Separating a Mixture by Filtration
Physical and Chemical Changes

Introduction

Most of the matter around us consists of mixtures, or physical blends, of many substances. The main characteristic of a mixture is that it has a variable composition—the components of the mixture may be mixed in varying proportions. The substances in a mixture retain their distinctive chemical identities, as well as some of their unique physical properties. How are the properties and composition of a mixture affected by physical and chemical changes?

Concepts

- Mixture vs. pure substance
- Homogeneous vs. heterogeneous
- Physical and chemical changes
- Filtration

Background

Mixtures can be classified as either heterogeneous or homogeneous. A *heterogeneous mixture* is a mixture that is not uniform in composition. If one portion of the mixture were to be sampled, its composition would be different from the composition of another portion. Soil, containing bits of decayed material along with sand, silt or clay, is a heterogeneous mixture. A *homogeneous mixture* (e.g., a solution) is a mixture that has a completely uniform composition. The components of the mixture are evenly distributed throughout the sample. Air, saltwater, and brass are examples of homogeneous mixtures. Air is a gaseous solution consisting of a mixture of nitrogen, oxygen, and carbon dioxide. Saltwater is a liquid solution containing sodium chloride dissolved in water, and brass is a solid solution of two metals, copper and zinc.

Many mixtures, both homogeneous and heterogeneous, can be separated into their components using physical separation techniques such as filtration, evaporation or distillation. The properties of each component before mixing and after separation will not be altered by undergoing the physical separation. Consider, for example, a homogeneous mixture (a solution) of sugar in water. The sugar can be recovered by evaporation of the water; the water can be recovered by condensation. The sugar has the same properties before mixing and after separation. The same is true of the water.

In this experiment, the components of a mixture will be separated using a combination of chemical and physical changes. The mixture to be separated consists of charcoal, an activated form of carbon that is used to purify water, and salicylic acid, an organic compound used in drug manufacture. Activated charcoal filters are used on water faucets to make drinking water taste better, in gas masks to absorb toxic gases, and in aquarium tanks to remove chemical and biological pollutants. Salicylic acid is the parent compound of a class of drugs called the salicylates. The most important drug in this class is aspirin (acetylsalicylic acid), which is made by reacting acetic acid and salicylic acid. Salicylic acid was first isolated in nature in 1827 from the bark of the willow tree. (The curative powers of willow tree bark had been known since the times of the ancient Greeks.)

Salicylic acid is a white solid which melts at 157–159 °C. Although salicylic acid is essentially insoluble in water, it will dissolve in water containing bases, such as sodium hydroxide. Charcoal is a black solid with a very high melting point. It is completely insoluble in water and in dilute solutions of acids or bases. When salicylic acid (abbreviated SA–H) dissolves in sodium hydroxide solution (NaOH), it loses a hydrogen ion (H^+) and is converted to an ionic form (Na^+SA^-) that is soluble in water (Equation 1). Adding hydrochloric acid to the resulting solution reverses the process—the SA^- anion picks up an H^+ cation, reforming the neutral compound, SA–H, which then precipitates from solution (Equation 2).

$$\text{SA–H(s)} + \text{NaOH(aq)} \rightarrow \text{Na}^+\text{SA}^-\text{(aq)} + \text{H}_2\text{O(l)} \qquad \textit{Equation 1}$$

$$\text{Na}^+\text{SA}^-\text{(aq)} + \text{HCl(aq)} \rightarrow \text{SA–H(s)} + \text{NaCl(aq)} \qquad \textit{Equation 2}$$

