butanol

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Effect of N-Butanol Blending with a Blend of Biodiesel from Crude Palm Oil and Diesel on the Performance and Quality of the Blends

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Abstract: The increasing demand of diesel fuel resulted the emission that is harmful to the environment. In addition, the increasing of diesel fuel could diminishing fossil fuel due to its non-renewable source. To solve this, diesel fuel could be blended or replaced with biodiesel. However, long storage could lower the quality of the blending. To solve this, the quality of the mixture could be enhanced by adding an additive. This research investigated the effect of n-butanol as an additive to the blending of biodiesel from crude palm oil with diesel fuel. Crude palm oil was firstly trans-esterified in a three neck bottle. The biodiesel product was then mixed with 50% v/v diesel fuel and n-butanol at different concentrations (0-10%). Results showed that the increasing concentration of n-butanol could lower the kinematic viscosity, cetane number, pour point, flash point and density. By adding 2% of n-butanol, the blend of 50% v/v biodiesel and diesel fuel could meet the national biofuel standard (Pertamina).

Key words: Blending · Biodiesel · n-butanol · Crude palm oil · Diesel

INTRODUCTION

The increasing demand of diesel fuel resulted the emission that could threat the environment. In addition, the increasing of diesel fuel could diminishing fossil fuel due to its non-renewable source. To solve this, diesel fuel could be blended or replaced with biodiesel [1]. Biodiesel has a lower environmental impact due to the lower emission resulted from the burning process and the fuel is easily degraded. However, the utilization of biodiesel is hardly implemented since it requires a special machine to burn the biofuel. The utilization of 100% biodiesel to a common machine could create a corrosion, clogging the filter and breaking the machine. To solve this, biodiesel could be mixed with diesel fuel.

Recently, the utilization of a blending fuel which contains 20% biodiesel and 80% diesel fuel has been implemented in Indonesia. The government has aimed that in 2025, the utilization of biofuel will be increased to 4.7% and 31% in 2050 [2]. This target has been run to utilize a blend of biodiesel from 20 to 50%. However, recently, the utilization of biodiesel above 20% to the blending fuel still face several problems. For example, the long storing time of the blending fuel could lower the quality of the biofuel [3]. To solve this, an additive could be added to restore the quality of the biofuel so the cetane number, kinematic viscosity and the burning value could still meet the requirements [4]. The latest researcher informed that the addition of n-butanol as the additive could refine the quality of blended biodiesel from eucalyptus oil and diesel fuel [5]. However, the addition of n-butanol to the blended biodiesel from crude palm oil (CPO) has not been investigated so far. The aim of this research was to study the effect of n-butanol as an additive to 50% blended fuel from biodiesel and diesel fuel and analyse the quality of the blended fuel.

MATERIALS AND METHODS

Biodiesel Production and Blending: NaOH 1.1% w / w by weight of oil was mixed with methanol.Then, the mixture was added to CPO: methanol with mole ratio of 1: 7 and then it was trans-esterified for 30 minutes at 60°C. Biodiesel was washed by using warm water (50°C) and

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stirred for 15 minutes. A three phase consisted of biodiesel, methanol and water was separated by using decantation process overnight. The upper layer was taken and further by decanted overnight to ensure the separation of methanol and water until a reddish yellow biodiesel was obtained.

A mixture of 50% v/v of biodiesel and 50% diesel fuel was mixed by adding n-butanol at different concentrations (0-10 %). The mixture was mixed at a constant speed for 1 hour.

Analysis

Analysis of FFA (Free Fatty Acid): One gram of crude palm oil was mixed with 10 mL of methanol and boiled for 1 h. After cooled, phenolphthalein indicator (300 μL) was added and titrated using 0.1 N NaOH solution until a pink color was achieved. The required NaOH to titrate the sample was recorded and calculated to obtain FFA.

Biodiesel Analysis: Kinematic viscosity analysis was done based on ASTM D-445 standard by using a viscometer. The time required for a sample liquid flowing in the viscometer was measured at a temperature of 40°C. The kinematic viscosity value was obtained by multiplying a constant from the calibration results with the time obtained. Density was found as according to the ASTM D-1298 standard by using a hydrometer at a temperature of 15°C. Cetane number was measured by using CFR F5 engine, according to the ASTM D-613 standard. The combustion characteristics in the test engine was compared with the reference fuel mixture whose numbers were known under standard operating conditions.

Flash point was measured according to the ASTM D-93 standard with 5 to 6°C / min at stirring speed of 60 to 120 rpm. Pour point analysis was done as followed by standard ASTM D-97 at atemperature close to the pour point temperature of about 9°C above the pour point, for every 3°C.

