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Fuel Physical Characteristics of Biodiesel Blend Fuels with Alcohol as Additives

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Abstract

Biodiesel and its alcohol blend fuels are considered as alternatives to current fossilized fuels. Their fuel physical characteristics are among the most important parameter to determine the quality of each fuel. Strict procedures are used in observation and measurement to obtain the flash point, viscosity, density, acid value and Cetane number in order to define the actual properties of biodiesel and its alcohol blend fuels. These obtained properties are very beneficial to be used in any arithmetical simulation for further findings. These properties provide good explanations on how the engine operates with those fuels in terms of performance, combustion and emission characteristics. Biodiesel and its alcohol blend fuels analysis were conducted in UMP Chemical laboratory using different analytical apparatus including viscosity bath, acid value & acidity tester, density meter and bomb calorimeter. Properties comparison were been made between mineral diesel, B100, B20 and B20 alcohol blend fuels. The results show that the presence of alcohol helps to reduce the viscosity and density of biodiesel concentration when blending with mineral diesel. On other hand, a significant increase in Cetane number as a result of an increase in alcohol concentration in the biodiesel blend fuels. However, the properties of biodiesel and its alcohol blend fuels still meet the requirement of EN14214.

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Keywords*: Biodiesel, palm-diesel, alcohol, additives, fuel properties*

1. Introduction

Biodiesel is a alkyl monoester originated from vegetable oils, waste cooking oils or animal fats. It been derived through a transesterification proses with a presence of methanol as a catalyst. European Union and United States define biodiesel under technical regulation of EN14214 and ASTM 6751-02. These standards regulate the biodiesel to conform the standard in the fuel production process when removing glycerin, catalyst and alcohol in minimal levels. The transesterification

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process is functioned to remove the unnecessary constituents include dirt and water from the oil. Studies conducted by different researchers around the world revealed that biodiesel is proven as a substitute for mineral diesel and at the same time reducing the emission significantly [1-4]. As for the current trend, the use of additives such as alcohol has been diluted with the biodiesel to achieve the similar objectives. Moreover, several authors have evaluated the performance characteristics of conventional diesel engine fuelled with biodiesel and their blend with mineral diesel with alcohol as an additive [3, 5-7].

In general, biodiesel that originated from palm oil has different properties as compared to other biodiesel made from other organic sources as well as mineral diesel. Palm oil has greater density and viscosity compared to mineral diesel [8]. Therefore, a comprehensive data of biodiesel and their blend fuel physical properties is required to analyze the characteristics of biodiesel when operated with conventional diesel engines. The fuel physical properties are very critical parameters in the atomization process in compression ignition engines. Viscosity plays an important roles in the atomization quality of fuel injection within the combustion chamber, distribution of fuel droplet size and the uniformity of the mixture. In addition, larger surface tension affects the dissolution of a liquid jet into smaller fuel droplets.

Viscosity can be defined as resistance of oil to flow smoothly or the measurement of internal friction. The viscosity of biodiesel is greatly higher compared to mineral diesel, but approximately less than straight vegetable oils. Fuel viscosity can be significantly reduced by using a transesterification process. Viscosity has a greater impact under low temperatures that resist the fuel to flow smoothly from the storage tank into the engine. Higher viscosity causes poorer atomization of the fuel spray and inaccurate fuel injectors operation.

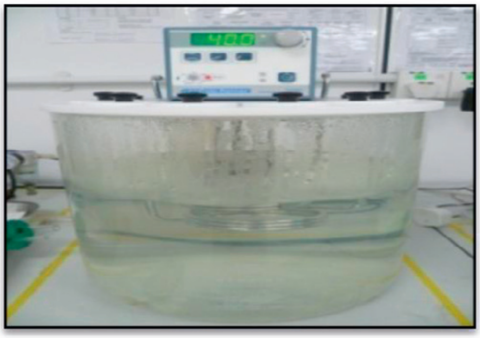
In addition, fuel density is a weight of unit volume of fuel. The minimum value of density is desirable to obtain the maximum engine power through the fuel flow control in the injection pump. It also required minimizing the smoke formation when operates with maximum power [9]. Acid value number is defined as the amount of potassium hydroxide (KOH) in milligrams that is necessary to neutralize free fatty acids (FFAs) contained in 1 gram of oil. It possesses as the vegetable oil quality indicator to monitor the oil degradation during storage period. According to ASTM D 6751, the maximum value of acid number is 0.5 mgKOH/g [10].

