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The Comparison of Preheat Fuel Characteristics of Biodiesel and Straight Vegetable Oil

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Abstract

Biodiesel is an alternative fuel derived from varies sources of vegetable oils, animal fat, or waste frying oil to give the corresponding fatty acid methyl ester. The properties of alternative fuel of CPO biodiesel and SVO biodiesel have been investigated at different temperature. The biodiesel was blended up palm oil blending ratio from 5~15vol% (B5~B15) and straight vegetable oil ratio from 5~15vol% (S5~S15). The properties were tested at 27.5°C, 40°C, 50°C and 60°C with observed the changes of the density, kinematic viscosity, flash point, water contents, and acid value. In this study, properties of CPO biodiesel were found to have a higher value and diesel fuel under all ambient temperature. Under all ambient temperature, preheating CPO fuel increased value of density, kinematic viscosity, water contents, and acid value than SVO biodiesel.

Introduction

Biodiesel is the renewable and environmental friendly fuel which comprised mono alkyl of long chain free fatty acid of vegetable oil and animal fat. Vegetable oil or animal fat was transesterified using methanol in the presence of NaOH as a catalyst in process of making biodiesel to make it suitable to use in engine[1-2]. Different with straight vegetable oil, avoided of transesterification process make it low of energy consumption and reducing considerably the environmental impacts due to less harmful emissions and fewer chemicals consumption. Although there are some similarities between transesterification oil and straight vegetable oil with diesel fuel, they present some physicochemical or properties differences with diesel fuel such as higher density, viscosity, water content, acid value and lower of flash point that can give effect to the performance and condition of engine such as atomization of combustion, injector choking, filter gumming, stuck in piston ring and engine deposit. Hence, some improvement should be taking such as preheat and blending process to outcome the problem to make it suitable use in diesel engine as fuel[3].

The transesterification crude palm oil or crude palm oil biodiesel (CPO) and straight vegetable oil biodiesel (SVO) than diesel fuel at room temperature have 10 times higher viscosity and 15 times higher, respectively[4]. Viscosity of the blending fuels can be supposing to increase the value because both diesel and biodiesel fuels are completely miscible and non-polar when the volume of mixture are addictive. Experiment of Esteban et al. [5] show that the density of straight vegetable oil is higher than biodiesel when comparison with diesel is make with 9.4% and 5.6% respectively. Density of biodiesel is higher than diesel because diesel has collected variety of hydrocarbons with different volatilities. The value of water contents for diesel fuel is half than B5 biodiesel and the value are keeping increasing when the percentages of blending with biodiesel are increase[6-8].

In addition, acid value can be decreasing by increase the percentages of biodiesel due to the fuel is degrades cause by contact with air or water. Therefore, the heating process is necessary to reduce the CPO's viscosity to close as the level of diesel's viscosity. The preheating shown the CPO's viscosity is decreased and provided smooth fuel flow, but did not affect the injection

system[9]. Compared with straight vegetable oils that have about 80% to 90% heating value of diesel which may causes a drop in brake specific thermal efficiency, while high viscosity also causes lower thermal efficiency due to poor atomization and combustion characteristics, thermal efficiency of vegetable oils gets relatively higher than that of diesel once the engine is modified[10]. The decreasing of density occur at preheating process is happen by the existence oxygen in methyl ester molecules energy per unit mass was slightly reduced and gives the biodiesel greater density. Preheating of biodiesel can decreasing the viscosity and supply smooth flowing fuel to avoid fuel filter clogging when achieve to 100°C[11]. Different with flash point, preheating and mixing process are increasing the value. The higher value of flash point is an advantage for biodiesel because the higher flash point makes its safe for handling, storages, and transportation .

Purpose of this study is to analyze the effects of preheat temperature of variant blending biodiesel fuel and straight vegetable on the fuel properties. In this study, the sample of biodiesel with variant percentage will keep at the variant preheat temperature of 27.5°C, 40°C, 50°C and 60°C. It is expected that this work will provide knowledge to the best preheat temperature for BDF and SVO due to the variation in the fuel properties that strongly influences to the fuel-air mixing, burning process and combustion characteristics.

Experiment set up

The study used sevens kinds fuels combining form grade II diesel (D), crude palm oil (CPO) and straight vegetable oil (SVO). The biodiesel that have used is CPO that was taken from UTHM's biodiesel pilot plant and the SVO used is brand of Saji Cooking Oil from Delima Oil Products Sdn Bhd. The fuels tested were a grade II diesel (D), blends of 5(B5), 10(B10) and 15vol%(B15) palm oil with the diesel fuel, and blends of 5(S5), 10(S10) and 15vol%(S15) straight vegetable oil with the diesel fuel, as shown in Fig.1. The properties of grade II diesel selected as a reference standard fuel (D). Thus, the results for all the biodiesel conditions were compared with baseline operating conditions of standard diesel (D). In preparing biodiesels blend, diesel fuel was blend with palm oil and straight vegetable oil in various concentrations in blending machine that operated at 60°C and the mixture was stirred at 70°C for 1 hour. The rotating blade speed was adjusted to maintain the same speed at 270 rpm.

