Properties of biodiesel derived from vegetable oil, animal fat and waste cooking oil

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Abstract

Vegetable oil, animal fat and waste cooking oil can be derived to utilize as biodiesel. The fuel properties of biodiesel are one of the most important parameter to verify the quality of biofuel. The objective of this study is to produce biodiesel from vegetable oils and animal fat and to evaluate their potential as alternative fuel. In this research, methanol solvent (CH_3OH) and sodium methoxide catalyst (CH_3NaO) were used as a solvent for transesterification process. The key fuel properties such density, viscosity, cetane number, flash point, cloud point and pour point of the biodiesel were measured using the International Standard methods. All of six of crude biodiesel extracted oil namely; palm oil, corn oil, soybean, sunflower, waster cooking oil (WCO) and chicken fat were undergoing these analyses by using different analytical machine. The experimental results show that the properties of six different biodiesel meet the requirement by international standard (EN14214). As a conclusion, the study indicates that vegetable oil, animal fat and WCO derived fuel can be utilized as alternative fuel for biodiesel.

Keywords: Fuel properties; biodiesel; vegetable oil; animal fat; waste cooking oil.

1. Introduction

Biodiesel is one of the main alternative fuel due to their good properties as diesel engine fuel and can be utilized in diesel engines [1]. Currently biodiesel is compatible in blended form with mineral diesel in the ratio 20 (biodiesel): 80 (mineral diesel). Biodiesel and diesel have similar properties and can be used directly in existing engines. Biodiesel fuels are characterized by their viscosity, density, cetane number, pour and cloud points, flash point and etc. Cunha et al [2] reported that biodiesel and mineral diesel have very similar densities. The performance characteristics such as cetane number (CN) are related to density [3-5]. The higher value of CN can cause incomplete combustion and smoke, while lower value will cause engine roughness, misfiring, higher air temperatures and slower engine warm-up [6-9]. Acid value is an important indicator of vegetable oil quality as well as monitoring oil degradation during storage. Kardash and et al. [10] reported that, according to ASTM D6751 the maximum value of acid number is 0.5 mgKOH/g. Demirbas [11] reported that the flash point values of fatty acid methyl esters are significantly lower than flash point values for vegetable oils. In this study, transesterification processes were used to produce biodiesel vegetable oil, chicken fat and waste cooking oil (WCO).Then, the fuel properties were measured using different analytical instrument machine following procedure from ASTM standard. There were seven main fuel properties that have been analyzed namely; density, viscosity, cetane number, flash point, cloud point, pour point and acid value. The results were then compared with mineral diesel and international standard of EN 14214.

2. Materials and Methods

In this research, transesterification processes were used to produce biodiesel with aid of methanol solvent (CH_3OH) and sodium methoxide catalyst (CH_3NaO). 1 liter of the pure virgin oils (palm oil, corn oil, sunflower oil and soybean oil) were prepared. Extraction process from chicken fat itself is needed in order to get the chicken fat oil (Figure 1). 1.5 wt% sodium methoxide mixed with methanol and heated up to 70 ^oC. The methanol to oil ratio used is 3: 1. After that, mixed up the two solutions and keep the heat up to 70 ^oC. The thermometer attached to ensure the temperature is not above 70 ^oC. After the transesterification process, If the mixture contains two layers formation, the upper layer is a FAME (Fatty Acid Methyl Esters) or crude biodiesel with lighter yellow colors while the lower layer is a glycerin with darker yellow colors. The bottom layer which is glycerin was taken out because it is soap while the upper layer is crude biodiesel transferred out into another beaker for further process. The excess methanol during the transesterification process will be recovered in a vacuum at the temperature 70 ^oC. Then, the crude biodiesel was washed with water at 80 ^oC by slowly pouring hot water into crude biodiesel solution to remove remaining methanol, catalyst and glycerin. Then, the crude biodiesel was filtered using filter paper to remove remaining solid, impurities and contaminant in the solution. The measurement of the fuel properties are conducted by using different analytical instrument machine shown by Figure 1 and the method follows procedure form ASTM standard. There are seven physical properties of crude biodiesel that needed to be analyzed which are the density, viscosity, cetane number, flash point, cloud point, pour point and acid value. All of six of crude biodiesel extracted oil were undergoing these analyses and they were used only once for each of testing properties.

