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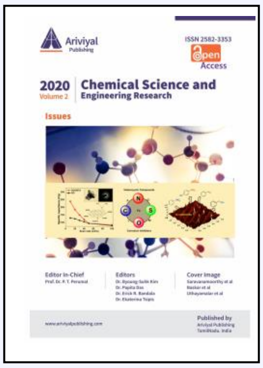

Properties of Blend Local Palm Biodiesel with Diesel Fuel

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Abstract: Biodiesel and diesel could be advantageous and disadvantageous in their respective terms, blending them would yield a fuel with intermediate properties which may improve the combustion and emission characteristics of neat palm biodiesel and thus it is very useful as a fuel in a diesel engine. This study has established relationships between the percentage of palm biodiesel blended with diesel and the properties like density, kinematic viscosity, fire point and flash point. The vegetable oil considered for the experiment was palm oil, which was obtained from commercial source. The feedstock was then converted to methyl esters by the process of transesterification. Ostwald's U-tube glass viscometer was used to determine the kinematic viscosity (at 38°C) of each sample prepared. Density of the blends at a temperature of 38°C was measured using a pycnometer of 25 mL capacity. Cleveland's open cup apparatus was used to determine the flash and fire points of the prepared samples. Analysis was carried out for three separate determinations. The kinematic viscosity of the blends ranges from 3.10 – 6.24 mm^2/s which is in range with the specification made in ASTM D6571. The difference in the densities of the blend palm biodiesel is not highly appreciable as the difference between the density of PBD0 and PBD100 is 0.049 gm/cm^3. Neat palm biodiesel PD100 is found to have flash point of 161˚C, which does not satisfy the ASTM D93 standards according to which the maximum limit is 130˚C. The fire point of the blend increases with increase in the biodiesel percentage.

Keywords: Palm biodiesel; Diesel fuel; Blend Biodiesel; Viscosity; Density; Flash point; Fire point

1. Introduction

The demand for energy consumption has over the years increased which have caused cost inflation.[1-4] Combustion of petroleum based fuels also has been the major contributor in the emission of greenhouse gases which contributes to global warming. It is known that 73% of produced CO_2 is originated from fossil-based fuels. In addition, it is predicted that petroleum reserves are limited sources and they will be depleted in near future.[5-26] Research revealed that vegetable oils can be used with close performance to diesel fuel in compression ignition engines.[1,5,17-20,26] For instance, soybean (Glycine max Merr.) oil composed of five fatty acids (palmitic acid (~13%), stearic acid (~4%), oleic acid (~18%), linoleic acid (~55%) and linolenic acid (~10%)) has been tested as oil-derived biodiesel.[1] Similarly, the use of vegetable oils, such as palm, soya bean, sunflower, peanut, and olive oil, as alternative fuels for diesel engines has also been widely studied. Vegetable oils have two main problems; 1) the vegetable oil solidifying in cold temperatures and 2) the oil changing its molecular structure in high temperatures causing it to permanently solidify. Waste vegetable oil-diesel fuel blends can recycle used frying oil, which is essentially a waste product.

Diesel fuel flash points vary between 52 and 96 °C (126 and 205 °F).[2,6,10-14,19-22,25] Diesel is suitable for use in a compression-ignition engine. Air is compressed until it has been heated above the auto-ignition temperature of the fuel, which is then injected as a high-pressure spray, keeping the fuel–air mix within flammable limits. In a diesel-fuelled engine, there is no ignition source (such as the spark plugs in a gasoline engine). Consequently, diesel fuel must have a high flash point and a low auto-ignition temperature.[2,19,20,23] Biodiesel and diesel being advantageous and disadvantageous in their respective terms, blending them would yield a fuel with intermediate properties which may improve the combustion and emission characteristics of neat palm biodiesel and thus its usage as a fuel in a diesel engine. This study aims to establish the relationships between the percentage of palm biodiesel blended with diesel and the properties like density, kinematic viscosity, fire point and flash point.

