STEM ED/CHM Nanotechnology at UMass Amherst

A Teacher's Guide for the Oleic Acid Thin Film Activity

The Nanoscale Context: This activity provides an opportunity for students to apply an understanding of relationships among area, depth, and volume as they calculate the nanoscale thickness of a thin layer of oleic acid.

The STEM Context: This activity can be integrated into a study of measurement systems, miscibility of liquids, and the characteristics of chemical bonds.

National Science Education Learning Standards Examples

- Science as Inquiry Standard; Grade 5-8 (Page 145): "Use appropriate tools and techniques to gather, analyze, and interpret data."
- Physical Science Content Standard B; Grades 9-12 (Page 179): All students should develop an understanding that "The physical properties of compounds reflect the nature of the interactions among its molecules……"

Massachusetts Science and Technology/Engineering Learning Standards Examples

- Physical Science; Grades 6-8 (Page 67): "Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools …..and knowledge and use of significant digits."
- Chemistry, High School (page 70): "Identify how hydrogen bonding in water affects a variety of physical, chemical, and biological phenomena……."

Massachusetts Mathematics Learning Standard Example

- Measurement; Grades 7-8 (Page 65); "Demonstrate and understanding of the concepts and apply formulas and procedures for determining measures……"
- Measurement; Grades 9-10 (Page 75); "Describe the effects of approximate error in measurement and rounding on measurements and on computed values from measurements."

Materials for the Activity

- Isopropyl alcohol can be used as a solvent rather than methyl or ethyl alcohol. Caution should be taken since alcohols are flammable.
- Oleic acid may be purchased from sources that include: Sargent-Welch catalog #WLC94631-06; $14.60 per half liter.
- Lycopodium powder was once used for the activity but is an allergen for some students. Chalk dust, finely ground pepper, baby power can also be used.
- Circular flat trays that have a diameter of approximately 40 cm are available from suppliers such as: http://foodservice.chef2chef.net.
- Pipettes or 10 mL graduated cylinders can be used to measure 1.0 mL of liquid.
- Larger graduated cylinders (e.g., 25 ml) are needed to make solutions.
- Medicine droppers are needed to determine the number of drops of oleic acid solution in 1.0 mL of solution.
- Medicine dropper bottles can also be used to make and store oleic acid solutions.

Sample Results

- Step 1 : The volume fraction = 1 / 25
- Step 2 : 0.04 cm^3
- Step 3 : 0.04 cm^3 / 25 = 0.0016 cm^3
- Step 4: An example would be; 40 drops = 1.0 cm^3.
- Step 5: If a group determined that 40 drops of the second solution of oleic acid had a volume of 1.0 cm^3, then 0.0016 cm^3 / 40 = 0.00004 cm^3.
- Step 6: If that group estimated that average diameter their thin film of oleic acid was 14.50 cm, then the average radius is 7.25 cm,
- Step 7: Area = 3.14 x R^2 For example: The area of that film was 165.05 cm^2
- Step 8: **If** Volume = Area x Depth; **Then**: Depth = Volume / Area. The thickness of the example group's film would be 2.42 x 10^{-7} cm.
- Step 9: 2.42 x 10^{-7} cm = 2.42 x 10^{-9} m = 2.42 nanometers
- Question 1: Some students will comment in the accuracy of their measurements. It may also be true that the oleic acid formed a layer that was several molecules deep.
- Question 2: Some student will suggest that repeated trials be conducted.
- Question 3: An example would be as follows:

Calculate the number of drops of oleic acid in a liter of pure oleic acid. Set up the proportion: 1.0 drop / 0.00004 ml = x drops / 1000 mL. For this example group, there would be 25,000,000 (2.5 x 10^7) drops per liter. As a result, the area of the thin film would be 2.5 x 10^7 times larger that the area from the activity.

For this example group, 165.05 cm^2 x (2.5 x 10^7) = 4.13 x 10^9 cm^2. There are 10,000 cm^2 (1.0 x 10^4) in a square meter. The area would equal 4.13 x 10^5 m^2. There are 1 x 10^6 m^2 in a square kilometer. Therefore, based on this group's results, the area of a thin film of 1.0 liter of oleic acid would equal 0.413 square kilometers.

Examples of Accompanying Activities

- Some students benefit from an activity that illustrates relationships among volume, area, and depth of a structure. This can be accomplished with materials like pizza dough.
- Soap is made in the saponification process when oils or fats react with sodium hydroxide. This activity requires the use of sulfuric acid and a caustic hydroxide.
- Research projects can include an investigation into the impact of thin films on the exchange of gasses between a body of water and the atmosphere.
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Web sites that provide information about this oleic acid films include:

- http://jxb.oxfordjournals.org/cgi/content/abstract/39/12/1679
- www.chymist.com/size%20fatty%20**acid**.pdf
- http://www.chemheritage.org/educationalservices/pharm/tg/antibiot/activity/size.htm
- http://www.sargentwelch.com/pdf/opinstr/72701-81.pdf
- http://chem.lapeer.org/Chem1Docs/OleicAcidLab.html
- http://www.gpc.edu/~ddonald/chemlab/oleicavagno.html

Web sites with information about Benjamin Franklin's observations of a thin film include:

- http://www.nyas.org/ebriefreps/main.asp?intSubsectionID=2071
- www.**ben**franklin300.com/_etc_pdf/Dutch_Joost_Mertens.pdf
- http://www.historycarper.com/resources/twobf3/letter3.htm