International Journal of Emerging Engineering Research and Technology
Volume 2, Issue 7, October 2014, PP 36-42
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Investigation of Various Properties of Biodiesel Prepared from Waste Cooking Coconut and Palm Oil and Comparison with the Petroleum Diesel

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Abstract: *The use of biodiesel in the automotive industry has been continuously increasing for the last few years. Bio Diesel is a renewable fuel derived from biological sources such as waste cooking oils, animal fat, virgin oils, etc. Bio diesel is a replacement fuel for conventional petroleum diesel with the advantages of reducing exhaust emissions of carbon monoxide and hydrocarbons. In the present work, two samples with Molar ratios 7:1 and 8:1 were prepared from both coconut and palm oil at a reaction temperature of 45°C and a reaction time of two hours in the presence of KOH catalyst. The bio diesels were prepared by single step transesterification process. This paper discuss about the preparation of biodiesel from waste cooking coconut and palm oil and a comparative study of different properties of the blends with the petroleum diesel.*

Keywords: *Biodiesel; Waste cooking oil; Transesterification; Calorific value; Density; Flash and Fire point; Cloud and Pour point; Viscosity*

1. Introduction

Alternative and renewable sources of energy have become more attractive in recent years due to many reasons like depletion of world petroleum reserves, increasing energy demand and increasing environmental concerns due to rising green house gas emissions. Owing to the increasing price of crude oil and environmental concerns, bio diesel fuel which chemically constitutes methyl esters of long chain fatty acids has attracted considerable attention over recent decades. Biodiesel is a non-petroleum based fuel that consists of fatty acid alkyl esters derived from either the transesterification of triglycerides or the esterification of free fatty acids with low molecular weight alcohols. The flash point and lubricant of the bio diesel are better than those of the fossil diesel. A biodiesel source does not contain significant amounts of nitrogen and sulphur compounds. Therefore it has fewer amounts of NO_x and SO_x emissions much cleaner than fossil diesel fuel. Bio diesel can be employed as a clean substitute for fossil fuel without any modification in the diesel engines. It is technically proven that more than 300 types of fatty acids, majorly from animal fats, plant lipids, can be used as a feed stoke for the bio diesel production. Biodiesel is a viable alternative to petroleum diesel due to its proper lubricate, low toxicity, excellent combustion efficiency, environmental safe and biodegradability.

Compared to petroleum diesel, biodiesel production price is high particularly for virgin oil which is one of the major hurdles to commercialize it. The production cost can be significantly reduced by using low cost feed stock such as waste cooking oil or animal fat.

There are four major biodiesel production processes that have been studied extensively. ie.dilution, micro-emulsification, pyrolysis and transesterification techniques. Of all these process, transesterification is the most popular. In transesterification, three consecutive reactions convert triglycerides into mixture of esters and glycerol in the presence of suitable catalyst and alcohol. The selection of biodiesel production method also depends on the level of free fatty acids present in the feed stock. Used cooking oil normally has higher acid value than refined vegetable oil due to the presence of high free fatty acid content. Oils with free fatty acid content > 5% cannot be used directly in a base catalysed transesterification reaction. This free fatty acid can react with a base catalyst and accelerates the base catalysed transesterification reaction and lowers the yield of biodiesel. Therefore a pre treatment stage (esterification) is used to reduce the amount of free fatty acid content in the feedstock before the base catalysed transesterification.

Most biodiesel processes use homogeneous catalysts because of their simplicity. Homogeneous catalysts are favourable due to their capability to produce a high yield of biodiesel under mild reaction conditions and short reaction times. However, homogeneous catalysts suffer from a number of drawbacks including corrosion of equipment, side reactions, generation of a substantial amount of waste water, a high production cost due to additional equipments for separation process and difficulty in catalyst recovery. The use of heterogeneous catalyst simplifies the production and purification process because they can be easily separated from the reaction mixture. In addition, neutralization process is not needed and less unit operations are required when using heterogeneous catalysts for biodiesel. On the other hand, solid base catalysts are proved to be effective for transesterification of feed stocks with low free fatty acid content. In this present study low cost feedstock waste cooking coconut oil and waste cooking palm oil were used to produce biodiesel using single step transesterification process in the presence of Potassium Hydroxide (KOH) as the base catalyst. The process parameters such as catalyst loading, feed molar ratio, temperature of the transesterification reaction, reaction time were studied. The transesterified oil was characterized using different techniques to check the quality of produced biodiesel as per the ASTM standards.