2. Experimental Section

The vegetable oil considered for the experiment was palm oil, which was obtained from commercial sources. Methanol was added to palm procured oil in 1:4 ratios (20 mL: 80 mL) along with sodium

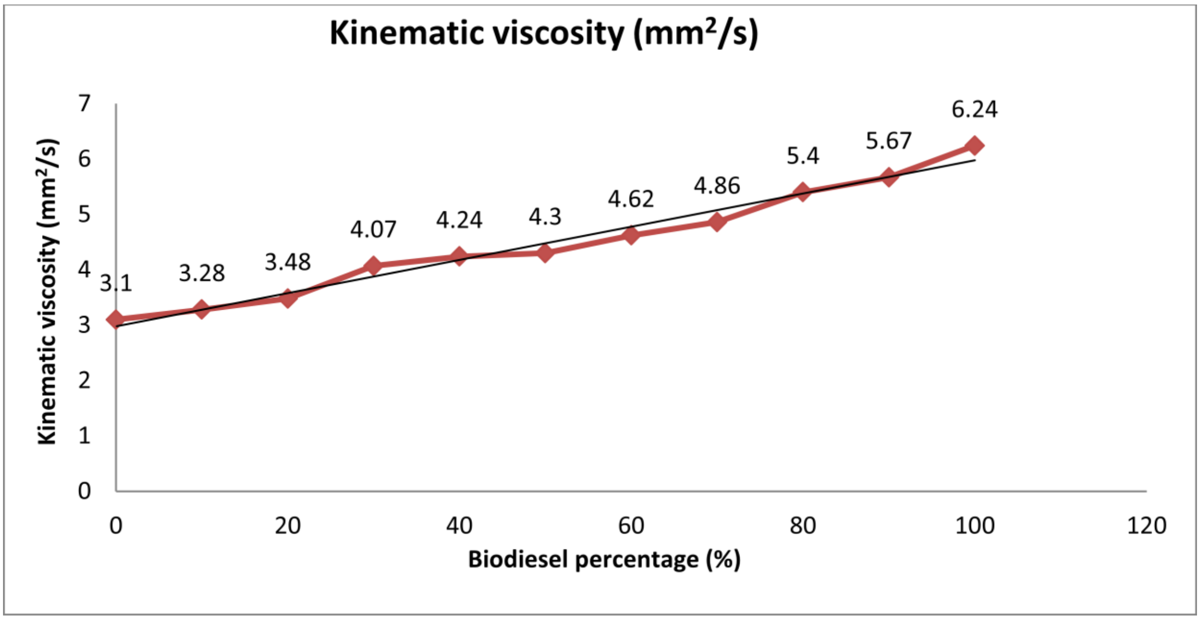

Fig. 1. Variation of kinematic viscosity of the blends with the biodiesel percentage blended.

Table 1. Properties of the palm biodiesel blend

Blend	Kinematic viscosity (mm^2 /s)	Density (gm/cm^3)	Flash point (°C)	Fire point (°C)
PBD0	3.10	0.798	52	56
PBD10	3.28	0.802	61	64
PBD20	3.48	0.811	68	73
PBD30	4.07	0.816	70	75
PBD40	4.24	0.824	72	77
PBD50	4.30	0.827	74	80
PBD60	4.62	0.829	78	81
PBD70	4.86	0.830	84	86
PBD80	5.40	0.833	102	106
PBD90	5.67	0.840	118	120
PBD100	6.24	0.847	161	174

PBD = Palm Biodiesel

hydroxide pellets (2 g) and was heated to 60°C for 6 hours. This converted it to 90-97% of palm biodiesel with remaining 3-10% of glycerol. It was then allowed to settle for 16 hours and glycerol was separated from the processed biodiesel. To ensure zero moisture, the obtained biodiesel was reheated for 3 hours at 60°C. Thus, the feedstock was then converted to methyl esters by the process of transesterification. Blend of the produced palm biodiesel and diesel fuel in different volume percentages were prepared and labelled appropriately. Ostwald's U-tube glass viscometer was used to determine the kinematic viscosity (at 38°C) of each sample prepared. Density of the blends at a temperature of 38°C was measured using a pycnometer of 25 mL capacity.[1,3,6,11,17,22,24] Cleveland's open cup apparatus was used to determine the flash and fire points of the prepared samples. All the analyses were carried out for three separate determinations.