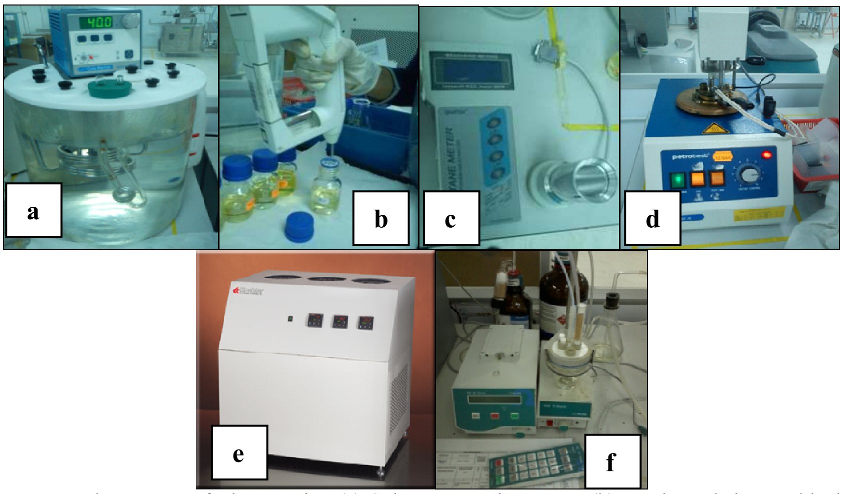

Fig. 1. Equipment used to measure fuel properties; (a) Cole-Parmer Viscometer, (b) Mettler Toledo portable density meter, (c) cetaneanalyzer , (d) Petrotest Flash Point & Auto ignition tester (e) Koehler K46100 Cloud Point & Pour Point Bath and (f) acid value and acidity tester.

3. Results and discussions

There are seven physical properties that have been analyzed which are density, viscosity, cetane number, flash point, cloud point, pour point and acid value (Table 1). It is obvious that the diesel, D2 contains different characteristic as compared to mineral diesel.

Table 1. Fuel properties test data

Property	D2	Palm	Corn	Chicken fat	Soybean	Sunfl ower	WCO
Density, kg/m3	837	874	884	877	886	887	878
Kinematic Viscosity, mm2/sec	4.237	3.9192	3.796	4.1445	4.031	4.046	4.4727
Cetane Number	71.6	60	39	54	42	36	46
Flash Point, oC	70	150	260	165	238	160	178
Cloud Point, oC	10	14	-2	10	-1	2	-4
Pour Point, oC	3	10	-12	7	-3	-3	-9
Acid Value, mgKOH/g	0.24	0.05	0.15	0.3	0.21	0.18	0.27

It is found from Figure 2(a) that palm oil has the lowest density compare to others biodiesel feedstock. While sunflower has highest density of 0.887 kg/m^3. The density for all vegetable oil and fat oil are in the range of 874–887 and it is about 6–4% lower when comparing with mineral diesel. It was found that corn has the lowest viscosity, while palm is second lower in viscosity while waste cooking oil has the highest viscosity (figure 2(b)). It can be concluded that corn is the most suitable as a biodiesel fuel to run the engine vehicle in term of viscosity parameter. Figure 2(c) above shows the result of cetane number for different feedstock. Palm has higher cetane number which is 60. It is because the fatty acid carbon chain of palm is longer than other feedstock. Following by chicken fat oil with 54, waste cooking oil 46, soybean oil 42 and corn oil with 39. Sunflower oil has the lowest cetane number which is 36. Figure 2(d) shows the acid number for different biodiesel oil. For a neat biodiesel, B100, the acid number is a measure of free fatty acid in a fuel. Chicken fat oil has highest acid number following by waste cooking oil. It is indicates that these two biodiesel oil is not suitable for engine performance. Palm oil has the lowest acid value number, which means good for engine vehicle.

