Heather Graehl

Title: Experiment 2: Synthesis of Aspirin

Pre-lab questions:

Compound	Molecular weight	Hazards	Density	Melting point
Salicylic acid	138.12	Irritating to eyes and skin. Toxic if inhaled.	X	156-161 C
Acetic anhydride	102.09	Corrosive, flammable, irritating to eyes and skin. Toxic if inhaled.	1.081g/mL (20C)	-73 C
Phosphoric acid	98.00	Corrosive, irritating to eyes and skin.	X	40 C
Acetic acid	60.05	Corrosive, flammable, toxic if inhaled, irritating to eyes and skin.	1.049g/mL (25C)	16.2 C
Ethanol	46.07	Flammable	.789g/mL (25C)	-114 C
Aspirin	180.16	Toxic if in contact with skin, swallowed or inhaled	X	134-136C

1. Acetic anhydride has poor solubility in water at 25C (1g of acetic anhydride dissolves in 300mL water) and has even worse solubility at lower temperatures. When ice water is added, it is used to separate the crude from the product leaving the acetic anhydride in the Buchner funnel as the ice cold water rinses out the crude.

2. A. 0.90g

   B. 0.10g

   C.10% yield

   D. Repeat this process over again using the remaining 0.90g not used. Each time you will receive approx 10% yield but by repeating the process you do not waste the left over materials.

3. pH=-log(Ka) and Ka=[H+][aspirin –H+]/[aspirin]

   pKa=4.5, Ka=-.65321

   $(x^2)/.1-x=-0.65321$

   $X^2+.06532x-0.06532$

   Quadratic formula gives x=.224996

   -log.224996=.658

   pH=.658 which is less than 4.5

4. A buffer will stabilize the pH to a desired level.

Purpose: To synthesize and purify aspirin from salicylic acid and acetic anhydride.

Procedure:

Day 1:

1. Weigh and put 1.0g salicylic acid into 50mL Erlenmeyer flask
2. Add 2.0 mL of acetic anhydride under fume hood and mix by rotating flask
3. Add 5 drops 85% phosphoric acid and mix by rotating flask
4. Put flash in 45-50°C water bath for 5 minutes
5. Place flask in ice water bath. Scratch walls of flask with glass rod as it cools
6. After product forms, add 15 mL ice water.
7. Stir with glass rod to break up solid
8. Get tare weight of microscale Buchner funnel. Record
9. Vacuum filter solid on microscale Buchner
10. Rinse and scrape remaining product
11. Remove small amount of crude and save for next day's experiment
12. transfer solid from Buchner funnel to a 50mL Erlenmeyer flask
13. add 1.5mL ethanol and dissolve solid completely (heat if necessary)
14. Gradually add 10mL of 50-60°C water and allow t cool to room temperature
15. Place flask in ice-water bath for 5-10 min
16. Vacuum filter solid onto clean Buchner funnel
17. Place Buchner funnel with product in drawer to dry and resume on day 2.

Day 2:

1. Weigh Buchner funnel with dried aspirin
2. Using melting point apparatus, determine the melting point of crude aspirin, recrystallized aspirin, and commercial aspirin.
3. draw a line 1cm from bottom of TLC plate with pencil
4. make 3 dots and label each for a corresponding solution of crude, recrystalized, and commercial aspirin.
5. prepare chromatography jar with less than .5 cm from the bottom.
6. Place TLC plate in the bottle and cap it
7. Wait approx 10 min for solvent to migrate up the TLC plate.
8. Remove TLC plate and mark the position of the solvent
9. Use a short wavelength UV lamp to see the position of the solution and outline with a pencil.
10. Find the distances the spots migrated and calculate R_f for each spot
11. Perform HPLC of crude and recrystallized aspirin and record conditions.