Figure 1: Sample of SVO and Biodiesel

Table 1: Specific standard use for properties testing

Properties	Standard
Density	ASTM D1217
Viscosity	EN 3679
Water Contents	EN 12937
Flash Point	EN ISO 2719
Acid Value	EN 14104

The properties tests considered to be investigated are included density, kinematic viscosity, water content, acids value and flash points test. These properties test are based on the European Standard for Biodiesel (EN 14214) and American Society of Testing Materials (ASTM D6751), as shown in Table 1. The density properties were measured by Metter Toledo Diamond Scale modeled JB703-C/AF. Kinematic viscosity is referring to the time taken by a volume of sample (liquid form) to flow under gravity through a calibrated glass capillary viscometer. The water content and acid value in biodiesel sample were measured by Volumetric KF Titrator model v20 and titration process. The term of acid value is expressed as the amount (mg) of potassium hydroxide required to neutralize one gram of the biodiesel. During acid value measurement, sample is titrated with alcoholic KOH using phenolphthalein as indicator. The flash point measured by Pensky-Martens PMA 4.

Result and Discussion

Comparison preheat properties of palm oil biodiesel (BDF) and straight vegetable oil (SVO)

The effect of properties biodiesel blending ratio on preheat temperature was investigated at the base diesel fuel (D) for BDF of 5 (B5), 10 (B10) and 15vol%(B15) for temperature of 27.5°C, 40°C, 50°C and 60°C. Figure 2 shows the changes fuel properties of BDF with the preheat temperature. B15 has a higher value of density compare to other and followed by B10, B5 and diesel and B15 biodiesel has a higher value of density compare to other fuel at every conditions of temperature due to the existence of oxygen in the methyl ester molecules. Same as density, the value of viscosity for diesel, B5, B10, and B15 are decreasing with temperature form 27.5°C to 60°C and the viscosity increased with percentages of blend. In addition, the value of viscosity for diesel, B5, B10 and B15 are constantly decreased and the all the data is close to each other at every temperature. As seen in Figure 2, the flash point for each biodiesels is constantly increased with temperature and percentages of blends. Same as other properties, flash point of B15 biodiesel is higher compared to diesel, B5 and B10. The higher value of flash point is an advantages for biodiesel because the higher flash point makes its safe for handling, storages, and transportation. From the experiment result, the water contents are decrease with temperature and increased with percentages of blends. B15 biodiesel has a higher value of water contents and usually the value is three times higher than diesel. On the other hand, The value of water contents for diesel fuel is half than B5 biodiesel and the value are keeping increasing when the percentages of blending with CPO are increase. The water contents are decreasing for each fuels when temperature is increase. This situation happen because of the water contents inside the fuels react with the heat, the water are through the process of vaporization and transform the water into steam. When the heat supply or the temperature increase, more water will transform into the steam through this physics process.

