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Physico-chemical properties of diesel-biodiesel-ethanol blends

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Abstract— A number of studies currently focus on the renewable fuels to reduce the reliance on petroleum fuels. Bio fuels such as ethanol and biodiesel have been studied and tested in many countries including India. One of the methods to reduce the use of fossil fuel is blending ethanol with fossil diesel. However an emulsifier or a co-solvent is needed to homogenize the diesel-ethanol blends. The rice bran oil biodiesel offers an alternative application as an emulsifier for diesel and ethanol blends. The present work is aimed to investigate experimentally the physic-chemical properties of the ternary blend (diesel-biodiesel-ethanol) and compared with that of diesel fuel. We studied the fuel properties such as density, viscosity, heat of combustion, cetane number, flash point, pour point, cloud point, water and sediment, sulphur, ash, oxygen content of ternary blend. It was found that the fuel properties were close to the standard values of diesel fuel: however, the flash point of the blends was quite different from that of conventional diesel fuel it is due to low flash point of the ethanol. The high cetane value of biodiesel could compensate for the decrease of the cetane number of the blends caused by the presence of ethanol. The heating value of the blends were lower than the diesel fuel, this is due to lower heating value of ethanol. The ternary blend was analysed by gas chromatography (GC).

Index Terms— Biodiesel, emulsifier, ternary fuel blend, physical, chemical properties, gas chromatography.

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1 Introduction

For the past few decades, a lot of effort has been made to reduce the dependency on petroleum fuels for power generation and transportation all over the world. Among the proposed alternative fuels, biodiesel and alcohols have received much attention in recent years for diesel engines and could be one remedy in many countries to reduce their oil imports. Biodiesel and alcohol have many advantages over regular diesel as renewable and domestically produced energy resources. Moreover, they are recognised as environmentally friendly alternative fuels. Biodiesel is an alkyl ester of fatty acids made from a wide range of vegetable oils, animal fat and used cooking oil by the transesterification process. Moreover, biodiesel has been used not only as an alternative for fossil diesel, but also as an additive for diesohol- a blending of ethanol with regular diesel.

Diesohol is considered to be a candidate alternative to diesel in order to decrease the use of conventional diesel. Ethanol is used as an alternative fuel, a fuel extender, an oxygenate and an octane enhancer. Moreover, the use of ethanol can also increase farmer's income, because it can be produced domestically from many kinds of agricultural products such as sugar cane, molasses or cassava root. Generally, ethanol can be blended with diesel and can be used as a fuel with no engine modifications [1]. However, a major drawback in diesel-ethanol blends is that ethanol is immiscible in diesel over a wide range of temperatures and water content. These can result in fuel instability due to phase separation.

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Prevention of this separation can be accomplished in two ways; by adding an emulsifier, which acts to suspend small droplets of ethanol within the diesel fuel, or by adding a co-solvent, which acts as a bridging agent through molecular compatibility and bonding to produce a homogeneous blend [2]. In this work rice bran oil biodiesel was used as an emulsifier for diesel and ethanol blends.
There is a little research on the use of rice bran oil biodiesel (RBBD) in diesel-ethanol blends for diesel engines. Rice is the main cultivation in subtropical southern Asia and is a staple food for a large part of the world's human population. Rice bran oil (RBO) is extracted from the germ and inner husk of the rice. Rice bran is mostly oily inner husk of the rice grain which is heated to produce RBO [3]. RBO is not a common source of edible oil compared to other traditional cereals. One of the best ways for the potential utilization of RBO is the production of biodiesel. Rice bran biodiesel can be directly used in diesel engines, or mixed with any proportions of diesel fuel in diesel engines. The performance and emission characteristics of the biodiesel blended up to 20% were close to that of diesel fuel [4, 5]. In this present investigation the physic-chemical properties were studied by using 20% of rice bran oil biodiesel in the diesel- ethanol blends and compared with that of the diesel fuel.

