5.2: Aspirin Procedure

Learning Objectives

- Understanding the chemical reaction involved (esterification)
- Accurately performing laboratory techniques like weighing, heating, and filtration.
- Calculating the percentage yield of the product
- Practicing safe lab techniques in a chemistry lab under the supervision of a trained instructor.

Safety

- Keep acetic anhydride under the hood and avoid breathing its vapors.
- Use the hood when using acetic anhydride or phosphoric acid.
- Place all waste in organic waste containers in the fume hood.
- If you spill acetic anhydride, notify your instructor.
- If you spill phosphoric acid, notify your instructor.
- Do not ingest the aspirin.
- Take care not to directly touch the chemicals.

Introduction

In CH 106, you have been introduced to organic chemistry nomenclature and functional groups. The active ingredient in commercial aspirin is the organic compound, acetyl salicylic acid which is classified as an ester. The general formula for esters is RCOOR', where R and R' may be different alkyl (carbon) groups.

Esters are widespread in nature and are often responsible for pleasant flavors in fruits and floral aromas. Esters are most often prepared from an esterification reaction between a carboxylic acid (R-COOH) and alcohol (R-OH) in the presence of a catalytic acid. The reverse reaction, a hydrolysis, also occurs.

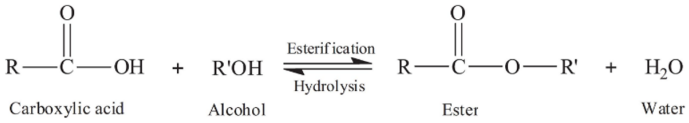

Figure 5.2.1. General format of an esterification reaction.

In today's lab, we will react salicylic acid, a naturally occurring pain reliever found in the bark of willow trees, with acetic anhydride. The mechanism of this reaction is similar to an esterification forming acetyl salicylic acid (aspirin), and acetic acid as a byproduct.

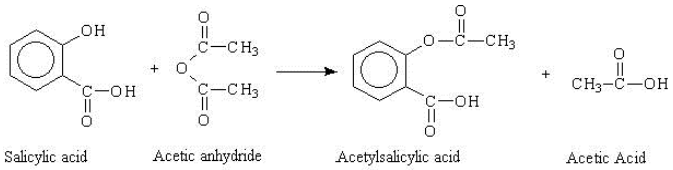

Figure 5.2.2. The synthesis of aspirin is an esterification reaction.

Organic chemistry reactions seldom result in pure products. A desired reaction may have unreacted starting materials or competing reactions resulting in additional products. There are ways to purify the sample including recrystallization, which is based on chemical solubilities within a mixture. Impurities will dissolve within a hot solution and upon cooling, the desired pure substance may form crystals that may be collected.

To test the purity of the aspirin we created we will determine the melting point of our sample. The melting point is the temperature at which the solid coexists in equilibrium with the liquid at atmospheric pressure. Most pure organic compounds have sharp melting points; that is the process of melting occurs over a very narrow range of temperature. Impurities have a dramatic influence on the melting points of organic compounds. They typically lower the melting point and widen the melting point range. For example, while pure acetyl salicylic acid (aspirin) melts sharply at 138 – 140 °C, a sample of wet acetyl salicylic acid (water is the

impurity) may melt in the range 126 – 130 °C. In contrast the melting point of salicylic acid is 158 – 160 °C. A melting point range larger than 3°C is an indication that the sample is either impure or wet.

Procedure

Part 1. MSDS and GHS

An MSDS (Material Safety Data Sheet) is designed to give information about the risks involved with using a particular chemical. For every chemical PCC purchases, it is required that the appropriate MSDS is loaded into our online database. You will read the MSDS's for the chemicals in today's lab. First focus on the GHS pictograms that appear at the beginning of the MSDS. These are an international system intended to give a quick overview of the risks associated with a particular reagent. Here is a table of what the pictograms mean:

Hazard Class Pictograms ☝

Read the hazard statements that directly follow the pictograms. They will give a more complete picture of what you need to be mindful of using a particular reagent.