3. Results and Discussions

The kinematic viscosity (v), density (ρ), flash point (FlP) and fire point (FiP) of the prepared blends are determined and tabulated as Table 1. The effect of blending on kinematic viscosity of palm biodiesel (v), density, flash point and fire point were investigated.

3.1. Effect of blending on Kinematic Viscosity of Palm Biodiesel (v)

Viscosity is a fluid property in which one layer of the fluid offers resistance over its adjacent layer against their relative motion. The cold flow properties of biodiesel are also poor when compared to diesel.[3,15, 23-26] The viscosity of many biodiesels is found to be slightly more than that of mineral diesel, which is in general not acceptable. A fuel with high viscosity has poor atomization characteristics and narrow spray angle. One with poor viscosity leads to excessive wear and poor lubrication.[11,12] Thus, it is desired for a fuel to possess optimum value of kinematic viscosity. Kinematic viscosity is included in biodiesel standards and the range is 1.9-6.0 mm^2/s according to ASTM D6571 and 1.3-2.4 mm^2/s according to ASTM D975.[3] Fuels with higher viscosity increases the problems in atomization and damages the fuel injector, thus ultimately results in incomplete combustion and poor engine performance leads to damaging of the engine and also the deposition of solid unburned particles. The fuels with lower viscosity does not provide lubrication to the pump and injector, so, damaging takes place hence optimum viscosity is needed

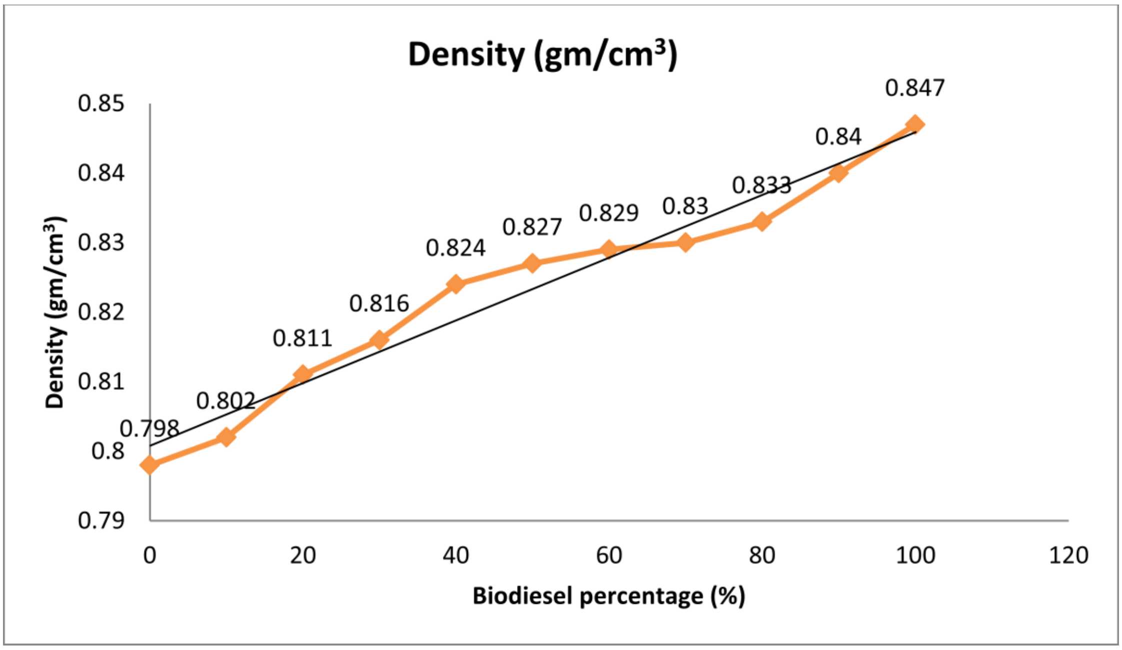

Fig. 2. Variation of density of the blends with the biodiesel percentage blended.

