Taking Apart the Pieces

How does starting your morning out right relate to relief from a headache?

It is a lazy Saturday morning and you’ve just awakened to your favorite cereal “Morning Trails” and milk. As you pour your bowl of cereal you remember the part about your favorite cereal that you don’t like - the almonds. “Morning Trails” contains all of your favorite things like granola, raisins, oats, and crispy flakes; however, in your disgust for almonds, you pick them out. Well how can breakfast relate to mixtures? You use different characteristics within the cereal to pick out what you don’t like. You can see the appearance, the taste, the smell, and the way that it feels. In the same way we can use different characteristics to separate other mixtures.

Introduction

Often a mixture contains two or more substances that can be separated from each other by their physical properties. There are two categories into which mixtures can be divided: heterogeneous and homogeneous. A heterogeneous mixture is a mixture that contains visibly different parts, much like your cereal. A homogeneous mixture is a mixture than does not contain visibly different parts, much like coffee after the creamer and sugar has been stirred in.

Whether heterogeneous or homogeneous, chemists often need to separate the components of a mixture. Many techniques have been developed for separating a mixture. These techniques are based on the different characteristics of the compound or element in the mixture.

One technique used for the separation of a heterogeneous mixture is filtration. This is used when a heterogeneous mixture contains both a solid and a liquid component. In filtration, a mixture is poured through a piece of filter paper seated in a funnel. The solid components of the mixture are trapped on the paper while the liquid components drain into a receiving container.

Other common techniques used for separating mixtures by physical changes include distillation, chromatography, and crystallization. Distillation takes advantage of
the characteristic of compounds that have different boiling points. For example, in a mixture of two liquids with two different boiling points, the one with the lower boiling point will boil first and undergo a phase change into a gas. The gas will then travel to a separate container to cool and change form back into a liquid again. Certain methods of distillation can separate liquids in a mixture that vary only by a few degrees Celsius. Chromatography is a method that can be used to separate a mixture whose components have different properties that allow them to move at different rates along such items as a strip of paper or a column.

Crystallization is a technique that is often used to produce solids with very high purity. In this lab we will separate the components of aspirin tablets using crystallization. Aspirin tablets are actually a mixture. The ones you will use are made up of about two thirds medicine that helps pain to cease and one third coating, binders and fillers. Binders and fillers hold the pill together to help it reach the appropriate part of your body before becoming active. Such ingredients in binders and fillers may include cellulose, dyes, starch, as well as many other ingredients to accompany the active ingredient on its way through your body.

In this lab, we will start by grinding up the aspirin tablets and dissolve the mixture in hot water. A large amount of aspirin will dissolve in hot water, but only a very small amount will dissolve in cold water. We can use this solubility difference to separate the impurities that do not dissolve in hot water from the aspirin by filtering out the insoluble impurities. The hot solution containing the aspirin will then be allowed to cool in an ice bath where the aspirin should pop out as crystals. Now when the cold solution is filtered through a new piece of filter paper almost all of the solid aspirin will remain in the filter paper and the impurities that are soluble in cold water will remain in the water. To remove more soluble impurities, the aspirin crystals are then rinsed with only a very small amount of ice cold water. Since only a very small amount of ice cold water is used, only a small amount of aspirin will dissolve and be lost.

**Objectives**

- To use physical properties to separate the components of a mixture.
- To use laboratory techniques to separate the components of a mixture.
Pre-lab Questions

1. Name two homogeneous mixtures and two heterogeneous mixtures that you come across daily.

2. How would you separate a solid mixture of sand and salt?

3. Why must you rinse the final aspirin crystals remaining in the filter paper with only a small amount of ice cold water?
Procedure

1. Fill a 600 mL beaker or the largest available beaker about half full with water.

2. Place the beaker on a hot plate. Set the heat so as to make a gently boiling hot water bath. **CAUTION: Hot plates can become very HOT very FAST.**

3. Prepare an ice water bath by obtaining a 600 mL beaker with ice filled ¾ of the way full and add water. Place a wash bottle filled with distilled water in the bath.

4. Place four Safety Coated Low Dose (81 mg) Bayer Aspirin pills into a mortar and gently crush the pills with the pestle.

5. board and gently crush the pills with a hammer.

6. Place all of the ground powder into a test tube. **HINT:** Pour all of the powder onto a piece of paper. Shape the paper so it will allow the powder to funnel into the test tube.

7. Add 10 mL of distilled water to the powder in the test tube and stir with a stirring rod. **CAUTION: The bottom of test tubes can be easily broken when too much force is applied with a stirring rod.**

8. Use a test tube holder to place the test tube in the hot water bath while it is heating to a boil. After the water reaches a gentle boil, let the test tube stay in the bath for at least an additional 5 minutes. Stir the solution in the test tube frequently while it is being heated. Continue to heat until it appears like most of the powder has dissolved. Record your observations in Table 1 of the data section.

