

11.2 Polydensity Bottle (Educational Innovations Inc product #DEN-460)

Subjects: Intermolecular forces, liquids, solutions, salting out, density

Description: When a 1 L bottle is shaken, the blue and white beads mix within the liquid as expected. However, when allowed to settle, the beads separate, white at the top and blue at the bottom. Shortly, the two separated colored beads slowly come together until they meet in the center of the liquid, white on top of blue. The mixing and separating can be observed over and over.

Materials: (Located in the flammables cabinet)

Pre-prepared polydensity bottle (containing rubbing alcohol, water with NaCl, and polydensity beads)

[See Educational Innovations website for preparation of bottle contents.]

Procedure:

1. Shake the bottle to mix the contents, let stand, and observe.

Discussion: (taken from Educational Innovations website)

Water and isopropanol are soluble in all proportions; they are miscible. Both the water molecules and the alcohol molecules have -OH groups that easily hydrogen bond to each other. The sodium chloride salt particles, Na^+ and Cl^- , however, preferentially bind with the water molecules, forcing the alcohol molecules out of the water solution. This causes two layers to form: alcohol on top and the more dense water and salt layer on the bottom. Isopropanol and salt water are immiscible; they do not mix in all proportions. This "salting out" technique is commonly used to remove organic molecules from an aqueous solution.

When the bottle is shaken, the two liquid layers momentarily mix, forming a pseudo homogenous mixture with a density between the two separate liquid densities. The white beads with a lesser density than this liquid mixture float on top and the blue beads with a greater density sink to the bottom. Then, as the aqueous salt layer separates from the alcohol, the blue beads rise in the bottom aqueous layer and the white beads sink in the top alcohol layer until they meet in the center. From lowest density to highest density the order is as follows: isopropanol, white beads, blue beads, and salt water. Because the beads float between the two liquids, the actual alcohol/salt water interface is difficult to observe, adding to the mystery. Order spontaneously forming from disorder is unexpected and gives the illusion of a violation of the Second Law of Thermodynamics.

Safety: Isopropal alcohol is a flammable liquid. Handle the bottle with care so as not to spill or break it.

Disposal: None

References:

1. Educational Innovations Inc. (www.teachersource.com)