Category	Pictogram	Information
Explosives		Explosives, Self-Reactives, Organic Peroxides
Flammables		Flammables, Pyrophorics, Self-Heating, Emits Flammable Gas, Self-Reactives, Organic Peroxides
Oxidizers		Substances that can cause or enhance the combustion of other materials.
Compressed Gases		Compressed Gases, Liquified Gases, Dissolved Gases
Corrosives		Skin Corrosion/Burns, Eye Damage, Corrosive to Metals
Acute Toxicity		Acute Toxicity (fatal or toxic)
Irritant		Irritant (skin and eye), Skin Sensitizer, Acute Toxicity (harmful), Narcotic Effects, Respiratory Tract Irritant
Health Hazard		Carcinogen, Mutagenicity, Reproductive Toxicity, Respiratory Sensitizer, Target Organ Toxicity, Aspiration Toxicity
Environment		Aquatic Toxicity (Non-Mandatory)

To identify the hazards associated with the chemicals in this lab, complete the table in your post lab. The first line is completed as an example. The MSDS documents you need can be found posted with the labs online.

Part 2: Synthesize the Aspirin

1. Place a heating/stir plate in the fume hood. Place approximately 350 mL of tap water in a 500 mL beaker. Place a stir bar in the beaker, and place the beaker on the hot plate. Set the stirring at 200 rpm and turn the heater ¾ of the way to full. Place a portable ring stand on one side of the stir plate and attach a utility clamp to the ring stand.
2. Tare a scale with a 125 mL Erlenmeyer flask on top. Place about 2 g of salicylic acid in the flask and record the mass.
3. In the hood, add 5.0 mL of acetic anhydride to the Erlenmeyer flask. Your instructor will move the bottle of acetic anhydride from one hood to another. Use the pipette attached to the side of the bottle to dispense the anhydride into a 10 mL graduated cylinder.
4. Add 5 drops of 85% phosphoric acid to the Erlenmeyer flask. Use the pipette attached to the side of the phosphoric acid bottle. Your instructor will move the bottle of phosphoric acid from one hood to another.
5. Attach the Erlenmeyer flask to the utility clamp. After it is secure, lower the flask into the beaker of tap water.
6. Take the glass stirring rod and place it in the Erlenmeyer flask. Every few minutes, stir the contents of the flask until you see that the salicylic acid has completely dissolved. Leave the glass stir rod in the flask.
7. Let the flask sit in the water bath until the water reaches boiling. This will probably take about 20 minutes.
8. Once the water reaches boiling, turn off the heat on the hot plate but keep it stirring. Let the Erlenmeyer flask remain in the water for 10 minutes.

Complete steps 9 and 10 while you are waiting.

9. While you are waiting, place about 50 mL of distilled water in a 100-mL beaker and place it into an ice-water bath. The ice-water bath is made by filling a 500-mL beaker half-full with ice, then just covering the ice with tap water.
10. Also while you are waiting, weigh a watch glass with a piece of filter paper.
11. After your reaction has sat for 10 minutes, raise the clamp on the ring stand so the Erlenmeyer flask is no longer in the water bath. Add 2 mL of room temperature distilled water. Stir the mixture and then allow it to sit for a minute. This water decomposes any unreacted acetic anhydride to acetic acid.
12. After a minute, add 20 mL of room temperature distilled water. Stir it a couple of times and then leave it alone. Let it cool to room temperature undisturbed. Be patient. After time has passed and the flask no longer feels warm to the touch, take it out of the hood and place it in your ice+water bath. Leave it alone and let it cool further. Let it sit in the ice for at least ten minutes. You can do steps 13 and 14 while you wait.
13. While you are waiting, clean up the stir plate, ring stand, beaker, and clamp that were in the hood.
14. Set up a Buchner funnel on a vacuum flask. Use a ring stand and clamp to stabilize the Buchner funnel. (See Figure A below) You will need to place a rubber cuff between the funnel and the flask. Attach tubing from the flask to the vacuum line in the hood. Place the paper filter you weighed into the top of the funnel (do not place the watch glass in the funnel).

