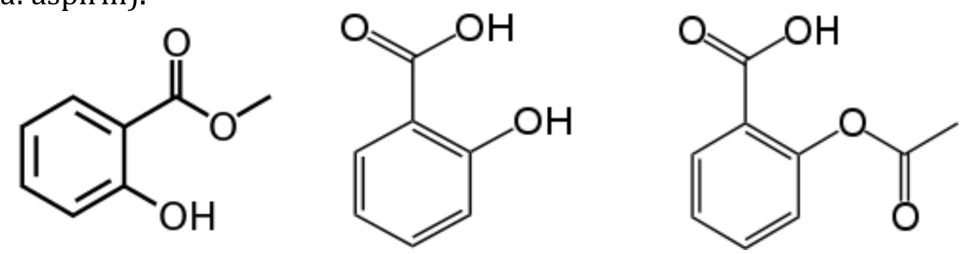
12BL Experiment 3: Salicylic Acid Synthesis

Safety: Proper lab goggles/glasses must be worn (even over prescription glasses). As always, ask where organic waste containers are located in the lab.

Background: Over the course of this experiment and the next, you will synthesize salicylic acid from methyl salicylate (aka: wintergreen oil), and then use your salicylic acid for a second synthesis in which you will derive acetyl salicylic acid (aka: aspirin).

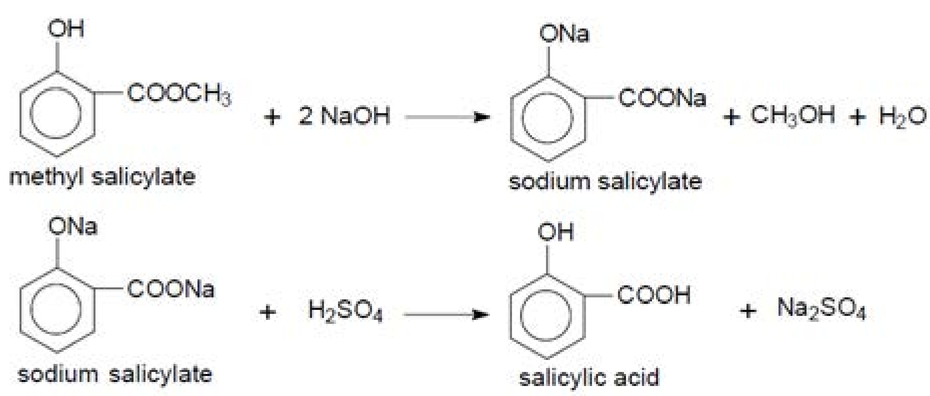


Methyl Salicylate — Salicylic Acid — Acetyl Salicylic Acid

If you pay attention to the ingredients on many facial creams and facial washes you may be familiar with both salicylic acid and wintergreen oil – both are natural products used as antim   inflammatories and bacterial cleansers in skincare; in addition, salicylic acid was taken as an analgesic drug in the past; however, it was extremely harsh on peoples' intestinal tract – can you explain why using organic functional groups? Thus, salicylic acid was converted to a more "mild" drug, acetyl salicylic acid. Ironically, aspirin is still very difficult for many people to take.

In today's lab, you will be performing the hydrolysis of an ester in excess base, also known as saponification. Hydrolysis converts an ester to what functional group? Hint: same functional group responsible for the harsh side effects found in both salicylic acid and aspirin when taken as an analgesic!

You may be surprised to find that an immediate inorganic reaction occurs before you reflux your solution in order to hydrolyze the ester. What most acidic atom will the strongly basic hydroxide attack first upon combining of methyl salicyclate and sodium hydroxide? Remember, it takes a lot of energy for organic reactions to occur in which bonds to carbon are being broken and new bonds forming – hydroxide will not attack the carbonyl carbon of the ester until it has sufficient energy obtained from refluxing.



Objective:
To synthesize pure salicylic acid and obtain a maximum yield in order to convert to aspirin in the next lab.

Procedure:

1. Set up a microscale reflux apparatus using a hot plate as your heat source (heat on low setting until you figure out appropriate low boil setting).