2. MATERIALS AND METHOD:

The fuel stability and properties, of the diesel- biodiesel-ethanol blend were studied by using diesel, ethanol (99.9%) from local market and biodiesel (rice bran methyl ester) from department of biochemistry, Gulbarga University Gulbarga. The blends were obtained by mixing diesel, biodiesel, and

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ethanol by volume in the proportions of 70%, 20%, and 10% respectively. This proportion was chosen by taking in to consideration of the recommendations from the literature. Many researchers have recommended that for the effective ternary (diesel-biodiesel-ethanol) blend the ratio of biodiesel to ethanol should be greater than 1:1, and the ethanol proportion was 5-10%. Thus in this work the ratio of biodiesel to ethanol was 2:1, and ethanol proportion was 10%
The blends were prepared in two steps:
1. First biodiesel was blended with the ethanol.
2. Lastly diesel was added to the blend.

All the three components were mixed in to a homogeneous mixture by a magnetic stirrer, and then the final blend was kept in a glass bottle with screw cap for observing the physical appearance. Laboratory tests were then carried out using ASTM test standards to determine the following properties: density, viscosity, gross heating value, flash point, pour point, cloud point, cetane number, water and sediment, carbon residue, ash and sulphur content. The ternary blend was analysed by GC. Table.1 shows the gas chromatography of diesel-ethanol-ricebran biodiesel.

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3. Results and Discussions

3.1 Density

Density of ethanol is inferior to diesel fuel; whereas the density of rice bran biodiesel is higher than the diesel. Fig.3.1 shows, the densities of diesel fuel, diesohol, and ternary blend. The density of ternary blend is higher than the diesohol and nearer to the diesel fuel.

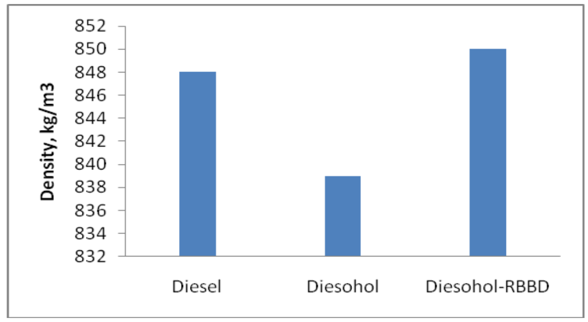

Fig.3.1. Density of the samples

3.2 Kinematic viscosity:

Viscosity is another important property of fuel. If very low viscous fuel is used, it could cause the fuel system leakage. It typically results in smaller mean droplet diameters, thereby increasing the surface area of the fuel droplets and significantly influences the evaporation characteristic time. On the other hand high viscosity of the fuel can cause the following:

- Poor fuel atomization and incomplete combustion.
- Increasing the engine deposits.
- Requiring the more energy to pump the fuel.
- Causing the more problems in cold weather.

When ethanol is blended with diesel fuel, which has got a viscosity nearer to the minimum (approximately 1.10 mm^2/s at 40^oC), yields an overall viscosity of the blend lower than the ASTM minimum. This decreased viscosity of the diesohol blends significantly affects the fuel injection system. Again when the biodiesel is added to this blend, its high viscosity compensates the low viscosity of the diesohol blend. Fig.3.2, shows the variation of kinematic viscosities of sample blends.

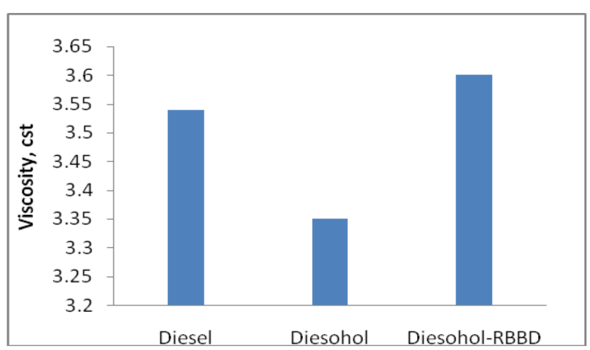

Fig. 3.2. kinematic viscosity of samples.

