Preparation of Aspirin

Salicylic acid

Performance Goal

31–1 Beginning with salicylic acid and acetic anhydride, prepare a sample of aspirin.

CHEMICAL OVERVIEW

Acetic acid

Chemically speaking, aspirin is an organic ester. An ester is a compound that is formed when an acid reacts with an alcohol (or a compound containing an —OH group):

where R_1 and R_2 represent alkyl or aryl groups, such as CH_3 —, C_2H_5 —, or C_4H_5 —.

High-molar-mass esters such as aspirin are generally insoluble in water and can be separated from a reaction mixture by crystallization. Aspirin can be prepared by the reaction of salicylic acid with acetic acid:

As the double arrow indicates, the reaction does not go to completion, but reaches equilibrium.

Aspirin

A better preparative method—the one you will use in this experiment—employs acetic anhydride instead of acetic acid. Acetic anhydride may be

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considered as the product of a reaction in which two acetic acid molecules combine, with the resulting elimination of a water molecule:

The anhydride reacts with salicylic acid to yield the ester (aspirin):

Excess anhydride reacts with the water produced in the esterification, thereby shifting the equilibrium in the forward direction and giving a better yield of the desired product. A catalyst, normally sulfuric or phosphoric acid, is used to increase the rate of the reaction.

SAFETY PRECAUTIONS AND DISPOSAL METHODS

Both acetic anhydride and phosphoric acid are reactive chemicals that can produce a serious burn on contact with the skin. In case of contact with either, wash the skin thoroughly with soap and water. Avoid breathing acetic anhydride vapors. Wash any spillage from the desk top. The aspirin you will prepare in this experiment is relatively impure and should not be taken internally.

Dispose of any excess solid chemical in a special container. Do not pour acetic anhydride down the drain. Follow the directions given by your instructor.

PROCEDURE

1. Preparation of Aspirin

- **A.** Preweigh a 50-mL Erlenmeyer flask on a centrigram balance. Add 1.9 to 2.2 g of salicylic acid and weigh the flask again to the nearest 0.01 g.
- **B.** Pour 5.0 to 5.5 mL of acetic anhydride into the flask in such a way as to wash down any crystals of salicylic acid that may have adhered to the walls.
- **C.** Add 5 drops of concentrated phosphoric acid (85 percent) to serve as a catalyst.

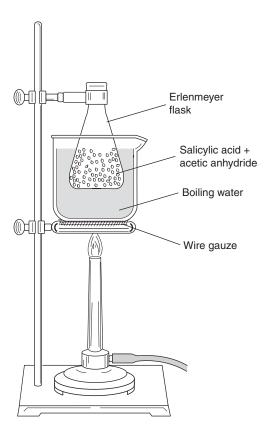


Figure 31.1 *Preparation of aspirin*

- **D.** Clamp the flask in a beaker of water supported on a wire gauze (Figure 31.1), or use a hot plate. Heat the water to about 75 °C, stirring the liquid in the flask occasionally with a stirring rod. Maintain this temperature for about 15 minutes, during which time the reaction should be complete.
- **E.** Cautiously add 2 mL of water to the flask to decompose any excess acetic anhydride. Hot acetic acid vapor will evolve as a result of the decomposition.
- **F.** When the liquid has stopped giving off vapors, remove the flask from the water bath and add 18 to 20 mL of water. Let the flask cool for a few minutes, during which time crystals of aspirin should begin to appear. Put the flask into an ice bath to hasten crystallization and increase the yield of the product. If crystals are slow to appear, it may be helpful to scratch the inside of the flask with a stirring rod.
- **G.** Weigh a piece of filter paper on a centigram balance before inserting it into the funnel. Collect the aspirin by filtering the cold liquid through a Büchner funnel, using suction, as in Figure 31.2. Disconnect the rubber hose from the filter flask, pour about 5 mL of ice-cold deionized water over the crystals, and suck down the wash water. Repeat the washing step with a second 5-mL rinse of ice-cold water. Draw air through the funnel for a few minutes to help dry the crystals, and then transfer the filter paper and crystals to a clean watch glass.

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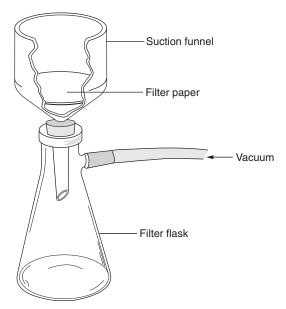


Figure 31.2 *Vacuum filtration apparatus*

H. To determine the yield of aspirin in your experiment, it is necessary that the product be dry. If you do not have time to complete the experiment, store the watch glass carefully in your locker. At the beginning of the next laboratory period, weigh the filter paper and aspirin to the nearest 0.01 g. Record your data in the space provided on the work page.