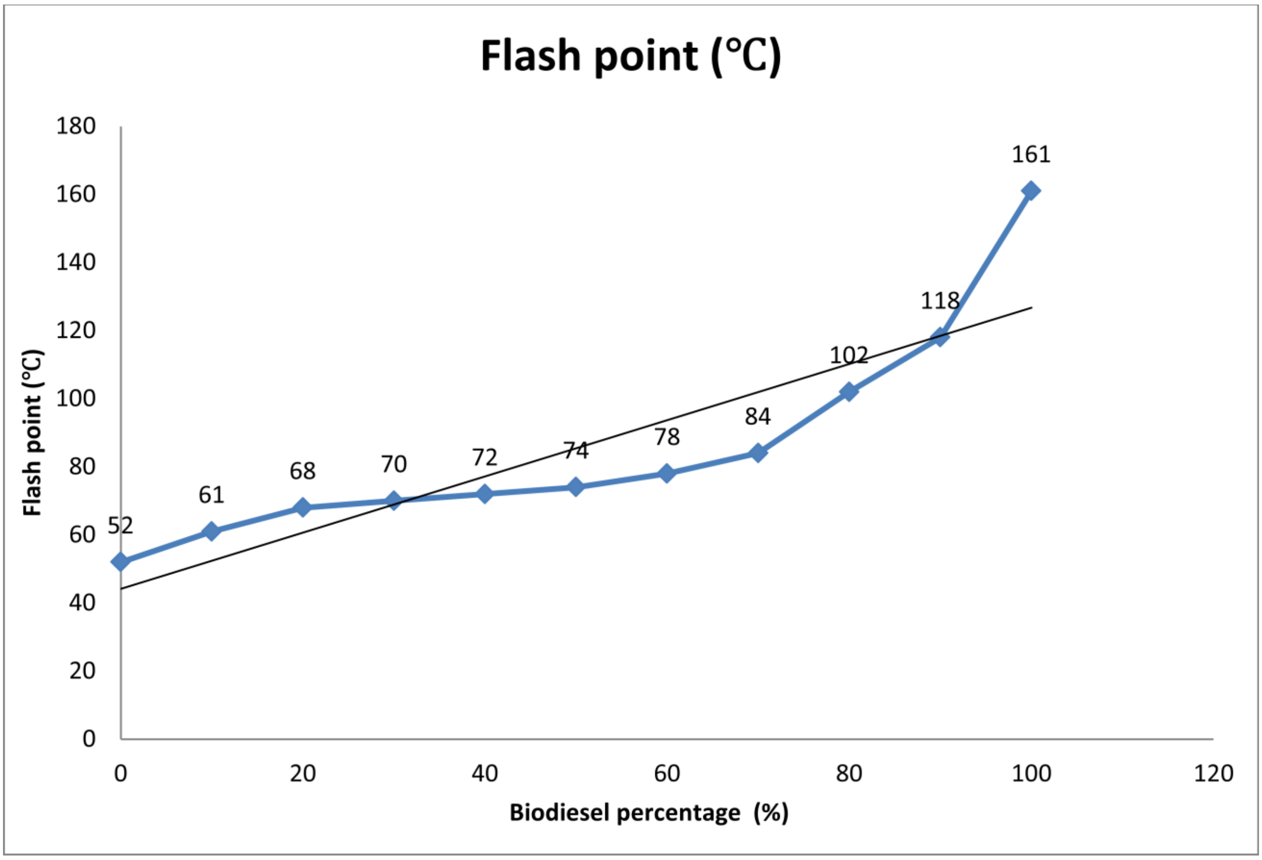

Fig. 3. Variation of flash point of the blends with the biodiesel percentage blended.