3.3. Gross heat of combustion:

The calorific value of biodiesel and ethanol is less than the diesel fuel. Thus their addition to the diesel fuel lowers the

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calorific value of the final blend lower than the diesel fuel. However, the blends containing ethanol 10% are seemed to have a heating value nearer to diesel fuel. The heating value of the ternary blend is slightly higher than the diesohol. This is because of higher heating value of biodiesel.

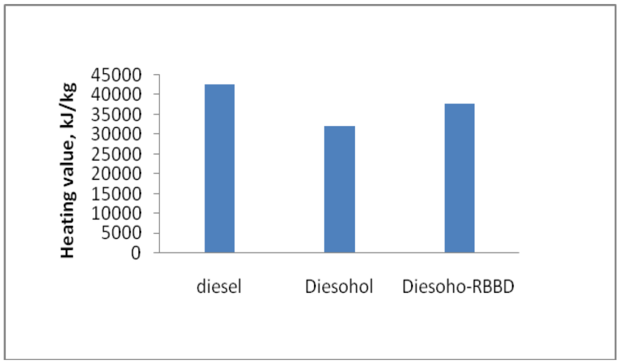

Fig.3.3. Gross calorific value of samples fuels.

3.4. *Flash point:*

According to ASTM the flash point of the biodiesel should be greater than 120°C, for diesel fuel, it should be higher than the 55°C and in case of ethanol it should be below 16°C. Due to the low flash point of ethanol, the flash point of the ternary blends also becomes very low. Even though the biodiesel have higher flash point it will not have any influence on the flash point of the ternary blend.

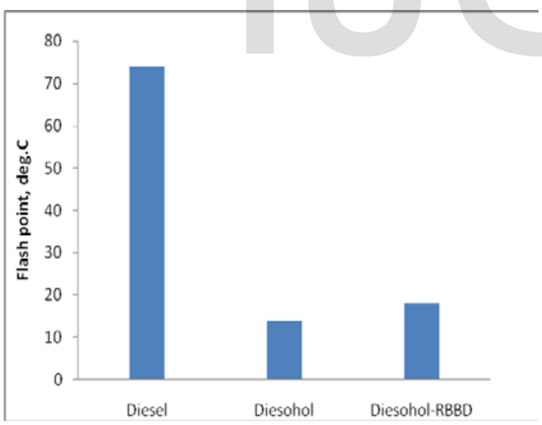

Fig.3.4. Flash point of sample fuels.

3.5. Cetane number:

As specified by the ASTM the minimum cetane number of the diesel fuel should be 40. The ethanol has low cetane number of 5-8. The biodiesel have higher cetane number of 45-55. Addition of biodiesel in the blend increases the blend cetane number as the biodiesel fuel has a greater cetane number compared to both diesel fuel and ethanol. Fig.3.5 shows the cetane number of diesel, diesohol, and ternary blends.

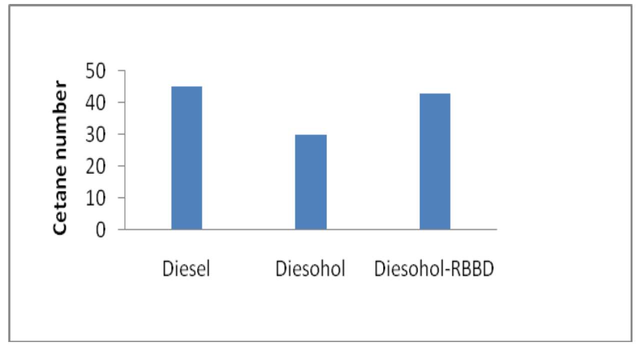

Fig.3.5. Cetane number of sample fuels.

