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Comparison between Transesterification Reaction with Microwave Heating and Conventional Heating for Biodiesel Production from Coconut Oil with Alkaline Catalyst

Srunika Boangmanalu*, Elfrida Ginting

Department of Chemistry, Faculty of Mathematics and Sciences, Universias Negeri Medan, Medan 20221, Indonesia
**Email: srunikhaboman2312@gmail.com*

ABSTRACT

Biodiesel is a biofuel made from vegetable oil through an esterification-transesterification process. The process of making biodiesel is carried out by conventional heating methods and microwave heating. The reaction process was carried out according to the specified variables, with a concentration of 0.1% of the volume of methanol and a variable microwave power of 135, 225 and 315 watts with time variations of 5, 3 and 1 minute, as well as conventional heating at 60°C for 1 hour. The best result is the one using microwave heating with a power of 315 watts for 1 minute. The best biodiesel yield is 88.879%, with water content of 0.01%, an acid number of 0.56 Kg-KOH/g, a density of 0.892 g/mL and a viscosity of 2.617 cSt. The best result of biodiesel oil in comparison of is using the microwave heating method.

Keywords: biodiesel, coconut oil, transesterification, microwave, conventional.

1. INTRODUCTION

Coconut (Cocos nucifera L.) is a plant that is very common in the tropics. Coconut is an annual plant, has a hard stem and is generally monopodial and has fibrous roots. The growth of coconuts is usually upright, but in coastal areas, riverbanks, the stems grow curved towards the sun.[1] Coconut trees can reach more than 10-14 meters in height, leaf midribs are more than 34 meters long with fins that support each leaf.[1,2] In currently the need for fuel oil is increasing along with the increasing population and the development of technology without being matched by the existence of reserves of petroleum resources derived from fossils which are dwindling and almost depleted due to their non-renewable nature. Several countries, including Indonesia, have conducted a lot of research in the search for renewable fuels, one of

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which is research on biodiesel. Biodiesel is a renewable fuel made from vegetable/animal oil with many advantages over petroleum diesel fuel, including: derived from renewable raw materials, high lubricity, easily decomposed, non-toxic, can reduce gas emissions. hydrocarbons and carbon monoxide.[1.3]

Several studies have been carried out previously on the manufacture of biodiesel from coconut oil using a microwave with an alkaline catalyst, one of which is the research from Prayanto et al. Based on Prayanto et al's research regarding the manufacture of biodiesel from coconut oil using microwaves with alkaline catalysts, namely the continuous production of biodiesel was successfully carried out in the trans-esterification reaction with microwave heating, the higher the microwave power, the higher the percentage of catalyst concentration, and the higher the slow feed rate (longer heating process), higher yield of biodiesel produced, while the viscosity and density of biodiesel is getting smaller,

Continuous process produces the smallest biodiesel yield of 71.76% at 100 Watt power, 0.25% catalyst concentration, and 0.25% catalyst rate feed 1.72 ml/s and the best yield is 89.55% at 800 Watt power, 1% catalyst concentration, and feed rate 0.73 ml/s, and the biodiesel product produced by the continuous process is in accordance with the characteristics of SNI biodiesel.[2] Coconut oil can produce a biodiesel using a microwave with an alkaline catalyst. Based on this, it is necessary to carry out further research with more different treatments regarding "Comparison Between Transesterification Reaction with Microwave Heating and Conventional Heating for Biodiesel Production from Coconut Oil with Alkaline Catalysts" so that it is expected to produce new alternative sources of biodiesel.[2.2]

Biodiesel is one of the promising alternative fuels, is environmentally friendly, does not have an effect on health which can be used as a motor vehicle fuel which can reduce emissions when compared to diesel oil. Biodiesel can be used pure or mixed and is specifically for diesel type engines. Biodiesel is used to reduce diesel fuel consumption. [3] The water content, acid number, density, and viscosity increase when the reaction time is increased. The best results of biodiesel from Kara brand coconut oil in a comparison of microwave and conventional heating methods is using the microwave heating method. One of the consequences of the deficiency in the formation of biodiesel is the lack of methanol in the reaction for the formation of biodiesel. The weight of methanol used is moles of oil and methanol is 2:1 of the sample weight in the transesterification reaction. Whereas in previous studies using 1: 9 of the sample weight.

2. EXPERIMENTAL

2.1. Chemicals, Equipment and Instrumentation

The main ingredient used is commercial coconut oil. The process of extracting active compounds from coconut oil uses methanol (CH_3OH) 99% (NoBrand), alcohol (C_2H_6O) 96% (NoBrand), phenolphthalein indicator ($C_{20}H_{14}O_4$), potassium hydroxide (KOH) 0.1% base catalyst, distilled water (H_2O)). The tools used include beaker glass, erlenmeyer, measuring cup, measuring flask, separatory funnel, 2 neck flask, 3 neck flask, condenser, thermometer, burette, glass stirrer, pycnometer, Ostwald viscometer, spatula, rubber stoppers, statives and clamps.

