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EFFECT OF BIODIESEL ON FEW COMPONENTS OF FUEL INJECTION SYSTEM

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Abstract: *Biodiesel is a renewable alternative fuel to the fossil diesel and is getting more popularity because of depletion of fossil fuels and their lower environmental pollution. When biodiesel is used as a substitute for the diesel in the internal combustion engines, it significantly increases the energy security and rural economy of the country and also helps to reduce the environmental pollution. However, there are concerns over the compatibility of biodiesel on the engine components due to its corrosive characteristics which can corrode the metallic components and degrade elastomer parts. Hence, the study of corrosion characteristics of biodiesel is important for long term durability of engine components. This paper discuss the production of biodiesel from Jatropha oil and the effects of Jatropha biodiesel on the fuel filter, gasket and fuel tubing of the fuel systems used in the diesel engine.*
Keywords: *Alternative fuel, biodiesel, corrosive characteristics, engine components*

INTRODUCTION

The economic growth of any country depends on the availability of the energy sources such as coal, petroleum and natural gas. The world is presently facing two major problems namely fossil fuel depletion and environmental degradation. Hence, it is necessary to find suitable renewable alternative fuel for better energy security and environmental protection. Among the available renewable alternative fuels, biodiesel is considered as a better substitute for the fossil diesel [1,2]. In recent years, India is a significant consumer of fossil fuels due to high economic growth rates and over 15% of the world's population. India does not have enough fossil fuels sources and hence imports crude petroleum oil from other countries to meet the local demand. However, Indian government encourages the use of biofuels produced from feedstocks available within the country as the substitute for the fossil fuels. In India's bio-fuel policy, ethanol and biodiesel derived from vegetable oils is being considered as substitute for the petroleum fuels because these bio-fuels can provide employment generation to rural people through plantation of vegetable oils and can be beneficial to sugarcane farmers through the ethanol program [3].

Jatropha curcas is a multipurpose, drought resistant, perennial plant belongs to Euphorbiaceae family. It grows in tropical and sub-tropical regions of the world and can be grown in low to high rainfall areas either in the farms as a commercial crop or on the boundaries as a hedge to protect fields from grazing animals and to prevent erosion. It has large green to pale-green leaves and can attain a height of upto eight or ten meters under favourable conditions. It starts yielding from the second year onwards and continues for 40 years [4,5].

Figure 1. a) Jatropha b) Jatropha Seeds

Figure 1 shows the Jatropha and its seeds. In a combustion study of Jatropha oil, it is reported that the fatty acid burned in the first step and glycerol does in the second step [6]. The by-product of the oil extraction is seed cake which contains 24 to 28% protein on dry basis. It is reported that the seed cake protein showed most promising results on adhesive and emulsifying properties, which increase the value of the Jatropha.

Pere et al [7] studied the agronomic and economic viability and livelihood impacts of Jatropha curcas plantations on private farms in Tamil Nadu, India and they found that the crop impoverishes farmers, particularly the poorer and socially backward farmers. Simon et al [8] conducted a full life cycle assessment on Jatropha-based rural electrification and then compared with other electrification approaches such as photovoltaic, grid connection and a diesel-fuelled power generator. They reported that the Jatropha-based electrification reduces greenhouse gas emissions over the full life cycle by a factor of 7 compared to a diesel generator or grid connection.

Siddharth et al [9] reported that the Jatropha has potential for the production of biodiesel. Hence, in this work, biodiesel was produced from the Jatropha oil and studies were carried-out to study its effect on the engine components. If the acid value of the vegetable oil is high, then a two-step transesterfication is one of the ways of producing biodiesel from it [10,11]. The biodiesel produced from vegetable oil should satisfy the ASTM / EN Standards. It is reported in the literature that the engine performance with the biodiesel is similar to the diesel [12,13]. The properties of the biodiesel produced from different vegetable oils are shown in the Table 1.