9. Attach a ring to a ring stand. Place a filtering funnel in a ring that is attached to a ring stand. Fold a piece of filter paper in half and then in quarters. Place the filter paper in the funnel so that three quarters are open on one side and one quarter is on the opposite side.

10. Place a clean test tube under the funnel. It can be held in place by setting it in a clean beaker or a test tube rack. Seat the filter paper into the funnel by moistening the filter paper with a very small amount of distilled water. Discard any water that filters into the test tube.
11. Use a test tube holder to remove the test tube from the hot water bath. Pour about half the hot contents in the test tube into the filtering funnel. Immediately place the test tube back into the hot water bath. Allow all the liquid to completely filter into the test tube.

12. Use a test tube holder to remove the test tube from the hot water bath again. Pour the rest of the hot contents that are in the test tube into the filtering funnel. HINT: If the solution had begun to filter slowly towards the end of the first half of the solution being filtered, replace the filter paper with a new piece of filter paper folded and placed into the funnel the same way as before for the second half. CAUTION: This solution is extremely hot. Do not touch it directly with your hands. Clean the filtering funnel for later use.

13. Allow the hot solution to cool until it is no longer warm. Place the test tube with the cooled filtered liquid into the ice water bath. Continue to cool the solution until generous amounts of crystals form. This should take about 5 minutes. If crystals do not form, try scratching the sides of the test tube with a glass stirring rod until the crystals begin to form. Record your observations.

14. Pre-weigh a sheet of filter paper and a watch glass. Record each mass in the data section.

15. Set the pre-weighed filter paper into the cleaned filtering funnel. Place a clean test tube under the funnel. Hold the test tube in place as you did previously. Seat the filter paper into the funnel by moistening the filter paper with a very small amount of distilled water. Discard any water that filters into the test tube.

16. Transfer the crystals into the filtering funnel. Use small amounts of ice cold distilled water to rinse the crystals. DO NOT USE MORE THAN A SMALL AMOUNT OF ICE COLD WATER TO TRANSFER AND RINSE THE CRYSTALS OR SOME OF YOUR CRYSTALS WILL DISSOLVE.

17. Carefully remove the filter paper containing the crystals and place it on the pre-weighed watch glass. Set the crystals aside to dry. DO NOT THROW THE CRYSTALS AWAY. Allow the crystals to dry overnight or until the crystals are completely dry. Record your observations.

18. Clean up by washing any dirty glassware. Be sure that you do not throw away the crystals drying on the filter paper!

19. After the crystals are completely dry, weigh them on pre-weighed filter paper. Record the mass in the data section. DO NOT THROW THE CRYSTALS AWAY. THEY WILL BE USED FOR A LATER LAB.
Data and Calculations

1. Pre-weighed filter paper mass
2. Pre-weighed watch glass mass
3. Filter paper, watch glass, and aspirin mass
4. Mass of aspirin obtained
5. Calculate the percent recovery using the formula below:

\[
\frac{\text{Actual (amount of aspirin obtained)}}{\text{Theoretical Yield (0.081g x # of pills used)}} \times 100\% = \text{_____ \%}
\]
Table 1. Observations for Lab

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Crushed aspirin and water in hot water bath</td>
<td></td>
</tr>
<tr>
<td>2. Aspirin in ice water</td>
<td></td>
</tr>
<tr>
<td>3. Aspirin crystals</td>
<td></td>
</tr>
</tbody>
</table>

**Post Lab Questions**

1. What important characteristic of aspirin did you use to separate it from the other pill components?

2. Evaluate your percent recovery. Give an explanation if your recovery was more than 100% or very low? How could you improve your results?
Chemical or Physical?

What does chemistry and superheroes have in common?

Movie producers often make action movies where an everyday person will dramatically turn into a superhero. In the movies when a crisis hits, a normal guy or girl will disappear in a flash. Suddenly he or she will radically reappear disguised as a superhero who then destroys the horrifying villain and saves the day! In slightly the same way, molecules can transform their identity. Molecules can change into something that may appear physical different or chemically act very differently. Sometimes these changes occur in appearance, while other times, these changes make a different molecular substance.

Introduction

Within the science of chemistry there are many types of changes that can take place. These changes can be categorized into two primary types, physical changes and chemical changes.

A physical change alters the state of a substance without altering the identity of the substance. This includes dissolving, crushing, tearing, heating, melting, evaporating, sublimation or cooling. Sublimation is a type of physical change that occurs when a solid goes directly into a vapor state without going through a liquid state. Only a small number of substances sublime; an example is carbon dioxide. You can observe this by setting out a piece of frozen carbon dioxide. The carbon dioxide does not melt, but it goes directly to a gas.