Data/Observations:

Day 1:

Description	Weight
Salicylic acid	1.004g
Buchner Funnel	38.161g
Recrystalized aspirin	0.23g

Day 2:

Melting Point

Description	Melting Point Low	Melting Point High
Crude aspirin	56.0°C	78.2°C
Recrystallized aspirin product	110.8°C	116.2°C
Commercial aspirin	127.0°C	135.0°C

TLC

Description	Initial length	Final length	Distance
1. Crude aspirin	.5	.5	0
2. Purified aspirin	.5	.5	0
3. Commercial aspirin	.5	.5	0

Problem with solvent. Calculate R_f for each spot

Results:

Melting Point:

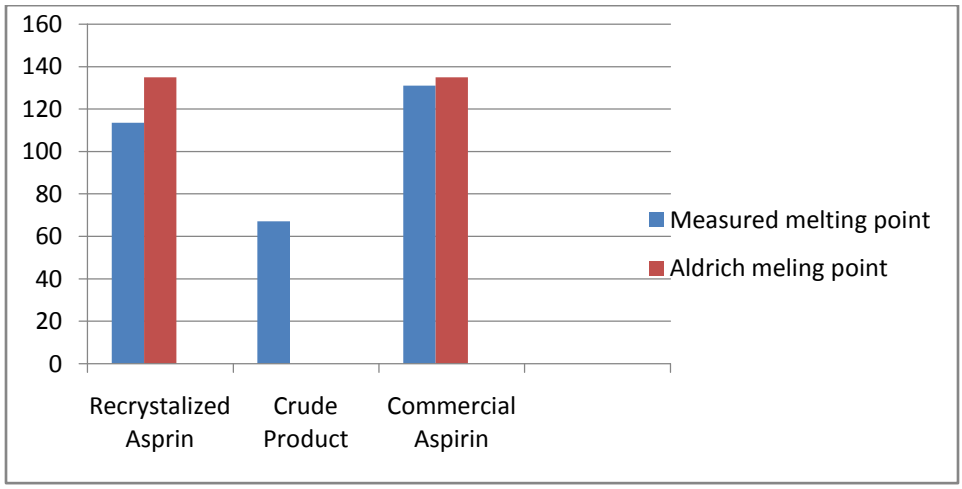

Figure 1

TLC plate sketch:

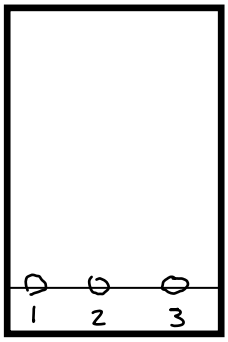

Figure 2

HPLC data:

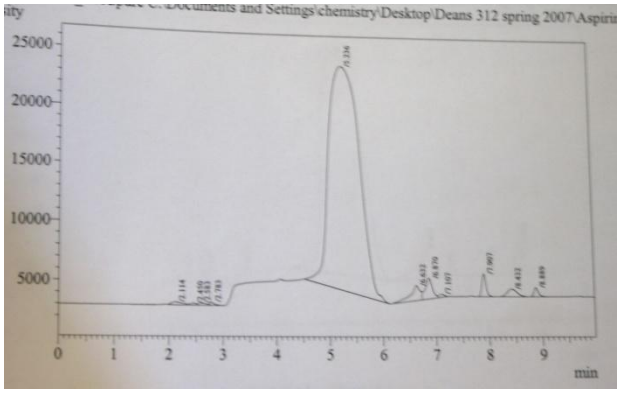

Figure 3

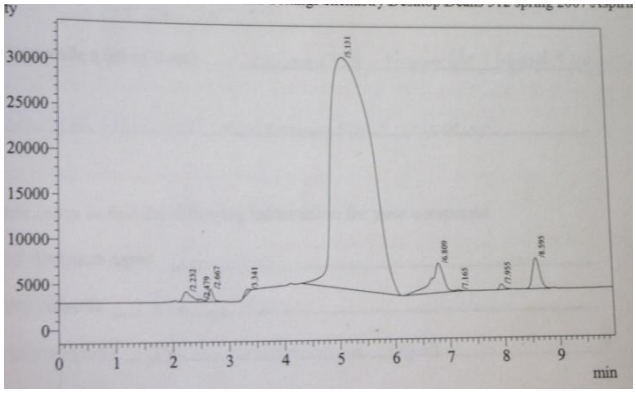

Figure 4

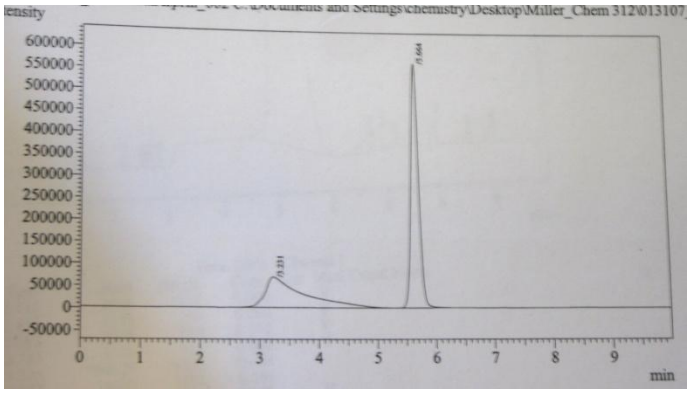

Figure 5

Figure 2: Comparing melting point analysis results to actual melting points from Aldrich. Since melting points were measured as a range, the graph represents the median of the high and low of measured melting point.