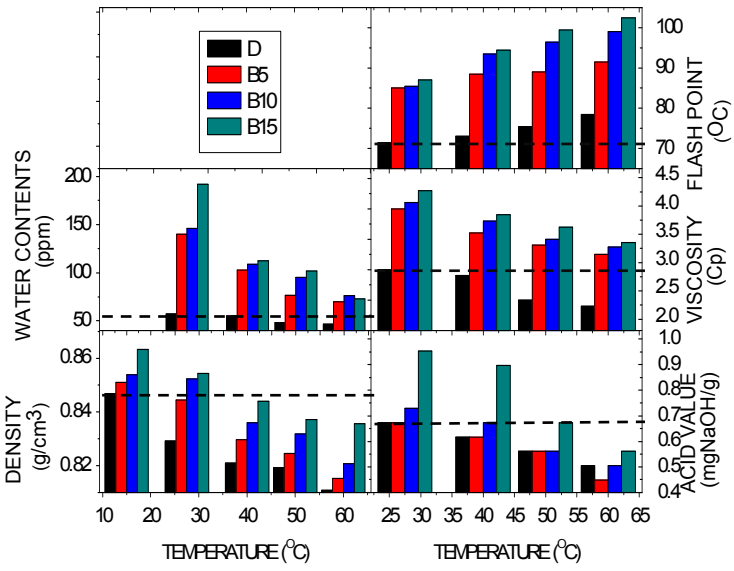

Figure 2: Properties value of biodiesel

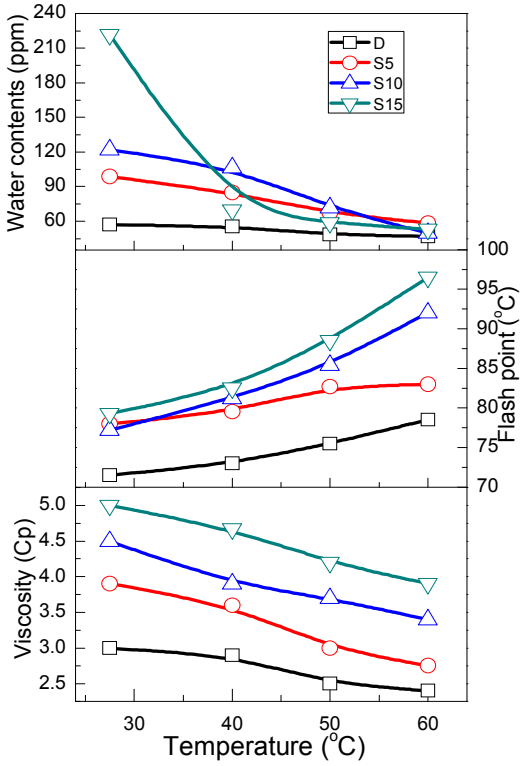

Figure 3: Properties value of SVO

The effect of properties straight vegetable oil on preheat temperature was investigated at the base diesel fuel (D) for SVO of 5 (S5), 10 (S10) and 15vol%(S15) for temperature of 27.5°C, 40°C, 50°C and 60°C. Figure 3 clearly demonstrates the realtion of the changes fuel properties of SVO with the preheat temperature. S15 biodiesel has a higher density compare to other and followed with S10, S5 and diesel fuel from 15°C to 60°C. The value obtained from our experiments at ambient temperature of diesel state the range of density are between 0.810876g/cm^3 to 0.846752g/cm^3. The result state about 10% of pure straight vegetable oil at ambient temperature state the range of density are between 0.820g/cm^3 to 0.933g/cm^3. The fuels that has lower density than diesel show up the lower average droplet size where follow up with earlier injection and better atomization in engine. The result obtained shows that the S15 has a higher value of viscosity compare to diesel, S5, and S10 at each condition and temperature. However, the conducted preheat process state the decreasing linearly of viscosity for S15, S10, S5 and diesel fuel is resemble due to the linearly decrease of S100 SVO's viscosity when the temperature increase. In addition, S15 has a higher flash point compare to S5, S10 and diesel due to the low volatility from mixing of alcohol in with water due to the polar nature of OH group. The high value of flash point a point of incapability to smoke under the smoke point test. In addition, the preheat process can decrease the value of water contents. The range of S15 water contents was 221.6 to 53.1ppm, follow with S10 with 122 to 49.88ppm range of data, 98.6 to 58.3ppm range for S5, and 57.0 to 46.7ppm from diesel. Highly value of water contents leads to blockage of component, erosion, and corrions in engine.

Comparison of preheat properties between Crude Palm Oil and Straight Vegetable Oil Biodiesel

Next, this section tries to compare the cahnges of properties biodiesel blending ratio and SVO on preheat temperature for temperature of 27.5°C, 40°C, 50°C and 60°C. Figure 4 and Figure 5 compare the changes fuel properties of SVO and BDF with the increasing of preheat temperature. As seen in Fig. 4, SVO biodiesel has a higher density compare to CPO biodiesel and the close characteristic of density with diesel is B5 biodiesel. Because of the existence of oxygen in the methyl ester molecules, energy per unit mass was slightly reduced and gives the biodiesel greater density. Different to diesel, the pattern of graph state a slightly decrease from 27.5°C to 40°C and continues to constantly decrease to 60°C. Therefore, the highest viscosity value between seven fuels that used is S15 and follows with S10, B15, B10, B5, S5 and diesel. The SVO biodiesel has a higher viscosity and more and easily to react with diesel compared with CPO biodiesel. The SVO biodiesel fuel is more reacted with diesel fuel by change the characteristic of properties drastically.

As seen in Fig. 5, the highest flash point between all the seven fuels is B15 biodiesel and follows with B10, B5, S15, S10, S5 and diesel. CPO biodiesels was monopoly the higher rate of flash point compare with SVO biodiesels. The SVO biodiesel might not give a drastic effect at flash point because of this fuel is not strongly react with heat compared with CPO biodiesels. The lower value or closest value with diesel fuel is S5 biodiesel. The highest or increasing of flash point of biodiesel is because of the low volatility from mixing of alcohol in with water due to the polar nature of OH group. The high value of flash point a point of incapability to smoke under the smoke point test.