2. Purity of Aspirin (Optional)

Very pure aspirin melts at 135°C. By determining the melting point of your aspirin, you may estimate its purity, because the purer the aspirin, the closer its melting point will be to 135°C.

- **A.** Assemble the apparatus shown in Figure 31.3, using a large oil-filled test tube as the heating bath.
- **B.** Crush some of your aspirin crystals on a watch glass with a spatula. Form a mound from the powder and push the open end of a melting-point capillary into the mound. Hold the capillary vertically and allow it to drop against the table top, compacting the powder into a plug in the bottom of the tube. Repeating the process, build a plug about $\frac{3}{4}$ to 1 cm long.
- C. Attach the filled capillary to a thermometer with a rubber band or slice of rubber tubing, and immerse it in the oil bath. Do not allow the open end of the capillary to come into contact with the oil. Heat the bath rapidly with a Bunsen burner to about 100°C. As the melting point is approached, the crystals will begin to soften. Report the melting point as the temperature at which the last crystals disappear (the tube looks transparent).

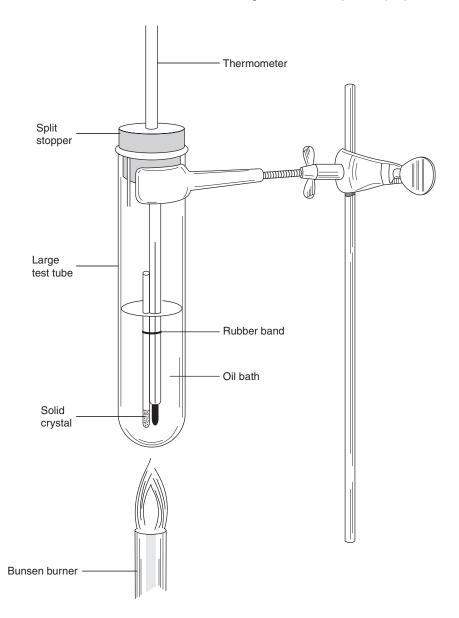


Figure 31.3 *Apparatus for melting-point determination*

CALCULATIONS

The actual mass of aspirin is obtained by taking the mass of filter paper + aspirin and subtracting the mass of the filter paper. Based on the actual mass of salicylic acid used, calculate the theoretical yield of aspirin in grams, using Equation 31.4. Then determine the percentage yield,

$$Percentage \ yield = \frac{actual \ yield}{theoretical \ yield} \times 100$$

where *actual yield* means the number of grams of product actually obtained. Record your results on the work page.

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Name	Date	Section
Experiment 31		
Advance Study Assignment		
1. How would you test the purity of aspirir	n prepared in this experime	nt?
2. Calculate the theoretical yield of aspirin i	if you started with 1.75 g o	f salicylic acid.
3. Write the chemical equation for the chem	nical reaction used in this ex	xperiment to form aspirin.
3. Write the chemical equation for the chem	nical reaction used in this ex	xperiment to form aspirin.

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Experiment 31		
Work Page		
Part 1 —Preparation of Aspirin		
1A. Mass of 50-mL Erlenmeyer flask (g)		
1B. Mass of flask and salicylic acid (g)		
1C. Mass of salicylic acid (g)		
1D. Mass of filter paper (g)		
1E. Mass of filter paper and aspirin (g)		
1F. Mass of aspirin (actual yield) (g)		
Theoretical yield of aspirin (show calculation	s below):	
, .		
		_
		g
Percentage yield (show calculations below):		

%

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_____°C

Part 2—Purity of Aspirin (Optional)

Melting point of aspirin

ivame	Date	Section	
Experiment 31			
Report Sheet			
Part 1 —Preparation of Aspirin			
1A. Mass of 50-mL Erlenmeyer flask (g)			
1B. Mass of flask and salicylic acid (g)			
1C. Mass of salicylic acid (g)			
1D. Mass of filter paper (g)			
1E. Mass of filter paper and aspirin (g)			
1F. Mass of aspirin (actual yield) (g)			
Theoretical yield of aspirin (show calculations	below):		
			,
Percentage yield (show calculations below):			

%

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Part 2—Purity of Aspirin (Optional)

Melting point of aspirin _____°C