hk/filemanager/en/content_131/formula.gif

Image 3

Image file: iron oxide nanoparticles (Fe3O4).jpeg

ADA Description: This picture shows iron oxide nanoparticles.

Source/Rights:

http://www.wsd.gov.hk/filemanager/en/content_131/formula.gif

Grade Level 10 (9-12)

Time Required approx. 225 minutes

Time Required Note This activity is designed for 5-class periods of 45 min

Group Size 4 students per group

Expendable Cost per Group US $0.00

Summary

This lesson houses two parts; one for the lecture and one for the lab. In the lecture students investigate the need of clean and safe water around the world, the negative impact of man and nature on water sources, the current techniques for water treatment, and the newest techniques for water remediation. In the lab students synthesize iron nanoparticles implementing a modified co-precipitation method somehow compatible to the one used by engineers.

Engineering Connection

Iron nanoparticles are being extensevely used in the innovation for new water remediation techniques. Students synthesize iron nanoparticles implementing a simplified co-precipitation method compatible with the one used by engineers.

Engineering Category

1. Relating science and/or math concept(s) to engineering
2. Engineering design process

Keywords

Nanoparticles, innovation, remediation, engineer, nanomaterials, pollutants

Educational Standards

State STEM Standard

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;

ITEEA Standard Standards for Technological Literacy: Content for the Study of Technology

Identifier: http://purl.org/ASN/resources/S11416B3

NGSS Standard

HS-ETS1- Analyze a major global challenge
1.-Analyze complex real-world problems by specifying criteria and constraints for successful solutions

CCSS Standard

STS IV: Science, Technology, & Society

A. Interaction between innovation & science

Recognize how scientific discoveries are connected to technological innovations

Pre-Requisite Knowledge

Students should know that:

- Water is one of the most valuable resources in our planet and clean water is necessary for life
- Safety guidelines for laboratory activities

Learning Objectives

After this activity, students should be able to understand that:

- Improved water quality is needed worldwide
- Current technologies may be improved through applied science
- Nanotechnology provides a platform for further investigation on how to synthesize compounds that might solve the challenges of water treatment

Materials List

Classroom Activity

- Teacher needs a computer with internet access and a projector
- Each group needs a computer and access to internet
- Classroom Video Activity
  20 Shocking Facts About Global Water Crisis: https://www.youtube.com/watch?v=zPuq2KLEWuA
- Video Companion Worksheet
- Rubric for Student's Presentation
- Rubric for Students Group Work
- Rubric for Student's Essay
- Guideline on How to Report a Scientific Research Paper

To share with the entire class:

- Research Power Point Presentation

Lab activity

- Gloves, lab coat, and goggles
- 250 mL beaker
- 50 mL graduated cylinder
- Plastic pipettes
- Stirring spin bar
- Neodymium magnet
- Distilled water
- $FeCl_3$ (Ferric chloride)
- $FeCl_2$ (Ferrous Chloride)
- NH_4O_4 (Ammonium Hydroxide)
- Ethanol
- Hot plate

Introduction / Motivation

In this activity students acknowledge the need of clean and safe water worldwide. The lesson begins with a short video called *20 Shocking Facts About Global Water Crisis* (4.4 min). Students view the video and take notes, (completion of the companion worksheet, at teacher's criteria) (see attached doc.). After viewing the video, students participate in a pair share experience for 5 minutes. Students then switch partner and discuss their notes, looking to grab any information they missed (5 minutes). Students work individually, after the pair share, to write a brief reflection on the video (10 minutes). Students are asked to explain the reasons why this video was made, to summarize the facts, to explain what they consider to be the most important fact stated, and to provide possible solutions in the crisis of water. Teacher then opens a classroom talk and motivates students to share their reflection with the entire class (5-7 minutes). The teacher proceeds to summarize the points of discussion and re-state the need for water quality

improvement and some of the innovation toward facing and solving this concern. Following the classroom discussion the students receive instructions for their assigned topic research, the creation of the power point, and the oral group presentation. At this point students receive the rubrics (see attached doc.) that serve as guidelines for obtaining high grades in this activity. Teacher explains all rubrics and clarifies expectations.