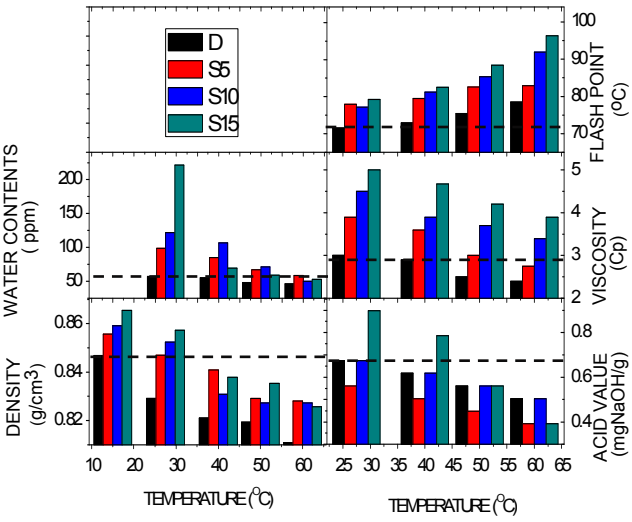

Figure 4: Properties value of SVO biodiesel

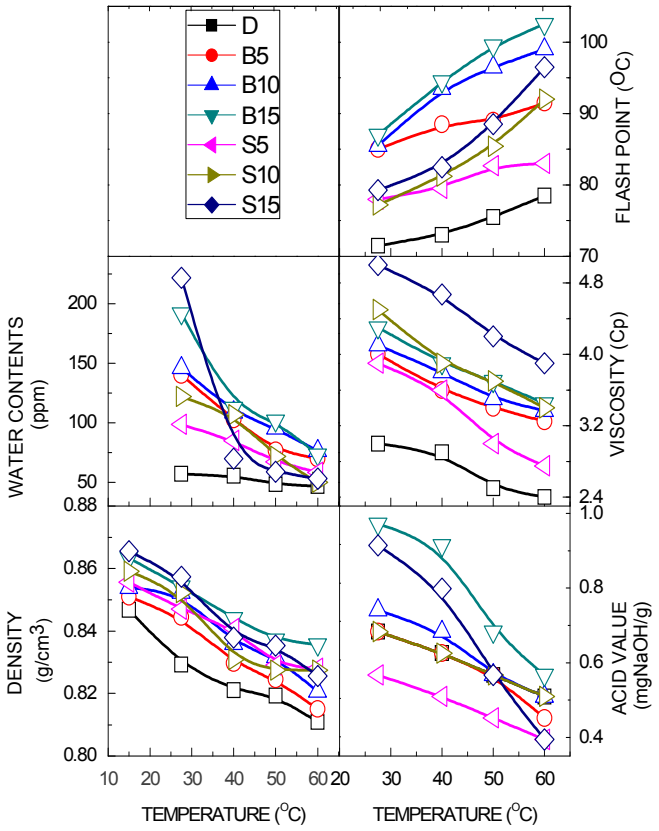

Figure 5: Comparison of crude palm oil and straight vegetable oil biodiesel properties

In addition, water contents are also dominated by CPO biodiesel at the highest value compared with SVO biodiesel where most of the fuels are closest to characteristic of diesel. The closest value with diesel fuel is S5 biodiesel. The highly value of water contents leads to blockage of component, erosion, and corrions in engine. While the reducing of water content can reduce the Magnesium and Calcium contents where can lead to phosporus, deposit form, and corrosion on the hot parts of engine. The highest value of acid value between the sevens fuels is B15 biodiesel follow with S15, B10, S10, diesel, B5, and S5. Acid value properties shown that both CPO and SVO biodiesel are reacting equally with diesel where we can see that the value form the highest to lower value of acid value are interval between CPO and SVO biodiesels. The closest characteristics value with diesel fuel is winning by S10 biodiesel with 0% of difference.

Conclusion

The study used the sample of biodiesel and SVO with variant percentage will keep at the variant preheat temperature of 27.5°C, 40°C, 50°C and 60°C in order to investigate the effects of preheat temperature of variant blending biodiesel fuel and straight vegetable on the fuel properties. The results of the study may be summarized as follows:

1. Preheat process can change the properties of the biodiesel and diesel fuel. The process of preheat and blending was reducing the value of density, viscosity, acid value and water contents and increase the value of flash point. The biodiesel that was blended and classify was shows the difference by its physical form were the color of fuel is getting darker when the percentage of diesel in blend was increases.
2. Preheat process also making the properties of biodiesel fuel become close to diesel fuel properties at some condition of temperature. As example, the result of viscosity and water contents of both CPO and SVO biodiesels is getting close to baseline diesel fuel. Therefore,

preheat process changes of all five properties being better than baseline diesel fuels and preheat process of diesel fuel also changes the properties being better than at ambient temperature.

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