Influences of Storage Duration on the Fuel Properties of Biodiesel derived from Jatropha and Waste Cooking Oil

Nadiarulah Nanihar1, Amir Khalid*1,2,a, Fathul Hakim1, Norshuhaila Mohamed Sunar1, Bukhari Manshoor1, Izzuddin Zaman2
1Automotive and Combustion Synergies Technology Group, Advanced Technology Centre (ATC), Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat 86400 Johor, Malaysia
2Combustion Research Group (CRG), Centre for Energy and Industrial Environment Studies (CEIES) Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, Malaysia

*Corresponding Author: amirk@uthm.edu.my

Abstract. Biodiesel is an alternative fuels that have competitive properties as petroleum diesel. Biodiesel is usually can be derive from any fatty acid or oil by transesterification process. This research is to investigate the effects of storage duration and indoor ambient condition on biodiesel properties and characteristics. There are three types of blending which is 5vol% blends (5vol% plant oil 95vol% diesel), 10vol% blending (10vol% plant oil and 90vol% diesel) and 15vol% blending (15vol% plant oil and 85vol% diesel) each called CPO5 (crude palm oil 5vol%), CPO10 (crude palm oil 10vol%), CPO15 (crude palm oil 15vol%), JO5 (jatropha oil 5vol%), JO10 (jatropha oil 10vol%), JO15 (jatropha oil 15vol%) WCO5 (waste cooking oil 5vol%), WCO 10 (waste cooking oil 10vol%), and WCO15 (waste cooking oil 15vol%) respectively. All samples are store at indoor condition and he changes of fuel properties such as acid value, water content, flash point, density and viscosity were measured until 1960 hours periods. The result showing and increasing value is the water content and density. But for the acid value and viscosity the data was showing a constant value throughout the time period. In flash point case the data was varied by the type of oil used, for jatropha group it was showing and increasing value and for another group was showing a decreasing result. Under 1960 hours of storage duration, the effect of degradation was happen although the effect is not significance because the changes are still in acceptable ranges.

Keywords: Biodiesel, Storage, Acid Value, Water Content, Flash Point, Density, Viscosity

1. Introduction
Biodiesel were known as Fatty Acid Methyl Ester FAME) is the most discussed among researchers a decade ago. It can be used as a pure fuel or blended with petroleum based fuel with different percentage but the standard storage and handling procedures used for biodiesel are the main issue due to the biodiesel fuel specifications [1-3]. This topic became an epidemics among the researchers because the increasing of the awareness about our renewable energy and alternative fuel. In this research, the characteristic of various sample [4-6]. Oxidative degradation undergo the complex secondary reactions further oxidize into acids, leading to an increase in acid value cause by the formation of hydrogen peroxide [2]. Increasing rate of acid value depends on storage duration [3–5]. High temperature of storage can cause the increasing value for the result [5]. Bouaid et al has done the
research using different storage condition (expose and not expose to sunlight). Sunlight give higher increasing rate of acid value to biodiesel storage [4]. M. Shahabuddin et al stated that acid value, density and viscosity is increasing throughout the time [5]. A. Obadiah et al. found that biodiesel without antioxidant gave a significant increase in kinematic viscosity after 50 weeks. The sample with antioxidant still maintain under control for kinematic viscosity. Antioxidant gives more stability to biodiesel to maintain its properties. Water content in sample would make the kinematic maintain and decrease because the kinematic viscosity is measure of resistance of substance to flow. From Khalid et al shows that the Crude Palm Oil Blending will decrease the emissions was recorded by using burner system [9-10]. So this could be the answer for the future, greener fuel.