Vocabulary / Definitions

- Applied science-is the application of scientific knowledge of diverse and specialized areas to solve problems. Engineering approaches these areas for the development of technologies
- Nanotechnology- is the manipulation of matter at the atomic level that can then be applied at a macroscale in multidisciplinary areas
- Nanoparticles- microscopic particle having a size that is less than 100nm ($1X10^{-9}$), (1 billionth of a meter)
- Pollutants- anything that pollutes, that makes unclean or corrupt
- Contamination- is the introduction in a medium of agents that makes it unsafe for its use
- Magnetic- that has the properties of magnetism, which is a force of attraction

Procedure

The teacher explains that there are several ways of synthesizing IONPs. Some of the known methods are co-precipitation, thermal decomposition, hydrothermal and solvothermal synthesis, sol-gel synthesis, micro-emulsion, ultrasound radiation, and biological synthesis. Today you are synthesizing iron nanoparticles using co-precipitation. The most conventional method of co-precipitation uses a mixture of ferric (Fe^{3+}) and ferrous ions (Fe^{2+}), but you are using a modified and simpler method that only utilizes ferric chloride ($FeCl_3$). Engineers and chemist synthesize magnetic nanoparticles that are used to form membranes in which the pollutants of water are trapped providing a mean for water remediation.

Students proceed as follow:

1. Mix 1.0 g of $FeCl_3$ with 100 ml of DI water in the 250 mL beaker and add a stir bar. Heat the resulting mixture, while stirring, to 80 °C degrees for 1 hour.
2. At the completion of the hour, let the solution cool down to room temperature and slowly add NH_4O_4 dropwise to the mixture to activate the precipitation of iron oxide nanoparticles.
3. After nanoparticles have precipitated separate them from the solution using a strong magnet.
4. Decant the supernatant and wash the nanoparticles two times with DI water and three times with ethanol.
5. After the last wash, heat the hot plate to 80 °C and place the beaker with the nanoparticles and leave it until the nanoparticles are completely dry.
6. Now you may observe the magnetic characteristics of the nanoparticles by using the magnet. Nanoparticles having magnetic characteristics will be attracted towards the magnet.

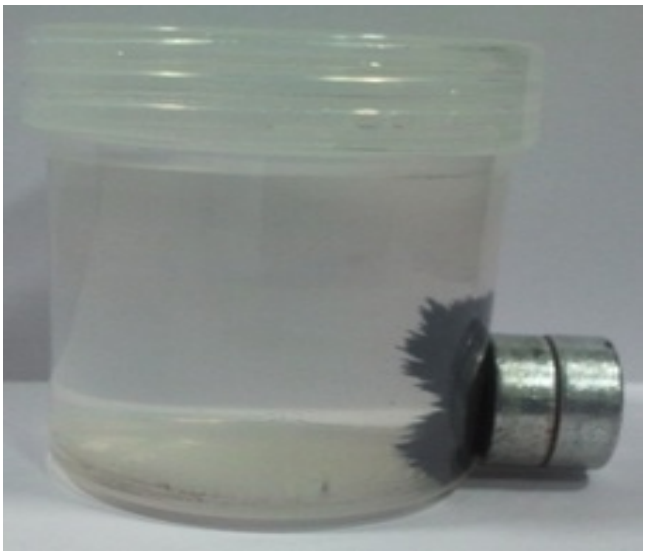

Image 4

Image file: iron nanoparticles.jpeg

ADA Description: This picture shows iron nanoparticles and their magnetic properties

Source/Rights:

http://4.imimg.com/data4/LD/HP/MY-19076988/iron-oxide-nanoparticles-250x250.jpg

Background

There is an increasing worldwide need to provide improved water quality. Some of the current methods of water treatment can be improved by making them more efficient and cost effective. Nanoscale materials such as those that contain iron are the most widely used and have proven to chemically reduced contaminants such as Tetrachloroethene (PCE) and Trichloroethene (TCE), among others. The synthesis of magnetic nanocomposites may provide a mean for water remediation with the desire characteristics of being more efficient by introducing magnetic properties for the removal of contaminants and being less expensive.