Cetane number is the ignition quality indicator of the fuel. It defines whether the fuel has longer or shorter ignition delay during the combustion period. An increase in Cetane number is because the carbon chain length increases. Typical diesel engines accept the Cetane number between 40 and 55 while below 38, a more rapid increase in ignition delay is occurred. In general, alcohol has lower Cetane number compared to mineral diesel and biodiesel. Among effects that could describe when operated with the fuel that has lower Cetane number are engine noise and longer ignition delay. The cetane number of neat alcohols is very low (8 for ethanol and 3 for methanol) which defines them as poor compression ignition engine fuels. Furthermore, the cetane number of diesel-alcohol blend fuel is dependent on the base diesel ignition quality, the percentage of the alcohol in the blend, and the addition of cetane improver additives.

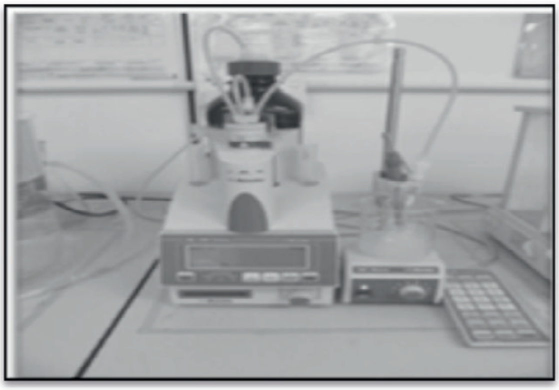
The objective of the study is to determine the fuel properties of the biodiesel B100, B20, B20-alcohol blend fuels of 5%/v and 10%/v with mineral diesel as a baseline fuel.

2. Research Methodology

There were seven types of fuel used in the study which includes, mineral diesel, biodiesel (B100), B20 (biodiesel 20% blend with 80% mineral diesel), B20 E5 (biodiesel 20% blend with 80% mineral diesel and 5% ethanol), B20 E10 (biodiesel 20% blend with 80% mineral diesel and 10% ethanol), B20 M5 (biodiesel 20% blend with 80% mineral diesel and 5% methanol) and B20 M10 (biodiesel 20% blend with 80% mineral diesel and 10% methanol). Figure 1 illustrates different analytical apparatus to measure the fuel properties. All the test methods are conformed to the strict ASTM procedures as recommended by manufacturers. Those tests were conducted under controlled room temperature, pressure and relative humidity to ensure that the result is not influenced from environmental errors.



(a) (b)



(c) (d)

Fig 1. Analytical instruments used to measure fuel properties; (a) Viscosity bath, (b) Density meter, (c) Pensky-Martens Closed Tester, (d) Acid value & acidity tester

3. Result and Analysis

Table 1 presents the results for fuel properties testing through experiments. The testing were repeated five times and were carefully recorded from the digital apparatus. It can be seen from the table that the fuel properties are greatly influenced by the concentration of biodiesel and alcohol in the blend fuels. It is obvious that the biodiesel and its alcohol blend fuels have different characteristics when being compared to mineral diesel. This because the component of the biodiesel contains free fatty acid (FFA) as the main constituent.

Table 1. Fuel Properties

Properties	Diesel	B20	B20 E5	B20 E10	B20 M5	B20 M10	B100
Flash point (°C)	70	110	43	48	45	49	180
Viscosity (mm^2/s)	4.24	4.51	3.14	3.09	3.28	3.63	5.68
Density (kg/m^3)	837	845	843	842	844	843	878
Acid Value, mgKOH/g	0.24	0.2	0.54	0.52	0.59	0.78	0.3
Cetane number	71.6	78.2	92.7	88.6	92.4	91.2	98