RESULT AND DISCUSSION

Kinematic Viscosity: Based on Figure 1, it was found that a mixture of B50 + 0% n-butanol, B50 + 2% n-butanol, B50 + 4% n-butanol, B50 + 6% n-butanol, B50 + 8% n-butanol, B50 + 10% n-butanol has a viscosity of 3.08; 3.07; 2.97; 2.93; 2.87; and 2.85 mm^2 / s, respectively. The increasing n-butanol concentration could lower the kinematic viscosity. N-butanol molecule undergoes solvation and n-butanol content in the mixture has bound and the interaction between the OH^- groups become prominent and could reduce the kinematic viscosity [6]. The viscosity value could showthe quality of atomization between fuel and air. The lower kinematic viscosity showed that the fuel became less evaporation thus the fuel combustion became incomplete [7]. If the blended fuel has a high viscosity, then the fuel will be difficult to flow which causes the injector to work heavy and the dirt could be settled.

Biodiesel has a high viscosity. By blending with diesel fuel which has a lower viscosity than biodiesel, it will produce a low kinematic viscosity. It was found that all the samples tested were following Pertamina standards (Table 1), where the kinematic viscosity is ranged from 2-4.5 mm^2 / s (Figure 1).

Cetane Number: Based on Figure 2, it was found that a mixture of B50 + 0% n-butanol, B50 + 2% n-butanol, B50 + 4% n-butanol, B50 + 6% n-butanol, B50 + 8% n-butanol, B50 + 10 % n-butanol resulted cetane number of 57.6; 56.8; 56.7; 54.9; 53.4; and 53.9, respectively. Cetane numbers are related to the fatty acid content of biodiesel. If biodiesel has long-chain carbon fatty acids, a high cetane number will be obtained. Cetane number is related to the combustion process.The higher cetane number resulted higher combustion process. If the air in a diesel engine is compressed to a pressure of 30-40 kg / cm^2, as a result, the pressure in the combustion chamber will increase. If the pressure rises too high, it will cause explosion. Detonation is the occurrence of a delay in the combustion process which causes incomplete combustion so that soot is formed [9]. It was found that all samples that had been tested were following Pertamina standards (Table 1) where the cetane number was recorded ataround 57 by adding 2% n-butanol.

Density: Based on the Figure 3, it was found that the addition of n-butanol could lowering density of the mixture B50. From these results, all samples were following Pertamina's standards, which ranged from 0.820 g / mL. to 0.860 g / mL (Table 1). The lowest density 0.841 g / mL was recorded at the addition of 10 % n-butanol.

Flash Point: Based on Figure 4, it wasrecorded that the mixture of B50 + 0% n-butanol, B50 + 2% n-butanol, B50 + 4% n-butanol, B50 + 6% n-butanol, B50 + 8% n-butanol, B50 + 10 % n-butanol resulted flash points of 78, 58, 48, 44, 42 and 42ºC, respectively. The addition n-butanol above 8% seems not decreasing the flash point.

Table 1: Standard Biodiesel from Pertamina [8]

			Value		Remarks
No.	Parameter	Unit	Min	Maks	ASTM
1.	Cetane number	-	53	-	D 613
	Or cetane index	-	48	-	D4737
2.	Density @ 15°C	kg/m^3	820	860	D 1298/D4052
3.	Viscosity @ 40°C	mm^2/sec	2.0	4.5	D 445
4.	Sulfur content	%m/m	-	0.05	D 2622/D 4294
5.	Distilation:				D 86
	Temp. @90%	°C	-	340	
	Temp. @95%	°C	-	360	
	Final boiling point	°C	-	370	
6.	Flash point	°C	55	-	D 93
7.	Pour point	°C	-	18	D 97
8.	Residualcarbon	%m/m	-	0.3	D 4530
9.	Water content	mg/kg	-	500	D 6340
10.	*Biological Growth*	-	Zero		
11.	FAME content	%v/v	-	10	
12.	Metanol content	%v/v	Not detectable		D 4815
13.	Corrosion from copper	minutes	-	Class 1	D 130
14.	Ash content	%v/v	-	0.01	D 482
15.	Sediment content	%m/m	-	0.01	D 473
16.	Strong Acid content	mgKOH/gr	-	0	D 664
17.	Total Acid content	mgKOH/gr	-	0.3	D 664
18.	Particulates	mg/L	-	10	
19.	Visual appearance	-	Clear and bright		
20.	Color	No. ASTM	-	1.0	D 1500
21.	*Lubricity* (HFRR wear scar dia. @ 60°C)	micron	-	460	D 6079

