The Effect Of Naoh Catalyst On The Manufacture Of Biodiesel From Crude Palm Oil Using Transesterification Reaction

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Abstract: Biodiesel seems to be an energy that has bright prospects and future, because Biodiesel is non-toxic, biodegradable, essentialy free of sulfur and carcinogenic benzene, produced from renewable materials, recyclable sources, does not add significantly to the accumulation of greenhouse gases. In general, biodiesel is made from transesterification reactions, i.e. alcohol reactions with triglycerides form methyl esters and glycerol with the help of base catalysts. In the manufacture of biodiesel, crude palm oil (CPO) raw materials are obtained from PT. Sinar Mas Sejahtera in Prabumulih, South Sumatra. This research was conducted by reacting the comparison ratio of CPO: Methanol (in this study the ratio is 1: 2, 1 : 3 and 1 : 4) with the help of NaOH catalysts (in this study catalysts used 1%, 1.5% and 2%) temperature of 70oC for ±3 hours. Through this experiment, biodiesel yield was obtained at cpo variation 1: 4 with NaOH catalyst of 1.5% by 70%. The final results of this study, from CPO and Methanol varying can be concluded that not all parameters correspond to SNI where the density obtained is 0.8387 while SNI (0.850 – 0.890 gr/ml). For viscosity it meets the standard of 4.8 – 5.5 cSt with SNI (2.3 – 6.0 cSt).

Index Terms: Biodiesel, Transesterification, Crude Palm Oil, Methanol.

1 INTRODUCTION

The number of vehicles, heavy equipment, and industry each year is increasing rapidly. This triggered a scarcity of fuel, especially diesel engine fuel. Petroleum that is the base of diesel oil is not enough to continue supplying fuel because of its increasingly dwindling supply. Petroleum will form after millions of years, while the need for petroleum increases every year. Therefore, the researchers conducted various studies to obtain alternative petroleum substitutes. As an agrarian country, Indonesia is famous for its agricultural products and plantations. The country has a s considerable oil palm plantation with CPO (Crude Palm Oil) production of 10.68 million tons/year [1]. Generally CPO is processed into cooking oil, but in recent years it has been known that CPO has the potential to be processed into Diesel Oil or better known as Biodiesel [2]. Nearly 70% of oil palm plantations are located in Sumatra, and the rest are spread across Aceh, Kalimantan, Sulawesi and Papua.. Palm oil plantations are not common in java because of soil characteristics and climate that are less supportive of palm oil growth. In Java, oil palm plantations can be found in west Java and Banten. This plantation is mostly derived from the transition of tea or rubber plantations. Palm oil production in the form of crude palm oil or CPO continued to increase from 2013 to 2017. In 2017, it is estimated that the number of CPO production increased by 9.46 perse to 34.47 million tons [3]. Biodiesel is a methyl ester compound created using a transesterification reaction. In this reaction is used an alkaline catalyst that serves to speed up the course of the reaction. Commonly used base catalysts are KOH and NaOH [4] . In this study, NaOH catalysts were chosen for cheaper reasons. The alkaline concentrations used vary between 0.5 – 1%wt against the oil mass [5], but there is no explanation for the methyl ester calitas and quantity produced by the use of catalysts between these limits. Therefore, we researched and discussed the effect of the number of NaOH catalysts on methyl ester production both in terms of quality and quantity, where variations in the number of catalysts used are 1%, 1.5% and 2%.Biodiesel is promising enough as an alternative fuel for diesel motors. Relatively low smoke levels at high rounds (below 4 BSU), lower NOx, and higher O2 content can reduce particulate formation. Palm oil is a mixture of glycerides with the composition shown by Table below [6]. Transesterification or often referred to as alcoholism is a reaction between triglycerides with alcohol producing esters and glycerin. Commonly used alcohol are methanol, ethanol, and isopropanol while the catalysts that are often used are KOH and NaOH. Alcoholism triglycerides with mild fractional alcohol such as methanol are a balanced reaction and the reaction calorific is small. To shift the reaction to the right usually use excessive alcohol. In this experiment, methanol was given more than glycerides so the reaction that occurred could be considered a direct reaction [7].

