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Jatropha Curcus Oil: A Potential Source for Blended Fuel

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ABSTRACT

Due to the scarcity of non-renewable sources of energy, synthesis and utilisation of blended fuel are one of the significant options in the energy sector throughout the world. Jatropha curcas oil (JCO) is used in the present research investigation for the synthesis of biodiesel and blended fuel was prepared by mixing it with diesel fuel in different proportions. Transesterification process was adopted for biodiesel preparation with methanol in the presence of enzyme Novozyme 435 (Candida antarctica) at 6:1 molar ratio of methanol to JCO maintaining a temperature of 600C and stirring speed of 550 rpm for 8 hrs. 94.17% biodiesel was obtained. Blended fuel was prepared by mixing it with diesel fuel as B20, B40, B60 and B80 composition. The characterization of blended fuel was done w.r.t. density, kinematic viscosity, flash point and cetane number and found expected outcomes. In conclusion, blended fuel from JCO can be used safely as renewable source of energy to mitigate the scarcity of non-renewable fuel in the future world.

KEYWORDS: *Blended fuel, Jatropha curcas oil, Candida antarctica, Biodiesel*

1. INTRODUCTION

JCO is one of the significant non-edible oils used for the preparation of alternative sources of energy, biodiesel. The scarcity of fossil fuels along with continuous environmental degradation for the last few decades demands an alternative source of energy like biodiesel. Blended fuel prepared from the mixing of biodiesel with diesel fuel in different proportions is a new concept as semi-conventional fuel in this scenario. JCO plays a significant role in this area. Different researchers [1-8] prepared biodiesel from JCO with the help of different process technology like chemical and biochemical methods. Present researchers also prepared biodiesel from JCO with recycling of enzyme [9]. They also made a comparative study with chemical vs biochemical methods for biodiesel preparation from JCO [10]. Present author also analysed mass transfer kinetics for biodiesel production through mathematical modeling [11]. Packed bed reactor are also used for the enzymatic preparation of biodiesel by the author [12].

Blended fuel is a new technique used instead of fossil fuel. It creates significant attention among semi-conventional energy sources. It is more environmentally friendly than pure fossil fuel. Present author prepared blended fuel from mahua oil [13], waste cooking oil [14], Palm oil fatty acid distillate [15] and sal oil [16]. Liaquat et al [17] successfully applied blended fuel in diesel engine. Ali and Jaafar [18] analysed the physical properties of waste cooking oil -diesel blends. Ali et al [19] also optimized the fuel properties of biodiesel-diesel blends and analysed the engine performance through response surface methods. Preparation and analysis of blended fuel is also done by other researchers [20-23].

But very few studies have been made by utilising JCO for this purpose. There is enormous prospect for utilising JCO for this purpose in India. Jatropha seed requires less care for it's grow and it can grow in harsh conditions. Fig. 1 shows the jatropha curcas trees and seeds. Dr. Abdul Kalam, the 11th President of India, was one of the strong advocates of Jatropha cultivation for the production of bio-diesel [24] citing the suitability of a large amount of wasteland in India for the cultivation of the plant [25]. The Government of India announced a National Biofuel Policy in 2008 that anticipated that around 20% of the country's domestic diesel demand would be met by biofuels including Jatropha-based fuels. So based on that, the present study is focused on blended fuel from JCO which may be one of the great sources for the preparation of semi-conventional fuel indicating a ray of light for the depletion of conventional fuels with saving environment.

Figure 1: Jatropha Curcas trees and seeds

2. MATERIALS

The JCO used in this study was provided by M/s. Arora Oils Ltd., Burdwan, West Bengal, India. The enzyme used in the following study was Novozyme 435 (Candida antarctica) immobilized lipase which was a kind gift of Novozyme South Asia Pvt. Ltd. Bangalore, India. The chemicals used in this work such as methanol and hexane were purchased from S.D. Fine Chemicals (Mumbai, India). Except otherwise specified, all other chemicals used were A.R. Grade.

3. METHODS

For the preparation of biodiesel, initially, 500 mL of JCO was filtered and taken in an Erlenmeyer flask and heated up to 80°C to drive off moisture by continuous stirring for about 1 h. After that, methanol was added through stepwise manner in an appropriate proportion (6:1::Methanol:JCO) using solvent hexane at a temperature of 600 C for 8 hours in the presence of 8% biocatalyst with a mixing intensity of 550 rpm. After completion of reaction, biodiesel was separated and dried for blending purpose. Characterization of biodiesel was done according to the American Standard Testing Method (ASTM).

