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Production and Characterization of Jatropha Oil Methyl Ester

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ABSTRACT

Biodiesel is emerging as a promising substitute of an alternative fuel and has gained significant attention due to the predicted depletion of conventional fuels availability in near future and environmental pollution concern. Utilization of biodiesel produced from Jatropha oil by transesterification process is one of the most promising options to replace conventional fossil diesel fuel. The physical properties such as density, Kinematic viscosity, flash point, carbon residue, Pour point and Cetane number were found out for diesel, Jatropha oil and Jatropha Oil Methyl Ester (JOME) produced in the laboratory. Properties obtained for the Jatropha oil methyl ester are very closely matched with the values of conventional diesel fuel and can be used without any modification in the existing diesel engine.

Key words*: *Jatropha oil, JOME, Transesterification, Biodiesel, Characterization

1. INTRODUCTION

During recent years, much activity can be observed in the field of alternative fuels due to the depletion of fossil fuels and fluctuations in their price. Methyl ester of oils or biodiesel has become more attractive because of its environmental benefits and is from renewable resources. Singh et al., [1-2] stated in reviewing that production source, characterization of vegetable oils, their methyl ester as a substitute of the petroleum fuel and future possibility of all type of biodiesels based on scientific articles. Biodiesel can be replaced partially with petroleum diesel as it has very similar characteristics and also lower exhaust emissions. Biodiesel has better properties than that of petroleum diesel such as renewable, biodegradable, non-toxic, and essentially free of sulfur and aromatics. Biodiesel fuel has potential to reduce the level of pollutants and probable carcinogens. Ma et al. [3] expressed that biodiesel has become more attractive recently because of its environmental benefits and fact that it is made from renewable resources. The raw materials being exploited commercially for the biodiesel are edible fatty oils derived from rapeseed, soybean, palm, sunflower, coconut, peanut and linseed etc. [4]. Mixing triacetin additive with biodiesel improves the cold flow, combustion efficiency, viscosity and reduces the engine detonation. The study shows that 10% of additive with COME could be a better fuel in terms of combustion pressure changes and heat release rate [5].

In recent years, research has been directed to explore plant based fuels and have bright future. Although all oils can be used as a source for biodiesel production has to be ruled out because some of them are required for cooking and food purposes. Therefore, non-edible oils are the premier raw material for the production of biodiesel. Seeds rich in oils are mostly produced by perennial species. Rapeseed oil methyl ester was the first type of biodiesel fuel produced commercially [6]. Recent developments have made biodiesel economical and interesting in view of the research potential and the possibility of improving environmental performance, along with employment generation and empowerment of rural economy. Senthil Kumar *et al.,* [7] made a comparative study of different methods to improve the engine performance using Jatropha oil as the primary fuel in CI engine. Raw Jatropha oil resulted in slightly reduced thermal efficiency, higher smoke emissions, increased hydrocarbon and carbon monoxide emissions. Dual fuel operation with Jatropha biodiesel engine results in good thermal efficiency and low smoke emissions, particularly at high power outputs [8].

The production and use of biodiesel from vegetable oils and fats may be a feasible solution for supplementing the ever growing demand of diesel. However, while selecting the sources of triglycerides for biodiesel production, special attention must be given to utilize the indigenous non-edible oils in place of edible oils which are used for domestic purposes. In this work Jatropha seeds were collected to produce biodiesel. The objectives of the present work are to produce biodiesel from the Jatropha seed oil by transesterification process and characterization of the biodiesel.

2. ABOUT JATROPHA CURCAS

Among the many species available, Jatropha can be used as a source of energy in the form of biodiesel. It is most suitable non-edible oil seed plant due to its various favorable attributions like hardy nature, short gestation period, adaptability in wide range of agro-climatic conditions, high oil recovery and quality of oil etc. Jatropha plants, plant with fruits, seed with shell and seeds are shown in figures 1-4.

Jatropha is a small tree of about 3.0 m height belonging to family Euphorbiaceae. It has a short trunk with thick branches spreading into a crown of dark green leaves. The bark is pale brown and the leaves are attached to long petioles [9]. Native to humid zones under arid and semi-arid conditions, jatropha thrives under a wide range of soil and climatic conditions. It grows under annual average rainfall of 480 mm to 2400 mm at an average temperature range of 20-28^{o}C, tolerates extreme temperature conditions as well and can withstand slight frost. Jatropha can grow on almost any site, ranging from gravel, sandy to clayey soils and highly eroded soils of low fertility and in alkaline soils. It tolerates drought by shedding the leaves, results in decreased growth. Jatropha comes into flowering during September to December and fruits mature within 2-4 months after flowering. When jatropha seeds are crushed, the resulting oil can be processed to produce a high quality biodiesel that can be used in a standard diesel car, while the residue (press cake) can also be processed and used as biomass feedstock to power electricity plants or used as fertilizer [10].

