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# SYNTHESIS OF ASPIRIN BY USING MICROWAVE ASSISTED METHOD

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## ABSTRACT

*Three laboratory reactions were given synthetic microwave methods. The process of making aspirin. All of these reactions are carried out in organic or general chemistry. Traditional heating techniques call for 30 minutes of heating at 55 °C in order to synthesize aspirin. The suggested microwave techniques maintain comparable, if not higher, yields with shorter reaction times (7 minutes at 175 watts). The Claisen condensation was cut down to 4.5 minutes, and the syntheses of aspirin and were cut down to 7 minutes. Aspirin yielded 85.88% by the microwave method and 72.08% by the conventional method.*

***Keywords:*** *Aspirin, Microwave oven, Organic chemistry*

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# INTRODUCTION

Many organic chemistry syntheses, when heated to standard temperatures, take hours. Such reactions can proceed much faster and with higher yields thanks to microwave chemistry. Polar molecules rotate in tandem with the magnetic field produced by oscillating magnetic fields produced by microwaves. More interactions between molecules result from this molecular movement. [1]

It has been demonstrated that microwave reactions occur much more quickly, which makes them valuable. Using microwave chemistry in the organic lab for undergraduate students is one such application. Students can learn about optimization in the organic chemistry lab and cut down on lab waste by using a microwave.[2]

In the time it takes to run one reaction, students can run multiple reactions.

In addition to being prescribed to patients who are more likely to have a heart attack, aspirin can be used as a pain reliever. Aspirin reduces the chance of blood clots forming in arteries, which lowers the risk of a heart attack. [3]

Aspirin reduces swelling and is also used as an analgesic in addition to being a blood thinner. Acetylation is the organic reaction used in the synthesis of aspirin. [4] When one of the carbonyl groups of acetic anhydrides is attacked by the alcohol group of salicylic acid, the reaction proceeds. The method used today is regarded as a crucial step towards green chemistry since it is more ecologically friendly. [5]

Aspirin synthesis has been a widely used experiment in teaching laboratories for organic chemistry and even in some laboratories for introductory chemistry .[6] Procedures for aspirin synthesis have been included in a lot of laboratory text books in order to study carbonyl nucleophilic substitution reactions in basic or acidic environments .[7] But these conventional experiments follow a recipe straight out of a cookbook, which prevents the student from applying critical thinking to fully comprehend the response.[8]

One of the most commonly used drugs in the world is aspirin. It is used as an anti-inflammatory, analgesic (pain relief), and anti-pyretic (fever control). More recently, research has shown that high-risk patients' daily small-dose aspirin use can reduce their risk of heart attack and stroke. [9]

The origins of aspirin and its precursor can be traced back to antiquity. Hippocrates, the father of modern medicine, is credited with writings from the fourth century B.C. that discuss using willow bark or a powder made from the bark and leaves of the plant to relieve pain. This cure was handed down through the generations. Now fast-forward to the 19th century, when the study of organic chemistry started to flourish greatly.[10]Chemists succeeded in separating, identifying, and purifying the willow bark ingredient responsible for its analgesic properties by 1838. The willow's genus name served as the basis for the compound's name, salicylic acid. [11]

Because of a terrible side effect that caused stomach pain and, in certain cases, ulcers, attempts to market salicylic acid were unsuccessful. Examining the salicylic acid molecule's structure (refer to the figure below) helps to clarify the root of the issue.[12]

Two functional groups are present in salicylic acid: an alcohol (-OH) and a carboxylic acid (-COOH). As the name suggests, the carboxylic acid group tends to produce H3O+ in aqueous solution.[13] Furthermore, because the alcohol group is attached to a benzene ring, it falls into a unique category of alcohols called phenols. One of the many distinctive characteristics of phenols is that they are significantly more acidic than other forms of alcohol. Consequently, the stomach's pH is lowered by the two acidic functional groups, causing the gastric discomfort mentioned earlier. [14]

