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Effect of Microwaves on Product Characteristics Biodiesel Products from Soybean Oil

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ABSTRACT: Biodiesel is made through a transesterification reaction between vegetable oil and short chain alcohol with a NaOH catalyst and microwaves. This research uses soybean oil as raw material, aiming to determine the microwave power and optimal concentration of the NaOH catalyst. The volume ratio of methanol and soybean oil is 1:12, with the NaOH catalyst weighed according to the variables. The transesterification reaction was carried out by mixing soybean oil and methanol, then heating using a microwave for 2.5 minutes. After that, the mixture was separated using a separating funnel and left for 2 hours until two layers formed: biodiesel on top and glycerol on the bottom. Biodiesel is washed with distilled water at 40°C, then heated in an oven at 100°C for 1 hour. After cooling, the biodiesel is weighed to calculate the yield and its viscosity and density are measured. The research results show that microwave power and NaOH catalyst concentration affect the quality of the biodiesel produced. The highest yield of 99.8% was obtained at 400 watts of power and a catalyst concentration of 0.5%.

KEYWORDS: Biodiesel; transesterification, catalyst, microwave; soybean oil

1. INTRODUCTION

Energy needs are increasing and the growth of EBT (New and Renewable Energy) is still slow, resulting in dependence on fossil energy, especially oil and fuel. In 2025 and 2050, respectively, it will be 23% and 31% of the total national energy needs. However, until 2020 the realization of the EBT share only reached 11.31%. Fossil fuels are not friendly to the environment because they are associated with high levels of toxicity, global warming, increasing carbon emissions from 312 ppm in 1950 to 401 ppm in 2015, according to data from the Environmental Protection Agency and cannot decompose naturally, making them an energy source which is not sustainable [1].

Biodiesel is an environmentally friendly alternative fuel, produced from vegetable oils or animal fats derived from vegetable oils such as soybean oil and several other types of plant oils. Soybean oil which can be used as biodiesel can be obtained from soybean plants. Soybeans are a grain that is rich in vegetable fats and protein. Its degradable nature makes it environmentally friendly [1].

The process of making biodiesel can be done using conventional transesterification methods or using microwave heating. The conventional method used has several disadvantages, namely that it can trigger corrosion in the reactor and saponification occurs [2]. Microwaves were chosen as a promising alternative for making biodiesel. The Advantage of using microwaves is that this technology can convert triglycerides into FAME quickly and can produce greater FAME yields. Microwaves provide even heating to the reacting molecules so that they can speed up the reaction rate [3].

Several previous studies have carried out biodiesel production using microwaves. The power used in previous research was 180, 350, 400, 600 and 800 watts in making used cooking oil biodiesel. [4]. In previous research related to making biodiesel using coconut oil using the microwave method with a NaOH catalyst with a power of 100 and 800 W, this process can produce biodiesel with high purity and yield in a short time. [5]. Suryanto *et all* [6] making biodiesel from used cooking oil using 100, 200, 400 and 600 watts of power.

Previous research has also carried out biodiesel production from candlenut seeds with a catalyst concentration of 3% [7]. Penelitian Prayanto *et all* [5] using catalysts with concentrations of 0.3%, 0.4% and 0.5% in making palm oil biodiesel. Pre research uses NaOH catalyst with concentrations of 0.25%, 0.5% and 1%.

In previous research, biodiesel was made from soybean oil. Biodiesel production from soybean oil uses a NaOH catalyst with concentrations of 0.5%, 1% and 5% and a mole ratio of oil to ethanol, namely 1:6 and 1:12. However, the yield produced was 64.36% which is the lowest yield and there was an increase in the mole ratio of 1:12 but only reached 85.73% which is still below the SNI standard (minimum 96.5%) [8].

Biodiesel is generally obtained from the transesterification process. Basically, transesterification aims to convert triglycerides into fatty acid methyl esters. The transesterification reaction aims to break down and remove triglycerides and reduce the viscosity of the oil [9].