In this study, six ratio of biodiesel blended from crude palm oil (CPO) based were using for this research, CPO5, CPO10, CPO15, JO5, JO10,JO15,WCO5, WCO10 and WCO15. All of the samples were stored in a liter transparencies glass bottles in two condition; indoor condition (22-24°C) and outdoor condition (28-30°C). Sample were stored for 1960 hours and tested every week. Five types of properties testing were tested for this study; water content, density, kinematic viscosity, flash point and acid value. For these testing, European standard testing procedures were used. In this study, biodiesel is be produced by using jatropha oil, waste cooking oil and palm oil were involve a number of processes including titration process, transesterification, and investigate the physical properties of biodiesel. First, the titration was run to determine the content of FFA in the JO. If the value is higher FFA content, JO then must go through to reduce the amount of FFA esterification under 2%. If the FFA content of less than 2%, it will involve this transesterification process [8-10].

Biodiesel is fuels that can be compose from mono-alkyl esters of long chain fatty acids originates from plant or animals that will need to fulfil requirement of ASTM D6751 fuel specification. The advantages of using extraction biodiesel is it can use either co-products or by-products [8]. Biodiesel is very environmental friendly and non-toxic. If compare with petroleum based diesel, biodiesel is the best in term of combustion emissions. It capable to reduce the emissions of carbon monoxide, particulate matter and unburned hydrocarbons [11]. Carbon dioxide produced form biodiesel can recycled by photosynthesis and will minimize the effects of greenhouse effects [12]. The comparison of diesel and biodiesel is described as Table 1;

### Table 1: The Comparison of Standards For Diesel And Biodiesel Based On American Society For Testing And Material (ASTM) [13].

| Fuel Property                  | Diesel ASTM D975 | Biodiesel ASTM D6751 |
|--------------------------------|------------------|----------------------|
| Lower Heating value, BTU/gal   | 129,050          | 118,170              |
| Kinematic viscosity @ 40°C, cSt| 1.3-1.4          | 4.0-6.0              |
| Specific gravity @ 60°C, g/cm3 | 0.85             | .88                  |
| Carbon, wt%                    | 87               | 77                   |
| Hydrogen, wt%                  | 13               | 12                   |
| Oxygen, by dif. wt%            | 0                | 11                   |
| Sulphur, ppm                   | 500              | 0                    |
| Boiling Point, °C              | 180 to 340       | 315 to 350           |
| Flash point, °C                | 60 to 80         | 100 to 170           |
| Cloud point, °C               | ~15 to 5         | ~3 to 12             |
| Pour point, °C                | ~35 to ~15       | ~15 to 10            |
| Cetane number                  | 40-55            | 48-65                |
| Lubricity (HFRR), µm           | 300-600          | <300                 |

### Jatropha Curcas

Jatropha (Jatropha curcas) is one of such non-edible oils, which has an estimated annual production potential of 200 thousand metric tons in India and it can be grown in waste land [14]. The oil content for jatropha kernel is 63.16% [15] and higher linseed, soybean, and palm kernel which is 33.33%, 18.35% and 44.6%, respectively [16]. Hence jatropha will be the perfect biodiesel because it more economical in term of oil contains. Table 2 shows the fuel properties of jatropha oil, jatropha
biodiesel, and diesel; Table below will show the fuel properties of jatropha oil, jatropha biodiesel, and diesel [17];

**Table 2:** Fuel properties of jatropha oil, jatropha biodiesel, and diesel.

| S.no | Fuel Blended | Density (Kg/m^3) | CV (kJ/kg) | Viscosity @ 40 °C (cSt) | Flash Point (°C) |
|------|--------------|------------------|------------|-------------------------|-----------------|
| 1    | Diesel       | 850              | 44000      | 2.87                    | 76              |
| 2    | JO20         | 852              | 43759.5    | 3.02                    | 88              |
| 3    | JO50         | 857              | 42673      | 3.59                    | 113             |
| 4    | JO100        | 873              | 43960      | 4.23                    | 148             |

**2.0 Storage Method and Parameter**

In this study, density, viscosity, acid value, water content and flash point of biodiesel blend were observed under ambient condition of range of 28°C and 31°C and stored up to 1960 hours of storage duration (10 weeks). Figure 3.1 shows the flowchart of the process involved in this study. Biodiesel samples were stored in glass containers and were monitored on a weekly basis through the test properties[18].

