RESEARCH EXPERIENCES for TEACHERS AT NORTHEASTERN UNIVERSITY

Classroom Lesson Development

Title of Lesson	**Polymers: Properties and Functions**
RET Project Connection	The George J. Kostas Center for High Rate Nanomanufacturing and Nanofabrication at Northeaster Univeristy performs research with carbon nanotubes. The deposition of these carbon nanotubes on various substrates are characterized by researchers using many instruments including the Scanning Electron Microscope (SEM) and the Atomic Force Microscope (AFM). My school does not have access to these instrument. However, carbon nanotubes (CNTS) can be regarded as belonging to a very broad category of macromolecules called polymers, which are often discussed in high school chemsitry courses and can be easily incorporated in the curriculum, as well as state and national standards/frameworks.
RET Teacher	Amie Milkowski
School	Malden High School
Town/District	Malden Public Schools
Subject(s) taught	Chemistry
Subjects covered in lesson	Polymer chemistry
Grades appropriate	11^{th} & 12^{th} grade chemistry students
Lesson duration	2 - 3 weeks
Goals/Objectives of lesson	- Students keeps a neat, thorough laboratory notebook. - Students engineer a polymer 'toy' based on their concept of the most desirable properties. - Students write a research paper on a polymer of their choice with a proposed function/use for the polymer. - Students create a web page for their polymer including the researched information and proposed function/use.
Background information	After participating, Northeastern University Research Experience for Teachers I am confident that nanotechnology must have a place in my science classroom. Many high school students are simply not aware of all the different possibilities and avenues science and engineering offer. Utilizing the inquiry method, scientific curiosity in polymer chemsitry and nanotechnolgy can be fostered in the classroom. Allowing students to create, observe, play/experiment with, investigate and research polymers is a tangible way to bring nanotechology into the classroom.
Essential questions	- What are polymers? - How can the many different properties of polymers allow them to be beneficial materials that can be used in many facets of our lives?

Links to Frameworks and Standards

National

Science as Inquiry Standard (9-12):
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Physical Science Standards (9-12):
- Structure and properties of matter
- Interactions of matter

Unifying Concepts and Processes (9-12):
- Organization
- Measurement
- Form and function

State

Properties of Matter

1.1 Identify and explain some of the physical properties that are used to classify matter.

1.3 Describe the four states of matter (solid, liquid, gas, plasma) in terms of energy, particle motion, and phase transitions.

Chemical Bonding

4.1 Explain how atoms combine to form compounds through both ionic and covalent bonding.

4.2 Draw Lewis dot structures for simple molecules.

4.3 Explain the difference between polar and nonpolar covalent bonds.

4.5 Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain common polyatomic ions.

Local

Malden High School Science Department's Educational Standards

Students' scientific understanding and appreciation for science will be developed by
- revealing the connections between and among powerful science ideas.
- promoting scientific inquiry and literacy.
- providing all students with challenging, interesting and stimulating science experiences.
- fostering an appreciation for science as a fascinating, diverse and significant area of human inquiry by presenting science in real life situations and by using scientific techniques to model situations and solve real-life problems.
- developing confidence and competency in science problem-solving and communication.
- developing critical and analytical thought processes.
- training students in basic laboratory techniques and procedures.

Materials required

- Beakers
- Polyvinyl alcohol soln.
- Rulers
- Cotton
- Plastic soda bottles
- Wool
- Stirring Rods
- Sodium borate soln.
- Distilled water
- Wood
- PVC piping
- Jell-O

Lesson development

The main ideas and activites of this mini unit are outlined here utilizing the 5E model.

- Engagement: Students are first introduced and given the 'hook' by placing them in a lab situation with no clear information other than they are going to combine to unknown solutions to create an unknown product and make thorough observations. The production is slime! After the students have been given plenty of time to play/observe and make notes, create a KTWL about polymers as a class. KTWL is a way for students to brainstorm what they Know, Think they know, Want to know, and eventually Learned. Expanding on the traditional KWL, adding a section for what students Think they know allows the class to come up with more ideas that can foster conversation in the class by other students (not teacher) confirmation or comment. These 'Think' you know ideas can also be a source for later exploration in the 5E model.

- Exploration: Give students, working in pairs/teams, the reagents needed to make slime. Allot them an entire class period to design the perfect toy. The objective is to decide what the characteristics/properties of slime made by different regeant ratios are and what are the most desirable for a toy. Encourage students to quantify and tabulate their testing (i.e. viscosity and bouncibity), and share results as a class.

- Explanation: Challenge students to debate whether their 'toy' is a solid or a liquid. Introduce the following concepts: polymerization, non-Newtonian fluids, crosslinking.

- Exploration: Give students, working in pairs/teams, several different samples of polymers (cotton, wool, wood, Jell-O, plastic soda bottles, rubber bands, PVC piping, etc). Ask students to characterized the properties and state of matter.

- Explanation: Task students with determing the functionality of each polymer, comparing and contrasting the samples, and sorting them into categories. Students should be able to discuss their reasonings as a class. Show students the "Modern Marvels: Polymers" DVD. If possible, bring students the the Polymer Outreach Presentation at UMass Amherst.

- Elaboration: Students, in pairs/teams, investigate a polymer of their choice. Students must research their polymer, propose a function and implementation for the polymer based on its physical properties and be able to support their proposal in written form.

- Evaluation: Each day students should be required to submit a "Ticket-To-Leave". This may contain two things the student learned that day and a question/confusion the may have. Add what they Learned and what they Want to learn from the ticket-to-leave to the KTWL. Briefly display/discuss the additions to the KTWL as a warm-up each following day. The final assessment for this mini-unit is the design of a web page (using Dream Weaver). In their pairs/teams, student develop a thorough and professional web page for their researched polymer proposal.

References - The National Science Education Standards & The Masssachusetts Curriculum Frameworks

- Macromolecular Materials Laboratory, Polymer Research Group at The University of Cambridge: http://www.msm.cam.ac.uk/polymer/index.html

- The Macrogalleria: A Cyberwonderland of Polymer Fun, The Department of Polymer Science at The University of Southern Mississippi:http://www.pslc.ws/macrog.htm

- Polymers and People, The National Academy Of Sciences: http://www.beyonddiscovery.org/content/view.article.asp?a=203

- Teaching Plastics in the Classroom, The American Plastics Council: http://www.americanplasticscouncil.org/s_apc/index.asp

- Polymer Discovery, The Key Centre for Polymer Colloids at The University of Sydney: http://www.kcpc.usyd.edu.au/discovery/

- Polymers and Liquid Crystals, Case Western Reserve University: http://plc.cwru.edu/tutorial/enhanced/main.htm

Polymers:
Properties & Functions

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Research Experience for Teachers
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Engagement

- Students enter the lab during the first day of the mini-unit and combine two reagents and…slime!
- Class develops a
  - **K** – What you know.
  - **T** – What you think you know.
  - **W** – What you want to know.
  - **L** – What you have learned.
  - Revised using daily ticket-to-leave.

Exploration & Explanation

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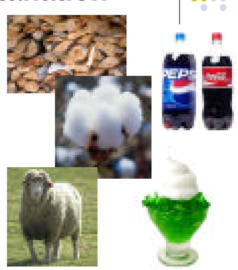

Elaboration & Evaluation

- Students, in pairs/teams, investigate a polymer of their choice. Students must research their polymer, propose a function and implementation for the polymer based on its physical properties and be able to support their proposal in written form.
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