Table 1. Properties of the biodiesel produced from different oils

Property	Honge Biodiesel [11]	Sunflower Biodiesel [12]	Cotton seed oil Biodiesel [13]
Kinematic viscosity (mm^2/s) (40 °C)	4.33	4.439	6.0
Acid Value (mg KOH/g-oil)	0.23	--	--
Density (kg/m^3)	--	--	850
Flash point (°C)	174	183	--
Cold filter plugging point (°C)	--	-3	--
Cloud point (°C)	--	3.4	-2

From the literature review, it is observed that the no work has been carried out to study the effect of biodiesel on engine fuel system components such as fuel filter, fuel gasket and fuel lining tube and hence, this work was carriedout.

OBJECTIVES

The objective of this research work was to produce biodiesel from Jatropha oil and to study the effect of Jatropha biodiesel on the fuel injection components such as fuel filter, fuel gasket and fuel lining tube. Also, the variation in the important properties of the biodiesel during the storage period was studied. In addition, a review work was carried-out and to provide details of effect of biodiesel on the engine components.

MATERIALS AND METHODS

The Jatropha oil was collected from university of agricultural sciences, Bangalore, India. This oil was filtered and refined and used for the production of biodiesel. The acid value of the Jatropha oil was 1.3 mg of KOH/ g of oil, and hence a single step transesterification reaction was followed to produce the biodiesel. Alkaline catalyst, potassium hydroxide was used as catalyst. Compared to other alcohols, methanol is cheaper and has better physical and chemical advantages (polar and shortest chain alcohol) and was used as the reactant. The potassium hydroxide and methanol were purchased from Merck Company, India. All the chemicals used for the transesterification were of analytical reagent grade.

BIODIESEL PRODUCTION

In this work, biodiesel was prepared from the non-edible jatropha oil using 25 lt capacity biodiesel plant. The Jatropha oil was filtered and refined. The sodium hydroxide pellets (1% wt of the oil) were added to the vessel containing methanol (25% wt of the oil) and mixed thoroughly until a homogenous mixture was produced. After that this homogenous mixture was added to the reactor vessel containing the Jatropha oil. An electrical heater and a mechanical stirrer provided in the reactor vessel was switched-on and the reaction temperature was maintained between 55 to 60°C, below the boiling point of the methanol and the stirrer speed was maintained at 200 rpm. The reaction was carriedout for two hour and the sample was taken to check for the phase separation.

After the confirmation of phase separation, the products of transesterification were heated above 70°C, to remove the excess methanol and then products were transferred to the settling tank. Then the products were allowed to settle for 8 hour and two layers were observed. The top layer containing biodiesel was removed and the washed with warm distilled water to remove the soap, catalyst etc. Figure 2 shows the biodiesel plant. The biodiesel properties were determined as per ASTM standards

Figure 2. Biodiesel plant

STATIC IMMERSION STUDY

A few automobile manufacturers extended their warranty only to lower blends of biodiesel (e.g. B5). But the higher blends (e.g. B50 or B100) are still not covered by warranty. In India's biofuels policy, Jatropha biodiesel is considered as an alternative substitute for the diesel. But many researches on Jatropha biodiesel have concerned the engine gas emissions and engine performances and not any significant work has been carriedout to study the effect of Jatropha biodiesel on the engine fuel injection components such as fuel filter, gasket and fuel tubing. Hence, this work has been carried out to study the effect of Jatropha biodiesel on the engine components by static immersion study and also to study the variation in the fuel property during long storage period. In static immersion study, the engine fuel filter, gasket and fuel rubber tubing were immersed in the fuel samples kept in the 500 ml beakers. The beaker top end was closed with the aluminum foil and the arrangements were shown in the Figure 3. The static immersion study was carriedout for the 12 month.

Figure 3. Fuel injection components in the biodiesel

RESULTS AND DISCUSSION

The biodiesel yield obtained by the biodiesel plant was 89.2%. The properties of the biodiesel were determined as per the ASTM standards. Table 2 shows the properties of the biodiesel and diesel.

