Bonding Bottles

Intermolecular Forces

Introduction

Use simple tests of common laboratory chemicals to demonstrate the properties of London dispersion forces and hydrogen bonding.

Concepts

- London dispersion forces
- Intermolecular forces

Materials

n-Amyl alcohol, $CH_3(CH_2)_4OH$, 25 mL

Glycerin, $C_3H_5(OH)_3$, 25mL

n-Heptane, C_7H_{16}, 25 mL

Isopropyl alcohol, $(CH_3)_2CHOH$, 25 mL

Pentane, $CH_3(CH_2)_3CH_3$, 25 mL

1,2-Propanediol, $CH_3CHOHCH_2OH$, 25 mL

Erlenmeyer flasks, 250-mL, 6

Parafilm M®

Rubber stoppers, size 6, 6

Safety Precautions

n-Heptane is a dangerous fire risk, a flammable liquid and slightly toxic by inhalation. n-Amyl alcohol is a moderate fire risk; slightly toxic by ingestion and inhalation; severe body tissue irritant. Glycerin should not contact chromium trioxide, potassium chlorate or potassium permanganate as it may cause an explosion. Some people are allergic to glycerin and may experience irritation to skin and eyes. Isopropyl alcohol is a flammable liquid; fire hazard; slightly toxic by ingestion and inhalation. Pentane is a flammable liquid and narcotic in high concentrations Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling and disposal information.

Preparation

1. Obtain six 250-mL Erlenmeyer flasks.
2. Pour 25 mL of n-amyl alcohol into one of the flasks.
3. Insert a solid, size 6 rubber stopper into the flask and wrap Parafilm M around the stopper at the top of the flask. Label the flask.
4. Repeat steps 2 & 3 with the remaining flasks and chemicals (glycerin, n-Heptane, isopropyl alcohol, pentane, 1,2-propanediol.

Procedure

Part A. Presence of alcohol

1. Obtain the two flasks containing pentane and n-amyl alcohol.
2. Shake both solutions at the same speed for the same amount of time. Observe which settles more quickly.

Part B. Comparing carbon count

3. Obtain the two flasks containing pentane and heptane.
4. Shake both solutions at the same speed for the same amount of time. Observe which solution settles the most quickly and which solution produces more or less bubbles.

Publication No. 91811
061616

Part C. Quantity of alcohol

5. Obtain the three flasks containing isopropyl alcohol, 1,2-propandiol and glycerin.
6. Shake all three solutions at the same rate for the same amount of time. Observe which solution settles most quickly and which produces more or less bubbles.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory wastes. List each chemical and/or waste product and the proper disposal method. For example, "The waste hydrochloric acid may be disposed of by neutralizing with base and then disposing of down the drain with plenty of excess water according to Flinn Suggested Disposal Method #24b."

Tips

- n-Amyl alcohol is also known as propanol as Peg Convery refers to the chemical in this episode.
- 1,2-Propanediol is also known as propylene glycol as Convery refers to the chemical in this episode.
- Glycerin is also known as glycerol as Convery refers to the chemical in this episode.

Discussion

Intermolecular forces include dipole–dipole attractions, hydrogen bonding, dipole-induced dipole attraction, and London dispersion forces. All of these types of forces are electrostatic in nature. Electrostatic forces arise when the molecules contain or are capable of creating areas of charge separation. Dipole–dipole interactions and hydrogen bonding play the most important roles in determining the overall properties of the compounds. Dipole–dipole interactions occur only in polar compounds. The greater the polarity of the molecules, the larger the force of attraction between those molecules.

Part A of this demonstration compares pentane, $CH_3(CH_2)_3CH_3$ and n-amyl alcohol, $CH_3(CH_2)_4OH$. Both molecules have an equal number of carbons, 5. The only difference between these molecules is that n-amyl alcohol contains an alcohol (–OH) functional group. When pentane and n-amyl alcohol are both shaken at the same rate for the same time the n-amyl alcohol will settle more quickly as it has stronger intermolecular forces.

Part B of this demonstration compares pentane to heptane. Pentane, $CH_3(CH_2)_5CH_3$, is a molecule containing five carbons while heptane, C_7H_{16}, contains seven carbons. When both solutions are equally shaken, the heptane settles more quickly. The greater the number of carbon molecules, the greater the London dispersion forces. Since heptane contains two more carbons than pentane it will settle more quickly.

Part C of this demonstration compares three solutions: isopropyl alcohol $(CH_3)_2CHOH$, 1,2-propanediol $CH_3CHOHCH_2OH$ and glycerin $C_3H_5(OH)_3$. Each of these molecules contains the same amount of carbons. The variable between the three is the amount of –OH groups attached to each. The more –OH groups a molecule has the stronger the hydrogen bonds will be between these molecules. Therefore, when all three solutions are shaken equally the solution with the most –OH groups will settle the fastest and produce the least bubbles due to its high intermolecular forces.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter, motions and forces
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure of atoms, structure and properties of matter, motions and forces

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Bonding Bottles* activity, presented by Peg Convery is available in *Intermolecular Forces* and *Properties of Liquids*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Bonding Bottles* are available from Flinn Scientific, Inc.

Catalog No.	Description
A0182	n-Amyl Alcohol, 100 mL
G0007	Glycerin, 500 mL
H0051	n-Heptane, 100 mL
I0019	Isopropyl Alcohol, 500 mL
P0213	Pentane, 100 mL
P0200	1,2- Propanediol, 100 mL
AP1500	Parafilm M®, 29 5 250 ft

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