2. Measure out **0.62 grams** of methyl salicylate (wintergreen oil) and add to your micro reaction round bottom flask.

3. Add **5.0 mL of 6.0M NaOH and a boiling stone.** Your solution should precipitate already as an an Inorganic acidm base reaction is occurring right now! What is it?

4. Bring the reaction mixture to a gentle boil and heat for 30 minutes.

5. After 30 minutes, evaluate your solution – “waft” the vapors towards you. If you still smell wintergreen, continue to heat for another 10 minutes or so.

6. When the reaction is complete, let it cool to room temperature before disassembling any glassware.

7. Transfer the reaction mixture (remove boiling stone) to a 25mL beaker.

8. **SLOWLY add 6.0 mL of 3M H_2SO_4** while gently swirling the beaker; your salicylic acid should begin to precipitate. Test the pH using pH paper. If your pH is still above 2, add a few more drops of acid and retest.

9. Cool the mixture in an ice-water bath – never put in a big class bucket of ice water – this is how you get your beaker knocked over and have to start again!

10. Filter your crystals using a micro filtration set-up. Rinse the beaker and crystals with ice-cold water.

11. Recrystallize your crude crystals using hot, boiling dI water. REVIEW recrystallization if necessary!

12. Filter and dry your pure crystals.

13. Obtain a melting point range and an IR - IR must show structure of product on it and all bonds & wavenumbers labeled on the spectrum.

14. **SAVE YOUR CRYSTALS – you will be synthesizing aspirin from your own sample of salicylic acid; make sure you have enough to work with! You may repeat this experiment to obtain more crystals if you lost too much along the way!**

12BL Prelab 3: Salicylic Acid Synthesis

1. Read the lab!
   a. Who is the limiting reactant in the experiment?

   b. Who is the excess reactant in the experiment?

2. Show all calculations fully – **dimensional analysis style. All units & chemical names must be shown – no numbers all alone.** (*Be sure to record your answers on your lab procedure as you are turning the prelab in.)

   a. Calculate the volume in mL of methyl salicylate to be used in this experiment – what physical property of methyl salicylate do you need to look up in order to convert from grams to mL?

   b. Calculate the theoretical yield of salicylic acid to be produced in this experiment.

c. Calculate the minimum amount in mL of hot water needed to recrystallize the theoretical yield of salicylic acid – what physical property of salicylic acid do you need to look up in order to convert from g of salicylic acid to mL of hot water?

12BL Postlab 3: Salicylic Acid Synthesis

All calculations should be shown through Dimensional Analysis. All numbers should have units and chemical names/formulas.

1. Attach your IR; all bonds and their wavenumbers must be labeled on the IR; also draw the structure of the product on the IR.

2. Draw the structure of the aromatic molecule that forms ***immediately*** after NaOH is added to the methyl salicylate (before reflux even occurs!).

3. Draw the structure of the aromatic molecule that forms ***after reflux*** *with NaOH.*

4. Draw the structure of the aromatic molecule that forms ***after addition of H_2SO_4.***

5. Show the complete ***Mechanism*** of the reaction of ethyl propanoate and NaOH, followed by addition of H_2SO_4.

6. The solubility of salicylic acid at 20.0°C is 0.18 grams per 100 mL of water. The solubility of salicylic acid in boiling water is 6.7 grams per 100 mL of water.
    a. A student obtained 5.0 grams of crude product in their experiment. Calculate the amount of **hot water** needed to dissolve this amount of product.

    b. The student now cools their hot solution from part a. to 20.0°C. Calculate the mass of product that ***does not*** recrystallize.

    c. Calculate the mass of product that **does** recrystallize and can be collected.

7. We have learned in first semester organic chemistry, that Lewis bases are atoms that are small and e-rich. In addition, Lewis acids are atoms that are e-deficient.

    a. What does e- deficient mean in terms of an atom's charge or partial charge?

    b. Are H+ ions the only acidic atoms that exist? Can other atoms be acidic? Give two examples.

    c. Draw the structure of salicylic acid in bond-line and circle the atom that is the most acidic. Explain clearly why. Your answer should bring up the topic of polarity!

    d. Now circle the atom that is the second most acidic atom in the molecule. Explain clearly why. Your answer should still bring up the topic of polarity.