Chemists attempted to alter the salicylic acid molecule, believing that by changing one of the functional groups, the compound's acidity could be decreased without compromising its therapeutic effects.[15] This was accomplished by utilizing some basic organic chemistry. An ester and water are produced when an alcohol and a carboxylic acid react in the presence of an acid catalyst thanks to the condensation reaction between the functional groups:

Even though this reaction was first achieved in the 1850s, acetylsalicylic acid was not recognized as a commercially viable compound until 1899 by scientists at the Bayer company in Germany. [16] They called it aspirin, which is derived from the name of the arcane genus meadowsweet, which is another natural source of salicylic acid. The medication was in great demand almost immediately, and Bayer quickly rose to prominence in the pharmaceutical industry. [17]

The fields of screening, combinatorial chemistry, medicinal chemistry, and drug development could be greatly impacted by this microwave-assisted technology, which is still underutilized in the lab. - The traditional method of organic synthesis typically requires more time for heating and laborious apparatus setup, which raises process costs and contributes to environmental pollution due to overuse of solvents and reagents.[18] Significant potential exists for reducing waste production, byproducts, and energy costs as a result of the growth of green chemistry. Microwave irradiation has improved many organic syntheses because it can couple directly with the reaction molecule and bypass thermal conductivity, which causes a rapid rise in temperature. (19)

Additionally, this experience demonstrates to the students how new discoveries from research can be used to develop alternatives to established practices. The experiment is also a good way to highlight how important green chemistry is. Additionally, this experiment gives the students the chance to evaluate critically the benefits and drawbacks of using microwave technology to synthesize aspirin. The fact that pure aspirin can be synthesized quickly is one benefit that students can recognize. However, because this experiment does not give the students enough time to optimize their reaction conditions— which is crucial, particularly for industry—they have to carry out their reaction within the allotted time, power, and catalyst amount. [20]

**Advantage Microwave Assisted Method:**

It reducing the duration of the reactions.

Raising their yields, and enhancing the heating's homogeneity

Rapid volumetric heating made possible by it leads to increased yields of products, selectivity, and reaction rates.

Improved chemical reaction rates can occur more quickly with microwave assistance than with traditional heating techniques.

Quicker responses

Fewer byproducts

Unadulterated substances

Total command over the parameters of the reaction.[21]

Selective heating and catalyst activation minimal energy input (typical reaction: 20 w, maximum 300 w).

Green solvents such as acetone, EtOH, and H2O reduced solvent use (per reaction, 0.5–5 ml) Documentation of experiments with software support. [22]

# MATERIAL AND METHOD:

## Operating Principal

Aspirin syntheses with microwave assistance for the organic chemistry lab. In organic chemistry, many syntheses require an hour of heating at room temperature. Microwave chemistry made it possible for this kind of reaction to proceed faster and with a higher yield. A microwave creates a magnetic field that oscillates, which increases molecular interaction.[23]

It has been demonstrated that microwave reactions occur much faster. putting these responses to good use. Using microwave chemistry in the organic lab for undergraduate students is one such application. In the organic lab, students can learn about optimization by using a microwave. [24]

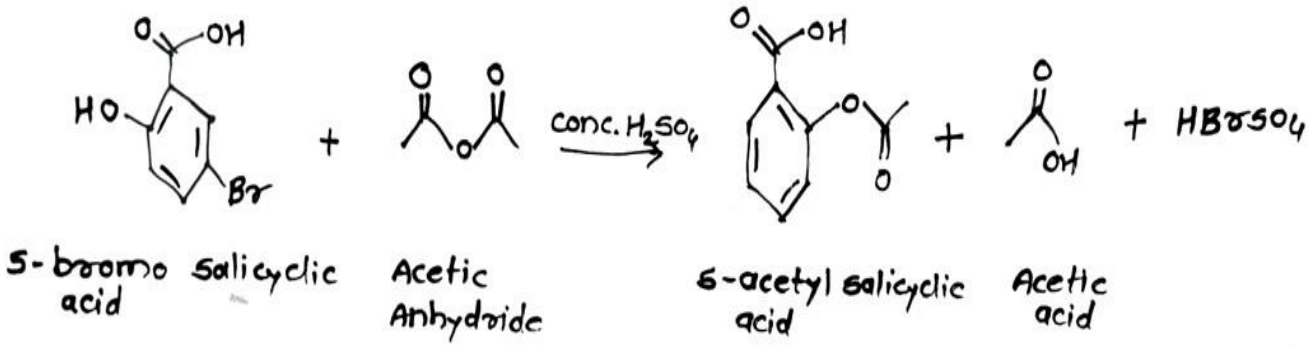
One of the most popular home appliances is the microwave oven. Microwave ovens are found in most homes and convenience stores. Its remarkable speed at which food cooks accounts for its popularity. length of time. [25]