that lies within the range prescribed by ASTM and EN standards. The kinematic viscosity of the blends ranges from 3.10–6.24 mm^2/s which is in range with the specification made in ASTM D6571. It can be noted that the viscosity of neat palm biodiesel, PBD100, is almost twice the viscosity of the mineral diesel, PBD0. However, the kinematic viscosity of the neat palm can be lessened to desired value by diluting it with diesel in different proportions, as shown in the Table 1. PBD10, blend with 10% of Palm in 90% of diesel has lowest viscosity followed by PBD20, PBD30, PBD40, PBD50 and so on. Addition of a higher viscosity component would obviously increase

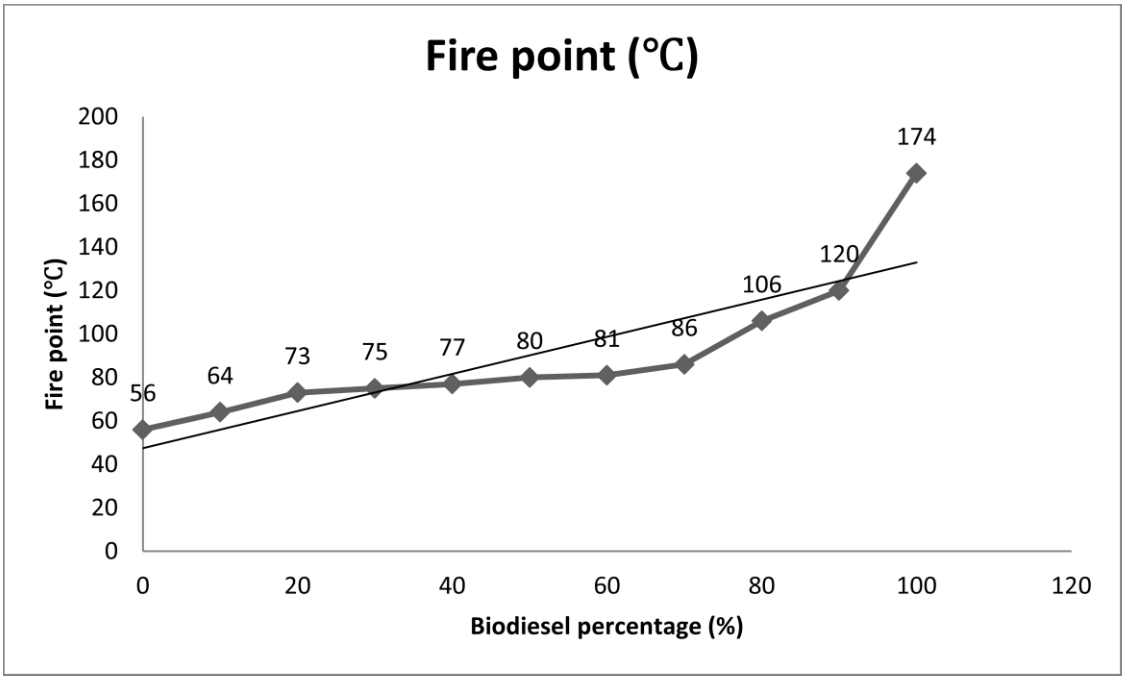

Fig. 4. Variation of fire point of the blends with the biodiesel percentage blended.

the viscosity of the sample. In short, when fuel mixes with the lubricant, it reduces the viscosity of the oil, meaning that the viscosity may be too low to create an oil film capable of withstanding heavy loads and speeds in some parts of the engine. This may result in friction between the metal surfaces and wear of the parts. For this reason, it is crucial to use properly formulated, high-quality engine oil capable of withstanding dilution by fuel, as well as the additional effects caused by the portion of biofuel.