A chemical change alters the identity of the molecular identity of the substance. An example is iron rusting. The iron metal changes to iron oxide by adding oxygen to its chemical formula.

This experiment involves changing the pain medicine aspirin both physically and chemically. The aspirin is changed physically through the process of dissolving it in hot water. It is also changed chemically by adding sodium bicarbonate (NaHCO₃) to it. When sodium bicarbonate is added to aspirin, it changes into a new substance. The new chemical has a different kind of bond known as an ionic bond. This makes it much more water soluble. You will study about this in a later laboratory experiment. We will call the new substance Aspirin*Na⁺. The Aspirin*Na⁺ is very soluble in water and will dissolve in a lot less water at room temperature. You will then change the Aspirin*Na⁺ back to the original aspirin by adding...
citric acid to it. After it is changed back, it is again not very soluble. Many medicines use a similar type of reactions in order to allow the human body to use them. Usually the medicine is made more water soluble by adding chemicals such as HCl or HBr to it.

Objectives

- To recognize the differences between chemical and physical changes.
- Determine if a change is physical or chemical.
Pre-lab Questions

1. Define physical change and list 2 examples of types of physical changes.

2. Define chemical change and list 2 examples of chemical changes.

3. Define sublimation.
Procedure

1. After the aspirin crystals obtained from the “Taking Apart the Pieces” lab have been weighed and recorded in the previous lab data section, divide them in half. You will now use half of the mixture to show the physical change of dissolving and the other half to show a chemical change.

2. Fill a 250 mL beaker about half full with water and place it on a hot plate. Gradually increase the heat so as to make a gently boiling hot water bath. CAUTION: Hot plates can become very Hot very Fast.

3. Place half of the aspirin (about 0.1 g) obtained from the Taking Apart the Pieces experiment into a medium size test tube labeled “P” for Physical change and the other half into a medium size test tube labeled “C” for Chemical Change.

4. Add 1.5 mL of distilled water to the test tube labeled “P” and swirl to mix. Record your observations in the data table.

5. Very slowly add 1.5 mL of saturated sodium bicarbonate solution (NaHCO₃) to the test tube labeled “C” and swirl to mix. If the crystals are not almost completely dissolved, add additional saturated sodium bicarbonate solution dropwise until almost all of the crystals have dissolved. You have now witnessed a chemical change to the Aspirin*Na⁺. Record your observations in the data table.

6. Compare the mixtures in the two test tubes. Record your observations in the data table.

7. Add 1.5 mL saturated citric acid solution to the test tube labeled “C” and swirl to mix. If crystals do not reform, add additional saturated citric acid solution dropwise until almost all of the crystals have reformed. You have now witnessed a chemical change back to Aspirin. Record your observations in the data table.

8. Add an additional 1.5 mL of distilled water to the test tube labeled P and swirl to mix. Record your observations.

9. Place the test tube labeled P into the hot water bath and stir.

10. Allow the aspirin to dissolve until no more particles can be seen in the test tube. You have now witnessed a physical change to the aspirin. Record your observations in the data table.

11. Turn off the hot plate. Cautiously remove the test tube using a test tube holder and place it in a test tube rack to cool. CAUTION: The test tube is extremely hot and can cause severe injury.

12. Allow the test tube to cool to room temperature. Record your observations in the data table.
### Data

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adding distilled water to the aspirin crystals</td>
<td></td>
</tr>
<tr>
<td>Adding NaHCO₃ to the aspirin crystals</td>
<td></td>
</tr>
<tr>
<td>Comparison of the two mixtures</td>
<td></td>
</tr>
<tr>
<td>Adding citric acid to the aspirin*Na⁺ solution</td>
<td></td>
</tr>
<tr>
<td>Adding 1.5 mL more water to the aspirin crystals</td>
<td></td>
</tr>
<tr>
<td>Placing test tube “P” in a hot water bath</td>
<td></td>
</tr>
<tr>
<td>Cooling the aspirin solution</td>
<td></td>
</tr>
</tbody>
</table>

### Post Lab Questions

1. The following are often changes that can take place. Define each as a chemical or physical change.
A. Igniting a Bunsen burner

B. Boiling water

C. Making popsicles

D. Melting ice cream

E. Rusting Iron

F. Subliming moth balls

2. When dissolving the aspirin in hot water, was the chemical structure changed? Explain your answer.

3. What are the crystals that formed when the hot mixture cooled?

4. Why is adding NaHCO₃ to the aspirin crystals considered a chemical change?

5. Why did adding a citric acid solution cause the aspirin crystals to reform?