Experiment Overview

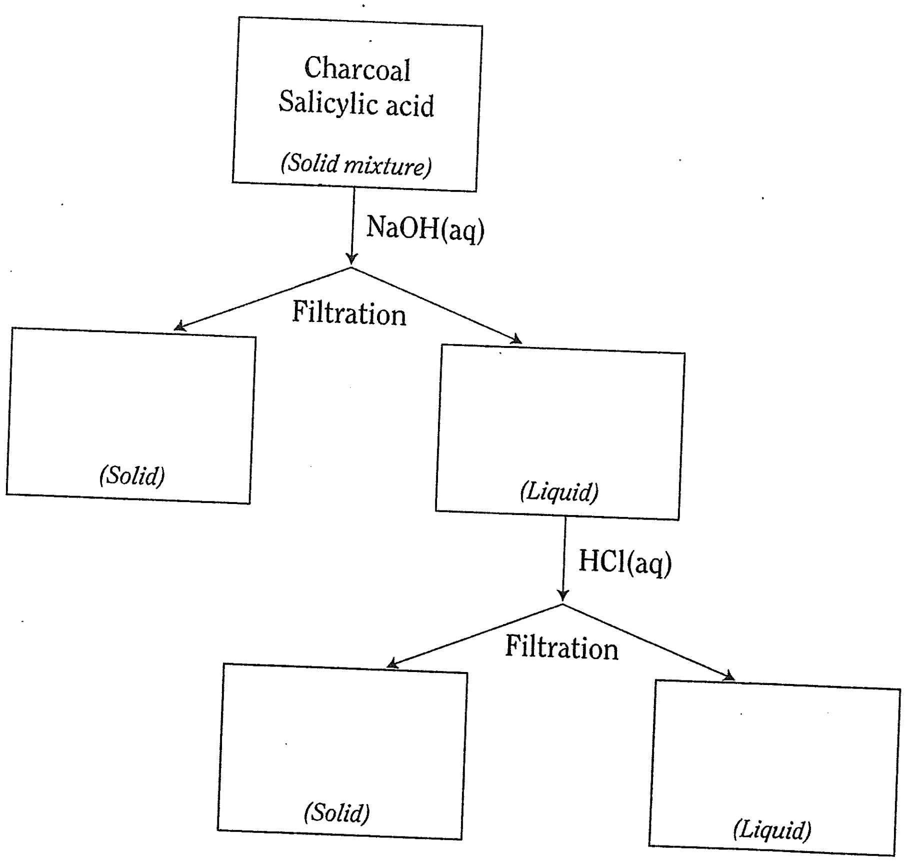
The purpose of this experiment is to separate a mixture of charcoal and salicylic acid and to determine the percent composition of each component in the mixture.

Pre-Lab Questions

1. In filtration, why doesn't the filter paper trap the dissolved solids the same way as it does the undissolved ones?

2. What is the filtrate?

3. Read the entire *Procedure* and the accompanying *Safety Precautions*. Complete the flow chart to show how the mixture of charcoal and salicylic acid will be separated in this experiment.



Materials

Balance, centigram (0.01-g precision)
Charcoal–salicylic acid mixture, 0.6 g
Hydrochloric acid solution, HCl, 1 M, 6 mL
Sodium hydroxide solution, NaOH, 0.2 M, 20 mL
Wash bottle and distilled water
Ring stand and ring clamp
Watch glasses, 2, or paper towels
Weighing dish
Beral-type pipets, 2
Erlenmeyer flasks, 50-mL, 2
Filter funnel, short stem, small
Filter paper, 11- or 12.5-cm, 2
Graduated cylinder, 25- or 50-mL
Magnifier
Spatula
Stirring rod

Safety Precautions

Hydrochloric acid solution is a corrosive liquid. Dilute sodium hydroxide solution is irritating to the skin and eyes. Salicylic acid is moderately toxic by ingestion. Charcoal is a flammable solid. Avoid contact of all chemicals with eyes and skin. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

Form a working group with three other students and divide into two pairs. Each pair of students will complete one trial (steps 1–18) and then share their data with the other pair of the same group to answer the *Post-Lab Questions*.

1. Obtain about 0.6 g of the charcoal–salicylic acid mixture in a weighing dish. Observe the physical appearance of the mixture using a magnifying glass—does the mixture appear to be homogeneous or heterogeneous? Record observations in the data table.
2. Weigh an empty 50-mL Erlenmeyer flask and record the mass.
3. Transfer about 0.5 g of the charcoal–salicylic acid mixture to the Erlenmeyer flask. Measure and record the combined mass of the flask and the solid mixture.
4. Using a graduated cylinder, add 15 mL of 0.2 M sodium hydroxide solution to the charcoal–salicylic acid mixture in the Erlenmeyer flask.
5. Gently swirl the flask to dissolve as much of the mixture as possible, and then allow the mixture to stand for a few minutes while setting up the filter funnel (steps 6–7).
6. Set up a funnel for filtration as shown in Figure 1. Place a clean 50-mL Erlenmeyer flask under the funnel to collect the filtrate.
7. Measure and record the mass of a piece of filter paper. Fold the filter paper into a cone and place it in the funnel (Figure 1). Wet the paper with a few drops of distilled water from a wash bottle.

