The Effectiveness of Hydroxychalcone Synthesis By Using NaOH And NaOH+ZrO₂ Montmorillonite Catalyst Through Conventional And Microwave Assisted Organic Synthesis (MAOS) Method

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Abstract. The aim of this research is to investigate the effectiveness of hydroxychalcone synthesis via Claisen-Schmidt condensation catalyzed by NaOH and NaOH+ZrO₂ montmorillonite catalysts by employing the conventional and microwave methods. Microwave method was an alternative innovation of the principle of green chemistry. The products were analyzed by FTIR, TLC scanner and ¹H-NMR. Synthesis of the hydroxychalcone compound was carried out between hydroxybenzaldehyde and acetophenone in the presence of 40% NaOH as a catalyst. A certain amount (0.1g) of ZrO₂ montmorillonite was added to the reaction system to determine its effect on the product of the two methods. Products which were produced through conventional methods were 10.37% and 24.31% of 2-hydroxychalcone for 3 hours. In the microwave method, which was added by NaOH and NaOH+ZrO₂ montmorillonite, irradiated using the microwave on 50% power produced 40.35% and 47.87% of 2-hydroxychalcone for 50 seconds. Based on these results, it can be concluded that the addition of ZrO₂ montmorillonite catalyst increase the effectiveness of the reaction and MAOS method has better effectiveness with percent yield 40.35% and 47.78% for 50 seconds than the conventional method.

1. Introduction
Chalcone derivatives are one type of secondary metabolites belonging to the flavonoid. Several compounds and their derivatives of chalcones can be used as an antioxidant [1-2], antibacterial [3-4], antimalarial [5-7] and inhibitor of cancer cell [8-9] so it should attempt to get chalcones by synthesis. Synthesize chalcones can be done through a condensation reaction of an aromatic aldehyde with an aromatic ketone in both acidic and base conditions, known as Claisen-Schmidt condensation. Chalcone derivates were synthesis from acetophenone reacted with benzaldehyde, p-anisaldehyde and veratraldehyde using KOH catalyst with percent yield 37.79%, 16.77% dan 57% [10]. Chalcone derivates were conducted using NaOH catalysts for 48 hours [1]. However, there were always some problems due to the long reaction time and the resulting low yields.

Today has developed heterogeneous catalysts in Claisen-Schmidt condensation reaction. Heterogeneous catalysts are catalysts that have different phases with phase reactants. A catalyst is usually a solid form, while the reactant is liquid or gas form. Claisen-Schmidt condensation reaction between benzaldehyde and acetone using homogeneous catalysts by the addition of NaOH compared to the synthesis of the same compound but used NaOH and heterogeneous catalysts like ZrO₂-
montmorillonite simultaneously and provide results that are very significant in terms to increase of the yield product when used combined catalysts in reaction [11]. Synthesize methods are being developed at this time is Microwave Assisted Organic Synthesis (MAOS) methods. Maos method is a method of synthesizing reactions of organic compounds with the assistance of microwaves. Chalcones are synthesized by MAOS produced yield percent greater than using conventional methods [12]. The use of microwaves in addition to shortening the time of synthesis was also carried out with free solvent conditions [13–15]. This method is expected to improve the synthesizing process becomes more efficient. To improve the efficiency of the synthesis of hydroxychalcone in this study will compare the reaction time required to synthesize hydroxychalcone with the conventional method and microwave method. The addition of ZrO$_2$ montmorillonite catalyst will be conducted with the hope to improve the efficiency of the synthesis hydroxychalcones via Claisen-Schmidt reaction.

2. Materials and Methods

2.1 Materials
Materials used for this experiment were used without purification, among others: acetophenone merk, ethanol merk, methanol merk, hexane merk, ethyl acetate merk, HCl 37% merk, 2-hydroxybenzaldehyde merk, sodium hydroxide merk, ZrO$_2$-montmorillonite, and aquadest. Hydroxychalcone synthesized were characterization used by Shimadzu Prestige-21 FTIR Spectrometer in KBr pellets, TLC scanner and 1H NMR (1H 500 MHz in chloroform).

2.2 Synthesize hydroxychalcone through the conventional method
Poured 0.61 g (0.005 mol) 2-hydroxybenzaldehyde in a mixture of 5 ml ethanol and 5 ml aquadest that contained 0.4 g NaOH and features a magnetic stirrer. Subsequently, 0.6 g of acetophenone was added to the mixture and stirred at room temperature for 3 hours. After 3 hours add a few drops of 37% HCl and let stand in refrigerator for 24 hours. The solid that formed was filtered and then dried and weighed. Then analyzed using FTIR spectrometer, TLC scanner, and 1H-NMR. The procedure is carried out simultaneously on 2 different variation Erlenmeyer which using a variety of NaOH catalysts and NaOH+ZrO$_2$-montmorillonite catalysts.