The tansesterification method is usually carried out with the help of a catalyst. The catalyst that can be used can be a homogeneous catalyst or a heterogeneous catalyst. In general, the catalyst used in the transesterification reaction to produce biodiesel is a base catalyst such as NaOH, KOH, Li/CaO, this catalyst is generally used in biodiesel production because it can be used at low reaction temperatures, and can achieve high conversion levels in a short time. Apart from basic catalysts, catalysts that are often used are acid catalysts such as H_2SO_4, AlCl3, $NaOCH_3$. Acid catalysts are not affected by FFA content and can be used in esterification and transesterification reactions, but have disadvantages, such as slow reactions, requiring a high molar ratio of alcohol and oil, and producing waste that has an impact on the environment. In addition, there are corrosion problems and difficulties in separating the catalyst from the product, as well as interference from FFA and water content [2].

This research was carried out with the aim of making biodiesel and studying the effect of catalyst concentration on biodiesel quality by testing density, yield and viscosity. Based on this description, in this research the microwave heating method was used using a NaOH catalyst. It is hoped that this research will be useful for society and the development of science.

2. EXPERIMENTAL

2.1. Materials and chemicals

The material used in this research is soybean oil as the main ingredient obtained from the local supermarket under the Mama Zola brand. The other materials used are sodium hydroxide (NaOH), methanol and distilled water catalysts.

2.2. Methods

2.2.1. Preliminary Treatment

Calculate the volume ratio of methanol and soybean oil with a ratio of 1:12, then the catalyst is weighed according to the specified variables. Next, the NaOH catalyst is dissolved by mixing and stirring the catalyst with methanol according to a predetermined ratio.

2.2.2. Transesterification and Separation

Soybean oil was added to the methanol and catalyst solution which had been mixed during catalyst preparation and stirred until homogeneous. After that, the microwave power was adjusted to the research variables. Next, the mixture was heated in the microwave for 2.5 minutes. After the heating process is complete, the results of the reaction process are put into a separating funnel. The mixture was then left for 2 hours until two layers were formed, namely the top (biodiesel) and bottom (glycerol). Biodiesel is then washed from impurities remaining during separation using distilled water at a temperature of 40˚C with a volume of 40% of the total solution volume approximately 3 times by leaving it for approximately 2 hours until two layers are formed, top (biodiesel) and bottom (distilled water). impurities). Then the biodiesel is poured into a sample bottle and the biodiesel solution is heated for 1 hour in the oven at a temperature of 100˚C. The biodiesel is then cooled to room temperature and the mass is weighed to calculate the yield, then calculate the viscosity and density.

2.2.3. Analysis of Results

2.2.3.1. Density

Density in biodiesel production is used to evaluate the composition and purity of the final product. Biodiesel density testing is carried out by weighing the empty weight of the pycnometer first and recording it as empty weight, then the biodiesel is put into the pycnometer and weighed using an analytical balance. To calculate biodiesel density, the following formula is used:

$$\rho = \frac{\text{Mass (pycnomass and sample - pycnomass)}}{\text{Sample volume}}$$

2.2.3.2. Viscocity

Biodiesel viscosity testing was carried out using an Ostwald viscometer to determine the viscosity of the biodiesel produced. Biodiesel testing with an Ostwald viscometer is carried out by measuring the flow time of biodiesel through the viscometer capillary. Biodiesel is put into a viscometer. The biodiesel is then sucked using a bulb until it passes through the upper tendon, then the liquid is allowed to flow and the flow time required for the biodiesel is calculated when the biodiesel is in the upper tendon until it reaches the lower tendon. To calculate the viscosity of biodiesel, the equation is used:

$$\eta_D = \frac{\pi \, . \, P \, . R^4 \; . \, t}{8 \, . \, v \, . \, L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\eta_k = \frac{\eta_D}{\rho} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

2.2.3.3. % FFA (Free Fatty Acids)

The FFA testing method for biodiesel is carried out by acid-base titration. The biodiesel sample is weighed and dissolved in a solvent, usually a mixture of neutral propyl alcohol and phenolphthalein indicator is added. This solution is then titrated with a standard base solution, such as NaOH until it reaches the end point of the titration, which is marked by a change in the color of the solution to pink. To calculate the % free fatty acids, use the equation:

$$\%FFA = \frac{\text{V NaOH x N NaOH x BM fatty acid}}{\text{Sample weight} \times 1000} \times 100\% \ldots\ldots\ldots.(3)$$

2.2.3.4. Yield Biodiesel

Biodiesel yield is measured by measuring the amount of biodiesel obtained using a measuring cup then dividing it by the volume of raw material used, namely 50 ml, then multiplying by 100%.

$$\text{Yield} = \frac{\text{Biodiesel volume}}{\text{Oil Volume}} \text{ x } 100\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4)$$

3. RESULTS AND DISCUSSION

3.1. *Effect of Power and Concentration on Yield*

The graph above shows that the greater the microwave power used, the greater the yield produced by biodiesel. The increase in biodiesel yield produced is influenced by the amount of microwave power during the transesterification process where more triglycerides in soybean oil react with methanol and produce a higher yield [6].