Yinnan Yuan et al. [1] conducted a study on combustion and emissions of the diesel engine using bio-diesel fuel. For the experiment, a natural aspirated, direct-injection diesel engine (YZ4102QF model from Yangzhou Diesel Engine Co, LTD in China) was used. Soya bean methyl ester was used as bio-diesel, and three types of fuel were used. R.Murali Manohar et al. [2] conducted a study on Thermal and emission properties of engine fuelled with Diesel and Bio-Diesel blends of B20N, B80N, B20K and B80K. For the experiment, used vegetable oil easter in the presence of two different catalyst such as sodium hydroxide (NaOH) and Potassium hydroxide (KOH) was used.

A.R. Pradeep Kumar et al. [3] conducted a study on performance comparison of diesel engine and Low Heat Rejection (LHR) engine with bio diesel as fuel. The experimental investigation was carried out with rice bran oil as a fuel and optimized blend was found to be 20 percent biodiesel by volume with diesel fuel. Y Sinuka et al. [4] conducted a study on performance testing of a diesel engine running on varying blends of Jatropha oil, waste cooking oil and diesel fuel. From the experiment it was seen that the BF100 blend produces 25.3% less power than that of base diesel but has an advantage of producing lower emissions compared to the other fuels.

A Anitha et al. [5] conducted a study on spent groundnut oil for biodiesel production using supported hetero poly-acids using transesterification process. Shivaji Bhandarkar et al. [6] conducted a comparative study of vehicular pollution load of biodiesel and conventional diesel fuel at north east Karnataka state road transport corporation, Gulbarga.

S. Murillo et al. [7] conducted a study on Performance and exhaust emissions in the use of biodiesel in outboard diesel engines. Bio diesel was made from waste cooking oil. Pure diesel (BD-0), 10% biodiesel, 90% diesel (BD-10), 30% biodiesel, 70% diesel (BD-30), 50% biodiesel, 50% diesel (BD-50), and pure biodiesel (BD-100) were prepared for the study. D.C. Rakopoulos [8] conducted a study on Combustion and emissions of cottonseed oil and its bio-diesel in blends with either n-butanol or diethyl ether in HSDI diesel engine. For the study, HSDI diesel engine was fuelled with 20% n-butanol or DEE in cottonseed oil and biodiesel.

Hu Chen et al. [9] conducted a Study of oxygenated biomass fuel blends on a diesel engine. For the study, vegetable methyl ester was added in ethanol–diesel fuel to prevent separation of ethanol from diesel. Experimental results showed that the torque of the engine was decreased by 6%–7% for every 10% (by volume) ethanol added to the diesel fuel without modification on the engine. C.D. Rakopoulos et al. [10] conducted a study on performance and emissions of bus engine using blends of diesel fuel with bio-diesel of sunflower or cottonseed oils derived from Greek feed-stock. BD10 and BD 20 were prepared for conducting the experiment. Ahmet Necati Ozsezen et al. [11] conducted a study on performance and combustion characteristics of a diesel engine fuelled with waste palm oil and canola oil methyl esters. Biodiesel was prepared using methanol to oil ratio of 6:1 with potassium hydroxide (KOH) as catalyst (1% of oil by weight).

2. METHODOLOGY FOR BIODIESEL PRODUCTION

Biodiesel is a clean burning alternative fuel formulated exclusively for diesel engines which is made from vegetable oil, animal fats, recycled cooking oil and greases. The manufacturing process for biodiesel combines oils and fats with methanol and a catalyst to produce fatty acid methyl esters, which are commonly referred to as biodiesel. Vegetable oils such as rapeseed, canola, soybean and palm oil are the most common raw material for commercial-scale biodiesel production. Biodiesel can be mixed with petroleum diesel in any percentage, from 1 to 99, which is represented by a number following a B. For example, B5 is 5 percent biodiesel with 95 percent petroleum diesel. B20 is 20 percent biodiesel with 80 percent petroleum diesel, or B100 is 100 percent biodiesel, no petroleum diesel.