Table 2. Properties of the Jatropha biodiesel and diesel

Property	Jatropha Biodiesel	Diesel
Kinematic viscosity (mm^2/s) (40 °C)	4.1	2.8
Acid Value (mg KOH/g-oil)	0.39	0.08
Density (kg/m^3)	0.88	0.84
Flash point (°C)	164	61
Calorific value (MJ/kg)	36.8	42.8
Ash Content (%)	0.01	0.01
Copper Corrosion, 3hr/50°C	1	1
Pour point (°C)	6	-19

From the Table 2, it is observed that the acid value, kinematic viscosity, flash point, pour point and density of the biodiesel are higher than the diesel. But the calorific value is lower than the diesel due to presence oxygen in its molecular structure. The ash content and copper corrosion values are remains same for both biodiesel and diesel. If any variation in the property of the fuel, then it may significantly affects the engine components.

The static immersion studies were carriedout for one year and after that the variation in the properties of the biodiesel were determined and is shown in Table 3. From the table, it is observed that the properties of the biodiesel vary significantly during the storage period.

Table 3 Properties of the biodiesel after one year storage study

Property	Jatropha biodiesel	Stored Jatropha Biodiesel
Viscosity (mm^2/s at 40°C)	4.1	5.3
Acid Value (mg KOH/g)	0.39	0.68
Iodine Value ($g\ I_2/100\ g$)	124	116

From the table, it is observed that the important properties of the biodiesel such as viscosity, acid value and iodine value varies significantly during the storage period. The increase in acid value of the biodiesel increase corrosive nature of the biodiesel. The increase in the viscosity value of the biodiesel significantly affects the fuel atomization, spray formation and combustion.

EFFECT OF BIODIESEL ON ENGINE COMPONENTS

The engine fuel injection components such as fuel filter, gasket and fuel lining tube were taken out from the beakers containing biodiesel (B100), B5 and diesel. These components were observed for the corrosion and sediment deposition. The size of the fuel filter was enlarged during the storage period as compared to the B5 and diesel. Figure 4 compares the fuel filter which was kept in the B5 and B100 samples. A thin layer of deposition was observed at the metal holder of the fuel filter which was kept in the Jatropha Biodiesel (B100) sample. The deposition in the fuel filter holder was removed and is shown in the Figure 5. Figure 6 shows the microscopic image of this deposition. This is due to the autooxidation, hygroscopic nature, polarity, higher unsaturated components and solvency properties of the Jatropha biodiesel. It also causes degradation elastomers. The metal holder exposed to B5 and diesel does not have any deposition. Hence, B5 use will not affect the fuel components which are used in the diesel engine components. If Jatropha Biodiesel (B100) is used as fuel in the diesel engine, then it will affect the fuel injection components which may leads to clogging of the injection pumps and filters, poor engine performance and early replacement of few fuel injection components.