3.6. *Pour point:*

Biodiesel generally has a pour point higher than conventional diesel while the ethanol has a very low pour point. Due to the extremely low pour point of ethanol, its addition to the diesel fuel decreases the pour point of the final blend significantly. This is the major advantage of using ethanol in the ternary blends. Although biodiesel has high pour point (Max 12 °C) than the diesel and ethanol, it does not affect the pour point of final blend. Fig.3.6, shows the pour point of diesel, diesohol, and ternary blend.

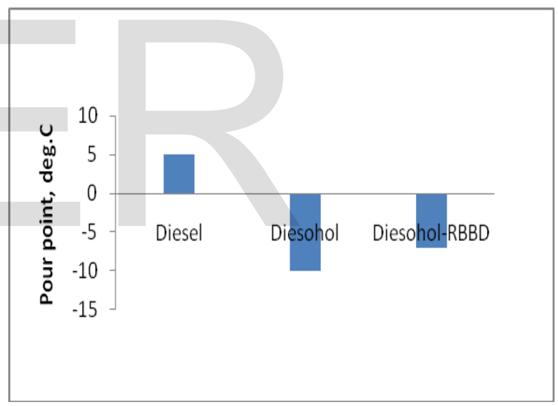

Fig.3.6. Pour point of sample fuels.

3.7. Cloud point:

Cold flow properties of ethanol are excellent, and in principle cold flow properties should be improve when blending ethanol in to diesel. Fig.3.7 shows the cloud point of the sample fuels.

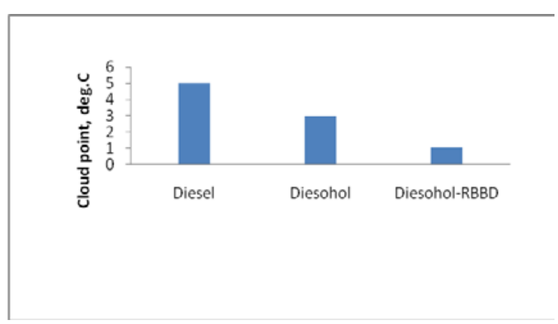

Fig.3.7. Cloud point of sample fuels.

Table. 1. Fatty acid composition, Methyl ester of Rice bran oil biodiesel: GC-57

Sl.No	Parameters	Chemical formula	Results
1	Caproic Acid	--	Nil
2	Caprillic Acid	--	3.20%
3	Capric Acid	--	3.48
4	Lauric Acid	--	3.18
5	Myristic Acid	C14H28O2	0.85
6	Palmitic Acid	C16H32O2	14.85
7	Stearic Acid	C18H36O2	1.84
8	Oleic Acid	C18H34O2	29.41
9	Linoleic Acid	C18H32O2	20.74
10	Linolenic Acid	C18H30O2	Nil
11	Archidonic Acid	C20H40O2	Nil
12	Behenic Acid		Nil
13	Erucic Acid	C22H42O2	Nil
14	Lignoceric Acid	C24H48O2	Nil

5 Conclusion:

1. The density of the diseohol blend was lower than diesel fuel, but addition of rice bran biodiesel to the diesohol increases the density and which is nearer to the diesel fuel.
2. Kinematic viscosity of the ternary blend is nearer to the diesel fuel.
3. The addition of rice bran biodiesel to the dieseohol increases the gross calorific value of the blend by 16% to 18%.
4. The blending of ethanol to diesel fuel reduced the flash point of diesel fuel (74°C) to 13°C. The addition of biodiesel slightly increases the flash point by 5°C.
5. Blending of ethanol to diesel fuel reduces the cetane number, but it can be regained by adding rice bran biodiesel. The cetane number of the diesohol was found to be 30, where as the cetane number of the ternary blend (43) was nearer to diesel fuel (45).
6. The pour point and cloud points of the ternary blend were better values than the diesohol.
7. Water content, carbon residue, and sulphur, was measured and they are 0.2% w/w, 0.07% w/w, and 0.002% w/w respectively.
8. There is no sediments and ash found in the ternary blend.

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