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2.2. Research Procedure

Microwave Transesterification Process

Coconut oil is mixed with methanol and KOH as a catalyst directly. The composition of coconut oil and methanol uses a ratio of 2:1 while KOH will be used as much as 0.1% of 50 mL by heating from a microwave at various power, namely 135 watts, 225 watts and 315 watts with successive times for 5 minutes, 3 minutes and 1 minute at 60°C.

Transesterification Process without Microwave (Conventional)

The coconut oil is weighed first, then methanol is added in a ratio of 2:1 while 0.1% of 50 mL of KOH is used and heated at 60°C on a hot plate for 1 hour.

Biodiesel Separation and Purification Process

The product from the transesterification process is then left for 24 hours in the separatory funnel to form two layers. Then separate the top layer, namely biodiesel and the lower layer, namely glycerol. The biodiesel product is then washed with distilled water 3 times and in the oven at 100°C to remove any remaining impurities and the total yield of the biodiesel product can be obtained by comparing the initial weight of the coconut oil.

Acid Number Test, 20 grams of biodiesel sample was put into the erlenmeyer and added 50 ml of 95% alcohol. Then it is heated in a water bath to a boil, in a water bath while stirring until a homogeneous solution is formed. After cooling, titrate with 0.1 N KOH using PP indicator until a pink color persists for 30 seconds.

Moisture content test, 3 grams of sample is weighed and put in a cup that has been dried and the weight is known. Then the sample and cup were dried in an oven at 100°C for 3 hours. Then the cup is cooled and weighed and then dried again until a constant weight is obtained.

Viscosity test, A total of 5 ml of sample was put into the Ostwald viscometer. Then the sample is pulled using a suction ball up to the boundary line a and the time the sample flows to the mark line b is recorded using a stopwatch.

Density test, Density analysis was carried out using the gravimetric method using a pycnometer. In the initial stage, the pycnometer was washed with distilled water and acetone, then dried. After drying, the

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pycnometer is weighed (w1). Then the pycnometer is filled with sample until it is full and closed. Then, wipe the outside dry and weigh (w2).

3. RESULTS AND DISCUSSION

3.1. Analysis of Characterization Results

Biodiesel Density, Density is the ratio of the mass of a substance to its volume at a certain temperature. In this study, the density of biodiesel was analyzed with time variations. The results of the density analysis of variations in reaction time for the formation of biodiesel. The reduced reaction time causes the density to decrease. This shows that the methyl ester content is increasing. The density of the biodiesel produced ranges from 892.7-896.8 kg/m3. This is not in accordance with the SNI standard for the density of biodiesel which ranges from 850-890 kg/m3, but at 1 minute of microwave heating it is slightly close to the SNI standard of 892.7 kg/m3, so the biodiesel from coconut oil does not meet the SNI standard. for biodiesel density.

Biodiesel Acid Number, The acid number indicates the amount of free fatty acids contained in biodiesel which affects the corrosion properties of the engine. This research has been carried out and it was found that the lower the acid number in biodiesel, the better the quality of biodiesel. Based on SNI standards, the maximum allowed acid number is 0.8 mg KOH/g. The longer the reaction time, the higher the acid number contained in biodiesel. The acid number of the biodiesel has a value of 0.5–0.8 mg KOH/g which is in accordance with SNI standards.

Biodiesel Viscosity, Too low a viscosity can cause fuel injection pump leakage, but if it is too high it causes too fast fuel injection and makes the fuel evaporation process difficult. According to SNI, the viscosity of biodiesel is 2.3-6 cSt. The value of the viscosity increases when the reaction time is increased. The viscosity value of biodiesel at all time variations is 2.428-2.617 cSt. The results of this viscosity are in accordance with SNI standards.

Biodiesel Moisture, Content Based on SNI standards, the water content contained in biodiesel is a maximum of 0.05%. Moisture content is one of the benchmarks for biodiesel quality. The water content value increases when the reaction time is increased. The value of the water content of biodiesel at all time variations is 0.01-0.02%. The results of the water content of coconut oil meet SNI standards.

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Biodiesel Analysis against GC-MS

These results can be seen from the peaks of the chromatogram as identification data from chromatography and mass spectrometry (MS) results seen from the mass spectrum with each molecular weight of the bioactive compound in Figure 1**.**

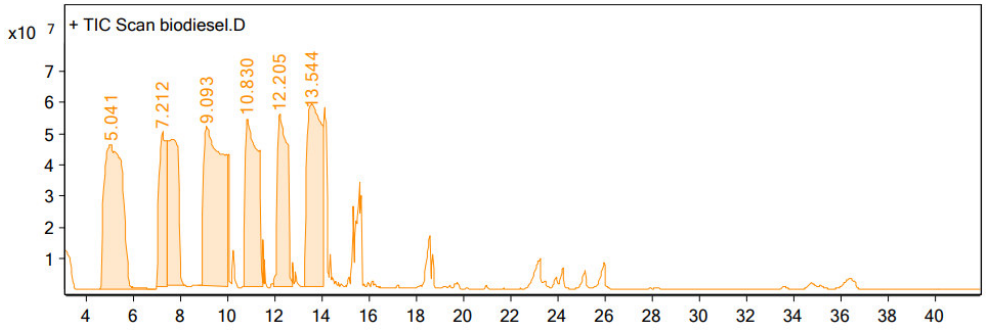

Figure 1. GC-MS Biodiesel Analysis with Microwave Heating Method

Based on the results of the GCMS analysis of coconut oil, the composition of the biodiesel compounds was obtained as shown in Table 1.