**Figure 1:** Experiment Flow Chart

This process was observed at a certain temperature and mixing them to produce biodiesel in the presence of methanol and base catalyst. Physical characteristics have been considered including acid value, viscosity, density, water content, and flash point.
In this study there are 4 samples are taken which is 5% blends of jatropha oil (JO 5), 10% blends of jatropha oil (JO 10), 15% blends of jatropha (JO 15). A block diagram of blending process and schematic diagram that used in the mixing process were shown in Figure 2 and Figure 3. In addition, Table 3 describes the blending machine components and its function during the blending process. The purified jatropha oil methyl ester was blended with commercial diesel. The mixer was scale at 60°C and the mixture was stirred at 70°C for 1 hour. The blade speed were maintained at 270rpm[9].

![Figure 2: The Blending Machine](image)

| Parts Number | Component          | Function                                      |
|--------------|--------------------|-----------------------------------------------|
| 1            | Diesel Tank        | Storage and level the diesel                  |
| 2            | Motor              | Transmit motion stir                          |
| 3            | Biodiesel Tank     | Storage and level the biodiesel               |
| 4            | Stir               | Stir the mixture and biodiesel                |
| 5            | Water Inlet Pipe   | Use to inlet at the around                    |
| 6            | Water Outlet Pipe  | To take out the water                         |
| 7            | Mixture Tank       | Mixture diesel and biodiesel                 |
| 8            | Switch Box         | On the devise and set the temperature         |
| 9            | Mixture Outlet Pipe| To take out the mixture                       |
Properties Test

All of the samples is kept on two different conditions, first is inside a cupboard, and another is on a field. Then the sample is undergo five monthly properties test, which is density, viscosity, water content, acid value and lastly flash point test. Density is an important property which influences the overall standard of a biodiesel. The density of biodiesel blend was measured according to, EN ISO 3675 European Standard. By taking approximately 30 ml of sample it was poured into a beaker and left to cool down to 15°C inside a refrigerator. We measured the weight of an empty 10.104 ml pycnometer by using a weighing machine and level the weight indicator. The cooled sample was poured into the pycnometer until it was completely filled it. The pycnometer was measured again on a weighing machine and the weight shown this time would be the weight of the sample inside the pycnometer. Hence, the density of the sample could be calculated as follow:

\[ \text{Volume} = 10.104 \text{ml} \]
\[ \text{Density} = \frac{1000 \times \text{weight (g)}}{\text{volume}} \quad (1) \]

Viscosity is an important property which indicates the ability of a material to flow. For the viscosity test, EN ISO 3104 European Standard was followed. The sample needed to be heated up to the temperature of 40°C. Heated sample was then poured into a graduated cylinder. A solid stainless steel sensor of the viscometer (Viscolite 700) was then immersed into the sample. The sample level had to be higher than the line on the sensor and the side of the viscometer sensor must not be touching with the graduated cylinder. The reading of the viscometer result was in centipoises (cPs). The left-over of sample on the solid stainless steel sensor was wiped cleanly after used.

The acid value analysis was based on the titration process of the sample through the use of sodium hydroxide, phenolphthalein and biodiesel sample. In the process of preparing the alkaline reagent, sodium hydroxide (NaOH) 0.1M, 2 g of sodium hydroxide (NaOH) in powder or pellets form were mixed with 500 ml of distilled water inside a volumetric flask. The alkaline mixture was mixed well by shaking the flask thoroughly. The mixture was poured into a burette until it was fully filled. In order to ensure no bubble was trapped inside the burette, few drop of solution was titrated out until the bubble was gone.

