Teacher's Preparatory Guide

Lesson #1 – Polarity and Solubility of Molecules

This is a series of four lessons which build upon each other to explore the use of nanotechnology in cosmetics as well as the social and ethical issues associated with nano-based cosmetics. The purpose of these lessons is to familiarize students with the chemistry of cosmetics and the anatomy of the skin.

Purpose: This lesson will familiarize students with polar and non-polar substances and chemical bonding.

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Time required: 50 minute class period

Level: AP Chemistry, Honors Chemistry, and/or Human Anatomy

Teacher Background: Teacher will have to be familiar with polar and non-polar substances. Most high school chemistry textbooks will have sections on polar and non-polar bonds. There is a discussion of this under "Directions for the Activity" section which is below. Internet resources are listed at the end of the unit.

Materials:

- Student notes and websites (see Resources)
- Vegetable oil (~1 quart)
- Water
- Food coloring (a few drops)
- Clear plastic see-through bottle (1-2 Liter)
- Student worksheet
- Hexane
- Plastic spoons
- Spray adhesive
- Magic Sand
- Play sand
- Beakers
- Pipettes

Advance Preparation:

1. Teacher will check websites and applets to make sure they are currently available.
2. Teacher will prepare notes on polar and nonpolar molecules.

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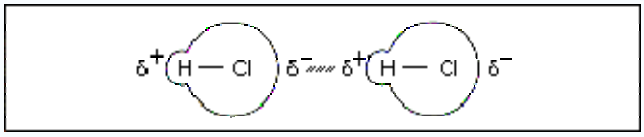
3. Teacher will prepare a demonstration on the immiscibility of polar and nonpolar molecules.
4. Teacher will make copies of the student worksheet.

Directions for the Activity:

1. Teacher will discuss what makes molecules polar and non-polar while reviewing intermolecular forces.

- A difference in electronegativities determines if a molecule contains bonds that are polar or non-polar. In molecules with polar bonds, there is an uneven sharing of electrons in a covalent bond (C-Cl bond). In molecules with nonpolar bonds, there is an equal sharing of electrons (C-C bond). A molecule can be made up of polar bonds yet it is nonpolar if these bonds are equally dispersed throughout the molecule and there is no net dipole moment. In this case, the molecule would be nonpolar.
- Intermolecular forces are the forces that are 'between' molecules. There are three main types of intermolecular forces: London dispersion, dipole-dipole forces, and hydrogen bonding. All of these are forces of attraction between atoms or molecules. The forces involved with the skin and with penetration of cosmetics into the skin are dipole-dipole forces (forces between polar molecules). One specific type of dipole-dipole force is hydrogen-bonding (a dipole-dipole force between hydrogen and another very electronegative atom such as chlorine, oxygen, or nitrogen). Below is an example of hydrogen bonding between two molecules of hydrochloric acid.



(Bonder Group, 2008)

- Polar and nonpolar molecules are not immiscible in each other; they will not mix. An important ingredient in skin care products is silicone polymers because they possess properties such as the ability to reduce surface tension, wetting, and emulsification. Silicone polymers are neither oil-soluble (nonpolar) or water-soluble (polar). They are hydrophobic and oleophobic (O'Lenick Jr. & O'Lenick, 2007). Hydrophobic means lacking an affinity for water and oleophobic means lacking an affinity for oils.

2. Teacher will fill a clear-plastic see-through bottle half full with water. Add a couple of drops of the food coloring of your choice to the water. Now fill the bottle the remainder of the way up with oil. Have students make a prediction about what will happen when the

bottle is shaken (ex. The two liquids will mix completely together and become one.) Show students that polar and nonpolar molecules do not mix. Reiterate the meaning of hydrophobic and olephobic.

3. Give each student two spoons each sprayed with adhesive – one covered with magic sand and one covered with regular play sand. Give each student a beaker with water and a pipette. Ask each student to use the pipette to put some water on each spoon and have them make observations. Discuss the students' observations with them (magic sand is hydrophobic, doesn't mix with water, sand is silvery, etc. regular sand absorbs water, doesn't "bead up," gets soggy, etc.). Teacher will then discuss that magic sand is covered with nano-size silicon compound that makes it nonpolar and therefore hydrophobic. Teacher will then take a beaker of hexane and add magic sand to the hexane. They will mix. Have students make observations – students should come up with the idea that the liquid must be nonpolar. Then add water to the solution and the sand comes out of the solution again. This will help the students decipher between polar and nonpolar properties.

4. Teacher will visit website resources to help support the notes just given.

5. Teacher will hand out student worksheet to reinforce the lesson's material.

- Cleanup: The teacher will clean-up the demonstration of the oil and water. Students will turn their spoons into the teacher and pour the water down the sink.

Assessment:

- Worksheet on determining polar and nonpolar molecules.

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Student Worksheet on Polarity

Instructions: Determine whether the following are covalent or ionic compounds. If covalent, determine if they contain polar or nonpolar bonds. Finally, determine if the molecule is polar or nonpolar.

Compound	Ionic or Covalent	Polar/Nonpolar bonds	Polar/Nonpolar Molecule
NaCl	Ionic	----------	----------
CO_2	Covalent	Polar	Nonpolar
CCl_4	Covalent	Polar	Nonpolar
H_2O	Covalent	Polar	Polar
$MgCl_2$	Ionic	----------	----------
NO_2	Covalent	Polar	Polar
NH_3	Covalent	Polar	Polar
NH_4^+	Covalent	Polar	Nonpolar
HCl	Covalent	Polar	Polar
CH_4	Covalent	Polar	Nonpolar
CH_3Cl	Covalent	Polar	Polar
BF_3	Covalent	Polar	Nonpolar
KBr	Ionic	----------	----------
N_2	Covalent	Nonpolar	Nonpolar

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Resources:
To learn more about intermolecular forces, here are some web sites to go along with this lesson:

- http://sag1.chem.pitt.edu/~daniel/forces.html
- http://www.chalkbored.com/lessons/chemistry-11.htm (Great PowerPoint Lesson on intermolecular forces!)
- http://en.wikipedia.org/wiki/Mars_sand
- http://www.youtube.com/watch?v=-1id-gHQjbs

Sources for magic sand:

- http://www.stevespanglerscience.com/product/1331
- http://www.teachersource.com/Chemistry/HydrophilicHydrophobicPolymers/MagicSand.aspx
- http://www.discountschoolsupply.com/product/productdetail.aspx?product=23527&es=10190200000

National Science Education Standards
Content Standard B: Physical Science (grades 9 – 12)

- Structure of atoms
- Structure and properties of matter
- Chemical reactions

References:

Bonder Group, (2008). Intermolecular Forces. Retrieved March 22, 2008, from The Bonder Group Chemical Education Division Web site: http://chemed.chem.purdue.edu/genchem/topicreview/bp/intermol/intermol.html

O'Lenick Jr., Author's first name initialAnthony J., & O'Lenick, Kevin A. (2007). Silicone Polymers in Skin Care. *MRS Bulletin. 32*, 801-806.

Schneider, Jeremy (2008). Chemistry PowerPoint Lessons, Handouts, Labs, and Worksheets. Retrieved March 23, 2008, from Chalkbored Web site: http://www.chalkbored.com/lessons/chemistry-11.htm

Schofield, Daniel (2008). Daniel Schofield - Intermolecular Forces. Retrieved March 22, 2008, from Daniel Schofield - Post doctoral Fellow, University of Pittsburg Web site: http://sag1.chem.pitt.edu/~daniel/forces.html

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