Chemically, biodiesel (from transesterification) refers to mono-alkyl esters of long chain fatty acids derived from natural oils. The use of biodiesel is conventional diesel engines results in substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matters. Compared to petroleum diesel fuel, biodiesel has several superior combustion characteristics. Approximately 10% wt of the biodiesel is Oxygen. This will promote a more complete combustion and effectively reduces the production of unburned HC, CO as well as suspended carbon particles. The carbon and hydrogen in the biodiesel combine with oxygen of air (combustion) to form CO_2 and H_2O.

2.1 Biodiesel Properties

The knowledge of fuel proportion helps in selecting the right fuel for the right purpose and efficient use of the fuel. The proportions of the fuels which are generally used for assessing the nature and quality of the diesel fuels includes Calorific value, Density, Flash and Fire point, Cloud and Pour point, Viscosity, Specific heat and Cetane number.

In this work, 4 samples of biodiesel were prepared from 2 oils in different molar ratios in the presence of Potassium Hydroxide (KOH) catalyst. The table.1 shows the 4 types of samples prepared.

Table1. *Biodiesel samples*

Sample	Oil used	Molar Ratio
1	Coconut oil	8:1
2	Coconut oil	7:1
3	Palm oil	8:1
4	Palm oil	7:1

3. Results and Discussion

The results of the various experiments carried out to investigate the comparison of properties, performance and emission on a diesel engine with diesel and biodiesel as fuel. ASTM standard tests have been conducted to determine various physical properties of the diesel fuel as well as biodiesel, under identical laboratory condition and results obtained are discussed.

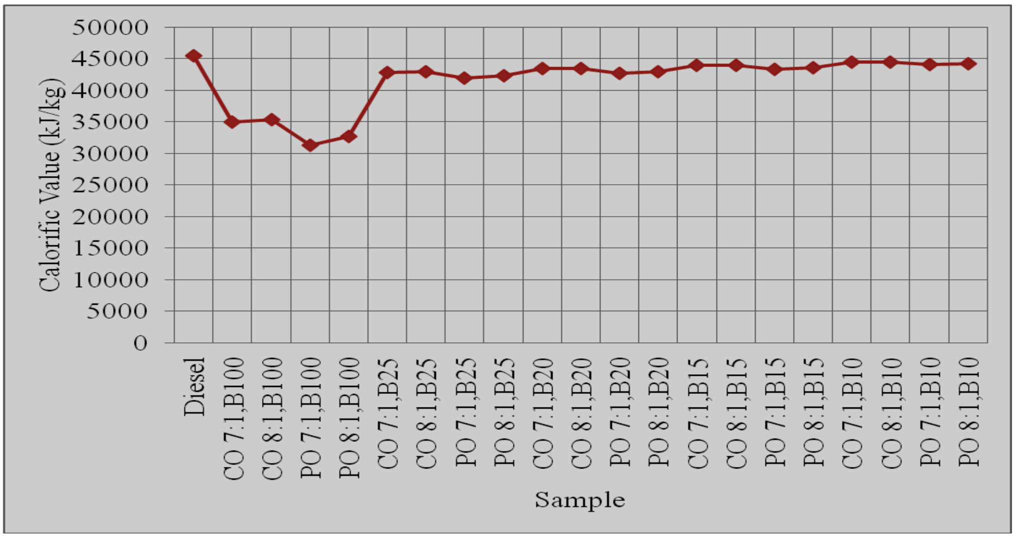

Fig 2. *Comparison of calorific values of various blends with diesel*

3.1 Calorific Value

The fig 2. shows the variation of calorific value of diesel and the various blends of biodiesel. It is clearly seen that the calorific value of diesel is higher than any other blends of biodiesel which may be due to the presence of high carbon concentration in diesel. The calorific value of biodiesel made from waste cooking coconut oil is higher than that of palm oil in all blends.

