Polar and Nonpolar Molecules

Polar vs. Nonpolar Compounds

Introduction

Use this "hair-raising" demonstration of static electricity to show students what it means to say that water is a polar molecule.

Concepts

- Chemical bonding
- Polar and nonpolar molecules
- Electrostatics

Materials

Toluene, $C_6H_5CH_3$, 50 mL
Water, 50 mL
Animal fur friction pad
Beakers or flasks, 150-mL, 2
Buret clamp, double
Burets, 50-mL, 2
Ebonite (rubber) friction rod
Glass or plastic rod
Silk friction pad
Support stand

Safety Precautions

Toluene is moderately toxic by ingestion, inhalation, and skin absorption. It is a flammable liquid and a fire risk—avoid contact with flames, heat, and other sources of ignition. Work with toluene in a hood or well-ventilated lab only. Wear chemical splash goggles, chemical-resistant gloves, and chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Clamp two 50-mL burets to a support stand using a double buret clamp.
2. Fill the two burets with liquid, one with water and the other with toluene.
3. Rub the glass rod with silk—the glass rod will become positively charged.
4. Partially open the stopcock on the buret filled with water and allow water to flow into an empty beaker or cup. Hold the positively charged glass rod next to the water stream from the buret and observe. The stream of water will be "bent" toward the glass rod.
5. Discuss the nature of electrostatic attraction and repulsion (opposites attract). What is the "charge" on the water molecules?
6. Rub the ebonite (rubber) rod with animal fur or wool—the rubber rod will become negatively charged.
7. Hold the negatively charged rubber rod next to the water stream from the buret and observe. The stream of water will be "bent" toward the rubber rod.
8. What is the "charge" on the water molecules? It appears from steps 4 and 7 that water molecules are both positively and negatively charged! Discuss the separation of charges or partial positive and partial negative charges on different atoms in water and other polar molecules.
9. Repeat steps 3–8 on a stream of toluene from the second buret. Collect the toluene in a clean beaker or flask. No effect is observed when charged rods are brought near the toluene stream. Toluene is a nonpolar compound—the bonding electrons are approximately equally shared between atoms and the substance is neither attracted to nor repelled by a charged rod.

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Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Collect and save the toluene for subsequent use. Toluene may be disposed of according to Flinn Suggested Disposal Method #18b.

Tips

- Other nonpolar hydrocarbon solvents such as hexane or petroleum ether may be substituted for toluene. These solvents are more volatile and a greater fire risk than toluene. Work with volatile organic solvents in a hood or well-ventilated lab only.
- Static electricity experiments always work best on a dry day. Lower humidity days are better than high humidity days. Air-conditioned air or heated winter air tends to be drier and thus, more conducive for electrostatic demonstrations.
- If the area surrounding the burets is highly charged, the demonstrations may not work well. Wipe down the area with a damp cloth and dry with a towel.

Discussion

Rubbing different materials together creates different charge combinations. Some materials or substances hold onto electrons more tightly than others and thus, depending upon the materials, positive or negative charges will be created. Oppositely charged particles attract each other and like-charged particles repel each other. The relative electrostatic position of common substances, from those that most freely give up electrons and become positively charged, to those that only reluctantly give up electrons and thus become negatively charged, is as follows: acetate, glass, wool, fur, silk, paraffin, ebonite, brass.

When ebonite (rubber rod) and fur are rubbed together, some of the electrons from the atoms in the fur are "captured" by the atoms of the ebonite, which exert stronger forces of attraction on those electrons than do the atoms of the fur. Thus, after the rubbing, the ebonite has an excess of electrons (negative charge) and the fur has a deficit (positive charge). If any two substances are rubbed together, the substance that is higher in the list becomes negatively charged, while the lower substance becomes positively charged. Knowing these properties allows you to explain the electrostatic attractions and repulsions in this demonstration.

Water is a highly polar molecule, characterized by charge separation between the oxygen and hydrogen atoms in its O—H bonds. Molecules are classified as polar or nonpolar based on the nature of the electron sharing between atoms. In polar covalent bonds the bonding electrons are not equally shared between atoms. In the case of water molecules, oxygen is more electronegative than hydrogen and thus has a greater affinity for the bonding pairs of electrons. Each O—H bond has a dipole moment, with the oxygen atoms described as bearing a partial negative charge and the hydrogen atoms having a partial positive charge. The stream of water was attracted to both positively and negatively charged friction rods.

Polar bonds are a necessary but not sufficient condition for a molecule to be classified as polar. If individual bond dipoles cancel each other out due to the overall molecular geometry of the molecule, the molecule and the compound itself will be nonpolar. Polar molecules tend to exert stronger attractive forces than nonpolar molecules. The polarity of a compound determines the types of intermolecular attractive forces between molecules and is an important factor influencing the physical properties of a substance.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter
Content Standard G: History and Nature of Science, nature of scientific knowledge

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Polar and Nonpolar Molecules* activity, presented by Irwin Telesnick, is available in *Polar vs. Nonpolar Compounds*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Polar and Nonpolar Molecules* are available from Flinn Scientific, Inc.

Catalog No.	Description
T0019	Toluene, Reagent, 500 mL
GP1087	Buret, Flint Glass, with Teflon Stopcock, 50-mL
AP2261	Double Buret Clamp
AP9203	Solid Glass Friction Rod
AP9169	Hard Rubber Friction Rod
AP9208	Silk Friction Pad
AP9204	Animal Fur Friction Pad, Large

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.