3.2. Effect of blending on density

Density of a fuel influences its consumption. It is preferred to have a less dense fuel whose consumption would be less. Palm biodiesel is slightly denser than conventional diesel as shown in Table 1. Blending Palm biodiesel with diesel would reduce its density to some extent. The higher the palm biodiesel content, the higher is the density of the blend as shown in Fig. 2. However, there is no much appreciable change found in the density of the sample. It is related to the content of Palm biodiesel in the blend.

Blending of diesel oil with palm biodiesel increases the density of the resulting blends. The difference in the densities of the blend palm biodiesel is not highly appreciable as the difference between the density of PBD0 and PBD100 is 0.049 gm/cm^3.

3.3. Effect of blending on Flash point

Flash point is the minimum temperature that fuel releases vapor which is needed for ignitable mixture. This property is important for transportation and safety. High flash point means safe fuel. Neat palm biodiesel PD100 is found to have flash point of 161˚C, which does not satisfy the ASTM D93 standards according to which the maximum limit is 130˚C.[11,16-18] Adding diesel to it in 10%, pulled down its value within the limits specified by ASTM D93. The flash point increases on increasing the percentage of palm biodiesel in diesel, as shown in Table 1.

3.4. Effect of blending on Fire point

It is observed that the fire point of the sample increases with increase in the biodiesel percentage, as shown in Fig. 4 and Table 1.

The flash point is a descriptive characteristic that is used to distinguish between flammable fuels, such as petrol (gasoline in the US), and combustible fuels, such as diesel. It is also used to characterize the fire hazards of fuels.[1-3] Fuels which have a flash point less than 38 °C (100 °F) are called flammable, whereas fuels having a flash point above that temperature are called combustible. Flash point is the lowest temperature, to which a lubricant must be heated before its vapour, when mixed with air, will ignite but not continue to burn. The fire point is the temperature at which lubricant combustion will be sustained. The flash and fire points are useful in determining a lubricants volatility and fire resistance. The flash point can be used to determine the transportation and storage temperature requirements for lubricants. Lubricant producers can also use the flash point to detect potential product contamination. A lubricant exhibiting a flash point significantly lower than normal will be suspected of contamination with a volatile product. Products with a flash point less 38 °C (100 °F) will usually require special precautions for safe handling. The fire point for a lubricant is usually 8 to 10% above the flash point. The flash point and fire point should not be confused with the auto-ignition temperature of a lubricant, which is the temperature at which a lubricant will ignite spontaneously without an external ignition source.[3,7-9]

All liquids have a specific vapour pressure, which is a function of that liquid's temperature and is subject to Boyle's Law. As temperature increases, vapour pressure increases. As vapour pressure increases, the concentration of vapour of a flammable or combustible liquid in the air increases. Hence, temperature determines the concentration of vapour of the flammable liquid in the air. A certain concentration of a flammable or combustible vapour is necessary to sustain combustion in air, the lower flammable limit, and that concentration is different and is specific to each flammable or combustible liquid. The flash point is the lowest temperature at which there will be enough flammable vapour to induce ignition when an ignition source is applied.[13,16]

4. Conclusions

This study has established relationships between the percentage of palm biodiesel blended with diesel and the properties like density, kinematic viscosity, fire point and flash point. The viscosity of the blend biodiesels was slightly more than that of mineral diesel, which is in general not acceptable. This implies that the blend biodiesel product of this analysis is not desirable for use in all ignition engines within a temperate region as lower temperatures could cause congealing of the blends leading to the blockage of the engine. To some engines with a given specification, this blend will be desirable since the kinematic viscosity of the blends ranges from 3.10–6.24 mm^2/s which is in range with the specification made in ASTM D6571.

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Conflicts of Interest

The authors declare no conflict of interest.

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