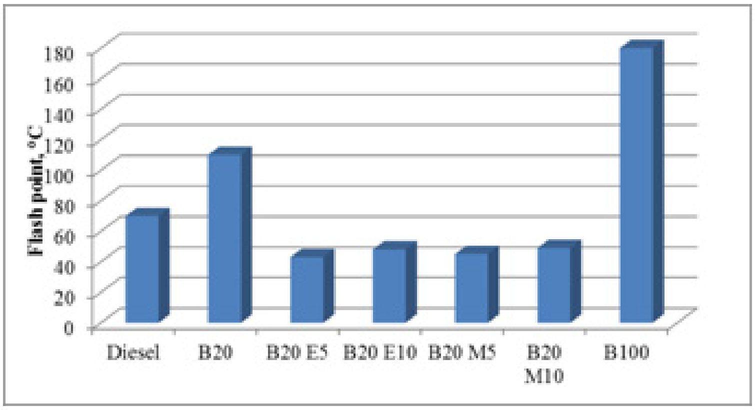


Fig 2. Flash point of mineral diesel, biodiesel and its alcohol blend fuels

Figure 2 presents the flash point of the fuels measured byPensky-Martens closed tester (refer Figure 1c). It can be seen from the figure that the flash point biodiesel (B100) is greatly different by 85% with mineral diesel and B20-alcohol blend fuels. That means in this case the biodiesel is hardly to ignite itself with higher flash point. However, when alcohol additives, 5% and 10% by volume diluted into biodiesel blend fuel, B20, the flash points for those B20-alcohol blend fuels are lower when compared to mineral diesel and biodiesel B100. Average flash point between 40 °C and 50 °C are achieved for those biodiesel-alcohol blend fuels.

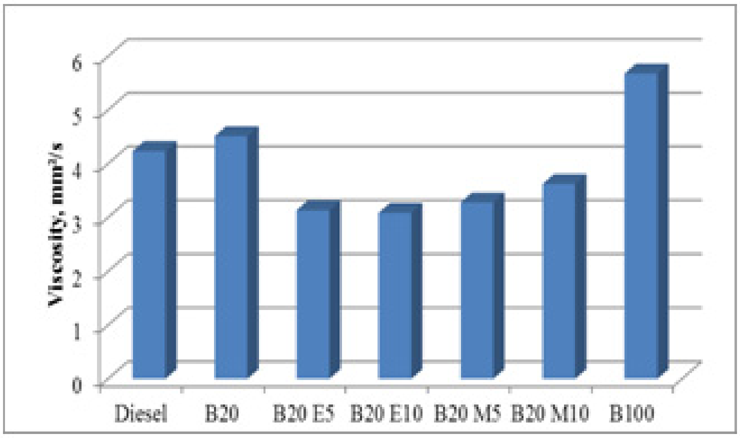


Fig 3. Viscosity of mineral diesel, biodiesel and its alcohol blend fuels

Figure 3 shows viscosity of the fuel measured by viscosity bath in Chemical Laboratory. It clearly shows that the B100 is greatly different by 40% with mineral diesel and biodiesel-alcohol blend fuels. This because the free fatty acid (FFA) concentration in biodiesel. In addition, the transesterification process, which used to convert the vegetable oils into biodiesel is greatly reducing the viscosity of the fluid. The viscosity of mineral diesel is recorded as the lowest number at 4.24 mm^2/s. Therefore, an increase in viscosity of the blend fuel as a result of an increase in biodiesel concentration. As comparison, the viscosity of diesel and biodiesel (100%) is greatly difference by 34%.

On other hand, the small amount of alcohol dilution in the biodiesel blend fuel is proven to reduce the viscosity of the fuel. It can be seen from the figure that the flash point for B20 when diluted with 5% and 10% by volume of ethanol and methanol.

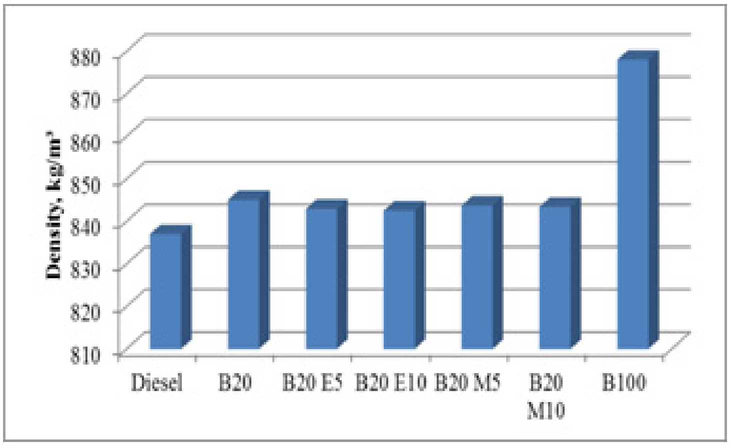


Fig 4. Density of mineral diesel, biodiesel and its alcohol blend fuels

Figure 4 shows the density of mineral diesel, biodiesel B100, B20 and B20-alcohol blend fuels used through the study. It is found that the density of the B100 is the highest at 0.878 kg/m^3 and density of the mineral diesel is the lowest at 0.837 kg/m^3. The removal of the glycerol from B100 has significantly reduced the density of the fuel by 4.3%. It is clearly shown that the raise of the biodiesel content in the fuel blend will increase the density of the fuel. Moraes et. al. [9] reported that conventional diesel and biodiesel have very similar densities, but it should be considered that the density of biodiesel is affected from the sources of raw material (feedstock) in their productions.