3.2 Viscosity

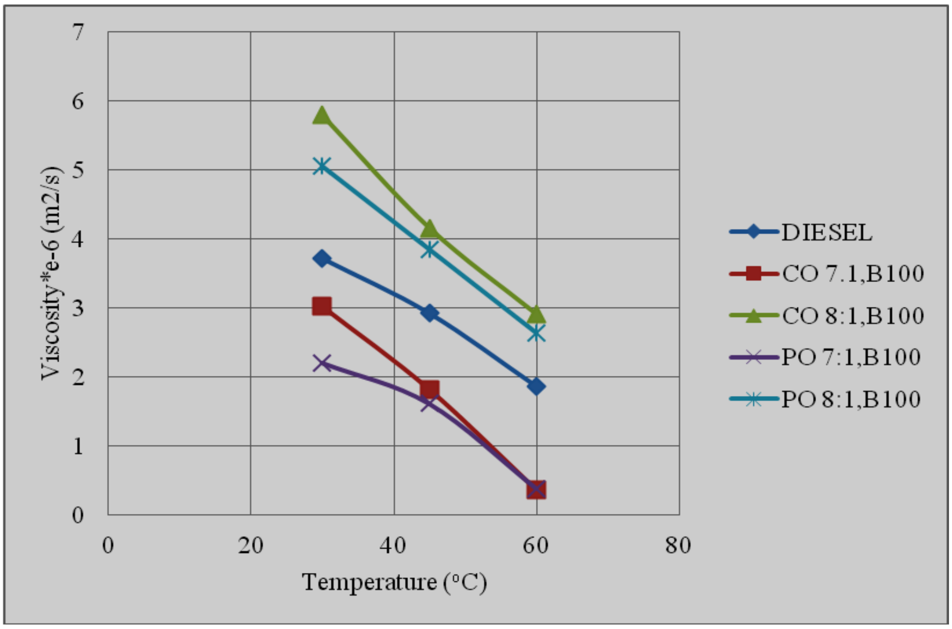

Fig3. *Comparison of viscosities of various blends with diesel*

The fig 3. shows the viscosity of diesel and the various blends of biodiesel. It is clearly seen that the viscosity decreases with the increase in temperature. Biodiesels with molar ratio 8:1 has higher viscosity than biodiesel with molar ratio 7:1. The viscosity of biodiesel made from waste cooking coconut oil is higher than that of palm oil which may be due to the methanol content in biodiesel.

3.3 Density

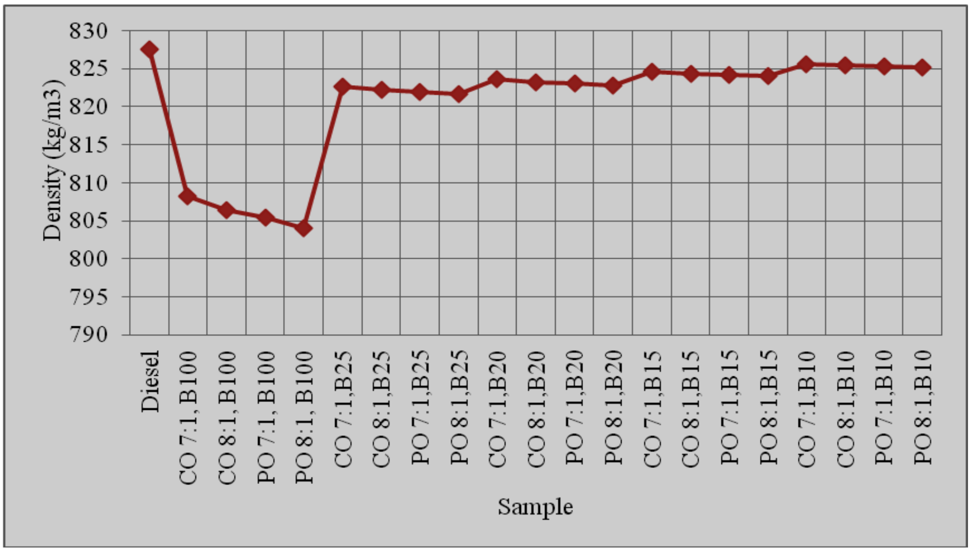

Fig4. *Comparison of Densities of various blends with diesel*

In the fig 4. shows the densities of diesel and the various blends of biodiesel. It is clearly seen that the density of diesel is higher than any other blends of biodiesel. The density of biodiesel made from waste cooking coconut oil is higher than that of palm oil in all blends.

3.4 Flash Point

The fig 5. shows the flash point of diesel and the various blends of biodiesel. It is clearly seen that the flash point of diesel is much higher than any other blends of biodiesel which may be due to the flash point of biodiesel made from waste cooking coconut oil is higher than that of palm oil in all blends.

