Effects of Storage Characteristics on Flash Point and Water Content of Biodiesel derived from Crude Palm Oil, Jatropha, and Waste Cooking Oil

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ABSTRACT

In recent years, there was a major drawback in the reduction of fossil fuels. Researchers attempts to find solutions to overcome this crisis including using biodiesel as replacement for fossil fuel. The aim of this study is to investigate the effects of ambient and storage characteristics on flash point and water content of biodiesel derived from crude palm oil, jatropha and waste cooking oil. There are three types of biodiesel blending which is 5 vol %, 10 vol % g and 15 vol% blending and compare with commercial diesel. There are three type of biodiesel blended from Crude Palm Oil, Jatropha, and Waste Cooking Oil. The biodiesel samples were stored in clinical compartment, at different temperatures and were monitored at regular interval over a period of 1960 hours' periods and storage temperature from 28°C~35°C. The analysis of blending biodiesel properties is performed with ASTM D6751 and EN 14214 standard. The changes of properties of biodiesel such as density, kinematics viscosity, acid value, water content and flash point of biodiesel were discussed in detail. High blending ratio CPO blends and longer storage period influences the increasing of viscosity for both conditions. Storage characteristics has a great influence on the biodiesel blends especially under high blending ratio. Increasing storage duration and temperature for all variant blending ratios are found to influences the increasing of the water content fuel density, resulting in increased the biodiesel viscosity. However, flash point of all biodiesel blends tends to decrease with increasing storage duration at different storage temperature.

Keywords:

Biodiesel; Storage; Flash Point; Water Content; Crude Palm Oil; Jatropha; Waste Cooking Oil

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1. Introduction

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Biodiesel is a form of diesel fuel derived from organics and consisting of long-chain fatty acid esters and it is compatible with existing diesel engines, heating oil and distribution infrastructure.

The power output of biodiesel depends on its properties which influences from blend, quality, and storage conditions. The thermal efficiency of biodiesel will vary due to the differing energy content of the various blends especially the fuel characteristics such as density, kinematics viscosity, acid value, water content and flash point of biodiesel; these characteristics will change as the blends as well as the quality of biodiesel varies [1-5]. The storage stability of biodiesel was studied since 1985, exposure to heat and air greatly accelerated degradation of biodiesel, but when stored at 20 °C in closed containers or stored after the addition of an antioxidant, the biodiesel remained stable. Furthermore, researcher monitored the production of acids, peroxides, and aldehydes, as well as increase in viscosity induction storage time over a period of 90 days [5-9]. It found that the stability of biodiesel for 180 days of storage showed that exposure to metals also increased the rate of degradation and exposure to higher temperatures in pro-oxidizing conditions accelerated loss of stability [10-15]. Previous researcher also found that sunlight give higher increasing rate of acid value and antioxidant gave a significant increase in kinematic viscosity which reflects from different storage condition [5-6]. Furthermore, it has been identified that biodiesel oxidized and degraded faster than diesel oil is changed during storage. The acid value and flash point temperature, density, and kinematic viscosity rise with the increase of storage time of biodiesel [11-13]. In addition, flash point has been defined as the lowest temperature at which fuel produces enough vapor to cause ignition leading to flame generation. The flash point value is an important property for determining the flammability of a fuel and important characteristics as a safety indicator for the storage and transportation of a fuel. The flash point of biodiesel exceeds 130 °C (266 °F), significantly higher than that of commercial petroleum diesel which may be as low as 52 °C (126 °F) and reflects to biodiesel has a higher flash point than conventional diesel [16-19].

The viscosity of a biodiesel blend is higher than the viscosity of fossil-diesel. Furthermore, some researchers have reported that the biodiesel viscosity can be up to 1.6 times that of diesel at 40 °C. Biodiesel produced using plant or animals was involving a number of processing including titration process, transesterification, and investigation of the biodiesel physical properties. Titration was run to determine the content of free fatty acids (FFA). Biodiesel can be composed from mono-alkyl esters of long chain fatty acids that fulfil the requirement of ASTM D6751 fuel specification. The advantages of using extraction biodiesel is it can be used either co-products or by-products [8]. *Jatropha* (*Jatropha curcas*) is non-edible oils have been estimated for annual production potential of 200 thousand metric tons in India and it can be grown in waste land [18-21]. The oil content for *jatropha* kernel is 63.16% and higher linseed, soybean, and palm kernel which is 33.33%, 18.35% and 44.6%, respectively [21-24]. Hence, *jatropha* will be the perfect biodiesel because it more economical in term of oil contains.

The objectives of this research are to investigate the effects of ambient and storage characteristics on flash point and water content of biodiesel derived from crude palm oil, *jatropha* and waste cooking oil. There are three types of biodiesel blending which is 5 vol % , 10 vol % and 15 vol% blends and compare with commercial diesel. There are three type of biodiesel blended from Crude Palm Oil, *Jatropha*, and Waste Cooking Oil. The biodiesel samples were stored in clinical compartment, at different temperatures and were monitored at regular interval over a period of 1960 hours' periods and storage temperature from 28°C~35°C. The analysis of blending biodiesel properties is performed with ASTM D6751 and EN 14214 standard. The changes of properties of biodiesel such as density, kinematics viscosity, acid value, water content and flash point of biodiesel were discussed in detail.