Before the Activity

Students should have an understanding on

- how important water is for life as we know it in our planet
- the worldwide need of clean and safe water
- some drinking water treatments
- Lab Safety Rules and Procedures/Data Safety Sheets on Ferric Chloride, Ferrous Chloride, Ethanol, Ammonium Hydroxide

Teacher has copies, for each student, of the followings:

- Group Work Rubric
- Oral Presentation Rubric
- Essay Writing Rubric
- Video Companion Worksheet
- Scientific Research Paper Report
- Iron Nanoparticles Synthesis Handout

With the Students

1. Students work in groups of four to search on assigned topics related to global water crisis and how to solve the problems that it generates. Each group prepares a 7 minutes power point presentation (7-10 slides) and shares their findings with the entire class. The assigned topics are be as follow:
2. Group #1: Water Contamination in the World, in the USA, in Texas, and in El Paso. This group will investigate the most important water contaminants in the specific areas.
   Group #2: Disasters and their Impact on Waters Sources (Katrina, Flint, Fukushima, and the Japanese Earthquake & Tsunami on March 11, 2011)
   Group #3: Conventional Water Treatment Technology
   Group #4: Newest Technology for Water Treatment (What is NEWT?
3. Students present their findings in a power point presentation. The presentation should not take more than 7 minutes per group. Students have receive a rubric for the group presentation and a rubric for group work on day #1, (see attached doc.), and they are expected to follow them for oral presentation and for group work grades. Students have been instructed to be prepared to answer questions from the audience and from the teacher as well. Students not presenting must take notes on each topic. These notes will be used to write the essay that is required as the science evaluate component of the lesson. The presentation holds 50% of the total grade.
4. In the hands-on component of this lesson the students will synthesize iron nanoparticles following a simplified co-precipitation method compatible with the ones engineers use. (See attached doc.) The lab activity produces a grade on its own.

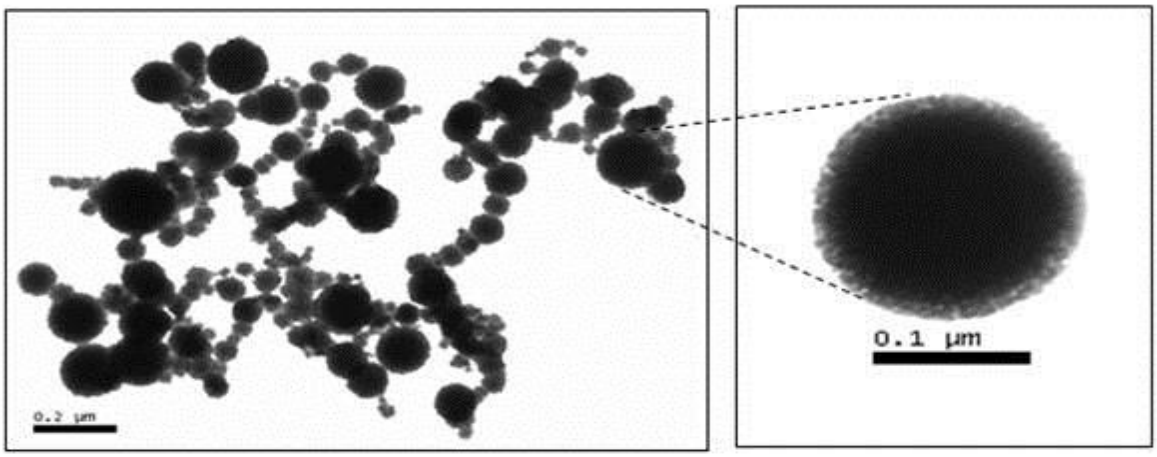

Image 5

Image file: nanoparticles.jpeg

ADA Description: This picture shows iron nanoparticles after synthesis through thermal solvent methods

Source/Rights:

https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.highlight/abstract/2365/report/F

Attachments

- Group Work Rubric
- Oral Presentation Rubric

- Essay Writing Rubric
- Video Companion Worksheet
- Scientific Research Paper Report
- Iron Nanoparticles Synthesis Handout

Safety Issues

- Students follow lab safety guidelines, rules, and procedures
- Students avoid skin and eyes contact of Ferric Chloride, Ammonium Hydroxide, and Ethanol
- Students avoid inhalation and ingestion of Ferric Chloride, Ammonium Hydroxide, and Ethanol
- Students extreme precautions on hot surfaces and glassware

Troubleshooting Tips

During the synthesis of iron nanoparticles there might be a delay in the precipitation of the particles towards the magnet, due to the fact that this modified method does not produce particles with good magnetic properties..