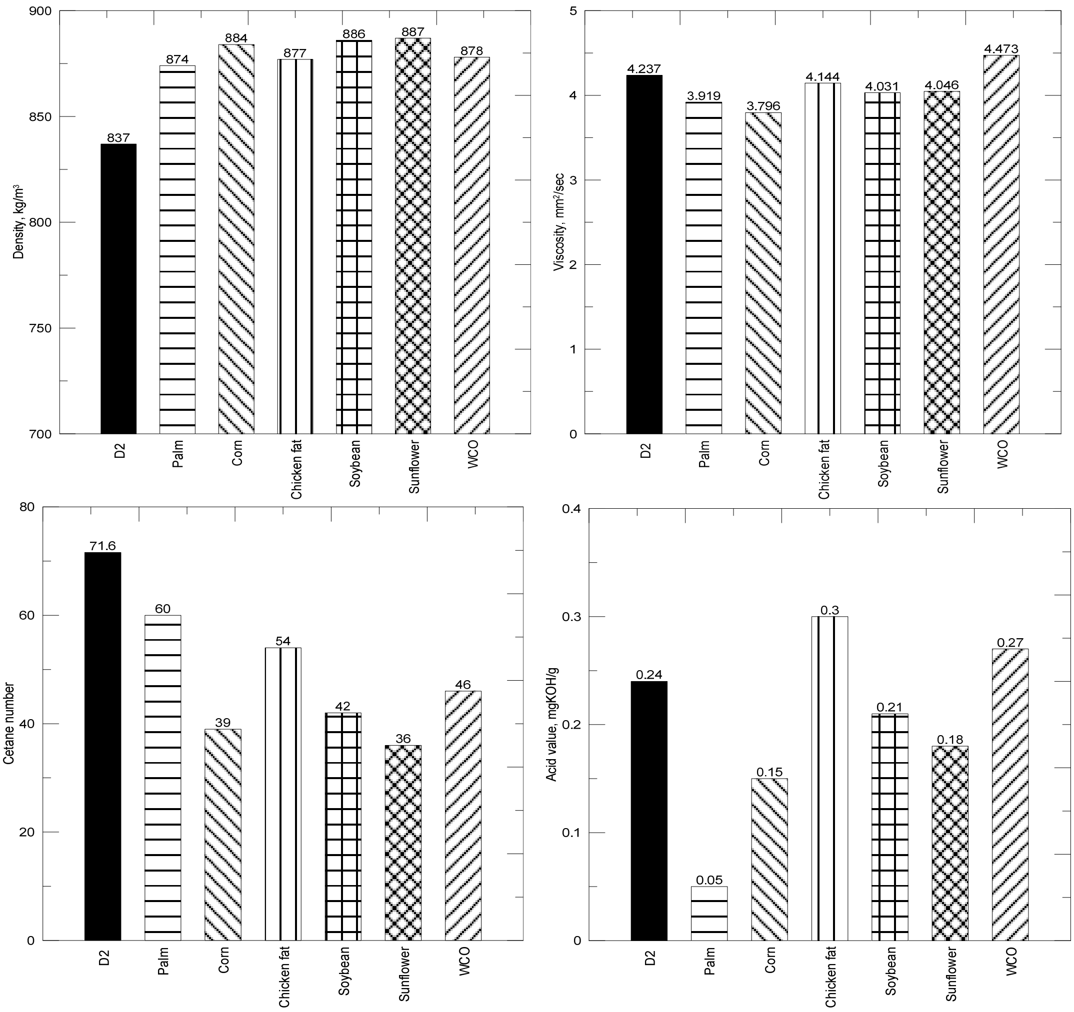

Fig. 2. Graph of biodiesel for different feedstock a) Density, b) Viscosity of Biodiesel, c) Cetane Number and d) Acid value