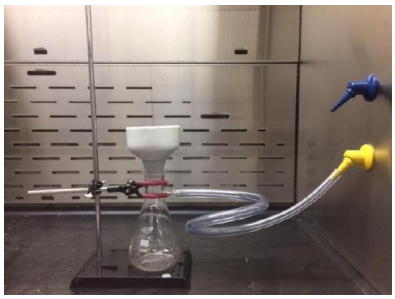

Figure 5.2.3. Buchner Funnel set up in a hood.

15. When crystals have fully formed in your flask, filter them. First, use distilled water from a squirt bottle to moisten the paper and make sure there is a good seal between the paper and the funnel. Turn on the vacuum line and then pour the contents of the flask onto the paper. Use the stir rod to remove as many crystals as you can. Rinse the flask several times using the 50 mL of distilled water that you cooled.
16. Turn off the vacuum!

> **Note**
>
> The oven must be set low for the next step. The aspirin could melt if the oven is set too high or in the oven too long.

17. Transfer the paper filter onto the watch glass you weighed. Use a metal spatula to help remove the paper. Be sure to label your sample so you know which one is yours. Place the watch glass and paper in the oven for 10 minutes. Do not use the bottom rack of the oven. While you are waiting, place the filtrate in the vacuum flask into the waste container in the hood.
18. Weigh the filter paper with the dried crystals.
19. You need to save your aspirin for Part 3.

Part 3: Melting Temperature of an Aspirin Sample

A melting point can be obtained by visually watching the substance melt. The picture below shows a Melting Point Apparatus commonly used in the laboratory. The substance to be measured is introduced into the apparatus by a narrow glass capillary tube as shown below left, just as you will use in this experiment. The tube is observed through a magnifying lens built into the apparatus during the measurement.

Figure 5.2.4. Melting Temperature Apparatus

1. Obtain a small amount of your synthesized aspirin from Part 2. The solid should be in a powdered form. If it is not, use a mortar and pestle to carefully grind the solid to a powder.
2. Place a small amount of the aspirin crystals into the open end of a glass capillary tube, but be very careful to not break the thin tube. This is best accomplished by gently pushing and tapping the capillary tube directly into the powdered aspirin crystals as shown to the right.
3. Move the powder toward the closed end of the capillary tube by gently tapping the closed end onto a hard flat surface. Repeat this process until the aspirin has settled into the closed end of the tube and occupies 1 to 2 mm of tube space.

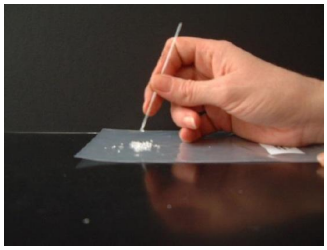

Figure 5.2.5. Loading a capillary tube with aspirin

Note that only a very small amount of material is used. If too much material is used, the temperature can vary from one end of the sample to the other, and the resultant melting point may be erroneous.

4. Check the control dial on the Melt Station to confirm that it is in the Off position. Connect the Melt Station power supply to a powered electrical outlet.
5. Connect the Melt Station to a computer. Choose New from the File menu of the data-collection program.
6. Carefully insert the capillary tube of solid into one of the sample holders of the Melt Station.
7. Begin collecting melting temperature data. In the first trial, you will want to observe the melting process and make a *rough estimate* of the melting temperature of your unknown sample.
8. When you have determined the approximate melting temperature range for the sample, stop data collection and turn the dial to the Fan/Cooling setting. Record the melting temperature range in your data table.
9. Now that you have a rough idea of the melting temperature, a more accurate determination of the melting temperature can be made. Prepare 2 samples in a capillary tube and determine the melting temperature of the samples one at a time, recording the melting range in your post-lab.

10. When finished, stop data collection and turn the dial to the Fan/Cooling setting. Record the melting temperature range in your data table.
11. At the end of the experiment turn the control dial on the Melt Station to Off. Dispose of the capillary tubes as directed by your instructor.
12. Complete the Data Analysis section before exiting Logger Pro. Print a copy of your graph for your lab group and/or save your data, as directed by your instructor.

Waste Disposal

Place the capillary tubes in the broken glass container. The aspirin and the contaminated filter paper should be placed in the solid waste container.
