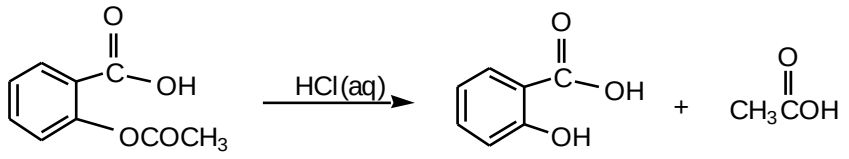
14 Synthesis of Salicylic Acid from Aspirin Tablets

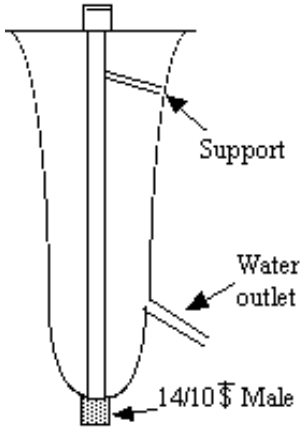
Purpose: Acetyl salicylic acid is extracted from aspirin tablets, then is hydrolyzed to form another white solid, salicylic acid.

Introduction:
The reaction below is for an acid-catalyzed hydrolysis. The reactant H_2O is in the aqueous HCl. The other product is acetic acid, the ingredient in vinegar. The hydrolysis of ASA takes place so easily that a vinegary odor can sometimes be detected in an opened bottle of old aspirin tablets.



acetyl salicylic acid (ASA) salicylic acid (SA) acetic acid

Apparatus: Heating without having vapors escape into the air is done by using an ice-cooled condenser. The water outlet drains water from the melted ice.
The ground glass joints (14/10 Male) shown in the diagram on the right are not needed in this experiment. The condenser can simply be placed on an Erlenmeyer flask using a cork.



Procedure
Part A: Isolation of acetylsalicylic acid (ASA) from aspirin tablets.
1. Place 50 aspirin tablets in a 250-mL Erlenmeyer flask. Record the mass of acetyl salicylic per tablet in mg and g from the bottle label. It is not necessary to crush the tablets ahead, even if they are coated. Add about 50 mL of isopropyl alcohol and warm gently on the low setting of your hot plate. The alcohol should not be boiling. Swirl the flask from time to time, until the tablets have all disintegrated. This may take as long as 20 minutes.

2. Using a single coffee filter, filter by gravity into a 500 mL beaker using a clamp on a ring stand to support the funnel. Wash the residue with a few mL of alcohol. Discard the filter paper and contents (insoluble binder.)

3. To the alcohol solution that passes through the filter (the filtrate) add about 250 mL of cold tap water. The acetyl salicylic acid immediately begins to crystallize because it is not soluble in water-diluted alcohol. Cool in an ice bath for about 5 minutes and/or drop in 3 or 4 ice cubes. When a large amount of solid has appeared and it looks like the crystals have stopped forming, filter to recover the white ASA. Wash with water to help recover any crystals sticking to the walls of the filtering flask or beaker.

4. Remove just a spatulaful, dried first by rubbing on a piece of filter paper. Place in an open plastic vial to dry. Label this. You will use this sample of ASA in to compare to your next product, salicylic acid, also a white solid.

5. You will not have time to dry the ASA before proceeding to the next reaction in Part B. Assuming that the yield for this extraction is 75%, find the amount of ASA isolated from the 50 aspirins. The amount of ASA in one aspirin tablet is 325 mg..
(Keep just 2 significant figures in your answer).

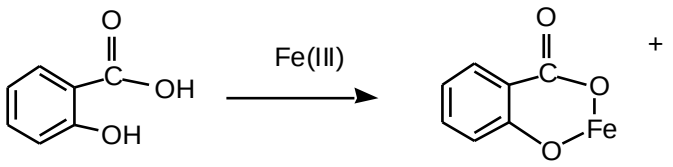
Part B: Hydrolysis of Acetylsalicylic Acid with HCl(aq) to produce Salicylic Acid

1. Mix the wet acetylsalicylic acid with 100 mL "muriatic acid" (20% HCl) in a 250 mL Erlenmeyer flask. Add a stir bar. Place the ice-cooled condenser on top of the Erlenmeyer using the cork provided. Put ice in the outside jacket of the condenser. Although the hydrolysis takes place rather easily, it will still require around 30 minutes of gentle heating on the low setting of a stirring hot plate (enough heat to maintain a temperature of about 50-60^{o}C) to assure complete conversion.

2. When the conversion has taken place you will notice an obvious thickening of the reaction mixture. Heat for another 10 minutes, then remove from hot plate and allow to cool, using an ice bath after the flask is no longer hot.

