The University of Texas at Austin
Department of Chemistry
College of Natural Sciences

Immiscible Liquids

Performer's Version

Safety Hazards

- Personal Protective Equipment
  - Safety glasses/goggles
  - Nitrile gloves
  - Chemical & flame retardant lab coat
- Chemical Hazards
  - Methylene chloride may cause skin irritation, eye damage; may cause drowsiness and dizziness; may cause damage to liver, kidneys, blood, and central nervous system; may cause cancer.
  - Copper(II) sulfate is harmful if swallowed; may cause skin irritation and severe eye irritation.

Materials

- Immiscible liquids demonstrations bottle.

Safety Data Sheet(s)

- Methylene chloride
- Copper(II) sulfate
- Alizarin yellow R

Procedure

1. The demo team will provide a bottle of 250 mL deionized water (colored blue with copper sulfate) and 250 mL of methylene chloride (colored yellow with alizarin yellow R).
2. Shake the bottle and the two liquids form a momentary green emulsion.
3. This emulsion quickly separates after shaking stops and the liquids separate from green to their respective blue and yellow layers.

Pedagogy & Supplemental Information

Miscibility refers to the ability of two liquids to mix and form a homogeneous solution. The miscibility of substances is largely determined by the nature of their intermolecular forces (IMFs) and their chemical properties. Substances with similar types and strengths of IMFs are generally miscible, following the principle of "like dissolves like." For instance, polar solvents tend to be miscible with other polar solvents due to the mutual attraction of their dipole-dipole interactions or hydrogen bonding, while nonpolar solvents mix well with other nonpolar solvents due to their dispersion forces.

In the demonstration involving water dyed with cupric sulfate and methylene chloride dyed with alizarin yellow R, the two liquids initially form a temporary green emulsion when mixed, but they quickly separate back into distinct layers. This behavior highlights their immiscibility. Water is a polar solvent with strong hydrogen bonding, while methylene chloride (dichloromethane) is a moderately polar solvent with significant dipole-dipole interactions but lacks the capability for hydrogen bonding. The disparity in their IMFs prevents them from forming a stable, homogeneous mixture, leading to the observed phase separation.

The principle behind the miscibility of organic compounds with water further elucidates this behavior. The length of the hydrocarbon chain in an organic molecule significantly affects its miscibility with water. Ethanol, with its short two-carbon chain, remains miscible with water due to the dominance of its hydroxyl group's hydrogen bonding with water molecules. However, as the hydrocarbon chain lengthens, as seen in 1-butanol with four carbon atoms, the nonpolar character of the molecule increases, reducing its miscibility with water. Octanol, with an eight-carbon chain, is practically insoluble in water due to the overwhelming influence of its nonpolar hydrocarbon chain.

This pattern extends to other functional groups in organic chemistry. For example, carboxylic acids up to butanoic acid are miscible with water, while those with longer chains, like hexanoic acid, are not. The same trend is observed with aldehydes and ketones. The increasing hydrocarbon chain length enhances the nonpolar characteristics of these molecules, diminishing their ability to interact with the polar water molecules through hydrogen bonding or dipole interactions, thus leading to immiscibility. This understanding of miscibility based on molecular structure and IMFs has practical applications in fields such as pharmaceuticals, where the solubility of compounds in various solvents can influence drug formulation and delivery.