Biodiesel fuel typically has higher cloud point, means that the crystals begin to form at higher temperature compared to standard diesel fuel (figure 3(a)). This feature has implication for biodiesel in cold weather performance. It was found that palm has the highest cloud point while waste cooking oil has the lowest cloud point. Corn oil and soybean has minus degree Celsius in temperature. It can be concluded that palm oil is not suitable to use in cold weather country, while corn oil, soybean oil and waste cooking oil can be used as commercial fuel in cold weather country. Figure 3 (b) show that the palm oil has the highest pour point which is 10°C followed by chicken fat oil 7°C. Both of these pour points are significantly higher than that of diesel fuel and may cause problems during cold weather. While for corn oil, soybean oil, sunflower oil and waste cooking oil have minus degree Celsius in temperature. Thus, corn oil, soybean oil, sunflower oil and waste cooking oil can be applied during cold weather due to their ability to gel at lowers temperature. Figure 3(c) shows the result of flash point for each feedstock in this experiment. Corn oil has the highest flash point compare to other biodiesel oil. While palm oil has the lowest flash point, it is easier to burn and needed more safety in handling compared to corn oil.

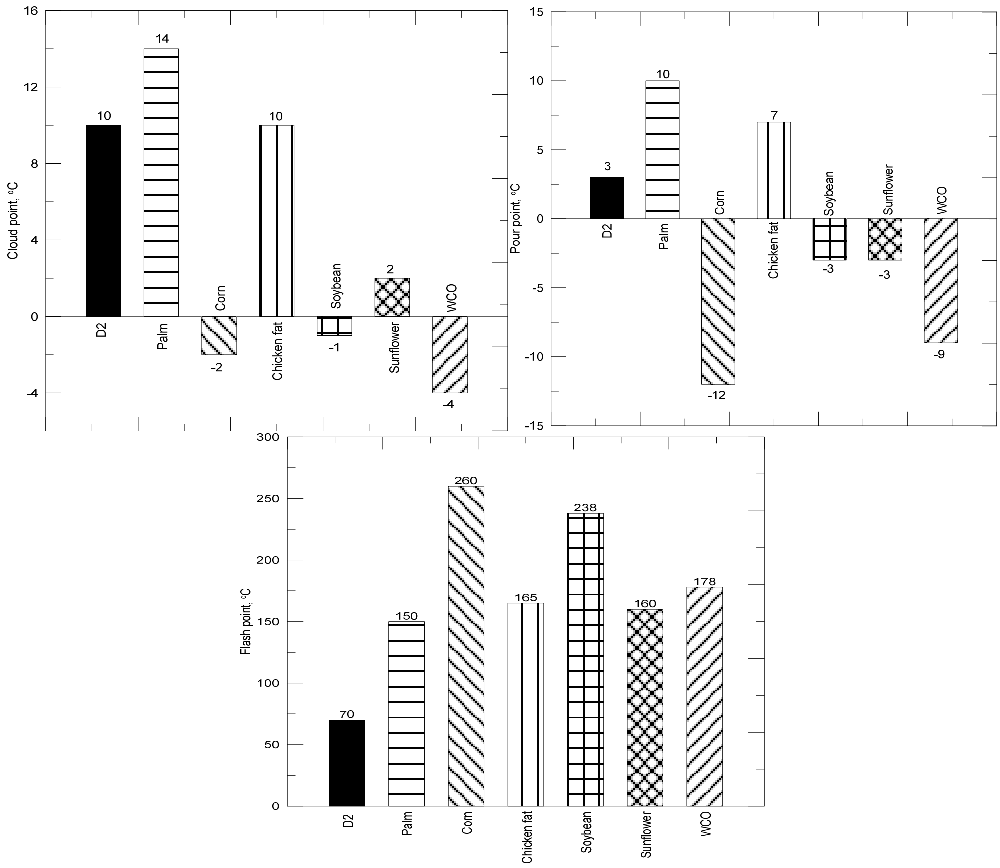

Fig. 3. Graph of biodiesel for different feedstock (a) Cloud Point, (b) Pour Point, (c) Flash Point

5. Conclusions

The biodiesel from various vegetables oil, waste cooking oil (WCO) and chicken fat were been produced. The result from the properties analyses shows that, most of these biodiesel properties results were closer to diesel fuel and meet the requirement by international standard (EN14214). There were few properties of biodiesel from WCO and chicken fat that not achieve the international standard. However these properties did not significantly affect the engine performance. Thus, biodiesel from animal fat and WCO need to further exploration in order to utilize this biodiesel in diesel engine.

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