3. When the mixture is near room temperature, remove the condenser.
CAUTION: The reaction mixture has a very strong odor of acetic acid.
Add about 100 mL of cool water, then filter using gravity. Wash several times with cold water to remove the acetic acid odor. Spread the material in the filter paper out on a paper plate and store until next week. You cannot proceed with the next step until this product is dry, since water will interfere with the esterification. Also since the samples must be dried before their melting points are taken, that must also wait until the next week.
CAUTION:Salicylic acid is irritating to the skin, and should be handled with care.
Note: The reaction mixture may turn violet, since salicylic acid forms a violet-colored complex with as little as a trace of iron.

4. Characterizing the Products (can be done with wet samples)
To compare the way in which acetylsalicylic acid and salicylic acid form complexes with iron, mix a small amount of each in two different test tubes and add about 5 mL of tap water to each. Place a small amount of ferric ammonium sulfate, $FeNH_4(SO_4)_2$, in each tube. Shake tubes and observe result. The reaction of Fe with salicylic acid produces complexes such as the one below which cannot form easily with acetyl salicylic acid. If you do not see a color change, inform your instructor.



5. The color of the complex can be altered by changing the pH. Try adding a few drops of 2M NaOH(aq) to the test tube containing the violet colored complex. Record any change in color.

Data and Results (salicylic acid)

Name(s) _____

Part A Isolation of acetyl salicylic acid (ASA) from aspirin tablets.

Number aspirin tablets _____

Mass ASA in 1 tablet (see bottle label) _____ mg or _____ g

Mass ASA in 50 tablets: _____ g

Mass of ASA isolated if the yield is 75%: _____ g

Part B: Hydrolysis of ASA with HCl(aq) to produce Salicylic acid (SA)

Complex Formation:

Compound	Molecular Formula	Appearance	Color with Fe(III)	Color with Fe(III) + NaOH
Acetyl Salicylic Acid (ASA)	$C_9H_8O_4$			
Salicylic Acid (SA)	$C_7H_6O_3$			

Question:
Assume that you started with 12 g ASA. Can you find the yield of salicylic acid by weighing it as soon as you finish the filtering step? Explain.

_____

Instructor's Guide
#14 Salicylic Acid

(**Data and Results**)

Part A Isolation of acetyl salicylic acid (ASA) from aspirin tablets.

Number aspirin tablets *50*

Mass ASA in 1 tablet (see bottle label) *325* mg or *0. 325* g

Mass ASA in 50 tablets: *16* g

Mass of ASA isolated if the yield is 75%: *12 g*

Part B: Hydrolysis of ASA with HCl(aq) to produce Salicylic acid (SA)

Complex Formation:

Compound	Molecular Formula	Appearance	Color with Fe(III)	Color with Fe(III)+ NaOH
Acetyl Salicylic Acid (ASA)	$C_9H_8O_4$	*white solid*	*none*	*none*
Salicylic Acid (SA)	$C_7H_6O_3$	*white solid*	*violet*	*red*

Question:
Assume that you started with 12 g ASA. Can you find the yield of salicylic acid by weighing it as soon as you finish the filtering step? Explain.

The salicylic acid or SA is still wet. It must be dried before the mass of product can be found and the yield calculated.

Instructor's Guide
Salicylic Acid (cont'd)

Time: 1 h
Equipment and Materials per group

Items	Number	Comment
stir/hot plates	1	
stir bars	1	
thermometers	1	
ice-cooled condensers	1	not essential; open flask is okay
aspirin tablets	1 bottle per class	cheapest brand is fine
250-mL Erlenmeyers	1	
spoon spatulas	1	
isopropyl alcohol	1 L per class	
500-mL beakers	1	
100-mL graduates	1	
20 mL vials	20 per class	
corks	1	
funnels	1	Large funnel with large diameter
test tube racks	1	
test tubes	2	
coffee filters	2	
fluted filter papers	2	
6M HCl(aq)	1 L per class	20% HCl
ferric ammonium sulfate	10 g per class	only small amounts are needed.
2M NaOH	1 dropper bottle	few drops/group
ice		
Safety glasses	1 per student	
Rubber gloves	1 box per class	

Ideas/ Information

Aspirin tablets each contain 325 mg (5 grains) of acetylsalicylic acid (ASA) and about 50 mg of inactive starch and cellulose ingredients. Concentrated isopropyl alcohol (91%) will not dissolve the inactive ingredients.

If desired, this extraction could be done in a single separate lab, so that the ASA could be dried and weighed before the next reaction. However, we have performed the extraction many times in our lab and have found the yield to be 75% giving around 12 g ASA. This is close enough to use in finding the overall yield in the next experiment.

6M HCl solution could be prepared by adding concentrated HCl (12 M) to a volumetric flask and then diluting with distilled water to the mark on the flask.

Molarity mol/L	mL con. HCl for 1 L solution	mL con. HCl for 500 mL solution
6	500	250

2M NaOH solution could be prepared by adding solid NaOH to a volumetric flask and then diluting with distilled water to the mark on the flask.

Molarity mol/L	g NaOH for 1 L solution	g NaOH 500 mL solution
2	80	40