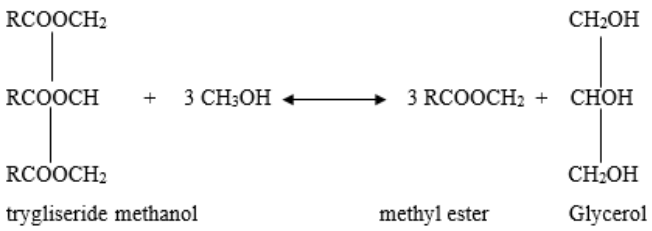

***Figure 1**. Mechanism of Transesterification Reaction*

Biodiesel is already widely used on unrecom moded diesel motors in the United States. The widely used mixture is 20% ME: 80% solar, and 35% ME: 65% solar. Pure biodiesel (100%) it has also been used since 1994, with the engine in modification or without modification [8]. The use of 100% ME can lower smog gas emissions by up to 50%, but it is not recommended, as it can damage and clog fuel lines such as pipes and vehicle deposition. Palm oil that has been reacted with methanol, with a ratio of 30% ME palm oil: 70% solar. Palm oil used is palm oil that is not processed into cooking, due to poor quality. Biodiesel seems to be an energy that has bright prospects and future, because Biodiesel is non-toxic, biodegradable, essentiallly free of sulfur and carcinogenic benzene, produced from renewable materials, recyclable sources, does not add significantly to the accumulation of greenhouse gases. In addition, scumacher and spataru research concluded that the increase in ME from soybeans and canola will result in a decrease in particulates, hydrocarbons and CO, but increase NOx emissions.Diesel oil

is a clear brownish-yellow distillate fuel. The use of diesel oil in general is for fuel on all types of diesel engines with high rotation (above 1000 rpm) which can also be used as fuel for direct combustion in small kitchens, which is mainly desired clean combustion. This diesel oil is commonly referred to as Gasoil, Automotive Diesel Oil (ADO), High Speed Diesel Oil (HSD.) The Government of Indonesia has appointed the Directorate General of Oil and Gas as an institution or body that determines the specifications / quality of oil fuels traded in Indonesia [9]. This is reinforced by the Regulation of the Directorate General of Oil and Gas on the specifications of oil fuels. Diesel oil specification data can be found in Table 1 below.

***Table 1**. Diesel Oil Specifications*

No	Nature	Limitation		Method
		Min	Maks	
1.	Spesifik gravity 60/60 ^{0}F	0.840	0.92	D-1298
2.	Kinematic viscosity 100 ^{0}F Cs	1.6	5.8	D-445
3.	Pour point, ^{0}F	35	65	D-97
4.	Flash point, ^{0}F	150		D-93
5.	Colour ASTM	3.0	6.0	D-1500
6.	Gross calorific value kcal/kg	10.160	11.000	D-4868
7.	Ash content, %wt		0.02	D-482
8.	Sulphur content, %wt		0.5	D-4294
9.	Water content, %vol		0.25	PTA-413
10.	Copper strip (3 hrs/100 ^{0}C)		0.1	D-189
11.	Sediment, %wt		0.01	D-974
12.	Alternatively calculated C.I			D-1551

2 MATERIAL AND METHOD

2.1 Material

Palm oil (CPO) obtained from PT. Sinar Mas Sejahtera, methanol 96% and NaOH catalyst 96%.

2.2 Experimental Method

The raw material is reacted in a batch reactor in the form of a three-necked pumpkin equipped with a thermometer as a temperature gauge. The reactor is assembled with a hot plate equipped with a magnetic stirrer and connected with a condenser.

In table 2 of the nine samples, the maximum yield %yield was given by the CPO sample 1:4 with catalysts of 1.5% and 2% , namely 70% and 67%. While the minimum result on CPO 1:2 with catalysts 1% and 2% is 55% and 57% . Figure 4 shows that the %maximum yield of biodiesel occurs in samples with a CPO of 1:4 catalysts of 1.5% with a %yield of 70%.

3 RESULT AND DISCUSSION

This research reacts to CPO (palm oil) as the main raw material and methanol as solvent. To accelerate the reaction used the base catalyst NaOH. Research conducted included the influence of variations in the number of NaOH catalysts on yield and test results of methyl ester physis properties. This study varied the number of NaOH catalysts used, namely 1, 1.5 and 2% of the weight of CPO. While other operating conditions are constant where the reaction temperature is 70^{o}C and the reaction time is 180 minutes. Reactants reacted were methanol and CPO with cpo comparison: methanol = 1:2