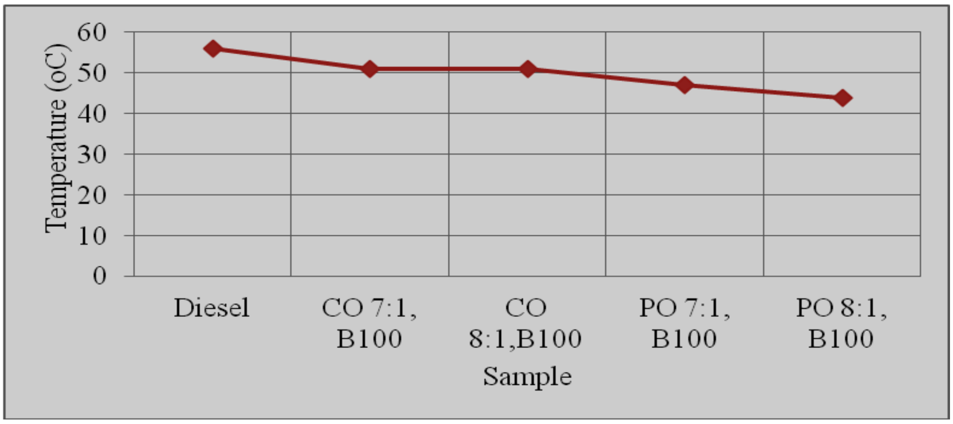

Fig5. *Comparison of Flash points of various blends with diesel*

3.5 Fire Point

In the fig 6. shows the fire point of diesel and the various blends of biodiesel. It is clearly seen that the flash point of diesel is much higher than any other blends of biodiesel. The fire point of biodiesel made from waste cooking coconut oil is higher than that of palm oil in all blends.