Investigating Questions

For the Classroom research activity:

- What pollutes water sources?
- What world catastrophes have had a negative impact on water sources?
- What technologies are been used to improve water quality?
- Can applied science solve the problem of water contamination? What is NEWT?

For the Lab activity:

- How iron nanoparticles are synthesized?

Assessment

Pre-Activity Assessment

Descriptive Title: ___Brainstorming

- Before releasing the video 20 *Shocking Facts About Global Water Crisis* , the teacher will introduce the lesson by directing the students to brainstorm properties, characteristics, and importance of water. Through this activity informal assessment will take place.

Activity Embedded Assessment

Descriptive Title: Topic Research Presentation

- During the power point presentation, informal assessment will be conducted by the teacher in the form of questions and answers.

Post-Activity Assessment

Descriptive Title: Writing to Learn

- After the presentations are completed students will write an essay on everything they learned during the power point presentations. Students will receive an Essay Writing Rubric on day #1, (see attached doc.), which will be used for grading. The essay will include all topics exposed through the different group presentations. Students will individually work the essay in the classroom and will use their notes. The essay will constitute 20% of the total grade.

Activity Extensions

Students will be encourage to investigate fields, outside of water treatment, in which Nanotechnology is been used and will write a report on their findings for extra points, (see attached doc.). The source will be a Scientific Research Paper. This activity will generate 10 extra points that the student may use at their convenience. This portion will be due one week after completion of the others and is optional. Sources like Wikipedia and Science Daily will not be accepted. Students will choose their own article from academic trusted sources such as, but not limited to:

CiteSeer^x (http://citeseerx.ist.psu.edu)
GetCITED (http://www.getcited.org/)
Microsoft Academic Research (http://academic.research.microsoft.com/)
Directory of Open Access Journals (http://www.doaj.org/)
PLOS ONE (http://www.plosone.org/)
BioOne (http://www.bioone.org/)
Science and Technology of Advanced Materials (http://iopscience.iop.org/1468-6996/)
ScienceDirect (http://www.sciencedirect.com/)

Activity Scaling

- For lower grades, ___ this lesson may be modified with a simpler research component at the grade level required with a hands on components of creating a 3D-poster depicting water crisis and possible water crisis solutions.
- For higher grades, ___ this lesson is designed for 9-12 grades

Additional Multimedia Support

Iron Nanoparticles synthesis
https://www.youtube.com/watch?v=Y59ZgdVAGhs

This video shows iron nanoparticles and their attraction towards magnet.

References

Gehrke, I., Geiser, A.& Somborn-Schulz, A. (2015) Innovations in nanotechnology for water treatment. *Nanotechnology, Science and Applications*, *8*, 1–17. http://doi.org/10.2147/NSA.S43773

Wei Wu, Zhaohui Wu, Taekyung Yu, Changzhong Jiang,& Woo-Sik Kim (2015). Recent progress on magnetic iron oxide nanoparticles: synthesis, surface functional strategies & biomedical applications. Science and Technology of Advanced Materials http://dx.doi.org/10.1088/1468-6996/16/2/023501

Contributors

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Classroom Testing Information

The lab activity has been successfully tested in Dr. Dino Villagrán Lab at The University of Texas El Paso on July 19, 2016.
The entire lesson is to be tested in the 10th grade science classroom and lab during the first week of school year 2016-2017, August 22-26, 2016, after which it will be re-submit to Teaching Engeneering.

IMPORTANT NOTE: This lesson has been successfully conducted by my 10th grade DCR Biol 1107