Radio waves make up microwaves. The typical radio frequency for a microwave oven is about 2500 megahertz. An intriguing feature of radio waves at this frequency is that when they are absorbed, they instantly transform into atomic motion, which in turn transforms into heat. Another intriguing feature of microwaves in this range is that they do not absorb well in most plastics, glasses, ceramics, or metals, which can lead to sparks in microwave ovens. Because conductor conductivity is infinite, as we learned in our course, there are no electronic waves inside of conductors, which explains why metal reflects microwaves. The fact that water resonates at a frequency of 2500 megahertz makes the property mentioned in this paragraph possible. [26]

Every food molecule is a dipole with a positive charge on one side and a negative charge on the other. All of the molecules are arranged so that the +ve charge is at the -ve pole and the -ve charge is at the positive pole when an electromagnetic field is applied.[27] Molecule heat is produced in this process fractionally.[28]

As we have seen, the microwave oven operates at a frequency of 2500 megahertz. Next, in a second, a microwave at this frequency reverses the electromagnetic field's direction 2,500,000,000 times. Consequently, a microwave oven has a very high heat efficiency. [29]

# REACTION




In the presence of concentrated sulfuric acid, 5-bromo salicylic acid can undergo a substitution known as the Finkelstein reaction, which replaces the bromine atom with an acetyl group from the acetic anhydride.[30] This results in the formation of 5-acetylsalicylic acid (aspirin) as the main product. [31]


**Figure No. 1: Microwave**

## EXPERIMENTAL WORK

### ASPIRIN SYNTHESIS BY MICROWAVE METHOD

**Procedure**:

Slowly mix 18 ml of acetic acid anhydride with 10 grams of 5 Bromo salicylic acid in a 250 ml Erlenmeyer flask.

Carefully add 10 to 20 drops of Conc. Sulphuric acid to the solution and mix thoroughly. [32]

Irradiate the mixture under microwave for seven minutes till all the salicylic acid dissolve.

After completion of the reaction, cautiously add 20 ml of distilled water to the mixture, add the cool solution on an ice bath until aspirin crystallize.[33]

Filter the crystals by using a Buchner filter and extract by using chilled water.

Dry the solid in oven at 100% for half hour, weigh and yield of products is 95% with a melting temperature range of 128–132-degree Celsius. [34]

### Calculation

Molecular weight of 5-bromo-Salicylic acid (reactant) = Molecular weight of Aspirin (product)

$C_7H_5BrO_3 = 217$ $C_9H_8O_4 = 180$

Theoretical yield = 9.12g

Practical yield = 11.04g,

Percentage (%) yield= 91%

# RESULT

**Evaluation of Aspirin:**

**Physicochemical characterization:**

| | |
|---|---|
| **Color** | White |
| **Appearance** | Crystalline-Powder |
| **Solubility** | Sample+Water_Soluble |
| **Odour** | Odourless |
| **State** | Solid |
| **Flame Test** | Positive |
| **Melting point** | 138 - 142 |
| **PH Determination** | 3.2 |
| **Sulphated Ash Value** | 0.2% |
| **Loss On Drying** | 0.5% |
| **Partition Coefficient** | (Log P) or K=2.05 |