Figure 2: Sketch of TLC plate from TLC analysis. Each blot on plate is labeled 1 for recrystalized aspirin, 2 for crude product, and 3 for commercial aspirin. Normally there would be movement up the TLC plate that could be observed under ultraviolet light, but none of the solutions moved from their original placement.

Figure 3: HPLC analysis of recrystalized aspirin measuring time (x) versus intensity (y). The largest peak measures at 5.236 just at 5 minutes.

Figure 4: HPLC analysis of crude product measuring time (x) versus intensity (y). The largest peak measures at 5.131 just at 5 minutes.

Figure 5: HPLC analysis of commercial aspirin provided by instructor. Two notable peaks are the highest at 5.664 between 5 and 6 minutes and 3.231 just after 3 minutes.

Post Lab Questions:

1. Salicylic acid or acetic anhydride limiting reagent?

$$1.004\,g\ \text{salicylic acid} \times \frac{1\,mol}{138.12\,g} = 0.007269\,mol$$

$$2.0\,mL\ \text{acetic anhydride} \times \frac{1.081\,g}{mL} \times \frac{1\,mol}{102.09\,g} = 0.02118\,mol$$

Salicylic acid is limiting reagent because there are fewer moles of salicylic acid and acetic anhydride and salicylic acid have a one to one molar ratio.

2. Mass of aspirin isolated: .023g
   Moles of aspirin isolated:

$$0.23 \times \frac{1\,mol}{180.16\,g} = .001278$$

Theoretical Yield: 7.269×10^{-3} mol
Actual yield: 1.28×10^{-3}
Percent yield: 17.56%

3. If a low percent yield occurred, this could be due to problems with purification such as not allowing the product to dissolve completely. A percent yield over 100% could be due to water not completely dissolving from the product.

4. Our crude aspirin had a melting point range of 56.0-78.2 C. Our recrystalized aspirin product had a melting point range of 110.0-116.2. We observed a melting point range of 127.0-135.0 with commercial aspirin while the actual melting point is reported as 134-136 C from sigma-Aldrich online. I predict that the melting point high range is due to the fact that multiple compounds with different melting points are present in our samples. Our recrystalized aspirin product had a significantly higher melting point than the crude product which shoes that the purification was successful to some degree. It was not successful to the same purity standards as commercial aspirin since our melting point was not quite up to about 130C.

5. The TLC was not successful and we observed no movement on the TLC plate. This problem was encountered by most groups in the laboratory and it was suggested that there was a problem with the solution used such as degradation.

6. Rf would be calculated by dividing the distance traveled by the product by the total distance travelled by the solvent. Since the TLC showed no movement in the 3 products, the Rf would calculate to 0; however, this experimental data is useless since TLC did not work properly.

7. The HPLC of our crude and recrystalized aspirin had the same number of peaks in the same location on their graphs, but the recrystalized aspirin had higher peaks in each local maximum that matched to the commercial aspirin and lower local minimums in areas that did not show in the commercial aspirin. This shows that our purification was successful to some degree, but it is not as pure as commercial aspirin. A company that sold aspirin commercially would likely use HPLC instead of TLC to test purity because minute differences and impurities can be detected and represented by accurate numbers with HPLC.

Conclusion:

We successfully synthesized and purified aspirin, but at a low 17.56% yield. The melting point of our recrystalized aspirin was 110.8-116.2 C which is not as high as commercial aspirin's 127.0-135.0. Although our recrystalized aspirin did not have as high of a melting point as commercial, it was significantly higher than the original crude product at 56.0-78.2 C. Sigmaaldrech online

reported melting point of 134-136C, so our commercial aspirin melting point was measured a little low. The TLC was a failure because none of the solutions moved on the TLC plate. If time permitted this could be repeated with correcting the problem with the solutions. Since all three had problems on TLC it is likely not the individual samples, but rather the solvent.