2.3 Synthesize hydroxychalcone through MAOS method
Acetophenone (0.005 mol), 2-hydroxybenzaldehyde (0.005 mol), 0.4 grams of NaOH catalyst and 2 ml of aquadest was homogenized using a mortar. The resulting mixture is then irradiated using a microwave for 30, 40 and 50 seconds at 50% power range. After the reaction is complete the mixture was cooled at room temperature and then dissolved in aquadest (15 mL). The solution was then added with a few drops of 37% HCl until a precipitate is formed and then allowed to stand for 24 hours in the refrigerator. Compounds synthesized filtered, dried, weighed and then determined yield percent. The results were analyzed by TLC, FTIR, TLC and 1H-NMR scanner. The procedure is carried out simultaneously at 3 different vessel variations of a variety of NaOH catalysts and NaOH+ZrO$_2$-montmorillonite catalysts.

3. Result and Discussion
Synthesized 2-hydroxychalcone with NaOH and NaOH+ZrO$_2$ montmorillonite catalyst have the shape of solid with orange color for the conventional method and reddish orange for the MAOS methods. The resulting compounds were analyzed by TLC and TLC scanner to determine the yield percent. The magnitude of yield percent synthesis results is presented in Table 1.

| Table 1. Yield percent 2-hydroxychalcone compound |
|-----------------------------------------------|
| Methods                        | Catalyst                      | Code  | Weight (grams) | TLC Area (%) | Yield (%) |
|--------------------------------|-------------------------------|-------|----------------|--------------|-----------|
| Conventional                   | NaOH                          | A11   | 0.32           | 36.30        | 10.37     |
| NaOH/ZrO$_2$ montmorillonite   | A12                           | 0.52  | 52.35          |              | 24.31     |
### Methods

| Catalyst                  | Code   | Weight (grams) | TLC Area (%) | Yield (%) |
|---------------------------|--------|----------------|--------------|-----------|
| Microwave                 |        |                |              |           |
| NaOH                      | A21100| 0.32           | 35.52        | 10.15     |
|                           | A21400| 0.33           | 63.30        | 18.65     |
|                           | A21500| 0.64           | 70.62        | 40.35     |
| NaOH/ZrO₂ montmorillonite | A22300| 0.47           | 42.51        | 17.84     |
|                           | A22400| 0.36           | 73.95        | 21.02     |
|                           | A22500| 0.82           | 65.39        | 47.87     |

Identification using FTIR spectrometer showed the absorption at 3464 cm⁻¹ region (A11), which proves the existence of the hydroxy group (-OH). Carbonyl group conjugated double bond is characterized by the emergence of absorption at 1651 cm⁻¹ region. Evidence supporting the existence of the C=C aromatic namely the appearance of absorption at 1566 and 1458 cm⁻¹. 2-hydroxychalcone compounds were synthesized by microwave method (A21, A22) has the FTIR spectra that can be said about the same or similar to the 2-hydroxychalcone compounds were synthesized by conventional methods. Based on the FTIR spectra of A21 and A22 compounds are the same compound with the A11, so the identification of compounds showed uptake of the carbonyl group (C = O), a hydroxy group (-OH), an aromatic group and an alkene group.

![Figure 1](image.png)

**Figure 1.** ¹H-NMR Spectra 2-hydroxychalcone

Identification of compounds with ¹H-NMR results produced spectra presented in Figure 1. and indicate the presence of 8 signals. H doublet signals in the chemical shift δ = 8.16 ppm and the F duplet signal the chemical shift δ = 7.7 ppm are the peak of the proton to the cluster of ethylene -HC=CH-characteristics the transposition. G doublet signals in the chemical shift δ = 8.03 ppm is equivalent to integration 2 H atom which is protons on the aromatic ring whose position is close to the carbonyl group. E multiplet signals in the chemical shift δ = 7.55 to 7.6 ppm which is equivalent to 2 H atoms integration made possible the incorporation of 1 proton signals in the aromatic ring near the cluster of ethylene with 1 proton on the aromatic ring to another. D multiplet signals in the chemical shift δ = 7.47 to 7.51 ppm are equivalent to integration 2 H atoms which are protons on the aromatic ring. C multiplet signals in the chemical shift δ = 7.25 ppm is equivalent to 1 atom integration H which is a proton on the aromatic ring contained a hydroxy group. B multiplet signal at the chemical shift δ = 6.89 to 6.96 ppm which is equivalent to 2 atoms integration made possible the incorporation of 1 proton signals in the aromatic ring.
ring close to 1 proton hydroxy group on the aromatic ring of the same. A singlet signal at the chemical shift $\delta = 6.56$ ppm which is the proton on the hydroxy group.

