**Title:** Synthesis and Characterization of Aspirin (Acetylsalicylic Acid)

Name:

Instution:

**Abstract:**
This experiment focuses on the synthesis of acetylsalicylic acid (aspirin) through the esterification of salicylic acid with acetic anhydride in the presence of sulfuric acid as a catalyst. The reaction mechanism involves nucleophilic acyl substitution, a key concept in organic chemistry. After synthesis, the crude product was purified using recrystallization. The final aspirin product was analyzed using melting point determination and Thin Layer Chromatography (TLC) to assess purity. The percentage yield of the reaction was calculated and compared to theoretical values. Results showed a moderate yield, and the melting point was close to literature values, suggesting successful synthesis with minor impurities.

## Introduction

Organic chemistry involves understanding reactions and mechanisms that drive the transformation of molecules. Aspirin synthesis is a classic organic lab experiment because it illustrates several fundamental concepts such as esterification, purification, recrystallization, and yield determination.

**Aspirin (acetylsalicylic acid)** is a widely used analgesic and anti-inflammatory drug. It is synthesized from **salicylic acid**, which contains both a phenol group (-OH) and a carboxylic acid group (-COOH). When reacted with **acetic anhydride**, the hydroxyl group of salicylic acid forms an ester, producing aspirin and acetic acid as a byproduct.

The reaction can be summarized as:

**Salicylic acid + Acetic anhydride → Acetylsalicylic acid + Acetic acid**

**Sulfuric acid ($H_2SO_4$)** or phosphoric acid ($H_3PO_4$) is commonly used as a catalyst to speed up the reaction. After the reaction, the crude product is purified by recrystallization using ethanol and water.

This lab report presents a complete synthesis process, followed by characterization and analysis of the synthesized aspirin.

## Materials and Methods

### Materials:

- Salicylic acid ($C_7H_6O_3$)
- Acetic anhydride ($C_4H_6O_3$)
- Concentrated sulfuric acid ($H_2SO_4$)
- Distilled water
- Ice
- Ethanol (95%)

- Watch glass
- Hot plate
- Beaker (250 mL)
- Flask (Erlenmeyer, 125 mL)
- Graduated cylinder
- Spatula
- Stirring rod
- Filter paper
- Buchner funnel and vacuum filtration setup
- Melting point apparatus
- Thin Layer Chromatography plates
- Capillary tubes

**Procedure:**

1. **Synthesis:**
   - In a 125 mL Erlenmeyer flask, 2.0 g of salicylic acid was added.
   - 5 mL of acetic anhydride was added to the flask.
   - 5 drops of concentrated sulfuric acid were added carefully using a dropper.
   - The mixture was swirled gently and then heated in a water bath at 60–70°C for 15 minutes.
2. **Crystallization:**
   - After heating, the reaction mixture was removed from the bath and allowed to cool slightly.
   - 50 mL of cold distilled water was added to decompose excess acetic anhydride and initiate crystallization.

- The flask was placed in an ice bath for 10–15 minutes to complete crystallization.

3. **Filtration and Drying:**
   - Crystals were collected by vacuum filtration using a Buchner funnel.
   - The product was washed with cold water to remove impurities.
   - The crude aspirin was dried on a watch glass.
4. **Recrystallization:**
   - The crude product was dissolved in a minimum amount of ethanol.
   - Hot water was added dropwise until the solution became clear.
   - The solution was cooled to room temperature, then placed in an ice bath.
   - Pure aspirin crystals were collected by vacuum filtration and dried.
5. **Melting Point Determination:**
   - A small amount of dried product was placed in a capillary tube.
   - Melting point was determined using a melting point apparatus.
6. **TLC Analysis:**
   - Aspirin product and salicylic acid were spotted on a TLC plate.
   - The solvent system used was ethyl acetate:hexane (3:1).
   - The TLC plate was developed, dried, and observed under UV light.

**Results**

**Observations:**

- Upon adding acetic anhydride to salicylic acid, the mixture turned cloudy.
- Heating caused the solution to become clear.
- Addition of cold water caused the formation of white, needle-like crystals.
- Recrystallized product appeared purer and finer than crude product.

- TLC showed a single major spot for the product, indicating good purity.

**Data:**

| Measurement | Value |
|---|---|
| Mass of salicylic acid used | 2.00 g |
| Molar mass of salicylic acid | 138.12 g/mol |
| Moles of salicylic acid | 0.0145 mol |
| Molar mass of aspirin | 180.16 g/mol |
| Theoretical yield of aspirin | 2.61 g |
| Actual yield after recrystallization | 1.92 g |
| Percentage yield | 73.6% |
| Melting point of product | 134–136°C |
| Literature melting point of aspirin | 135–136°C |

**TLC Results:**

- Rf value of product = 0.72
- Rf value of salicylic acid = 0.50

**Discussion**

**Reaction Mechanism:**

The synthesis of aspirin involves **nucleophilic acyl substitution**. The hydroxyl group (-OH) of salicylic acid acts as a nucleophile and attacks the carbonyl carbon of acetic anhydride. This leads to the formation of an ester linkage and acetic acid as a by-product.

Sulfuric acid catalyzes the reaction by protonating the carbonyl oxygen of acetic anhydride, increasing the electrophilicity of the carbonyl carbon, and facilitating the nucleophilic attack.

**Yield and Purity:**

The percentage yield of 73.6% indicates a fairly efficient reaction, though not complete. Losses may have occurred during transfer, recrystallization, or filtration. The observed melting point (134–136°C) is very close to the literature value, confirming the identity and purity of the product. Minor impurities or moisture may explain the slight deviation.

**TLC Analysis:**

The TLC analysis revealed one major spot for the aspirin product and no visible spot corresponding to unreacted salicylic acid, suggesting successful conversion. The Rf value for aspirin (0.72) was higher than salicylic acid (0.50) due to decreased polarity after esterification, which aligns with theoretical expectations.

**Sources of Error:**

- Incomplete drying could lower the melting point.
- Excess water in recrystallization could reduce crystal formation.
- Product loss during transfer or filtration.
- Inaccurate temperature control during synthesis might affect reaction completion.

**Conclusion**

The synthesis of acetylsalicylic acid from salicylic acid and acetic anhydride was successful. A good percentage yield and high purity were achieved, as indicated by melting point and TLC analysis. This experiment demonstrates essential techniques in organic chemistry, including esterification, recrystallization, yield calculation, and qualitative analysis through TLC.

The close agreement between the observed and literature melting points, and the successful purification steps, confirm that acetylsalicylic acid was synthesized with high efficiency and purity.

## References

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