# Sorting Out Solutions

Chemical Demonstration

## Introduction

Two clear liquids are combined to form a homogeneous mixture. As a solid is added, the solution begins to separate into two layers. As more solid is added, the two layers become more distinct.

## Concepts

- Miscible liquids
- Hydrogen bonding
- Salting-out

## Materials

Ethyl alcohol, 95%, 150 mL

Potassium carbonate, anhydrous, $K_2CO_3$, 85 g

Water, distilled or deionized, 150 mL

Beaker, 600-mL

Food coloring (optional)

Magnetic stirrer and stirring bar or stirring rod

## *Safety Precautions*

*Ethyl alcohol is flammable, a dangerous fire risk, and toxic by ingestion and inhalation. Keep from sources of heat and flame. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.*

## Procedure

1. Add 150 mL of ethyl alcohol to a 600-mL beaker.
2. Add 150 mL of distilled or deionized water to the same beaker.
3. Place a magnetic stirring bar in the beaker and place the beaker on the magnetic stirrer. (A stirring rod also works but takes longer.)
4. Mix the solution until it is homogeneous.
5. Add food coloring if available (see *Tips*).
6. Add 25 g of potassium carbonate to the solution and stir until all the solid has dissolved. Two separate layers will begin to appear. The top layer is the larger volume and is the organic mixture. The smaller, bottom layer is the aqueous mixture.
7. Continue to add potassium carbonate in 20-g portions. The two liquid layers will become equal in volume after approximately 85 g of potassium carbonate has been added.

## Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The resulting solution may be flushed down the drain with excess water according to Flinn Suggested Disposal Method #26b.



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## Connecting to the National Standards

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

***Unifying Concepts and Processes: Grades K–12***
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

## Tips

- Use a tall form beaker to enhance the effect.
- Use food coloring to enhance the visual effect of the demonstration. If you have McCormick® Assorted Food Colors (available in any grocery store) here are a few suggestions:
  - Use a few drops of blue and a few drops of yellow (following step 2 in the procedure) to make a green ethyl alcohol and water mixture. As the solution separates, the upper layer will remain green. The lower layer will be yellow.
  - If just green food coloring is used, the solution will "sort out" into a green upper layer and a lighter green lower layer.
  - Add different colors to the mixture and see what happens to the layers. Yellow is the only dye that is soluble in the organic and aqueous layers. Blue, red and green dyes (except the yellow portion) show a greater affinity for the organic layer.
- Methyl alcohol can be used instead of ethyl alcohol, but poses a greater safety hazard.

## Discussion

Water and ethyl alcohol are miscible liquids that are held together by strong hydrogen bonding. It is extremely difficult to separate this mixture—distillation even gives an azeotrope of water and ethyl alcohol. (Consult your textbook for more discussion on azeotropes.) When potassium carbonate is added to the solution, the potassium and carbonate ions dissociate and are hydrated. The ions attract the water molecules and disrupt the hydrogen bonds binding the water and ethyl alcohol molecules. As the layers form, the ethyl alcohol/water mixture will appear on top of the more dense aqueous potassium carbonate solution. As more potassium carbonate is added, more water will be removed from the ethyl alcohol/water mixture. The phenomenon is known as *salting-out* and is widely used to separate and purify organic compounds from aqueous mixtures. It is also used to precipitate proteins from aqueous cell extracts.

After adding 85 g of potassium carbonate, the two liquid layers will be approximately equal in volume and all water will be removed from the organic layer. Any additional potassium carbonate added will dissolve in the aqueous layer until it reaches saturation.

Food coloring dyes are large, organic molecules with a charged, polar end. The charged end allows the dye molecule to dissolve in water as well as organic solvents. When potassium carbonate is added, the water molecules are so attracted to the potassium and carbonate ions that no water molecules are available to hydrate the larger organic dyes. The organic dyes thus remain behind in the organic layer. Only the yellow dye will dissolve in both the ethyl alcohol layer and the potassium carbonate solution layer. The presence of the food coloring makes the demonstration more dynamic since one colored solution will separate into two different colored solutions.

## References

Shakhashiri, B. Z., *Chemical Demonstrations*, Volume III, Madison: University of Wisconsin, 1989; p 266.

Hapkiewicz, A., *M.S.T.A. Newsletter*, Winter 1992, Volume XXXVII, p 39.

## Materials for *Sorting Out Solutions—Chemical Demonstration* are available from Flinn Scientific, Inc.

| Catalog No. | Description |
|---|---|
| V0003 | Food Coloring Dyes |
| E0009 | Ethyl Alcohol, 95%, 500 mL |
| P0038 | Potassium Carbonate, Anhydrous, 500 g |
| AP8902 | Sorting Out Solutions—Chemical Demonstration Kit |

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