Viscosity Race

Intermolecular Forces

Introduction

The properties of liquids reflect the bonding within molecules and the nature and strength of forces between molecules. The difference in the viscosity of similar liquids is a good starting point to introduce the forces between molecules that influence the rate of evaporation, vapor pressure, and boiling point of the liquid.

Concepts

- Intermolecular forces
- Hydrogen bonding

Materials

1,2-Propanediol, $CH_3CHOHCH_2OH$, 100 mL
Copper, shot, about 20
Glycerin, $C_3H_5(OH)_3$, 100 mL
Isopropyl alcohol, $(CH_3)CHOH$, 100%, 100 mL
Balls, hollow plastic or similar, 3
Graduated cylinders, 100-mL, 3
Timers or clock with second hand, 3

Safety Precautions

Isopropyl alcohol is a flammable liquid and a fire hazard. It is slightly toxic by ingestion and inhalation. Use in a well ventilated room. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Some people are allergic to glycerin and may experience skin and eye irritation. Never allow glycerin to come into contact with strong oxidants as an explosion may occur. 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. Add 100 mL of each liquid to graduated cylinders.
2. Determine the correct number of copper balls to insert into the hollow plastic ball. The students should be able to see the difference between the "fall rate" for each of the three liquids.

Procedure

1. Simultaneously release one ball into each of the three graduated cylinders.
2. Record the time it takes for each ball to fall to the bottom of its graduated cylinder.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The isopropyl alcohol may be disposed of by allowing it to evaporate in a fume hood according to Flinn Suggested Disposal Method #18a. The 1,2-propanediol may be reused or disposed of using a licensed waste hauler according to Flinn Suggested Disposal Method 18b. Glycerin may be disposed of down the drain with an excess of water according to Flinn Suggested Disposal Method 26b.

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Tips

- Determine if the plastic balls react with the three liquids before performing this demonstration.
- Determine the number of copper balls necessary to sink somewhat slowly through the liquids.
- Fill tall test tubes with each liquid, add the weighted plastic ball, and cap the test tube to make a reusable version of this demonstration.
- The hollow blue balls discussed in the video are part of the kit Earth's Magnetic Field (Catalog No. AP7157), available from Flinn Scientific.
- Use this demonstration to speculate as to the ranking of the rate of evaporation, vapor pressure, and boiling point of each liquid.

Discussion

Molecules are "held together" in condensed phases (liquids and solids) by intermolecular forces. Intermolecular forces are defined as attractive forces between molecules. There are three kinds of intermolecular forces—dipole–dipole interactions, hydrogen bonds, and dispersion (London) forces. These forces vary in strength, with hydrogen bonds being the strongest and London dispersion forces being the weakest.

Hydrogen bonding is an especially strong form of dipole–dipole interaction. A dipole-dipole interaction is the attraction of the positive end of one polar molecule for the negative end of another polar molecule. In hydrogen bonding, a hydrogen atom serves as a bridge between two electronegative atoms (such as nitrogen, oxygen, or fluorine). Due to its strength, hydrogen bonding plays a major role in the properties of water and alcohols. Hydrogen bonding between water molecules leads to a very high boiling point when compared to other similar liquids.

The isopropyl alcohol molecules in the graduated cylinder are able to form one hydrogen bond with an adjacent isopropyl alcohol molecule. Diols, in this case 1,2-propanediol or propylene glycol, form two hydrogen bonds with adjacent molecules. Glycerin, also known as glycerol, forms three hydrogen bonds with adjacent molecules. The ball must work its way through the hydrogen balls as it falls through the liquid. The more hydrogen bonds it encounters the longer amount of time it takes for the ball to fall.

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
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

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

Materials for *Viscosity Race* are available from Flinn Scientific, Inc.

Catalog No.	Description
I0019	Isopropyl Alcohol, 100%, 500 mL
P0128	1,2-Propanediol, 500 mL
G0007	Glycerin, 500 mL
C0083	Copper, Shot, 100g

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