DECREASE IN VOLUME

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MATERIALS NEEDED

Glass tube, 7 or 8 mm outside diameter by 100 to 120 cm long with ends firepolished
2 corks or rubber stoppers to fit the glass tube
funnel to fit into glass tube (A funnel can be made by cutting off the top half of the bulb of a thin stem Beral pipet)
2 beakers, 100 or 150 mL
food color
ethanol, C_2H_5OH, anhydrous or absolute, 100% (specially denatured) (Note: substitute absolute methanol)
water
ruler or meter stick

SAFETY PRECAUTIONS

Wear safety goggles while performing this experiment.

Ethyl alcohol is flammable, keep it away from all flames.

The ends of the glass tubing should be firepolished to eliminate sharp edges and to provide strength. As an extra safety precaution, wrap a piece of clear packaging tape around the ends of the glass tube to protect against breakage. CAUTION: Do not substitute a piece of plastic tubing in place of the glass. The plastic tube will break due to the lower pressure produced in the tube by the reaction.

DISPOSAL

The alcohol solution produced in this experiment can be safely poured down a drain with running water.

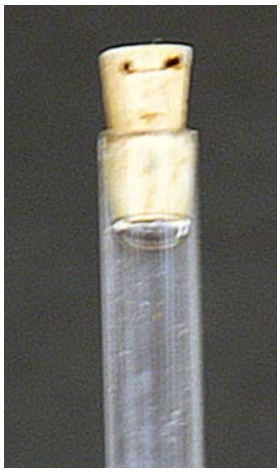
EXPERIMENTAL PROCEDURE

Add some food color to approximately 50 mL of water.

Stopper one end of the glass tube and, using a small funnel, half-fill the tube with the colored water.

Fill the glass tube the rest of the way with the absolute ethanol. Leave a small bubble, approximately 0.5 cm in length, at the top of the tube when it is stoppered. (You may want to measure the length of the air bubble.) (See Figures 1, 2, and 3)

Holding the stoppers in place, invert the tube so that the air bubble moves from the alcohol end to the water end. Observe the bubble and the degree of mixing between the water and the alcohol. (Note: The food color is an indicator of how much mixing occurs.)



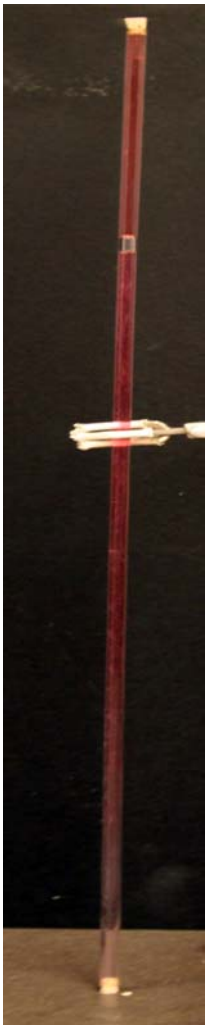


Figure 1. (Left) The initial tube filled with alcohol and colored water.

Figure 2. (Center, above) The initial bubble in the tube.

Figure 3, (Right) The inverted tube with the alcohol and water partially mixed.

Continue to invert the tube, letting the air bubble reach the opposite end of the tube each time before inverting the tube again. Observe the air bubble each time. When the color of the solution in the tube is uniform, the two liquids should be well mixed.

What happened to the air bubble? (Measure the length of the air bubble.) (See figures 4 and 5)

Figure 4. (Left) The moving bubble in the inverted tube.

Figure 5. (Right) The final bubble after the liquids are mixed.

EXPLANATION

Both water and alcohol molecules are polar with hydrogen bonding (the attraction between a hydrogen atom on one molecule with an oxygen atom on another molecule). In the pure liquids, the attraction of the molecules due to the hydrogen bonding and the normal repulsions due to similar atoms on the molecules (e.g., hydrogen-hydrogen repulsions or oxygen-oxygen repulsions between two water molecules) result in the molecules being separated by some average distance. This distance will vary in different liquids depending on their structures and is one of the factors that contributes to the density of the liquid.

In a solution of alcohol and water, the attractions and repulsions between the two different molecules is such that the alcohol and water molecules can move closer together than two water molecules or two alcohol molecules, resulting in a decrease in the volume of the solution compared to the sum of the individual volumes of the original liquids.

Acknowledgement

The author wishes to thank Dr. Courtney Willis, Department of Physics, University of Northern Colorado, for this demonstration.