**Table No.1: Physicochemical Characters**

**Identification test**

| Sr No. | Test | Observation | Inference |
|---|---|---|---|
| 1 | A boil approximately 0.5g After adding 10 milliliters of the NaOH solution for three minutes, let it cool, then add 10 milliliters of the sulfuric acid solution. After filtering and dissolving the white crystalline ppt in roughly 2 milliliters of water and ferric chloride test solution, | Dark violet color | Test is positive. |
| 2 | In test A add 3ml ethanol (95%) add 3ml sulphuric acid and heat. | Odour of ethyl acetate | Test is positive. |

**Table No.2: Identification Tests**

**Limit tests**

| Sr.no | Limit Test | Inference |
|---|---|---|
| 1 | **Chloride test:** Boil 1.75 g in 75 ml of water for 5 minutes, let cool, then add enough water to cover the contents and filter.25 milliliters of the filtrate pass the chloride limit test. | Positive |
| 2 | **Sulphate Test:** 10 ml of the filtrate obtained in the test for chloride complies with limit test for the Sulphate | Positive |

| | | |
|---|---|---|
| 3 | **Arsenic Test:**<br>Combine 5.0 g with 3 g of anhydrous sodium carbonate, then fully mix in 10 ml of bromine solution. The cooled residue was dissolved in 16 milliliters of brominated hydrochloride acid and 45 milliliters of water after being allowed to dry out on a water bath and gently ignited. Using 2 ml of stannous chloride as T, remove the excess bromine.<br>The resultant solution passes the arsenic limit test. | Positive |
| 4 | **Heavy Metal Test:**<br>Dissolve 2.0 g in 25 ml of acetone, add 1 ml of water and 10 ml of hydrogen sulphide solution; any colour produced is not more intense than that produced by mixing 25 ml acetone, 1.0 ml of lead standard solution and 10 ml of hydrogen sulphide solution. | Positive |

**Table No.3: Limit Tests**

**Observation of Assay of aspirin derivative**

| Sr No. | Titration | Burette Reading | | End point |
|---|---|---|---|---|
| | | Initial | Final | |
| 1 | Sample: 1.5g aspirin +15ml 0.0 ml 17.0 methanol +50ml 0.5N | 0.0 ml | 18.0 ml | Pink to Orange |
| 2 | Blank:15ml ethanol +50ml 0.5N NaOH boil for 10 min Titrate with 0.5N HCL with phenol red indicator | 0.0 ml | 33.0 ml | Orange to pink |

**Table No.4: Assay**

## DISCUSSION

The microwave procedure involved reacting salicylic acid and acetic anhydride for 7 min. at 175 watts in the microwave, shorting the reaction time 7 min. to prevent the trans-esterification, water was used to recrystallized the resulting the aspirin. Microwave-assisted synthesis utilizes microwave radiation to heat the reaction mixture directly, rather than relying on heat transfer through conduction or convection. Microwaves penetrate the reactants and cause rapid molecular motion, leading to faster heating and potentially shorter reaction times compared to conventional methods. In microwave-assisted synthesis of aspirin derivative, the reaction conditions such as temperature and time can be precisely controlled. This can lead to improved reaction efficiency and higher yields compared to traditional methods. The reaction typically takes only a few minutes under microwave irradiation, significantly reducing the overall reaction time. Microwave-assisted synthesis offers several advantages in terms of safety and efficiency. The reaction vessel is usually sealed, minimizing the risk of exposure to hazardous reagents or byproducts. Additionally, the shorter reaction times reduce energy consumption and increase productivity, making the process more environmentally friendly.

## CONCLUSION

In conclusion, the synthesis of Aspirin involves a targeted acetylation process of aspirin, typically using acetic anhydride or 5-bromo salicylic acid as acetylating agents. This synthetic pathway effectively introduces of the aspirin core, yielding a compound with promising potential in pharmaceutical and biomedical applications. The resulting combines the therapeutic properties of salicylic acid derivatives, such as anti-inflammatory and analgesic effects, with the potential for improved efficacy and safety profiles through further structural modifications and optimization. The synthesis process, therefore, not only provides a viable method for producing this compound but also lays the groundwork for extensive research into its pharmacological activities, safety assessments, and broader applications in various scientific and industrial fields.

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