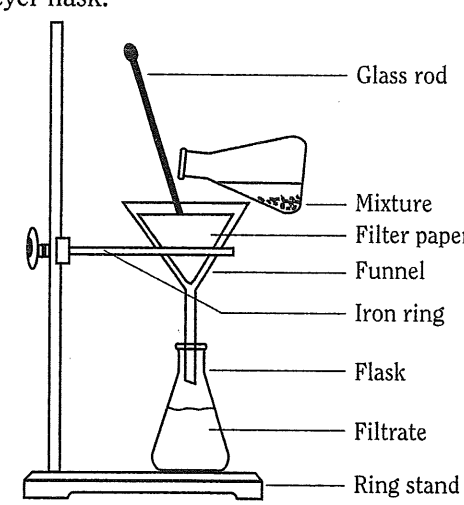


Figure 1.

8. Using a stirring rod to direct the stream of liquid, slowly pour the mixture from the Erlenmeyer flask (step 5) into the funnel. *Note:* Gently swirl the flask as you pour to transfer as much of the solid and liquid together as possible.
9. When most of the liquid has passed through the funnel, rinse any remaining charcoal from the Erlenmeyer flask into the funnel with a small amount (no more than 3–5 mL) of additional sodium hydroxide solution.
10. Rinse the solid on the filter paper with 2–3 mL of distilled water.
11. When the filtration is complete, carefully remove the filter paper with the charcoal from the funnel and spread it on a watch glass or on paper towels to dry. Label the watch glass with your initials. Save the filtrate for step 12.
12. Using a Beral-type pipet, add one pipet-full of 1 M hydrochloric acid at a time to the *filtrate* until no more white solid precipitates out. Swirl the flask to mix the contents. *Note:* Use no more than 6 mL total (three pipets-ful) of hydrochloric acid.
13. Measure and record the mass of a second piece of filter paper and place it in the funnel. Wet the paper with a few drops of distilled water from a wash bottle.
14. Slowly pour the mixture obtained in step 12 into the funnel.
15. When most of the liquid has passed through the funnel, rinse any remaining salicylic acid from the Erlenmeyer flask into the funnel with a small amount (3–5 mL) of distilled water from a wash bottle.
16. When the filtration is complete, carefully remove the filter paper with the salicylic acid from the funnel and spread it on a watch glass or on paper towels to dry. Label the watch glass with your initials.
17. Allow the solids to dry on the filter paper for at least 2 hours (overnight is best). Measure and record the mass of the filter paper and charcoal and the mass of the filter paper and salicylic acid.
18. The remaining filtrate may be rinsed down the drain under cold running water.

Name: ____________________

Class/Lab Period: ____________________

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Data Table

Charcoal–Salicylic Acid Mixture (Observations)		
	Trial 1	**Trial 2**
Mass of Erlenmeyer flask		
Mass of Erlenmeyer flask and charcoal–salicylic acid mixture		
Mass of filter paper (step 7)		
Mass of filter paper and charcoal (step 17)		
Mass of filter paper (step 13)		
Mass of filter paper and salicylic acid (step 17)		

Post-Lab Questions *(Use a separate sheet of paper to answer the following questions.)*

1. For each trial, calculate (a) the original mass of the charcoal–salicylic acid mixture, (b) the mass of recovered charcoal, (c) the mass of recovered salicylic acid, and (d) the total mass of recovered solids.

2. Calculate the *percent recovery* of the charcoal–salicylic acid mixture for each trial.

$$\text{Percent recovery} = \frac{\text{Total mass of recovered solids}}{\text{Original mass of charcoal–salicylic acid mixture}} \times 100\%$$

3. For each trial, divide the mass of recovered charcoal by the total mass of recovered solids and multiply the result by 100. This is the *mass percent of charcoal* in the mixture.

4. In a similar manner, calculate the *mass percent of salicylic acid* in the mixture.

5. Label each of the following as a *physical* or a *chemical change*. (a) Salicylic acid dissolves in the sodium hydroxide solution. (b) The mixture is filtered to separate the charcoal. (c) The filtrate is acidified to precipitate the salicylic acid.

6. Salicylic acid may be crystallized from hot water by dissolving the solid in a minimum amount of boiling water and then cooling the mixture to room temperature. Is this a physical or a chemical change?