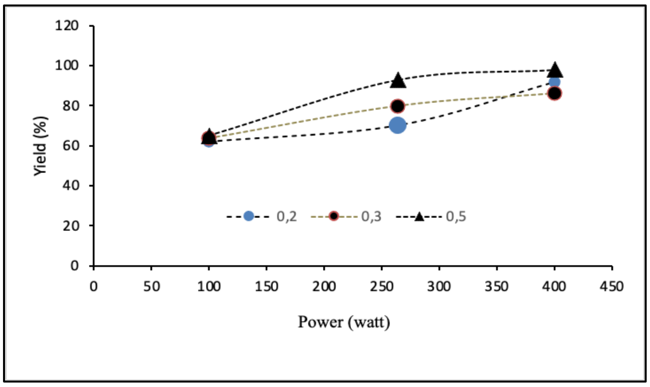

Figure 1. Effect of power on yield of soybean oil biodiesel.

At a catalyst concentration of 0.2 power of 100, 264 and 400 watts, the % yield produced was 61.8%, 63.8% and 64%. At a concentration of 0.3 power of 100, 264 and 400 watts, the % yield produced is 70%, 79.8% and 98%, and at a catalyst concentration of 0.5 power of 100, 264 and 400 watts, the % yield produced is 92%, 98% and 99.8% Judging from this, 400 watts of power is the best power that can produce the largest % yield, namely 99.8%. This shows that the influence of power on the yield of biodiesel produced is straight-line, where the higher the power (watts) used, the greater the biodiesel yield obtained [10].

3.2. *Effect of Power and Concentration on Viscosity*

The graph above shows that the viscosity value obtained meets SNI 7182:2015 concerning biodiesel, where the viscosity value of biodiesel at a temperature of 40°C is in the range of 2.3-6.0 mm^2/s

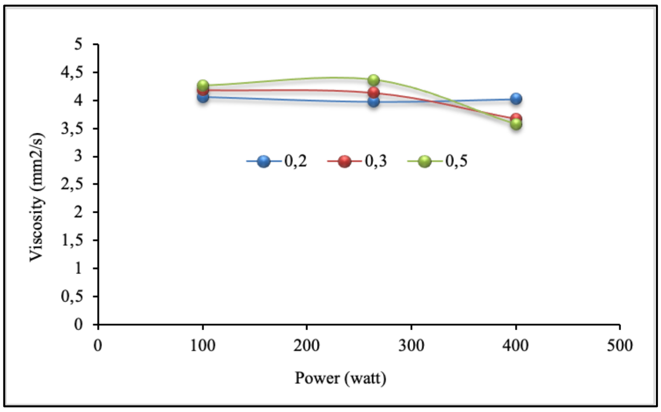

Figure 2. Effect of power on viscosity of soybean oil biodiesel.

In Figure 2, it can be seen that the lowest viscosity is at 400 watts with a value of 3,685 mm^2/s, which means that the greater the microwave power used, the lower the biodiesel viscosity. The greater the power used, the faster the microwave transfer, and the temperature produced by the microwaves will be higher, so that the collisions in the fluid will also be faster, and the formation reaction will also be faster. This will reduce the viscosity of the liquid and shows that the greater the power used in the transesterification process, the smaller the viscosity value will be. The viscosity values at 100, 264 and 400 watts meet SNI. This shows that the amount of power used is directly proportional to the increase in the viscosity of the biodiesel product produced [5].

3.3. *Effect of Power on Density*

Mahlinda, *et all* (2020), There are several factors that can influence the difference in density obtained, one of which is the level of purity of the raw material and the composition of the fatty acids. The density will increase as the number of double bonds in the fatty acid increases and the carbon length decreases. In this case, increasing microwave power in the transesterification process can change the composition of the double bonds of fatty acids in soybean oil, so that the density value can meet SNI.