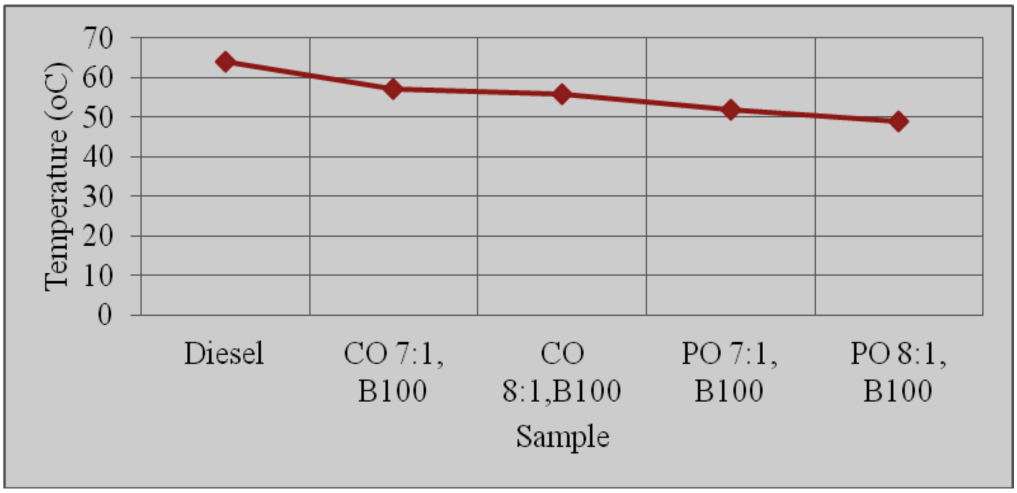

Fig6. *Comparison of Fire points of various blends with diesel*

3.6 Cloud Point

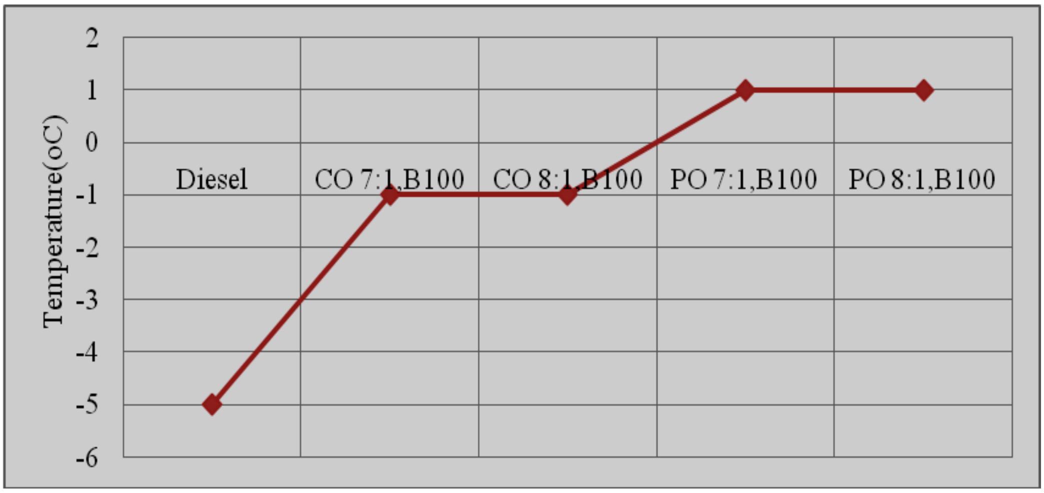

Fig 7. *Comparison of Cloud points of various blends with diesel*

In the fig 7. shows the cloud point of diesel and the various blends of biodiesel. It is clearly seen that the cloud point of diesel is much lower than any other blends of biodiesel. The pour point of biodiesel made from waste cooking coconut oil is lower than that of palm oil in all blends.

3.7 Pour Point

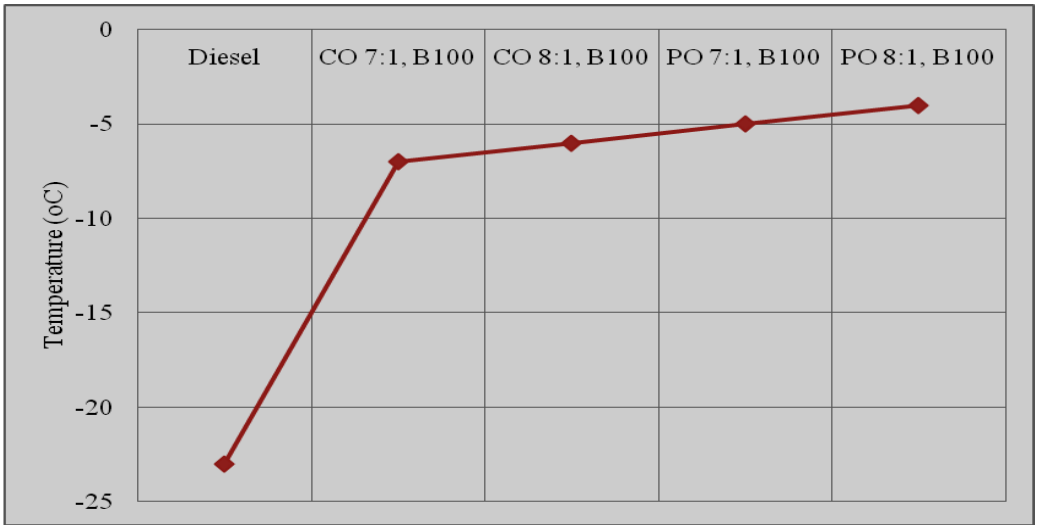

Fig 8. *Comparison of Pour points of various blends with diesel*

The fig 8. shows the pour point of diesel and the various blends of biodiesel. It is clearly seen that the pour point of diesel (-23^{o}C) is much lower than any other blends of biodiesel. The pour point of biodiesel made from waste cooking coconut oil is lower than that of palm oil in all blends.

4. Conclusion

Bio diesel is a replacement fuel for conventional diesel with the advantages of reducing exhaust emissions of carbon monoxide and hydrocarbons. For this work, waste cooking coconut oil and palm oil were used to produce bio diesel in 7:1& 8:1 molar ratios in the presence of Potassium Hydroxide (KOH) catalyst and it is seen that the waste cooking coconut oil and palm oil can have a transesterification reaction and the biodiesel obtained from these oils can be used as a fuel in diesel engines. From the comparative study conducted it is seen that diesel is having higher calorific value and flash and fire points compared to any other blends. Biodiesels with molar ratio 8:1 has higher viscosity than diesel and biodiesel with molar ratio 7:1. It is also seen that diesel is superior in density than any other blends. The properties of biodiesel is almost similar range with compared the ordinary diesel.

Acknowledgement

The authors wish to acknowledge Department of Mechanical Engineering, LBS College of Engineering, Kasaragod, India, for support and technical help throughout this work.

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