EFFECTS OF STORAGE DURATION AND AMBIENT CONDITION ON JATHROPHA DERIVED BIODIESEL PROPERTIES AND CHARACTERISTIC

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Abstract. Biodiesel is an alternative diesel fuel derived from vegetable oils, animal’s fats or used frying oils, largely consists of the mono-alkyl esters of the fatty acids comprising these feedstocks. This research will focusing on the effects of storage duration and ambient condition on jatropha derived biodiesel. The jatropha biodiesel will be classify by 3 sample which is 5% jatropha oil 95% commercial diesel (JO 5), 10% jatropha oil 90% commercial diesel (JO 10), and 15% jatropha oil and 85% commercial diesel (JO 15). The sample will split into two condition storage which is in a dark room and away from sunlight and left outside and expose to sunlight for 3 month period. The sample will tested monthly according these aspect; acid value, flash point, viscosity, water content, and density. It seems that the acid value and flash point almost constant along the time. The density, viscosity and water content is showing an increasing trend along the time. Low changes in the physical properties of biodiesel mixed samples when stored at ambient temperature or low temperature.

1.0 Introduction
Intercontinental transport and hemispheric air pollution by ozone jeopardize agricultural and natural ecosystems worldwide and have a strong effect on climate change. The impact of global air pollution on climate and the environment is a new focus topic that most of world population concern. So the production of biodiesel around the globes is significantly increase from years of 2005 and there still remains of concern about its resistance towards oxidative degradation during the storage. The cause of the problem is in its molecular level when the biodiesel consist of double bond in the molecule produce...
high level of oxidative reaction towards oxygen [1-5]. When the world is react on the greener energy such as biodiesel there come the concern the research on biodiesel is move into new topic which is the storage topic. The earliest journal found at 1995 form Paolo Bondioli. In my opinion the awareness on the storage aspect start from 1995 until today. The biggest issue why the biodiesel is cannot commercialize yet is because the world is facing the shortage on food. On the other hand the major issue is biodiesel viscosity is increasing along the time [6-8]. It may cause serious damage to the engine and can cause loss of profits. So many of biodiesel derivation is tested to produce a safe fuel that can replace petroleum based diesel [7-9].

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 fulfill requirement of ASTM D6751 fuel specification. The advantages of using extraction biodiesel is it can use either co-products or by-products [10-13]. 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 [13-14]. Carbon dioxide produced form biodiesel can recycled by photosynthesis and will minimize the effects of greenhouse effects [15-16].

The test of biodiesel storage for duration for 3 month which is about 12 week. The sample is left exposed to sunlight and the other sample will be placed in dark place. The blending ratio involve is from 5%, 10% and 15% and kept at indoor condition (room) outdoor condition (field). Each sample will open monthly. At the ends of this research there are 5 parameter to be discover; water content, acid value, flash point, density, and viscosity.

2.0 Methodology

In this study, biodiesel is be produced by using jatropha oil, was 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. The comparison of diesel and biodiesel is described as Table 1;

| 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                  |
| Sulfur, 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                |
2.1 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 [5]. The oil content for jatropha kernel is 63.16% [6] and higher linseed, soybean, and palm kernel which is 33.33%, 18.35% and 44.6%, respectively [7]. 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[8];

Table 2: The fuel properties of jatropha oil, jatropha biodiesel, and diesel.

| S.no | Fuel Blended | Density (Kg/m3) | 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            | 43690      | 4.23                    | 148              |

Testing Procedure
ASTM D4052
ASTM D240
ASTM D445
ASTM D93

2.2 Storage Method and Parameter

This study investigated the effects of different storage periods used in quality biodiesel blends waste cooking oil 5% diesel 95% (W5), waste cooking oil 10% diesel 90%(W10), waste cooking oil 15% diesel 85% (W15), of waste cooking oil and diesel fuel under low temperature and the temperature of the environment. Biodiesel samples were stored in glass containers under room temperature.
condition, and ambient temperature condition for 10 weeks in total. These samples were monitored on a weekly basis through the test properties[9]. The tested parameter is acid value, viscosity, density, water content and flash point. This process was be done at a certain temperature and mixing them to produce biodiesel in the presence of methanol and base catalyst. Then, unwanted products such as excess methanol, soap, and glycerin are removed before testing the physical properties happen. Physical characteristics have been considered including acid value, viscosity, density, water content, and flash point.

2.3 Biodiesel derivation

In this study there are 4 samples are taken which is 5% blends of jatropha oil (JO5), 10% blends of jatropha oil (JO 10), 15% blends of jatropha (JO 15). A block diagram of blending process and schematic diagram were shown in Figure 1 and Figure 2. The purified jatropha oil methyl ester were blended with commercial diesel. The mixer were scale at 60°C and the mixture were stirred at 70°C for 1 hour. The blade speed were maintained at 270rpm[10].

| 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      |

Figure 2.0: The Schematic Diagram of Blending Process

Properties Test- All of the samples is kept on two different condition, 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- 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:

\[ \text{Density} = \frac{1000 \times \text{weight (g)}}{\text{volume}} \]  

2.4 Viscosity

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.

Acid Value - 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.