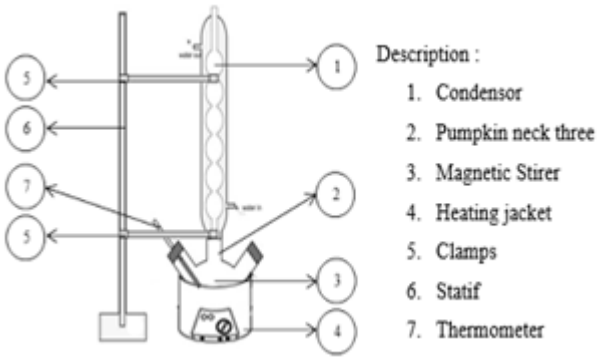

***Figure 2.** Metanolysis Batch Reactor Series*

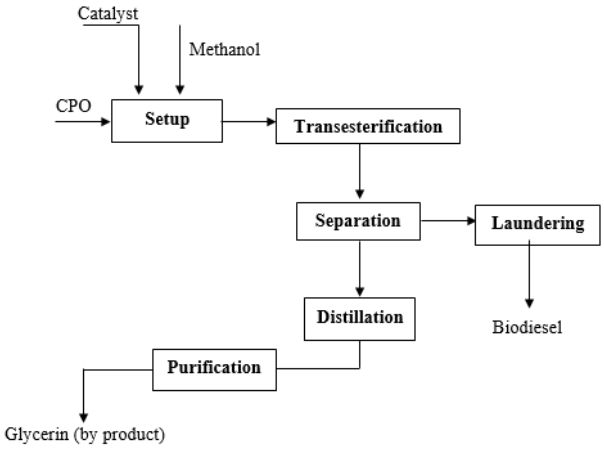

***Figure 3.** Process of Transesterification of Palm Oil and Methanol With NaOH Catalyst*

The methyl ester that is the result of the reaction is separated from the glycerol on the lower layer with a dividing funnel. Before testing its physic properties, this methyl ester needs to be purified by washing it with clean water to bind to the remains of glycerol and methanol, followed by stirring. Once two layers are formed, they are separated again using a separator funnel. The upper layer is methyl ester dioven at a temperature of approximately 100^{o}C to remove the remaining methanol and water. Residue which is a pure methyl ester tested its physical properties with SNI method in the Research and Bioprocess laboratory of Sriwijaya University Faculty of Engineering, then test results compared to diesel oil specifications based on National Biodiesel Standard SNI 04-7182-2006 [10]. As for the properties – methyl ester physic properties tested are type weight, viscosity and flash point. , 1:3 , 1:4 . The results of the study were then silenced until 2 layers formed, where the upper layer is methyl ester yellow and the bottom layer is white glycerol. The two layers are separated. To obtain a pure methyl ester, the methyl ester layer is washed with water and ovened. It is this methyl ester that is then analyzed the properties of fission. From the research that has been done, the data obtained the following observations.

3.1 Products Obtained (yield)

In this study, the operating conditions that varied were the number of comparisons of CPO with methanol which is 1:2, 1:3, 1:4 and the number of catalysts, namely as much as 1%,

1.5% and 2% of the weight of CPO. From the observational data as well as Figure 4 and 5 it can be seen that the number of catalysts used is less likely to affect the amount of biodiesel obtained.

***Table 2**. Biodiesel % yield data*

Catalyst (%)	% yield		
	1 : 2	1 : 3	1 : 4
1	57	60	67
1,5	60	63	70
2	55	58	65

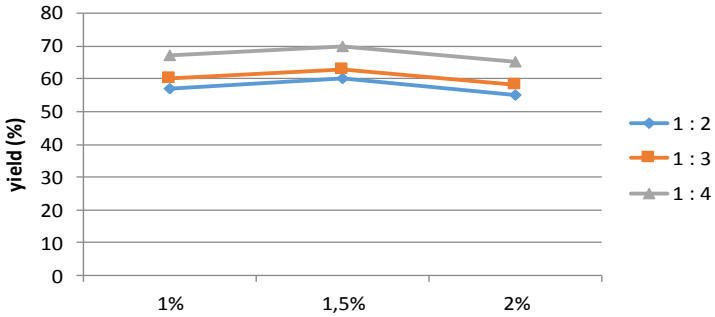

***Figure 4**. Graph of Catalyst Relationship with Biodiesel Products (% yield)*

***Table 3.** Biodiesel Product Data*

Catalyst (%)	Biodiesel (ml)		
	1 : 2	1 : 3	1 : 4
1	85,5	90	100,5
1,5	90	94,5	105
2	82,5	87	97,5