2. Storage Method and Properties Test

This research observed the effects of different storage periods under three types of biodiesel blending which is 5 vol % , 10 vol % and 15 vol % blends and compare with commercial diesel. There are three type of biodiesel blended from Crude Palm Oil, Jatropha, and Waste Cooking Oil. Biodiesel samples were stored in glass containers for 10 weeks under room (indoor) and outdoor condition. These samples were monitored weekly based on the physical properties; acid value, viscosity, density, water content and flash point. The biodiesel was prepared using blending machine. During blending process, the purified jatropha oil methyl ester was blended with commercial diesel where stirred at 70°C for 2 hours and the rotating blade speed was maintaining at 270 RPM as shown in Figure 1.

Fig. 1. (a) Blending machine and (b) Schematic blending machine

Samples of biodiesel were obtained from commercial suppliers and the properties tests that will be considered in this study are included density, kinematic viscosity, moisture content, acids value and flash points test. In this research, the kinematic viscosity of biodiesel blend was measured by Viscolite 700 model VL700-T15. The biodiesel density and flash point were measured by Mettler Toledo Diamond Scale modeled JB703-C/AF and Pensky-Martens PMA 4, respectively. In this research, Kinematic biodiesel 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 properties of water content and acid value of biodiesel sample were measured by Volumetric KF Titrator model v20 and titration process. In term of acid value measurement, sample is titrated with alcoholic KOH using phenolphthalein as indicator. The acid value is expressed as the amount (mg) of potassium hydroxide required to neutralize one gram of the biodiesel. The fuel properties shown in Table 1.

Table 1

Biodiesel from crude palm oil properties at initial condition (ambient temperature)

Fuel type	Properties Density (g/cm ³)	Kinematic viscosity (cP)	Flashpoint (°C)	Water content (ppm)
STD	0.833736	3	80	79.6
B5	0.837048	3	91.5	120.1
B10	0.837664	2.9	92	158.6
B15	0.840428	3	93.5	219
B20	0.841172	3.1	94.5	294.7
B25	0.841716	3	97	363.3
B30	0.845852	3.2	97.5	397.1
B35	0.844816	3.4	99.5	426.9
B40	0.848236	3.2	100	558

3. Results and Discussions

Firstly, the effects of storage duration of variant blending Crude Palm Oil (CPO) biodiesel ratio under different storage temperature on flash point and viscosity were investigated. The samples of CPO biodiesel blends were stored at different temperatures and monitored at regular interval over a period of 60 days. Blending of biodiesel was varied from 5vol%(B5)~ 45vol%(B45) and storage temperature at indoor 28°C and outdoor 35°C and the storage duration up to 63 days. Figure 2 shows the effects of storage conditions on properties of biodiesel such as viscosity and flash point of biodiesel blends which performed with ASTM D6751 and EN 14214 standard. Under high blending ratio CPO blends, increased of storage period influences the increasing of viscosity for both conditions. Viscosity is the important property that greatly effects to the combustion process. The higher viscosity interferes with common rails system and injector operation, resulting in poorer atomization of the fuel spray and associated with the increased of engine deposits.

Fig. 2. Effects the storage condition on flash point and viscosity of Crude Palm Oil (CPO) biodiesel

Next, this section will discuss the influences of storage characteristics and time for biodiesel derived from crude palm oil, jatropha and waste cooking oil. Figure 3 shows that the influences of the storage duration on flash point and water content under indoor and outdoor condition, which involve the biodiesel have been derived from crude palm oil, jatropha and waste cooking oil. The average storage temperature for indoor and outdoor temperature are 24°C and 33°C, respectively. It shows that the increasing trend for acid value, viscosity, density, and water content with increasing of storage time duration. Jatropha (JO) flash point value was increasing and slightly decrease on waste cooking oil (WCO) and the crude palm oil (CPO) for both indoor and outdoor condition. In addition, water content increased for both conditions.

Fig. 3. Influences the storage duration on flash point and water content (a) Indoor Condition (b) Outdoor Condition

Figure 4 presents the physical properties of acid value, viscosity and density with different storage time and ambient condition for jatropha oil, crude palm oil standard diesel and waste cooking oil. It can be seen that the changes of acid value and density are small, but viscosity is slightly increase especially under longer storage time period and outdoor condition. Therefore, increased in viscosity of the blend fuel reflects to increment of biodiesel concentration. As a result, the density of the biodiesel blend fuel is greatly increased particularly for the biodiesel from waste cooking oil.

Fig. 4. Properties of acid value, viscosity and density with different storage time and ambient condition

Figure 5 presents the relation of flash point, water content, acid value, viscosity and density with different storage time and ambient condition under biodiesel blends from jatropha oil, crude palm oil, standard diesel, and waste cooking oil. Among these figures, the flash point of all biodiesel blends tends to decrease with the increasing of storage duration at different storage temperature. The flash point value is an important property for determining the flammability of a fuel and important characteristics as a safety indicator for the storage and transportation of a fuel. In addition, water content is slightly increase with the increasing of storage time. These results suggesting that the storage temperature and high biodiesel blends will affect the degradation of biodiesel. In addition, the water content shows a great significant effect on the biodiesel storage time at different ambient condition.

Fig. 5. Relation of flash point, water content, acid value, viscosity and density with different storage time and ambient condition

4. Conclusions

In this research, the biodiesel derived from crude palm oil, jatropha and waste cooking oil with the blending ratio of 5 vol %, 10 vol %, and 15 vol %, which stored at different condition and storage characteristics. The summary as follows

- Under high blending ratio CPO blends, increased of storage period influences the increasing of viscosity for both conditions.
- Storage characteristics has a great influence on the biodiesel blends especially under high blending ratio. Increasing storage duration and temperature for all variant blending ratios are found to influences the increasing of the water content fuel density, resulting in increased of the biodiesel viscosity. However, flash point of all biodiesel blends tends to decrease with the increasing of storage duration at different storage temperature.

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