### Table 2. Tabulation of $^1$H-NMR spectra of 2-hydroxychalcone

| Protons at C atom | Chemical shift (δ) |
|-------------------|--------------------|
| C5'               | 6.89 (1.8 Hz, m)   |
| C3'               | 6.9 (1.8 Hz, m)    |
| C4'               | 7.25 (1.8 Hz, t)   |
| C6'               | 7.55 (1.8 Hz, t)   |
| C3'', C5''        | 7.5 (2.8 Hz, t)    |
| C4''              | 7.59 (1.8 Hz, t)   |
| C2                | 7.7 (1.16 Hz, d)   |
| C2'', C6''        | 8.03 (2.8 Hz, d)   |
| C3                | 8.16 (1.16 Hz, d)  |

Elucidation of $^1$H-NMR spectra of compounds synthesized 2-hydroxychalcone compared with the elucidation of the same compound synthesized by Primahana (2012) that has chemical shifts is relatively not much different (Table 2). Primahana has successfully synthesized the compound 2-hydroxychalcone with conventional methods and then to characterize the structure of compounds using $^1$H-NMR, $^{13}$C-NMR, HMBC, and HMQC.

The reaction that occurs in the synthesis of compounds 2 hydroxychalcone is Claisen-Schmidt condensation reaction caused by acetophenone have Hα atoms. Reaction mechanism synthesis using base catalyst presented in Figure 2.

**Figure 2.** Mechanism reaction of synthesizes 2-hydroxychalcone using base catalysts.
3.1 Influence of ZrO₂ montmorillonite Catalysts on the Synthesis of 2-Hydroxychalcone

Synthesis 2-hydroxychalcone was done by using two variety of catalysts that are NaOH and NaOH+ZrO₂ montmorillonite catalysts. Further, calculation of the percentage of hydroxychalcone products is presented in Figure 3.

![Figure 3](image)

**Figure 3.** Effect of catalysts on the synthesis of 2-hydroxychalcone.

Based on Figure 3 shows that there was a different percentage of the 2-hydroxychalcone formation. The presence of ZrO₂ Montmorillonite in the conventional and microwave methods provide a significantly increasing the products. Percentage of products give better results with the addition of ZrO₂ montmorillonite into the reaction system. The addition of ZrO₂ montmorillonite acts as a catalyst in the reaction of acid that can cause lone pair on the carbonyl oxygen can adsorb at the acid side on ZrO₂ montmorillonite so it would be a positive carbonyl carbon [7]. With the positive carbon atom in the carbonyl group will make carbanion attacks become easier to condensation. Mechanism of formation of hydroxychalcone products with the addition of ZrO₂ montmorillonite expected to follow the mechanism in Figure 4.

![Figure 4](image)

**Figure 4.** Mechanism formation of hydroxychalcone using ZrO₂ montmorillonite catalyst
3.2 Effect of Synthesize Method on Synthesis Hydroxychalcone

Differences in methods of synthesizing hydroxychalcone compounds were conducted to determine the method of synthesis that will give the percent yield better. The method used is the conventional method and microwave method. Synthesized by two different methods are presented in Figure 5.

Based on Figure 5 shows that the synthesis 2-hydroxychalcone via microwave method had the greatest percent yield using either NaOH or NaOH+ZrO_2-montmorillonite catalyst which has percent yield 40.35% and 47.87%. Microwave-Assisted Organic Synthesis (MAOS) method gives a very short time reaction is 50 seconds for a 2-hydroxychalcone with the yield percent better than the conventional method. The use of microwaves in the synthesis of compounds can improve product hydroxychalcone compounds significantly. Synthesis of 2-hydroxychalcone using the microwave with 2 ml of aquadest solvent, whereas the solvents used in conventional were ethanol and aquadest. The aquadest is an environmentally friendly solvent so that the microwave method can be said to be free solvent.

Figure 5. Products synthesized 2-hydroxychalcone by 2 methods

Microwave methods provide a faster reaction time to synthesize hydroxychalcone compared with conventional methods. So these method is an efficient method of its use in the synthesize hydroxychalcone. Microwave method is to apply the concept of green chemistry [16]. MAOS method can be said to satisfy the concept of green chemistry as one of the principles of green chemistry is proposing the use of safer solvents. Solvents were used in the synthesis of aquadest which is an environmentally friendly solvent.

4. Conclusion

The addition of ZrO_2 montmorillonite into the reaction system will increase the percent yield of 2-hydroxychalcone product which is 24.31% to 47.87%. Microwave method with NaOH+ZrO_2 montmorillonite catalyst provides the greatest percent yield is 47.87% for 2-hydroxychalcone for 50 seconds. MAOS method provide efficiency in synthesizing the 2-hydroxychalcone better than the conventional method.

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