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Title: Like Dissolves Like

Problem to be studied: Solubility of Polar and Nonpolar Substances

This lesson would be appropriate in the study of the solution process, which usually occurs late in the year during a first year chemistry course, or possibly early during a second year course. The students should have a prior knowledge of ionic, polar covalent, and covalent compounds.

The lesson would also be appropriate to introduce the distinction between polar and nonpolar substances, which would occur much earlier in a first year chemistry course.

Content Standard(s):

3.4.10A Explain concepts about the structure and properties of matter

Process Standard(s):

3.2.10B Apply process knowledge and organize scientific and technological problems in varied ways.

3.2.10C Apply the elements of scientific inquiry to solve problems

Assessment Strategies: (Evaluation)

Formative Evaluation:

1. Assess student models of solution process for all four types of solute-solvent systems.

2. Approve experimental design setup before solubility lab begins.

Summative Evaluation:

1. Students will write a formal lab report on their experiment.

2. Students will design an advertisement for soap which depicts the dual polar-nonpolar nature of the molecule.

Suggested Grade Level:

10-12

Materials:

Overhead transparency
Sharpie
Vis-aVis marker

Linseed oil colored with Oil paints
Shallow trays
Paper, 8.5” x 5.5”

Bananas
DNA extraction buffer
Isopropyl alcohol
Ice

Video clip, The Solution Process

Small magnets, many painted blue, some painted red.

Popsicle sticks, many painted blue, some painted red

Hexanes

Paint Thinner

Ethanol

Vegetable Oil

Automotive grease

Red Devil lye

Crisco

Olive oil

Procedures:

Engage:

Before class, write something on the OHP with a Sharpie. While taking roll, hand a student a damp paper towel and ask them to please clean off a section of the overhead for today's lesson. When the student can't get the transparency clean, grab a second towel prepared with isopropyl alcohol, clean the transparency, and express question as to why the student could not perform such a simple task himself. Discuss.

Molecular Art Activities: Linseed oil with oil paints on water; allow students time to create marbled papers.

DNA lab activity: Students will isolate DNA from living cells. Directions for spooling DNA are available from many sources; check related websites listed at the end of this document. Have students watch the interface with magnifying glass and note where the DNA strands become visible at the interface as the isopropyl alcohol is added. DNA shouldbe collected, redissolved in water, and saved for the next day.

Explain:

1. Show video clip of the solution process. Emphasize three processes in play: solute-solute attractions must be broken; solvent-solvent attractions must be broken; solute-solvent attractions must be formed. The first two processes require energy; the third process released energy (stabilizes the system). Water is polar, and will form attractions to other polar substances, but will not form attractions to nonpolar solutes. Nonpolar solvents such as kerosene and less polar solvents such as isopropyl alcohol will not be attracted to polar solutes, and would not be expected to dissolve these solutes. Connect to the Vis-à-vis markers and Sharpies.

2. Nonpolar solutes interfere with the attractions between water molecules without adding attractions of their own, so the water molecules will just push the nonpolar solutes out. Connect to linseed oil/water mixture.

3. Nonpolar solutes are neither attracted nor repelled in any great degree to nonpolar solvents, but there are no great solvent-solvent attractions to disrupt, either. Once mixed up, there isn't any reason for nonpolar solutes to separate out from nonpolar solvents. Connect to the oil paint/linseed oil mixture.

4. **(Evaluation for 3.4.10A)** Have students model the solution process with magnets and Popsicle sticks. Blue paint represents solvents. Red paint represents solutes. Students should model four systems: polar solute-polar solvent; polar solute-nonpolar solvent; nonpolar solute-polar solvent; nonpolar solute-nonpolar solvent. Check each model system as the students build and ask them whether the forces at play would allow the solute to dissolve.

5. Show video clip on soap structure. Explain the dual polar-nonpolar nature of the molecule. Explain micelle formation. Relate to the structure of the cell membrane. Finish by explaining the manner in which soap releases oil from clothing. Relate to the DNA spooling activity.

Explore:

Have students design a final project on solubility using the 4 Question strategy. Materials listed in box on page one may be used for the experiment (with the exception of the lye!). The students must design an experiment which studies a factor which may affect solubility. Students should pick one variable to study and one response to measure **(Evaluation 3.2.10C)**

Elaborate:

Discuss the DNA spooling experiment, and have students propose reasons why the DNA precipitated in isopropyl alcohol, but redissolved in water. (DNA must be polar). Ask the students to propose a way to get the DNA back out of the water, and allow them to try out their suggestions.

Pass out directions for soapmaking. Soap recipes can be found from many sources; several are listed in the references. Caution students concerning using lye solutions. Remind them to wear aprons and goggles at all times. Caution students not to try lab soaps on their skin. When their soap is finished, the students should design a procedure to demonstrate the soaps ability to disperse oil droplets in a test tube of water.

Evaluation Criteria:

Formative Assessment #1 (3.4.10A): Student groups should show correct models for ***each*** system:

Polar-polar: Red magnets for both solute; blue magnets for solvent; magnets should be mixed, showing attractions between the solute and solvent resulting in solution.

Polar solvent-Nonpolar solute: Red Popsicle sticks representing the nonpolar solute interfere with the blue magnets representing the polar solvent, so the solvent molecules push the solute out of solution; magnets and Popsicle sticks remain separate, representing no solution.

Nonpolar solvent-polar solute: there are no attractions between the red magnets and blue Popsicle sticks, so the solute-solute attractions are not broken, solution process cannot begin; magnets and Popsicle sticks remain separate.

Nonpolar solvent-nonpolar solute: Blue sticks represents the solvent, red sticks represent the solute; once the sticks are mixed, they stay mixed, representing successful solution.

Formative Assessment #2 (3.2.10B): Each group should have a design with *one* independent variable to be studied and one specific, quantitative response to be measured. Each group must have a hypothesis stated in if, then form.

Summative Assessment #1 (3.2.10C): Each group will submit a lab report which contains a statement of purpose, a hypothesis, a specific procedure which includes a list of materials and step by step instructions, a data table, and a conclusion which is supported by the data.

Summative Assessment #2 (3.4.10A) : Each group will design a poster which includes the name of their soap, and a diagram which demonstrates the relationship between the structure of the soap molecule and the function of facilitating the solution of a nonpolar molecule in water. Posters will be assigned a score with point scale divided evenly between scientific content and artistic/creative effort.

Related Web Sites:
services.juniata.edu/ScienceInMotion/bio/standardslabs/dna%20extraction.doc
/www.upb.pitt.edu/UPB%20SIM%20BIO/bio011b_BananaSpooling.doc
http://waltonfeed.com/old/soap/soap.html
www.ehow.com/ehow/ehowDetails.jsp?id=5911
http://members.aol.com/oelaineo/soapmaking.html
http://www.pinemeadows.net/recipes.php#r1