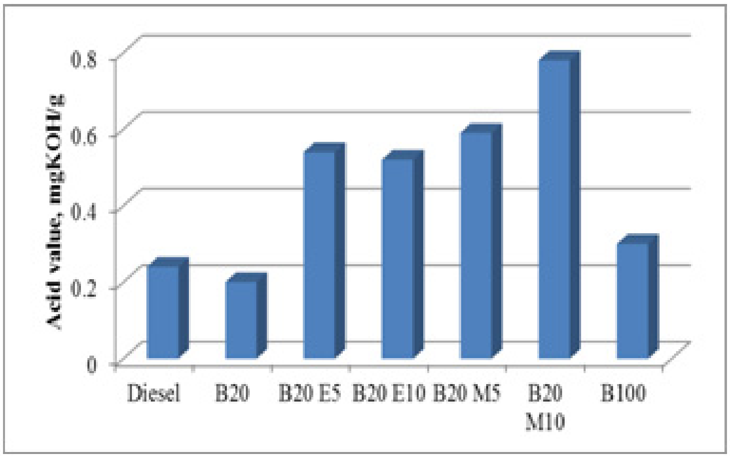


Fig 5. Acid value of mineral diesel, biodiesel and its alcohol blend fuels

Figure 5 presents the acid value for the tested fuels. It can be seen from the figure that the number of acid value for B20 M10 is the highest at 0.78 mgKOH/g. On other hand, the number of acid value for B20 is significantly low at 0.2 mgKOH/g, which is 16.7% lower than mineral diesel with 0.24 mgKOH/g. However, the number of acid value for biodiesel B100 is higher at 0.3 mgKOH/g. It is proven that the palm methyl ester biodiesel is greatly to be degraded at extensive storage period when being compared to mineral diesel.

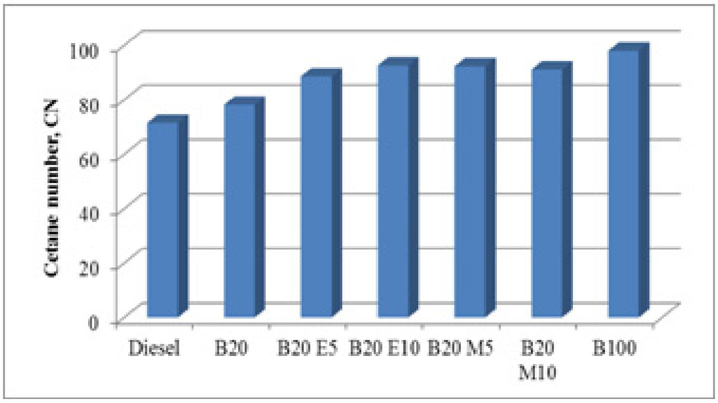


Fig 6. Cetane number of mineral diesel, biodiesel and its alcohol blend fuels

The Cetane number of the biodiesel is significantly high when compared to mineral diesel. Figure 6 illustrates different Cetane number of the tested fuels. It can be seen from the figure that the mineral diesel has the lowest Cetane number at 71.6 while the biodiesel B100 is the highest at 98 The Cetane number is found to be increased when the percentage of biodiesel blend is increase. This because the Cetane number of biodiesel depends on the distribution of fatty acids in the original oil or fat. The longer the fatty acid carbon dioxide (CO2) chains and the more saturated the molecules, the higher the Cetane number

4. Conclusion

The study on fuel properties for biodiesel and its B20-alcohol blend fuels when being compared with mineral diesel have been concluded into points as followed:

I. An increase in biodiesel concentration is greatly increased the density and viscosity of the biodiesel blend fuel, B20.

II. A small concentration of alcohol, 5% and 10% by volume diluted in B20 blend fuel significantly reduced viscosity and density of the B20 blend fuel. However, as a result, flash point and Cetane number are increased.

Acknowledgement

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