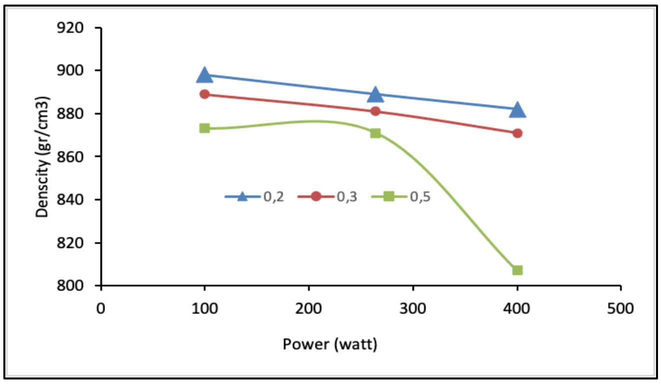

Figure 3. Graph of the effect of power on density of soybean oil biodiesel.

Based on Figure 3, the graph of the influence of power on biodiesel density shows that the biodiesel value obtained at 100, 264 and 400 watts meets SNI 7182:2015, which is in the range of 850-890 kg/m^3. The lowest biodiesel density value obtained was at 260 watts, namely 807 kg/m^3. This is caused by the increasing rate of conversion of triglycerides into methyl esters, so that the density of biodiesel will decrease. The increase in power provides a thermal effect with increased temperature and density. In the graph above you can also see the difference in density or density of biodiesel [4].

3.4. *Effect of Power on Acid Number*

Based on the graph presented above, it can be seen that the acid number obtained meets SNI 7182:2015, with a maximum of 0.5 mg KOH/g. The acid number obtained at 100, 264, and 400 watts of power was less than 0.5 mg KOH/g, with a range of 0.158-0.244 mg KOH/g. Increasing microwave power will increase biodiesel yield and cause a decrease in biodiesel viscosity and density. The higher the microwave power, the higher the reaction temperature, which causes the acid number to tend to rise and fall. This is caused by the occurrence of polymerization side reactions [11].

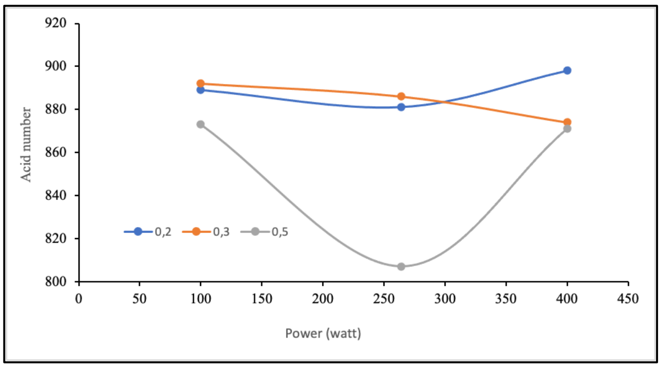

Figure 4. Graph of the Effect of Power (watts) on Acid Number (mg KOH/g max) Soybean Oil Biodiesel.

The microwave power used will affect the reaction temperature, where the greater the power, the higher the temperature. Temperature affects the reaction rate, where collisions between reactant molecules become faster. By increasing the temperature in the transesterification process, the frequency of collisions between molecules also increases, so that the opportunity for methyl ester formation is greater and the free fatty acid content will decrease [12].

4. CONCLUSION

The best microwave power to produce quality biodiesel from soybean oil using a NaOH catalyst is 400 watts. Microwave power in the transesterification reaction has a significant influence on the quality of biodiesel produced from soybean oil with a NaOH catalyst. The higher the microwave power used, the higher the yield value of the biodiesel produced. The highest yield, namely 99.8%, was obtained at 400 watts of power with a catalyst concentration of 0.5%. At catalyst concentrations of 0.2% and 0.3%, the yields obtained were 64% and 98% respectively.

The best concentration of NaOH catalyst to produce quality biodiesel from soybean oil is 0.5%. The concentration of the NaOH catalyst also has a significant influence on the quality of biodiesel. The higher the concentration of NaOH, the lower the viscosity and density of the biodiesel produced. The highest biodiesel yield, amounting to 99.8%, was obtained at a NaOH catalyst concentration of 0.5% with a microwave power of 400 watts.