Figure 4. Fuel filters which were kept in the B100 and B5

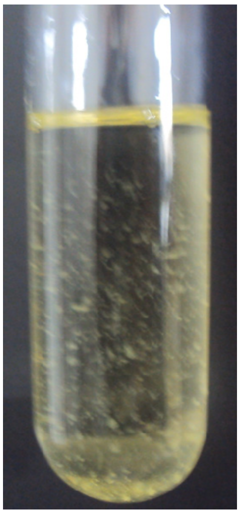

Figure 5. Deposition on the holder of the fuel filter

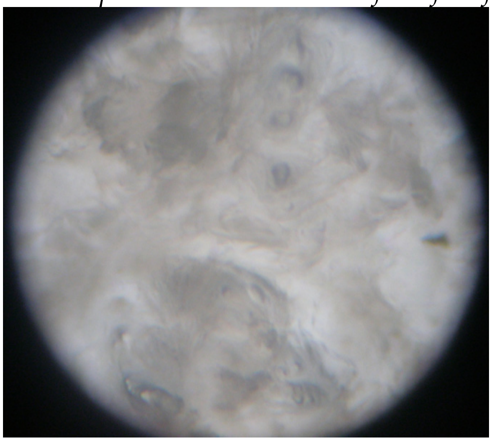

Figure 6. Microscopic View of the Deposition

REVIEW OF LITERATURE ABOUT BIODIESEL OXIDATION

The fuel properties of the brassica carinata biodiesel such as acid value, peroxide value and viscosity increases with the increase in storage period. However, the iodine value decreases with the increase in storage time [14]. María et al [15] reported that the fuel properties can be strongly affected if the biodiesel has been improperly stored or transported. The biodiesel quality is harmed by the oxidation products, which are corrosive to engine chambers. The oxidized biodiesel significantly affect the exhaust emissions such as CO and HC and there is no significant difference in smoke and NOx emissions of the oxidized and unoxidized biodiesel [16].

Amit et al [17] observed that small concentrations of metal contaminants showed nearly same influence on oxidation stability as large amounts. They reported that the copper has strongest detrimental and catalytic effect on biodiesel oxidation.

Agarwal et al. [18] studied the effect of 20 percent linseed oil methyl ester blend and diesel oil on the engine wear. They reported that the physical wear of various vital parts, injector coking, carbon deposits on piston and ring sticking were found to be substantially lower in case of B20 blend as compared to the diesel. From the atomic absorption spectroscopy tests they confirmed substantially lower engine wear and concluded that the B20 blend improves the life of biodiesel operated engines. Few researchers reported that the biodiesel significantly affect the components of an engine [19,20] as metallic materials of an automobile fuel system, like ferrous alloy and non-ferrous alloys and elastomers come in contact with fuel.

Fazal et al. [21] compared the corrosion behavior of aluminum, copper and stainless steel in both petroleum diesel and palm biodiesel by immersion tests in biodiesel (B100) and diesel (B0) at 80 °C for 1200 h. Their results show that the extent of corrosion and change in fuel properties upon exposure to metals are more in biodiesel than that in diesel. Copper and aluminum were susceptible to attack by biodiesel whereas stainless steel was not. Fazal et al [22] study aims to investigate the corrosion behavior of mild steel at three different temperatures such as room temperature, 50 and 80 °C. They carriedout static immersion tests in B0 (diesel), B50 (50% biodiesel in diesel), B100 (biodiesel) were carried out for 1200 h. Their results showed that the corrosion of mild steel increases with increase of temperature. They also observed that the water content and oxidation products are increased when exposure of biodiesel to mild steel at high temperature.

Fazal et al [23] reported that biodiesel from different origins is always seen to provide better lubricity than that of diesel fuel. However, in long term test it loses its lubricity due to its corrosive and oxidative nature.

Savita [24] studied the synthesis and characterization of biodiesel from non-edible oils like pongamia glabra, madhuca indica and salvadora oleoides and carriedout long duration static immersion test method corrosion studies on engine parts like piston metal and piston liner with neat diesel and biodiesel synthesized from these non-edible oils. From their study, they observed that the salvadora biodiesel showed significant corrosion on both metal parts of diesel engine whereas biodiesel from other oils showed little or/no corrosion as compared to neat diesel.

CONCLUSION

From this work, it is concluded that the properties of the Jatropha biodiesel vary significantly during the long storage period. Also the Jatropha biodiesel significantly affects the filter and filter holder material as compared to the B5 and diesel. Hence, it is recommended to use B5 blend as compared to the B100, as it may damage the fuel injection system. From literature review, it is observed that the corrosive chemical characteristics of the biodiesel may cause corrosive and tribological attack on metallic components and degrade elastomer parts of the internal combustion engine components. Hence, it is recommended to use B5 blend instead of using higher blends and B100.

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