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Relationships derived from physical properties of waste cooking oil / diesel blends and biodiesel fuels

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ABSTRACT – The aim of this study is to estimate mathematical relationships of vital fuel properties of waste cooking oil/diesel blends and biodiesel fuels. The origin of both waste cooking oil (WCO) and biodiesel (BD) are from palm oil to keep the uniformity of this study. To find the fuel properties, experiments are carried out to acquire data for each blend sample. The samples of blends prepared are ranging from 10% to 100% for both WCO and BD blend with diesel respectively. Mathematical relationships for each fuel property for WCO/Diesel and BD/Diesel blends are produced with their respective coefficient of determination denoted as R^2. The results have shown that the properties of the fuel mainly have polynomial relationships.

1. INTRODUCTION

Diesel is a very useful and incredible fuel with diverse use and applications. However, the usage of petroleum when it is at its high demand is actually costly since it is a limited source. With this apparent global energy issue and crisis, scientists have been working towards developing alternate source of energy that is more economical and sustainable in the ecology system of the earth. One of the options for alternative fuel that is often turned to these days is the waste cooking oil. Biodiesel on the other hand is also another alternate source that is too a well-known solution towards petroleum dependency. In addition, biodiesel is renewable and has a positive and less damaging impact on the environment and yet it could be a good substitution of diesel as an engine fuel thus reducing the demand of fossil fuel which is very limited source to cope with the global use.

Biodiesel is given its name because it is made up of variety of ester based oxygenated fuel produced from renewable biological resources [1-2]. As for the production of biodiesel, transesterification is the most common method [3]. This is because it produces and output high yield at low temperature and pressure and has short reaction time.

Waste cooking oil is the oil that is obtained from the fried food. When heated up to 180 °C in order to fry food, the chemical composition of cooking oil tends to change and thus the cooking oil is not advisable to be used over and over again because food will absorb over 5% of the used cooking oil and hence affect human health who consumed the fried food [4]. The global consumption of vegetable oil is increasing every year thus increase the waste oil production and disposal [5]. Waste cooking oil disposal is a problem.

There are numerous study and research made on engine testing and emission that require the input of fuel properties as the pre-requisite condition before applying any fuel in the engine. A study conducted by Liaquat et al. [5] emphasized on the performance of engine and emission nature of diesel engine by using coconut biodiesel blends. Aside from finding the fuel properties to perform engine testing, there is also a research that specify on the study of elemental properties of palm oil biodiesel blends. This study which is mentioned earlier was conducted by Pedro et al. [6] and Donald et al.[7].

In this study, the main fuel properties that are viscosity, density and heating value of diesel blends with respect to WCO and BD are to be determined and to estimate mathematical relationships of vital fuel properties.

2. METHODOLOGY

Sample preparation starts by collecting 4 liters of waste cooking oil (WCO) from local restaurants and purchasing of 4 liters of pure biodiesel (BD) and 6 liters of diesel. The collected waste cooking oil is first filtered by using coffee cloth prior to filtering using 11 micron paper filter. Then the filtered oil is heated at temperature exceeding 100°C so that all the water content in the oil is gotten rid of. The oil is then ready to be blended with diesel and thus prepared to be tested for its properties.

Blending is done to obtain two set of blending sample; one sample set is for BD blended with diesel and the other set is for WCO blended with diesel. The blending is done based on volume percentage ranging from 10% to 100% for both BD and WCO blend with diesel respectively.

The equipments used to measure for the basic properties or fuel characteristics of each blend are summarized in Table 1 as follows:

Table 1 Equipments used for fuel characterizations

Fuel characteristics	Equipment
Heating value	IKA C200 Bomb Calorimeter
Viscosity	Brookfield Viscometer
Density	Hydrometer

3. RESULTS AND DISCUSSION

Figure 1 shows the viscosity of both types of blends increases as the percentage of blend increases as they went from pure diesel to their pure forms of W100 and B100. Commercial diesel has the lowest viscosity of 6.2 cP whilst pure WCO, W100 is the most viscous fuel at viscosity of around 37 cP. It is also indicated that in the graph the pure biodiesel, B100 has slightly higher viscosity than diesel which is at around 6.7 cP.

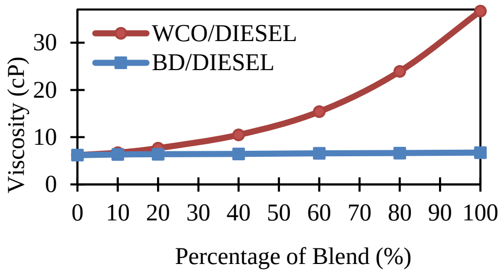

Figure 1 Viscosity against percentage of blend

Figure 2 shows the density for both types of blend is rising as the intensity of the WCO and BD rises. Diesel has the lowest density at 830 kg/m^3 while pure WCO (W100) has the highest density at 905 kg/m^3. Besides that, it is also recognizable that the densities of WCO blends are again greater than that of the BD blends.