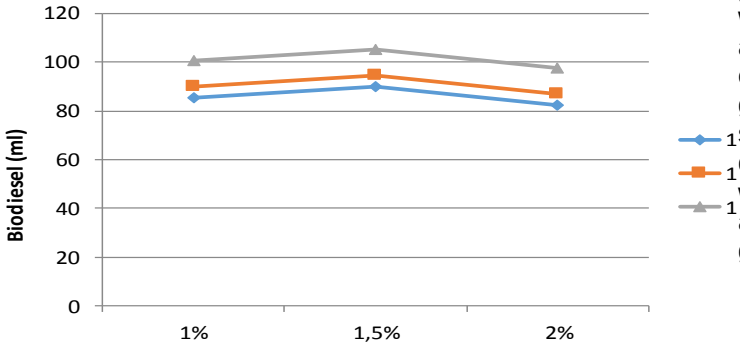

***Figure 5**. Graph of Catalyst Relationship with Biodiesel Products (mL)*

In Table 3 of the nine samples, the maximum yield of biodiesel products produced was found in CPO 1:4 with a catalyst of 1.5% with biodiesel yield obtained 105 ml and mininum results obtained at CPO 1:2 with a catalyst of 2% with biodiesel results obtained of 55 ml. Figure 5 shows that the maximum biodiesel product occurs at cpo 1:4 catalyst 1.5% with biodiesel obtained which is 105 ml. On the chart in the use of catalysts 1.5% shows an increase in biodiesel results and in the use of catalysts 2% there is a decrease in biodiesel results.

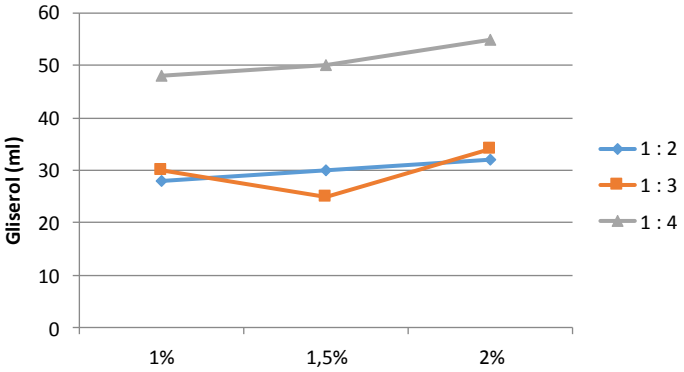

***Figure 6.** Graph of Catalyst Relationship with Glycerol (mL)*

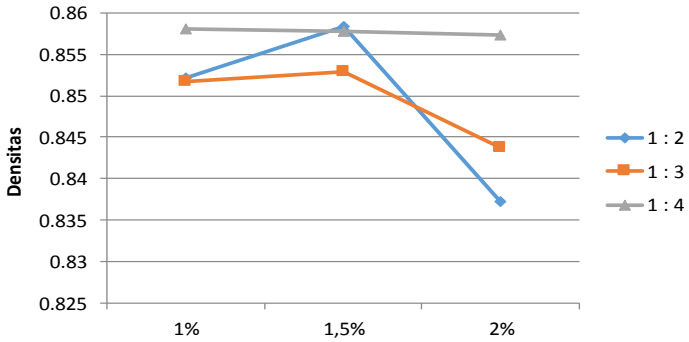

***Figure 7.** Biodiesel Type Weight Comparison Graph*

The effect of the number of catalysts on the formation of byproducts in the form of glycerol can be seen in Figure 6. This graph shows glycerol production that tends to increase with the more catalysts used. The use of catalysts of more than 1.5% actually increases glycerol production. The likely cause is that the number of base catalysts that exceed the provisions will increase the number of hoarding reactions which eventually leads to the increasing production of glycerol as a byproduct. Fugure 5 and 6 are closely related. If methyl ester production increases then the number of glycerol generally decreases, and vice versa. For example, for samples with a 2% catalyst, ester methyl production decreased compared to the 1.5% catalyst sample, and this was inversely proportional to glycerol production which actually increased. This is because CPO becomes more of a glycerol.

Table 4. Glycerol Data

Catalyst (%)	Biodiesel (ml)		
	1 : 2	1 : 3	1 : 4
1	85,5	90	100,5
1,5	90	94,5	105
2	82,5	87	97,5

3.2 Testing properties of Fisis Biodiesel

3.2.1 Weight Type

Diesel fuel oil has a type weight between 0.850 - 0.890 gr/ml,

while the resulting methyl esters all have a type weight below that value. Thus, if reviewed from the weight of the type then the resulting methyl ester is not included in the standard physic properties of diesel fuel. If biodiesel has a weight of type exceeding the provision, there will be an imperfect reaction to the conversion of vegetable oils. Biodiesel of this quality should not be used for diesel engines as it will increase engine wear, emissions, and cause damage to the engine. The weight of the type is also strongly related to the calorific value. If the weight of the type is low then the calorific value will be greater. The weight of the resulting methyl ester type can be seen in Table 5.