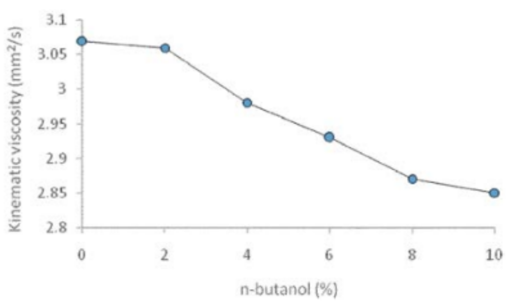

Fig. 1: Kinematic viscosity of blended diesel B50 at varying n-butanol addition

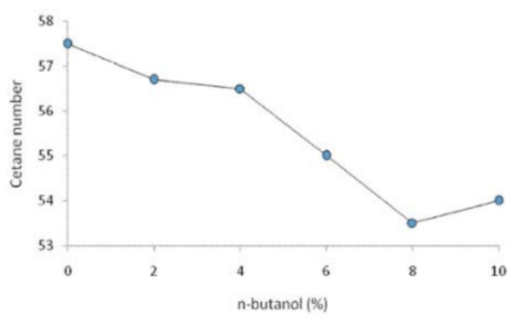

Fig. 2: Cetane number of blended diesel B50 at varying n-butanol addition

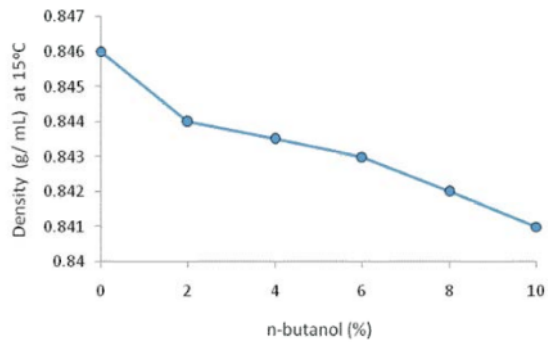

Fig. 3: Density of blended diesel B50 at varying n-butanol addition

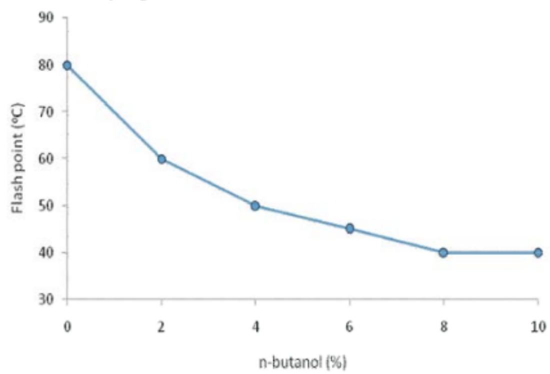

Fig. 4: Flash point of blended diesel B50 at varying n-butanol addition

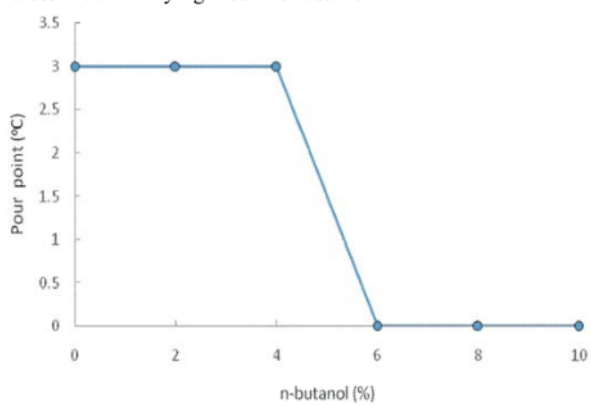

Fig. 5: Pour point of blended diesel B50 at varying n-butanol addition

Biodiesel is a non-volatile / non-volatile compound. Biodiesel has a higher flash point than diesel fuel and the decrease occurred due to the addition of 50% diesel so that a B50 mixture is formed which has a low flash point when compared to pure biodiesel (B100). The flash point relates to the ability of the material to burn and the level of the material to evaporate. The lower the flash point of the fuel, the faster it will burn.

The addition of n-butanol could decreasing the flash point until 8% n-butanol concentration. A low flash point will cause a decrease in lubrication, corroded injectors and material degradation in vehicles [10]. It was found that all the samples tested were following Pertamina standards where the minimum flash point was 55°C (Table 1) with the addition of 2 to 4% n-butanol.

Pour Point: Based on the Figure 5, it was found that the addition of n-butanol from 4 to 6% decreased pour point from 3 to 0°C. The lower the pour point of a fuel, the better quality of the fuel. Pour point is the point where a fuel will flow after freezing. The lower pour point will be useful when the fuel is used in a cold environments or freezing conditions because fuel can flow from the fuel tank to the combustion chamber. In this experiment, the mixture of B50 has low pour point which is in accordance to Pertamina standards (Table 1), below a maximum temperature of 18°C.

CONCLUSION

In overall, the mixture of 50% biodiesel and diesel fuel seems promising to be used in a commercial scale. The addition of 2% n-butanol as additive could refining the parameter of the biodiesel-diesel fuel which resulted kinematic viscosity 3.073 mm^2/s, cetane number 56.8, flash point 58°C, pour point 0°C and density 0.844 g/mL.

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