"Salting Out" Effect of Water and Methyl Alcohol

Properties of Solutions

Introduction

Two clear and colorless 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. What causes the liquids to separate?

Concepts

- Miscible liquids
- Hydrogen bonding
- Salting-out

Materials

Methyl alcohol, 150 mL

Potassium carbonate, K_2CO_3, 85 g

Water, distilled or deionized, 150 mL

Beaker, 600-mL

Food coloring

Magnetic stirrer and stirring bar or stirring rod

Safety Precautions

Methyl alcohol is a flammable solvent and a dangerous fire risk. It is toxic by ingestion and may cause blindness. Keep from flames and heat. Potassium carbonate is a corrosive solid. 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 methyl 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. Gradually 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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Tips

- Use a tall form beaker to enhance the effect.
- Use food coloring to enhance the visual effect of the demonstration. Add a few drops of blue and a few drops of yellow food coloring (following step 2 in the procedure) to give a green methyl alcohol and water mixture. As the solution sepa rates, 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.
- Ethyl alcohol can be used instead of methyl alcohol.
- To make a dramatic, red–white–and–blue density column, add blue food coloring to the aqueous potassium carbonate solution, and add a third liquid layer consisting of toluene and Sudan(III) dye. The toluene solution will form the top-most layer in this three-layer density column. See the "Red, White and Blue Density Column" Chemical Demonstration Kit available from Flinn Scientific, Catalog No. AP7089.

Discussion

Water and methyl alcohol are miscible liquids that form strong hydrogen bonds. When potassium carbonate is added to the solution, the ionic solid dissociates. The ions attract the water molecules and disrupt the hydrogen bonds between the water and methyl alcohol molecules. As two liquid layers separate, the methyl alcohol/water solution 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 methyl 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 85 g of potassium carbonate has been added, 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 having charged, polar end groups. The charged ends allow the dye molecules 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 methyl alcohol layer and the aqueous potassium carbonate layer. The addition of food coloring makes the demonstration more dynamic since one colored solution will separate into two different colored solutions.

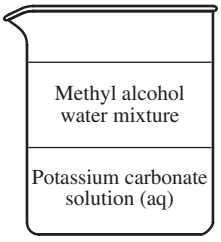
Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Answers to Worksheet Questions

1. Draw and label the contents of the beaker after the potassium carbonate hads been added. Label each layer.



2. When water and methyl alcohol are mixed, they form strong hydrogen bonds. How would the ions from the dissociation of solid potassium carbonate cause the two liquids to separate?

   The ions attract the water molecules and disrupt the hydrogen bonds binding the water and ethyl alcohol molecules.

3. Why does the food coloring remain in the organic layer upon the addition of potassium carbonate?

   Once potassium carbonate is added, the water molecules are so attracted to potassium and carbonate ions so that no water molecules are available to hydrate the organic dyes.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *"Salting Out" Effect of Water and Methyl Alcohol* activity, presented by Annis Hapkiewicz, is available in *Properties of Solutions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *"Salting Out" Effect of Water and Methyl Alcohol* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Sorting Out Solutions—Chemical Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP8902	Sorting Out Solutions—Chemical Demonstration Kit
M0054	Methyl Alcohol, Reagent, 500 mL
P0158	Potassium Carbonate, Reagent, 500 g
V0003	Food Coloring Dye Set
AP7235	Magnetic Stirrer, Flinn, 7" × 7"

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

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Discussion Questions

1. Draw and label the contents of the beaker after the potassium carbonate hads been added. Label each layer.

2. When water and methyl alcohol are mixed, they form strong hydrogen bonds. How would the ions from the dissociation of solid potassium carbonate cause the two liquids to separate?

3. Why does the food coloring remain in the organic layer upon the addition of potassium carbonate?