Table 1. Microwave Biodiesel Compounds

Compund Name	Chemical Formula	RT	Area	% Area
Methyl Octanoate	$C_9H_{18}O_2$	5.041	2502202005.03	89.1
Methyl Decanoate	$C_{11}H_{22}O_2$	7.212	1101550777.07	39.23
Methyl Laurate	$C_{13}H_{26}O_2$	9.093	2808231474.19	100
Methyl Myristate	$C_{15}H_{30}O_2$	10.83	1946062648.49	69.3
Methyl Palmitate	$C_{17}H_{34}O_2$	12.205	1600901908.82	57.01
Methyl Oleate	$C_{19}H_{36}O_2$	13.544	2477156903.47	88.21

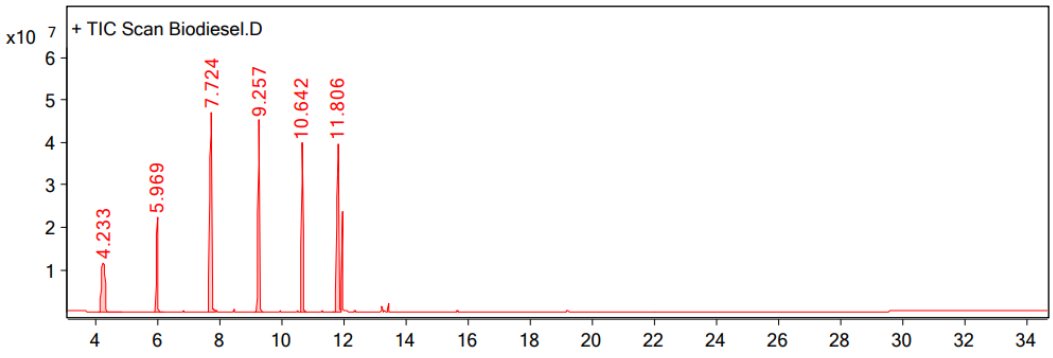

Figure 2. GC-MS Biodiesel Analysis with Conventional Heating Method

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Based on the results of the GCMS analysis of coconut oil, the composition of the biodiesel compounds was obtained as shown in Table 2.

Table 2. Microwave Biodiesel Compounds

Compund Name	Chemical Formula	RT	Area	% Area
Methyl Octanoate	$C_9H_{18}O_2$	4.233	99030720.72	41.77
Methyl Decanoate	$C_{11}H_{22}O_2$	5.969	73596328.59	31.04
Methyl Laurate	$C_{13}H_{26}O_2$	7.724	237071160.69	100
Methyl Myristate	$C_{15}H_{30}O_2$	9.257	167246151.34	70.55
Methyl Palmitate	$C_{17}H_{34}O_2$	10.642	119346885.17	50.34
Methyl Oleate	$C_{19}H_{36}O_2$	11.806	172564815.2	72.79

4. CONCLUSION

The best percent yield at 1 minute time variation in the microwave heating method is 88.287%. The water content, acid number, density and viscosity increase when the reaction time is increased. The GC-MS results of biodiesel showed methyl ester content, with the largest content being methyl laurate with an area % of 100%. The best results of biodiesel from coconut oil in a comparison of microwave and conventional heating methods is using the microwave heating method.

REFERENCES

1. Andalia W., & Pratiwi I. (**2018**). Kinerja Katalis NaOH dan KOH ditinjau dari Kualitas Produk Biodiesel yang dihasilkan dari Minyak Goreng Bekas. Jurnal Tekno Global. 7, 66-73.
2. Devita L (**2015**). Biodiesel Sebagai Bioenergi Alternatif dan Prospektif. Agrica Ekstensia. 9, 23-26
3. Evangeline G.S., & Muchtar Z. (**2021**). Synthesis and Characterizatin of α-Cellulose from Young Coconut Coir (Cocus Nucifera L.). 05, 28-30.
4. Hidayanti N., Arifah N., Jazilah R., Suryanto A., & Mahfud (**2015**). Produksi Biodiesel dari Minyak Kelapa dengan Katalis Basa Melalui Proses Transesterifikasi menggunakan Gelombang Mikro (Microwave). Jurnal Teknik Kimia. 10, 13-18.
5. Marlina., Wijayanti D., Yudiastari I.P., & Safitri L. (**2017**). Pembuatan Virgin Coconut Oil dari Kelapa Hibrida Menggunakan Metode Penggaraman dengan NACl dan Garam Dapur. Jurnal Chemurgy. 1, 7-12.
6. Prayanto D.S., Salahudin M., Qadiriyah L., & Mahfud. (**2016**). Pembuatan Biodiesel dari Minyak Kelapa dengan Katalis NaOH Menggunakan Gelombang Mikro (Microwave) Secara Kontinyu. Jurnal Teknik Its. 5, 22-27.

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