For the acid value test, EN 14104 European Standard was followed. The sample was heated up to around 60 – 70 °C. By taking 4 g of the heated sample was mixed with 50 ml of 2-propanol inside a conical flask. The mixture was heated up again to 40°C and then 5-7 drops of phenolphthalein is added in. It was titrated with the sodium hydroxide mixture until the first pink colour appeared and lasted for around 30 seconds. The volume of alkaline solution used for the reaction was recorded.

\[ \text{Volume of alkaline solution used, ml} = \text{Final volume} - \text{Initial volume} \quad (2) \]

\[ \text{acid value,} \% = \frac{\text{ml of alkaline x 0.1 x 36.1}}{\text{weight of sample}} \quad (3) \]

For the water content test, EN ISO 12937: 2000 European Standard was followed. Coulometric Karl Fischer Titrators. It was suitable for small water volumes such as biodiesel blend in ppm unit. A
syringe was used to draw approximately 5 ml of biodiesel sample and was weighted by using a weighing machine. The weighing machine was then levelled. The start button on the machine was pressed. The sample was injected into the machine solution through the inlet until a keypad screen appeared at the monitor. It was important that the sample is injected slowly so that no excess sample was injected. The remaining sample in the syringe was weighted again. The weight appeared was the amount of sample injected and was inserted into the machine through the keypad appeared. The result of total water content in the sample was shown in a few seconds. Flash point is a parameter of practical importance because as the flash point increases, the higher is the safety level during handling, transportation and storage. For flash point test, EN ISO 2719: 2002 European Standard was followed. By taking approximately 60 ml of sample was poured into the brass cup until the inner line had reached. Every parts of the flash point tester were assembled back carefully and the estimation of boiling point of the sample was inserted into the machine which is around 80°C. The machine was switched on and the sample was heated up. The overall process was comprised of heating and cooling down of the sample. The duration of the overall process was done in 20 minutes.

3.0 Results and Discussions
Effect of the storage duration of biodiesel blending ratio from jatropha oil (JO) under room temperature was investigated at the base STD (just after blends) for biodiesel JO 5, JO 10 and JO 15 respectively. The average storage temperature for room temperature and outdoor temperature are 24°C and 33°C, respectively. Figure 4 shows the flash point and water content with variant storage duration for standard diesel, JPO, WCO and CPO. For flash point the Crude Palm Oil Biodiesel (CPO) and Standard Diesel showing a steady trend but increasing trend for all of JO 5, JO 10 and JO 15.

Figure 4: Flashpoint and Water content in Indoor Condition
For jatropha derivation the lowest flashpoint recorded is at 120°C but the data keep increasing until JO10 reach peak value which is 150°C. Higher value of flash point is good for safety of a machine because diesel is self-ignition fuel so it can reduce the change of explosion during handling it. It shows that water content is increased with the increasing of time duration. The highest value is 0.0029% from JO 15 at 2190 hours. The lowest value is standard diesel at 1176 for 0.002% water content. Next Figure 5 elaborates the effects of CPO, JO, WCO and standard diesel for acid value, viscosity and density. The water content is closely related to acid value due to the hydrolysis of methyl ester that causes the increasing of water content value.
The acid value content is slightly increased for CPO, JO5 and standard diesel. For JO10 and JO15, there were showing a decreasing value. The highest acid value recorded at early state which is 7.9 mgKOH/g and the lowest is at 0.17 mgKOH/g. For the viscosity CPO, JO5 and standard diesel increase in value but for JO10, and JO15 the value is decreasing. The highest viscosity was recorded at 2190 hours, 4.6 cTs for JO5. The lowest viscosity is at 672 hours for 2.9 cTs. For density the JO show us a very distinct data which starting from 845 g/cm³ and the lowest is 835 g/cm³.

4.0 Conclusions
This research investigate the effects of ambient condition and storage time on flash point, water content, acid value, density and viscosity of CPO (crude palm oil, JO (jatropha oil) and WCO (waste cooking oil). The summary as follows: This study shows that low changes in the physical properties of biodiesel mixed samples when stored at ambient temperature or low temperature. Indoor storage conditions which are less susceptible to delayed break light chain fatty acids. Biodiesel storage at low temperatures is suitable and more advantageous because the impact on the physical properties is minimal and beneficial to slow down the degradation of biodiesel and storage. The physical properties majorly affected by the blending ratio and type of derivation used.

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