Experiment 8
Synthesis of Aspirin

Background

"Aspirin, which ranks as the most widely used drug in the United States, is one of a series of salicylic acid esters that has been known since antiquity to have therapeutic effects. In fact, many cultures have used plants containing significant amounts of these compounds in medications to relieve pain (analgesic), reduce fever (antipyretic), and decrease inflammation and swelling.

Until the turn of the century the compounds were extracted from the leaves and barks of plants. However, in the late 1900's, the Bayer Co. in Germany began chemical production of the acetyl ester of salicylic acid, which they trademarked as "aspirin." Bayer lost this trademark in the United States during World War II when the word became synonymous with the drug regardless of the manufacturer. In other countries, where Bayer retained the trademark, the generic form of the drug is called ASA as an abbreviation for the common name of the compound, acetylsalicylic acid. Another ester of salicylic acid, the methyl salicylate, commonly known as oil of wintergreen, is absorbed through the skin; it constitutes the active ingredient in many liniments and analgesic creams.

In addition to the three main uses for aspirin, recently it has been found to have other beneficial uses. Low daily doses (one tablet) can lessen the chance of heart attack in patients with certain heart problems and this dosage appears to reduce the occurrence of stroke in some men. The acidic nature of the compound, however, is known to irritate the stomach and/or cause ulcers in many people. As a precaution, many people routinely take a buffered form of aspirin to neutralize the acid as the tablet dissolves. Other side effects are also known. Reports have suggested that the use of aspirin in children and teenagers with fever due to a viral infection (especially flu or chicken pox) may cause Reye's syndrome, a serious brain illness. Aspirin is also not advised as a medication within two weeks before surgery, childbirth, or dental extractions as it may cause serious bleeding problems."[1]

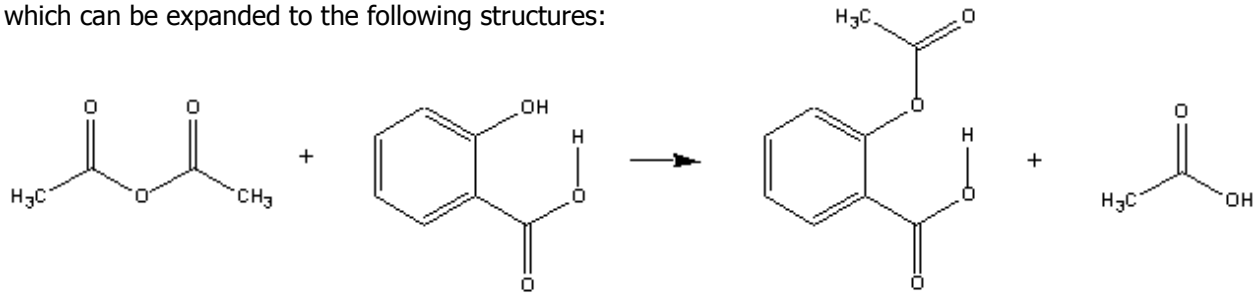
Purpose

In this experiment you will synthesize aspirin from acetic anhydride and salicylic acid. The reaction for the synthesis is given below.

$$\mathbf{C_4H_6O_3} + \mathbf{C_7H_6O_3} \rightarrow \mathbf{C_9H_8O_4} + \mathbf{HC_2H_3O_2}$$

Acetic Anhydride	Salicylic Acid	Aspirin	Acetic Acid

which can be expanded to the following structures:



Note: Carbons (and hydrogens) are implied where lines (bonds) meet.

[1] Taken from Synthesis and Analysis of Aspirin, UCLA Chemistry Department

Experiment 8 Turn-in Sheets

Use this space to record your observations and/or data

Warning: Phosphoric acid is used as a catalyst (it speeds up the reaction but does not get consumed). The aspirin you are making is relatively impure and should not be taken internally.

Experimental Procedure

Safety Hazards: Both acetic anhydride and phosphoric acid can cause bad burns if you get them on your skin. Be sure and handle them with care.