Table 5. *Biodiesel Type Weight*

Catalyst (%)	Weight Type (gr/ml)		
	1 : 2	1 : 3	1 : 4
1	0,8523	0,8510	0,8584
1,5	0,8583	0,8525	0,8573
2	0,8381	0,8463	0,8572

In table 5 of the nine samples, there were 7 methyl esters included in the biodiesel type weight conditions namely CPO 1:2 with catalysts 1%, 2%, CPO 1:3 with catalysts 1%, 1.5%, and CPO 1:4 with catalysts 1%, 1.5% and 2%. While there are 2 methyl esters that do not enter the condition of biodiesel type weight namely CPO 1:2 with catalyst 2% and CPO 1:3 with catalyst 2%. Based on Figure 7 seen weight loss type at the time of using the catalyst 2%, this proves that the large number of catalysts used can affect the weight of the biodiesel type of methyl ester produced.

3.2.2 Viscosity

The kinematic viscosity of diesel oil has a value between 2.3–6.0 Cst. The resulting methyl ester viscosity has a value between the viscosity of the diesel oil, so that if reviewed from viscosity then this methyl ester is included in the standard properties of diesel fuel fissile. Oil fuel viscosity is very important especially for diesel engines and boilers. If it is too viscosed the fuel will not burn in a short time and the productivity of the engine work will decrease. This can result in increased fuel consumption. Conversely, if the viscosity is too low then it should use lubricants with a viscosity high enough to lubricate moving parts of the fuel system and help seal moving parts to prevent leakage. The resulting methyl ester viscosity can be seen in Table 6.

Table 6*. Biodiesel Viscosity*

Catalyst (%)	Viscosity (Cst)		
	1 : 2	1 : 3	1 : 4
1	5,1624	5,2430	5,5014
1,5	5,2469	5,3178	5,3515
2	4,8601	4,8768	4,9847

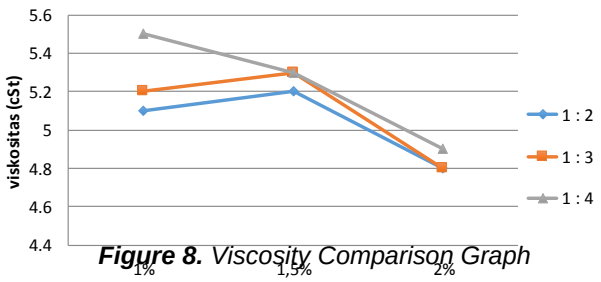

Figure 8. *Viscosity Comparison Graph*

In table 6 can be seen from the nine samples, the resulting methyl esters all come in the viscosity value of diesel oil. Based on graph 4.5 that there was a decrease in viscosity when using a catalyst greater than the previous catalyst. Where the highest viscosity is found in CPO 1:4 with a catalyst of 1% and the lowest viscosity is found in CPO 1:2 catalyst 2% and CPO 1:3 catalyst 2%. It can be concluded that the use of high catalysts can affect the viscosity value of the resulting methyl ester.

3.2.3 Flash Point

The flash point is the lowest temperature at which the oil vapor in the mixture with the air will ignite if test flame is subjected to certain conditions. Biodiesel also has a flash point and a fire point so that we know the temperature limit of the oil storage so that there are no explosions and fires. So with us knowing the flash point then we can be vigilant and control the temperature of the storage area and where the oil will pass.The kinematic viscosity of diesel oil has a value between 2.3–6.0 Cst. The principle of analysis is that a number of samples are heated at a certain heating speed while being stirred in a certain closed cup as well. Ignition testing begins when the sample reaches a certain temperature by bringing the ignition fire closer to the surface of the sample until a flash point is detected. In this study, the flash points tested only samples that had good specifications were in CPO 1: 4 with catalysts of 1.5% and 2%.

Tabel 7. *Value Flash Point*

	Catalyst	Flash Point
CPO 1 : 4	1,5%	90^{o}C
	2%	90^{o}C

From the results of the flash point test against biodiesel produced, the two biodiesels in the test have a flash point value of 90^{o}C. The determination of a flash point is intended for security and knowing to what temperature people can still work safely with a fuel without a fire hazard.

4 Conclusion

Methyl esters with the most quantity produced by samples in CPO 1:4 wrote 1.5% and 2%, while catalyst use of more than 1.5 % allows for a stockpiling reaction so that methyl ester production decreases. Variations in the number of NaOH catalysts have no effect on the weight of the type and viscosity of methyl esters but affect the value of acid numbers and their storage figures. From this study it is known that the best quality samples that match the specifications of diesel oil are samples that use a catalyst of 1.5 % in CPO 1:4.

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