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REFERENCES

1. A. R. Nabila, A. N. Aurunnisa, and M. Mahfud, "Pra Desain Pabrik Biodiesel dari Biji Nyamplung (Calophyllum inophyllum) dengan Proses Esterifikasi dan Transesterifikasi," *J. Tek. ITS*, vol. 12, no. 2, pp. 89–94, 2023, doi: 10.12962/j23373539.v12i2.120348.
2. A. A. Budiman and S. Samik, "Review Artikel : Produksi Biodiesel dari Minyak Goreng Bekas dengan Metode Transesterifikasi Menggunakan Katalis," *UNESA J. Chem.*, vol. 12, no. 2, pp. 36–38, 2023.
3. Y. T. Rahkadima and Q. A'yuni, "Produksi Biodiesel Dari Dedak Padi Secara in Situ Dengan Teknologi Microwave," *J. Kim. Ris.*, vol. 4, no. 2, p. 106, 2019, doi: 10.20473/jkr.v4i2.16047.
4. S. Oko, C. N. K. Mattanggung, M. N. Aulia, and R. Firdaus, "Pengaruh Daya Microwave Terhadap Pembuatan Biodiesel Dengan Katalis Fly Ash/Na2O Menggunakan Iradiasi Microwave," *Metana*, vol. 19, no. 1, pp. 53–61, 2023, doi: 10.14710/metana.v19i1.53241.
5. D. S. Prayanto, M. Salahudin, L. Qadariyah, and M. Mahfud, "Pembuatan Biodiesel Dari Minyak Kelapa Dengan Katalis NaOH Menggunakan Gelombang Mikro (Microwave) Secara Kontinyu," *J. Tek. ITS*, vol. 5, no. 1, pp. 1–6, 2016, doi: 10.12962/j23373539.v5i1.15173.
6. A. Suryanto, M. Mandasini, A. Djaharuddin, and A. Nabilla, "Pengaruh Daya Dan Waktu Mikrowave Produksi Bahan Bakar Nabati Dari Minyak Jelantah," *J. Chem. Process Eng.*, vol. 3, no. 2, p. 12, 2018, doi: 10.33536/jcpe.v3i2.257.
7. Mahlinda, L. Maurina, and Ellysa, "Secara Transesterifikasi In Situ Effect of Microwave Power on Yield , Quality and Component of Biodiesel from Candle Nut Seed Processed Through In Situ Transesterification," *J. Ind. Has. Perkeb.*, vol. 14, no. 1, pp. 69–77, 2020.
8. S. Oko, M. Mustafa, K. Andri, and W. Danu, "Sintesis Biodiesel Dari Minyak Kedelai Melalui Reaksi Transesterifikasi Dengan Katalis Cao/NaOh," *J. Teknol.*, vol. 13, no. Vol 13, No 1 (2021): Jurnal Teknologi, pp. 1–6, 2021, [Online]. Available: https://jurnal.umj.ac.id/index.php/jurtek/article/view/6581/4668
9. N. Suleman, Abas, and M. Paputungan, "Esterifikasi dan Transesterifikasi Stearin Sawit untuk

Pembuatan Biodiesel," *J. Tek.*, vol. 17, no. 1, pp. 66–77, 2019, doi: 10.37031/jt.v17i1.54.

10. N. Hidayanti, N. Arifah, R. Jazilah, A. Suryanto, and Mahfud, "Produksi Biodiesel Dari Minyak Kelapa Dengan Katalis Basa Melalui Proses Transesterifikasi Menggunakan Gelombang Mikro (Microwave)," *J. Tek. Kim.*, vol. 10, no. 1, pp. 13–18, 2015.
11. N. Nurhidayanti, "Studi Kinetika Reaksi Pembuatan Biodiesel dari Minyak Nyamplung Menggunakan Iradiasi Microwave," *J. Tekno Insentif*, vol. 12, no. 2, pp. 1–12, 2019, doi: 10.36787/jti.v12i2.100.
12. J. Monde, H. Fransiskus, M. Lutfi, and ..., "Pengaruh Suhu pada Proses Tranesterifikasi terhadap Kualitas Biodiesel dari Minyak Jelantah," *J. Pendidik.*, vol. 6, pp. 7–9, 2022, [Online]. Available: https://jptam.org/index.php/jptam/article/view/3113