For the preparation of blended fuel, JCO biodiesel was added to diesel fuel (v/v) slowly with proper care. The mixture was stirred for 30 min and left to reach equilibrium before analysis. Sal biodiesel was added to diesel fuel in volume percentages of 20% (B20), 40% (B40), 60% (B60) and 80% (B80). The characterization of blended fuel was done w.r.t. density, kinematic viscosity, flash point and cetane point. Values are reported as mean ± s.d., where n = 3 (n = no of observations).

4. RESULTS AND DISCUSSIONS

A. Analysis of JCO

Identification of initial physicochemical properties is important for the successful conversion of JCO to biodiesel enzymatically. Table 1 shows the properties of JCO. It has been observed from Table 1 that crude JCO contains nearly 77% unsaturated fatty acids while the saturated part is somewhat less (nearly 20%). Among the fatty acids, the content of oleic acid is the highest. Its properties were identified to determine its suitability for biodiesel production followed by the preparation of blended fuel.

Table 1: Characteristics of crude JCO

Characteristics	Value
Fatty acid composition (%):	
i) Palmitic acid	13.22±0.026
ii) Stearic acid	6.17±0.029
iii) Oleic acid	40.66±0.075
iv) Linoleic acid	36.07±0.081
Calorific value (MJ / kg)	39.11±0.079

Density at 15⁰C (kg/m3)	918.7±0.101
Flash point (˚C)	232±1.791
Kinematic viscosity at 40⁰C, mm2/s	33.61±0.106
Triglycerides (%)	90.19±0.113
Water content (%)	0.91±0.008
Free fatty acid (as oleic acid) (% w/w)	7.73±0.059

B. Blending of biodiesel with diesel fuel

Initially, JCO has been converted to biodiesel through transesterification reaction in the presence of Novozyme 435 (Candida antarctica) at 6:1 molar ratio of methanol to JCO maintaining a temperature of 60⁰C and stirring speed of 550 rpm for 8 hrs. The conversion was 94.17%. After that biodiesel was mixed with diesel fuel in different proportions (v/v) by moderate stirring. The mixing time was maintained for 30 minutes. Then the blended fuel was kept for nearly 45 minutes for stabilization. The blending composition of biodiesel and diesel fuel is shown in Table 2. In the blended compositions, the percentage of JCO biodiesel has been considered as 20 (B20), 40 (B40), 60 (B60) and 80% (B80) (v/v). The properties like kinematic viscosity, density, cetane point and flash point of the blends were analysed. The testing was repeated three times and was carefully recorded.

Table 2: Blending composition of JCO biodiesel and diesel fuel

Sample	JCO biodiesel	Diesel fuel
Diesel	0	100
B 20	20	80
B 40	40	60
B 60	60	40
B 80	80	20
B 100	0	0

C. Analysis of kinematic viscosity of blends

The efficiency of an engine importantly depends on viscosity of the fuel. It is well known that fuel atomization upon injection into a combustion chamber is controlled by fuel viscosity and cause formation of engine deposits. So proper viscosity contributes maximum efficiency of an engine. The mixing of biodiesel with diesel fuel changes the kinematic viscosity of blended fuel as shown in Fig. 2 at a temperature of 400C. It has been observed from Fig. 2 that enhancing the amount of JCO biodiesel in the diesel fuel increases the viscosity of the blended fuel. Transesterification reaction is needed for the JCO as the viscosity of JCO is high compared to diesel fuel. This reaction helps to lower the viscosity of the original oil and after that blending is done as per requirement.

D. Analysis of density of blends

Fuel efficacy is contributed from its density as the density of a fuel determines the spray characteristics and fuel injection property. The density of blended fuel has been analysed and compared with the diesel fuel as shown in Fig 3. It has been observed from the figure that the density of diesel fuel is less compared to blended fuel. Almost a linear proportional relationship has been observed for the increasing amount of biodiesel in blended fuel. The maximum density for blended fuel is observed for B 80 (882 Kg/m3) and the lowest density is observed for B20 (851 Kg/m³). The lowest density has been observed for diesel fuel as expected.

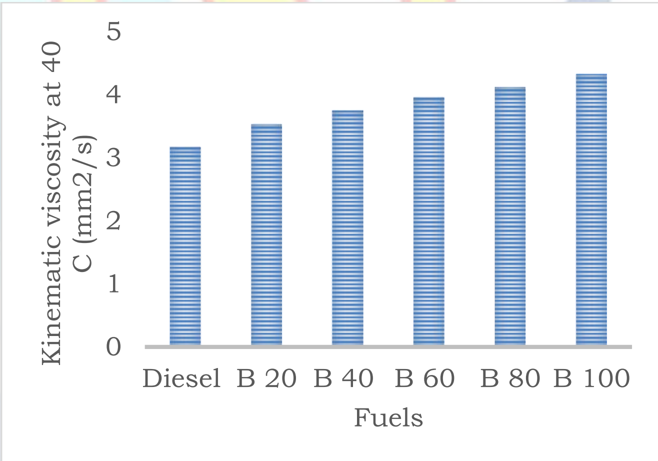

Figure 2: Analysis of kinematic viscosity of blends at 40⁰C (mm2/s)