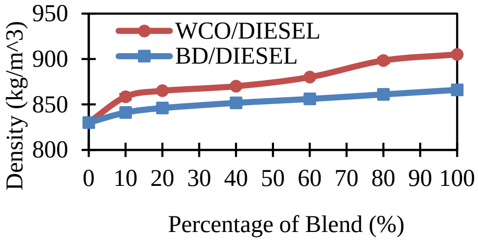

Figure 2 Density against percentage of blend

Figure 3 indicates that the heating value for both types of blend decreases as the percentage or intensity of the blend increases. This phenomenon is happening due to the increase in density of the oils. Heat is an extensive property whereby it is highly dependent on the size of the matter. Study has shown that the relationship between higher heating value (HHV) and density is inversely proportional [7]. This means that as the density of the fuel increases, the heating value of the fuel will continue to decrease.

In summary, the mathematical relationships for WCO/Diesel blends are resulted as follows:

$VIS = 0.0035x^2 - 0.0612x + 6.8241$

$DN = -0.0033x^2 + 0.9687x + 839.84$

$HV = -3E\text{-}05x^3 + 0.0043x^2 - 0.2122x + 46.464$

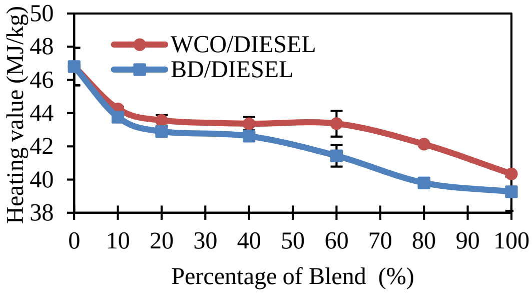

Figure 3 Heating value against percentage of blend

Concurrently, the mathematical relationships of BD/Diesel blends are recorded as follows:

$VIS = 0.0048x + 6.2646$

$DN = -0.0024x^2 + 0.5538x + 833.29$

$HV = -2E\text{-}05x^3 + 0.0029x^2 - 0.199x + 46.23$

4. CONCLUSIONS

From the results obtained, BD blends can be concluded as a better fuel in comparison to the WCO blends. This is because transesterification or alcoholyis has brought about positive effects on the properties of the blends. The fuel properties of BD blends especially B20 is compatible to be used in a CI engine on a par with diesel fuel without the need to an engine modification or special handling of the fuel. Besides that, the objective of this study is achieved by the generation of the estimated mathematical relationships of the fuel properties with respect to the blend intensity.

5. REFERENCES

[1] A. Pravin, T. Ashok. Pise and S. Chougule. “Properties of Biofuels and their Diesel Blends as a Fuel for C.l. Engines”in *IEEE-International Conference On Advances In Engineering, Science And Management*, 2012, pp.1-8.

[2] C.B. Daria. “Biodiesel Production from Non-foodstuff” *Chemistry, Catalysis and Engineering*. 2012, pp. 49-51.

[3] M. Mathiyazhagan. M., A.Ganapathi, B. Jaganath, N. Renganayaki, and N. Sasireka. “Production of Biodiesel from Non-edible plant oils having high FFA content”. *International Journal of Chemical and Environmental Engineering*, pp. 1-4. 2011.

[4] G.M. Kulkarni and A.K. Dalai. “Waste Cooking Oils - An Economical Source for Biodiesel: A Review.” *Ind. Eng. Chem. Res*, pp. 1-13. 2006.

[5] Liaquat A. M., Masjuki H. H., Rizwanul Fattah I. M., Hazrat M. A., Varman M., Mofijur M., Shahabuddin M. Effect of coconut biodiesel blended fuels on engine performance and emission characteristics . *Pro. Eng.* 56, pp. 683-690. 2013.

[6] Pedro Benjumea, John Agudelo, Andre´s Agudelo. Basic properties of palm oil biodiesel– diesel blends. *Fuel* 87, pp. 2069-2075. 2007.

[7] Donald A. Heck, Jordan Thaeler, Steve Howell and Joshua A. Hayes. (2009). Quantification of the Cold Flow Properties of Biodiesels Blended with ULSD, *Iowa Biodiesel Board*, pp.10-15. 2009.