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

\[ \text{acid value, %} = \frac{\text{ml of alkaline}}{\text{weight of sample}} \times 0.1 \times 56.1 \]  

Water Content -For the water content test, EN ISO 12937: 2000 European Standard was followed. Coulometric Karl Fischer Titrators was the equipment required. 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 leveled. 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 - 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 was 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

3.1 Influence of Different Blending under Indoor Condition

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 3 shows the increasing trend for acid value, viscosity, density and water content. 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.

The acid value content is slightly increase for CPO, JO5 and standard diesel. For JO10 and JO15, there were showing a decreasing value. The highest acid value recorded at 0 hours which is 7.9 mgKOH/g and the lowest is at 0.17 mgKOH/g. Graph of flash point showing us a constant data for standard diesel and CPO. 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. 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 cT for JO5. The lowest viscosity is at 672 hours for 2.9 cT. Graph water content showing us that all of the sample used is showing increasing in value. The highest value are 0.0029% from JO 15 at 2190 hours. The lowest value is came from standard diesel and at 1176 for 0.002% water content. The water content is closely related to acid value due to the hydrolysis of methyl ester that cause the increasing of water content value. For density the JO show us a very distinct data which starting from 845 g/cm³ and the lowest is 835 g/cm³.

3.2 Influence of Blending Under Different Ambient Condition

Figure 4 illustrate us the changes of physical properties of jatropha oil and crude palm oil on different storage condition which is on room condition and outdoor condition. Overall the graph for JO trends give the highest result then followed by CPO and standard diesel. For acid value testing, outdoor condition give us a significant increase for all of the sample. The highest value given by the JO 15 at 0.7 mgKOH/g and the lowest is JO5, 0.2 mgKOH/g. The increasing of acid value was cause by hydrolysis process of methyl ester that induce by the sunlight.

For flash point graph the reading of outdoor condition is lower than indoor condition for JO. The highest peak for JO store in indoor condition is almost 150°C but for the outdoor condition the value is below 140°C. For the viscosity graph outdoor condition give a surprising result. The JO viscosity decrease throughout the time. The sample JO 10 and JO 15 might stabilize throughout the time.
Figure 3.0: Graph of Different Blending at Indoor Condition

Figure 4: (a) Storage Duration on Indoor Condition. (b) Storage Duration on Outdoor Condition.
The water content was increased higher than indoor condition. The cause is same as acid value, hydrolysis of methyl ester promote by the sunlight. The peak of the data is at 2190 hours for JO 15 which is 4.4 cTs if we ignore the first data and the lowest is for CPO 10 at 3.0 cTs. The result for density is almost same over the time. What makes it differ the blending ratio, the higher the blending ratio the higher the density. The maximum value is at 880g/cm3 for JO 15 and the lowest is for CPO 10 along 840g/cm3.

3.3 Comparison of Influence Ambient Condition under Variant Alternative Fuel.

Figure 5 show us the changes of physical properties for jatropha oil, crude palm oil standard diesel and waste cooking oil on different ambient condition. Overall the trends of the graph for acid value was constant over time both indoor and outdoor condition. For flash point there were increasing in value for jatropha (JO) group and slightly decrease on waste cooking oil (WCO) group and the crude palm oil (CPO) group for both indoor and outdoor condition. For viscosity graph, WCO and CPO had an increase then maintain the value. For JO, JO 5 increase throughout the time but for JO 10 and JO 15 decrease. Water content graph is showing a linear data but for JO they were showing an increasing data development for indoor condition. For outdoor condition all of the sample give an increasing of value along the time study. Lastly the density for JO group showing a constant value but other group was showing a slightly increasing of data throughout the time.

For acid value, according to the European Biodiesel Standards EN 14104 the maximum acid value for a biodiesel is 0.5 mgKOH/g. The graph illustrate that most of 5% blends and 10% blends are suit for the standards even the sample was left for a long time periods both for indoor and outdoor condition. For flash point, according to the European Biodiesel Standards EN 14103 the minimum flash point for a biodiesel is 120°C. So the eligible fuels for flash point is JO5, JO 10 and JO 15. The ideal viscosity for a biodiesel is from 3.5-5.0 cSt referring to EN ISO 3679. So group WCO and JO was passed this requirement both indoor and outdoor condition.

Water content standard is 0.05% according to EN ISO 12937. So all of the sample is passed the requirement of the standard because all of the score the lower than 0.03% of the water content. The standard for density is 860-900 kg/m3 from EN ISO 3104. So the jatropha group is suit for the requirement for the standard. The group density was from 870 to 880 kg/m3.

In a general conclusion the best alternative fuels that suit the European Standard for Biodiesel (EN 14214) is JO5 and JO10.
Figure 5: (a) Storage on Indoor Condition (b) Storage on Outdoor Condition

4.0 Conclusions

In this research, the Jatropha biodiesel with different blending ratio JO 5, JO 10, and JO 15 which storage at indoor condition and outdoor condition. The summary as follows:

1. Low changes in the physical properties of biodiesel mixed samples when stored at ambient temperature or low temperature. However, indoor storage conditions which are less susceptible to delayed break light chain fatty acids.
2. 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.
3. The physical properties majorly affected by the blending ratio and type of derivation used. The best alternative fuel is JO5 and JO10 which is suit all requirement experiment for this research referring European Standard (EN14214).

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