1) Measure out 2.0 g of salicylic acid (SA) and place the SA in to a 50-ml Erlenmeyer flask.

2) Measure out 5.0 ml of acetic anhydride (d = 1.08 g/ml) in a graduated cylinder and then pour it into the flask in such a way as to wash any crystals of SA on the walls down to the bottom.

3) Add 5 drops of 85% phosphoric acid to serve as a catalyst.

4) Clamp the flask in place in a beaker of water supported on wire gauze on a ring stand. Heat the water with a Bunsen burner to about 75^0C, stirring the liquid in the flask occasionally with a glass stirring rod. **DO NOT OVERHEAT THE FLASK!!!!!** Maintain this temperature for 15 minutes.

5) Cautiously add 2 ml of distilled water to the flask to decompose any excess acetic anhydride. There will be some hot acetic acid vapors evolved so be careful.

6) Wait 2 minutes, then remove the flask from the water bath and add 20 ml of distilled water.

Use this space to record your observations and/or data

7) Let the flask cool in the air for a few minutes. You should start to see aspirin crystals start to form. Put the flask in an ice bath to hasten crystallization. If the crystals are slow to appear scratch the inside of the flask with the glass stirring rod. This will give the crystals a surface to grow on. Leave the flask in the ice bath AT LEAST 4.6 minutes.

8) Use a Buchner funnel to collect the aspirin crystals. Turn off the suction and add about 5 ml of **ice-cold** distilled water to the crystals. After 15 seconds turn the suction back on. Repeat the washing process with another portion of **ice-cold** distilled water. Let the suction run for a couple minutes and then transfer the aspirin to a piece of filter paper that has been labeled with your name. Place your aspirin in the tray to dry.

9) (Optional) Record the melting point of your aspirin if requested by your instructor.

Data Table

Record important data in an organized and clearly labeled table below. Include the mass (and/or volumes) of reactants used for the reaction. Include any other data that may be useful.

Calculations

Show your work and use the proper number of **significant figures**.

1) Determine the limiting reactant

a) What is the mass of salicylic acid used? _____ g SA

b) How many moles of salicylic acid was used? _____ moles SA

c) What is the mass of acetic anhydride used? _____ g AA

d) How many moles of acetic anhydride was used? _____ moles AA

e) What is the mole ratio of salicylic acid to acetic anhydride? ____ : ____ (see equation)

f) Based on parts a-e above, which is the limiting reactant? _____

2) Using the information above, determine the theoretical yield of aspirin:

a) How many moles of limiting reactant was consumed if it reacted completely? _____ moles

b) How many moles of aspirin should have been produced if there was 100% yield? _____ moles aspirin

c) How many grams of aspirin should have been produced if there was 100% yield? _____ grams aspirin (Theoretical Yield)

d) How many grams of aspirin were you able to isolate in your experiment?

_____ grams aspirin (Actual Yield)

e) What is the percent yield of aspirin you obtained in this experiment?

$$\frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = \%\ \text{yield}$$

_____ % yield

Follow-up Questions

Suppose your percentage yield was less than 100%. Provide **two** possible reasons why this may have occurred.

Suppose your percentage yield was greater than 100%. Provide at least one possible reason why this may have occurred.

Pre-Lab Assignment

You will need to be familiar with stoichiometry and the limiting reactant. See Chapter 6 in your textbook.

1) A student prepared aspirin using 2.019 g of salicylic acid and 5.2 ml of acetic anhydride (d = 1.08 g/ml).

    a. Which reactant is limiting, salicylic acid or acetic anhydride? (If you need guidance, use the worksheet in Part 1 of the Calculations section.)

    b. What is the theoretical yield of aspirin? (If you need guidance, use the worksheet in Part 2 of the Calculations section.)

    c. If the student obtained 1.789 g of aspirin, what is his percent yield? (If you need guidance, use the worksheet in Part 2 of the Calculations section.)