Graphite Disk Demonstration

Face-Up or Face-Down?

Introduction

Observe the orientation of graphite-coated paper disks in two-phase solvent systems containing water and an organic solvent. Will the graphite side of the paper disk emerge face-up or face-down in the solvent mixture? Use this demonstration to illustrate the difference between polar and nonpolar substances and their affinity for one another.

Concepts

- Covalent bonds
- Polar vs. nonpolar compounds
- Density

Materials

Food coloring (optional)
Hexane, C_6H_{14}, 50 mL
Trichloroethylene, C_2Cl_3H, 50 mL
Water, distilled 100 mL
Bottles, wide-mouth, with caps, or beakers, 250-mL, 2
Graduated cylinder, 50-mL
Index card, white, 3″ × 5″
Paper punch
Pencil, No. 2
Stirring rods, 2 (optional)
Test tubes, 4 (optional)

Safety Precautions

Trichloroethylene is a possible carcinogen. It is slightly toxic by ingestion and inhalation—the vapor may be harmful to the eyes, skin, and lungs. Avoid breathing the vapor and work with the solvent in a fume hood or well-ventilated lab only. Do not allow students to open the bottles and breathe the solvent vapors. Hexane is a flammable solvent and a dangerous fire risk; avoid contact with flames, heat, and other sources of ignition. Wear chemical splash goggles and chemical-resistant gloves and apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Using a No. 2 pencil, thoroughly blacken one side only of an index card with graphite (pencil lead). Punch out 20–30 paper disks with a paper punch.
2. Add 50 mL of water and 50 mL of trichloroethylene to a labeled wide-mouth bottle or 250-mL beaker.
3. Add about 10 graphite-coated disks to the bottle and cap the bottle, if possible.
4. Shake the bottle once (or stir the mixture in the beaker) and observe the orientation of the graphite disks in the two-phase solvent system.
5. *(Optional)* Pass the capped bottle around and ask students to suggest possible explanations for the observed orientation of the graphite and paper sides of the paper disks. *(The disks should all be lying with their graphite-coated sides face down toward the more dense, lower solvent layer, trichloroethylene.)*
6. Add 50 mL of water and 50 mL of hexane to a second labeled wide-mouth bottle or 250-mL beaker.
7. Add about 10 graphite-coated disks to the bottle and cap the bottle, if possible.
8. Shake the bottle once (or stir the mixture in the beaker) and observe the orientation of the graphite disks in the two-phase solvent system.
9. *(Optional)* Pass the capped bottle around and ask students to suggest possible explanations for the observed orientation of the graphite and paper sides of the paper disks. *(The disks should all be lying with their graphite-coated sides face up toward the less dense, upper solvent layer, hexane.)*
10. *(Optional)* Remove 10–15 drops of each liquid layer from the two solvent systems and place each liquid in a separate test tube. Add food coloring to determine which layer is which in each system. *(Food dyes are ionic and highly polar compounds that are soluble in water but insoluble in nonpolar organic solvents.)*

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Disposal

Consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. We have found that once made, the sealed bottles will keep for many months without discoloring or decomposing. Clearly label each bottle with the name of each solvent and save the graphite disk bottles for future use. When ready to dispose of the bottles, remove the graphite disks from the two-phase solvent systems and separate the two liquid layers in each bottle. Save the organic solvents in properly labeled bottles for future use.

Tip

- The recommended organic solvents are "hexanes," a mixture of *n*-hexane and other C_6H_{14} isomers, and trichloroethylene. Both solvents are nonpolar and immiscible with water. Other heavier-than-water halogenated organic solvents, such as methylene chloride or chloroform, may also be used instead of trichloroethylene. Take special care when using more volatile halogenated organic solvents—they have very low TLV values and may be narcotic even at low concentrations.

Discussion

Paper is made from cellulose, a polysaccharide composed of glucose repeating units. The presence of multiple –OH groups per glucose unit makes the paper surface very hydrophilic—it is attracted to water molecules. Graphite, the most stable form of the element carbon, is composed of rings of carbon atoms joined together via covalent bonds to form a layered structure. Because all of the atoms in graphite are the same, graphite is a nonpolar, hydrophobic substance. In a two-phase solvent system composed of water and a nonpolar organic solvent, the graphite disks will always orient themselves such that the paper side faces the water layer and the graphite side faces the organic solvent layer. Hexane is a nonpolar hydrocarbon solvent that is less dense than water. It forms the upper layer in a two-phase mixture with water, and the graphite disks are face-up in this mixture. Trichloroethylene is a halogenated organic solvent that is more dense than water. It forms the lower layer in a two-phase mixture with water, and the graphite disks are face-down in this mixture.

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

Reference

This activity was adapted from *Chemical Bonding*, Vol. 5 in the *Flinn ChemTopic™ Labs* series; Cesa, I., Editor; Flinn Scientific: Batavia IL (2004).

Materials for *Graphite Disk Demonstration—Face-Up or Face-Down?* are available from Flinn Scientific, Inc.

Catalog No.	Description
H0046	Hexanes, 100 mL
T0037	Trichloroethylene, 500 mL
AP8452	Bottle, French Square Style, 240-mL

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