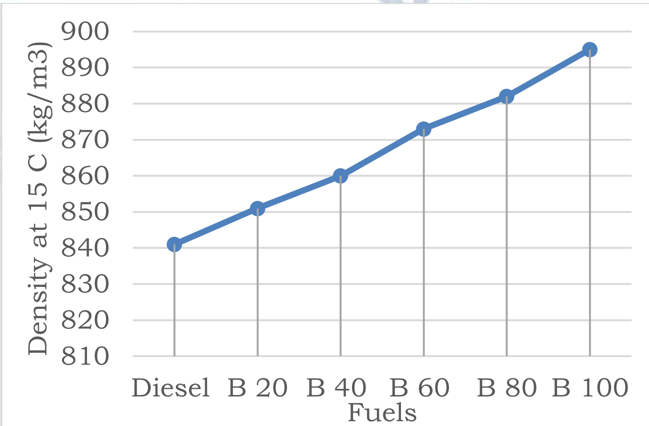

Figure 3: Analysis of density of blends at 15⁰ C (kg/m³)

E. Analysis of Cetane number and flash points of blends

Ignition delay of a fuel is measured by its cetane number. It is determined by the time period between the injection and combustion of the fuel. Higher the cetane number, better the fuel burns within the engine. Safety measures is the most important characteristics of a fuel which is determined by flash point of it. Because flash point is related to volatility and flammability of the fuel. Higher flash point indicates safe fuel. So fuels with higher flash point and higher cetane number are favourable. In our study, cetane number and flash point of the blended fuel along with the diesel fuel have been analysed as shown in Fig. 4. It has been observed from Fig. 4 that pure biodiesel shows much higher flash point than diesel fuel and hence it can be used safely in the diesel engine. Blended fuel also shows much higher flash point which indicates its safe use. Regarding cetane number, blended fuel shows higher in side than diesel fuel indicating its use in efficient manner.

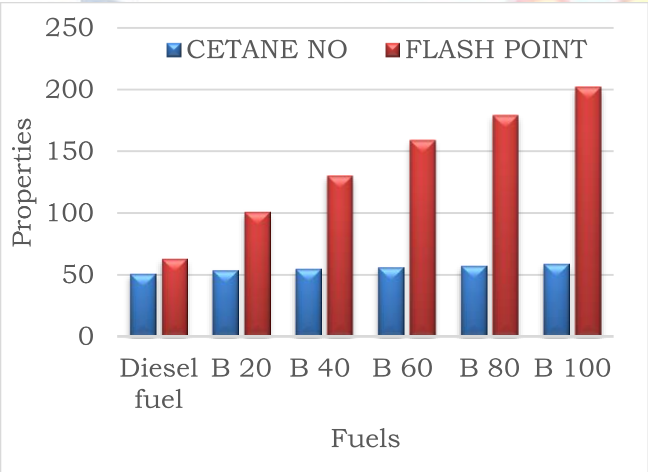

Figure 4: Analysis of cetane number and flash point of blends at 15^0 C (kg/m^3)

5. CHARACTERISTICS OF B30, B50, B70 AND B90 BLENDS

From the extrapolation of the graph, the kinematic viscosity, density, Cetane and flash point of B30, B50, B70 and B90 blends have been identified as shown in Table 3. These values are at per with the real values and helpful for further progress of work.

6. CONCLUSION

Blended fuel from jatropha curcus oil is prepared after converting it to biodiesel through enzymatic process. The characteristics like density, kinematic viscosity, cetane number and flash point of B20, B40, B60 and B80 blends have been analysed and found acceptable results. The same characteristics of other blends like B30, B50, B70 and B90 have been identified through extrapolation of graphs which are helpful for future work. Based on the availability of jatropha curcus oil in India, the present process technology for the preparation of blended fuel is useful for the alternative source of semi-conventional fuel in the near future.

Table 3: Comparative characteristics of extrapolated blends

Properties	B30	B50	B70	B90
Kinematic viscosity at 40^0C (mm^2/s)	3.34±0.029	3.61±0.017	3.84±0.009	4.21±0.011
Density 15^0C (kg/m3)	855±0.237	867±0.197	878±0.201	889±0.155
Cetane no	54.21±0.027	55.57±0.101	56.91±0.106	58.38±0.071
Flash point (^{0}C)	117±0.106	146±0.119	170±0.105	191±0.059

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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