Teachers Information:

The Shaping of Polymers

Activity: Why Use Nanofiber Bandage?

Lab: Effects of Heating and Cooling
Cycles in Thermoplastic Polymers

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Summer 2004

Support for Cornell Center for Materials Research is provided through NSF Grant DMR-0079992

Acknowledgments:

Development of this activity was made possible through Research Experience for Teachers, a program funded by the Cornell Center for Materials Research, and headed by Nev Singhota, the Educational Programs Director.

Dr. Yong Joo hosted my research experience and patiently explained much about nanofibers and Dr. Maura Weathers provided training and help with the SAXS data.

Horseheads High School and all those great students that make me want to learn more.

Connection to the Chemistry Curriculum:

Lab: "Effect of Cooling and Heating Cycles in a Thermoplastic Material"

3.2 a A physical change results in the rearrangements of existing particles in a substance. A chemical change results in the formation of a different substance with changed properties.

4.1 a Energy can exist in different forms, such as chemical, electrical, electro-magnetic, thermal, mechanical, nuclear.

4.1 b Chemical or physical changes can be exothermic or endothermic.

4.2 c The concepts of potential and kinetic energy can be used to explain physical processes that include fusion (melting), solidification (freezing), vaporization, condensation, sublimation, deposition.

"Why Choose a Nanofiber Bandage?"

3.4 f The rate of a chemical reaction depends of several factors: temperature, concentration, nature of the reactants, surface area, and the presence of a catalyst.

Development of these activities:

My research experience centered on the formation of nanofibers by electrospinning, annealing them at various temperatures and, through the use of the transmission electron microscope and small angle x-ray diffraction, determining the morphology of the structures formed. While these are things my students cannot do in the lab, I was also re-introduced to concepts such as block copolymers, thermoset vs. thermoplastic polymers and different methods of extrusion in my own reading to supplement the research experience that I can bring back to my students.

The first activity, "Why choose a nanofiber bandage?" is meant to show the increased surface area to volume ratio in fibers with very small diameters. The math would be hard for a lot of students, so I would probably do it as a "whiteboard activity" (3-4 students per small whiteboard), with aid given to individual groups, or to the whole class, as needed.

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The lab activity selected and modified is on the effects of melting and freezing a thermoplastic material. Resources include information on the history of fibers and the methods of extruding these fibers. While students cannot electrospin very small diameter fibers they can see that process and others that produce larger fiber through a power point presentation or in their reading, and the lab activity gives them an opportunity to work with a crude extrusion devise.

Details about the nanofiber activity:

(The idea was given to me by Dr.Joo at Cornell.)

Time required:

I'd probably spend about 40 minutes on this. It depends on your group and how long you want them to struggle.

Suggested group size:

I will have the work in groups of 3 or 4 and try to brainstorm a strategy to figure out the surface area and the volume of the fiber. We will stop periodically to get ideas from individual groups so they can help on another.

Results:

Film

surface area = 10 cm x 4 cm = $\underline{40\ cm^2}$

volume = 10 cm x 4 cm x .1 cm = $\underline{4\ cm^3}$

surface area/volume = 40/4 = **10**

Fiber

From the visual, we can estimate that the fiber would take up about 50% of the surface of the film. Then we can envision them lined up 10 cm long, laying side by side reaching a width of 2 cm.
(I divided the s.a. formula by 2 because I just wanted the s.a. touching the skin.)

surface area = pi (r) h
$= 3.14\ (5 \times 10^{-6}\ cm)\ 10\ cm =$
$7.85 \times 10^{-5}\ cm^2$

surface area of all cylinders
$2\ cm/1 \times 10^{-5}\ cm$ = 200,000 cylinders will across, so
$7.85 \times 10^{-5}\ cm^2\ (200,000) = \underline{15.7\ cm^2}$

volume = $3.14\ (5 \times 10^{-6})^2\ (10cm)$
$= 7.85 \times 10^{-10}\ cm^3\ (200,000)$
$= 1.57 \times 10^{-4}\ cm^3$
surface area/volume = $15.7/1.57 \times 10^{-4}$
= **100,000**

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Details about the lab:

Time Required:

1 to 2 hour long session is recommended. If your lab period is shorter students could test the viscosity of their samples the next day.

Safety:

Along with wearing goggles and cautioning students about how to hold the tubing, you may want to provide students with gloves and should definitely use a mini glue gun to reduce the volume of the hot polymer extruded.

Suggested Group Size:

Groups of 2 students are suggested. There is enough activity to keep 2 students very busy, but beyond that and you will have some students just watching.   While error will be minimized with one student uses the glue gun to fill the mold and one uses it as a melt index viscometer, it is up to the teacher as to whether to give that advise.

Results:

While I haven't used this yet in my classroom and I know there are definitely accuracy issues (especially in the use of the hot glue gun as a melt index viscometer), the original author found that conclusions could still be drawn that the viscosity changed more than 5%. Results were more accurate when 1 steady squeeze for 1 second is used to test the viscosity.

Resources:

http://www.terrificscience.org/freeresources/

An amazing resource, this is where I got the lab on heat and cooling cycles of thermoplastics. There were 27 lab activities for polymers, at the high school level many should be used as demonstrations because of the chemicals that are required.

http://www.fiberworld.com/

As the name says, there is a world of information on fibers here.

http://ckpmac7.yz.yamagata-u.ac.jp/E-Page/Project/research/spinning/spinning-E2.htm

Good diagram to show extrusion methods for fibers.

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http://nanotech-now.com/current-uses.htm

http://www.smalltimes.com/document_display.cfm?section_id=76&document_id=6749

http://www.hillsinc.net/submicron%20.shtml

Good information on research being done on the nanoscale. Second site explains nanotechnology and its use in clothing.

http://science.uniserve.edu.au/school/curric/stage6/snrsci/polymers

Stevens, E. S.(2002). *Green Plastics: An Introduction to the New Science of Biodegradable Plastics*. Princeton, NJ Princeton University Press.
Your students can make polymers from the "recipes" in this book without you worrying about the chemicals involved. Investigative labs can be developed as students vary amounts of chemicals to create polymers with various attributes. Also, student created polymers can be tested for tensile strength or time of degradation.

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