3. METHYL ESTER PREPARATION

In this study, the transesterification process is selected as shown in Fig. 5 to make biodiesel from Jatropha oil. Raw oil is filtered using surgical cotton to eliminate water, solid particulate matter and heated to 105^{0}C temperature and maintained at this temperature for fifteen minutes to remove all the water content from oil. Since for a successful and complete reaction, the oil must be free of water. In acid treatment methanol of 99 % pure, 120 ml per liter of oil is added to the heated oil and stirred for ten minutes. Methanol is a polar compound and oil is strongly non-polar, hence suspension of oil will form in the process. Two milliliter of 98 % pure sulfuric acid is added for each liter of oil. The mixture is heated and stirred for one hour at 60^{0}C in a closed conical beaker. Heating is stopped and continued to stirring for about one more hour; finally mixture is allowed to settle for four hours in a decanter to remove the glycerin and chemical water separated from methyl ester.

In base treatment for each liter of oil, 200 ml of methanol (20% by volume) and 6.5 grams of 97% pure NaOH (Sodium Hydroxide) is added. The mixture is stirred thoroughly until it forms a clear solution called "***Sodium Methoxide***". This solution is added to the oil and stirred for fifteen minutes continuously to neutralization sulfuric acid. The mixture is heated to 60^{0}C and maintained at the same temperature with stirring at 500 to 600 rpm in a closed container. When the solution turns into brown silky in colour, which shows that the whole reaction is completed. After settlement of the mixture in decanter, bottom part of the glycerin is separated from the biodiesel. Jatropha methyl oil ester (JOME) is bubble washed with distilled water for about half an hour to remove soaps and un-reacted alcohol. Washing is repeated till the JOME separated with clear water. Collected JOME is heated to remove water and formed biodiesel is taken for characterization.

Advantages

1. Biodiesel can be used as substitute or partial replacement to diesel fuel.
2. Special pumps or high pressure equipment for fueling are not required.
3. Biodiesel being an oxygenated fuel contributes to complete combustion hence, improved emissions profile reduce public health risks.
4. Reduces the dependence on imported petroleum diesel fuel.
5. It is safe to handle, store and transport as the flash point is more than 150^{0}C, compared to 68^{0}C for petroleum diesel fuel.
6. Superior lubrication capabilities of biodiesel increases engine life.
7. Easily decomposes biologically and in the case of an accident no harm is done to soil or ground water.

Disadvantages

1. NOx emissions are higher, since biodiesel tends to increase NOx emissions.
2. Due to lower energy content of biodiesel, engine performance will be less as compared to diesel.
3. Gum formation and piston sticking would occur under long term use of biodiesel due to the presence of glycerin.

4. BIODIESEL CHARACTERIZATION

The specific gravity reduces drastically and viscosity from 48.4 to 4.76 centistokes after transesterification process, which is acceptable as per ASTM norms for Biodiesel as shown in Table 1. The flash point of biodiesel was found to be 162^0C. Higher in the value of biodiesel is safe during transport, storage and handling. Flash point of Jatropha oil decreases after transesterification, which shows that its volatile characteristics had improved and safe to handle. Higher density means more mass of fuel per unit volume of vegetable oil compared to diesel fuel that would give more energy for work output per unit volume.

Higher viscosity is a major problem in using vegetable oil as fuel for diesel engines. Cloud and pour points are criterion used for low temperature performance of fuel. The cloud point for Diesel is 4^0C which is very low and the fuel performs satisfactorily even in cold climatic conditions. The higher cloud point can affect the engine performance and emissions adversely under cold climatic conditions. The pour point for Diesel is -4^0C, higher pour point often limits their use as fuels for diesel engines in cold climatic conditions. When the ambient temperature is below pour point of the oil, biodiesel lose their flow characteristics and wax precipitates, which blocks the filter and fuel supply line. Under these conditions fuel cannot be pumped through the injector.

Table 1 Comparison of Fuel properties

Property	Jatropha oil	Jatropha oil methyl ester	Diesel
Density at 15^0C(kg/m^3)	925	878	850
Viscosity at 35^0C (cst)	48.4	4.76	2.7
Flash point (^{0}C)	189	162	68
Carbon residue (%)	0.3	0.03	0.19
Pour point (^{0}C)	-6	-6	-20
Cetane number	24	53.8	48

Fig. 1 Jatropha plants

Fig. 2 Jatropha plant with fruits

Fig. 3 Jatropha seeds with shells

Fig. 4 Jatropha seeds

5. CONCLUSION

- In the current investigation, it has confirmed that Jatropha oil may be used as resource to obtain biodiesel. Result shows that alkaline catalyzed transesterification is a promising process to produce biodiesel in large scale.

- Effects of different parameters such as temperature, time, reactant ratio and catalyst concentration on the biodiesel yield were analyzed. The best combination of the parameters was found as 6:1 molar ratio of Methanol to oil, 6.5 grms of NaOH catalyst, 60^0C reaction temperature and 60 minutes of reaction time

- The viscosity of Jatropha oil reduces substantially after transesterification. Biodiesel characteristics like density, viscosity, flash point, carbon residue, pour point and cetane number are comparable to diesel.

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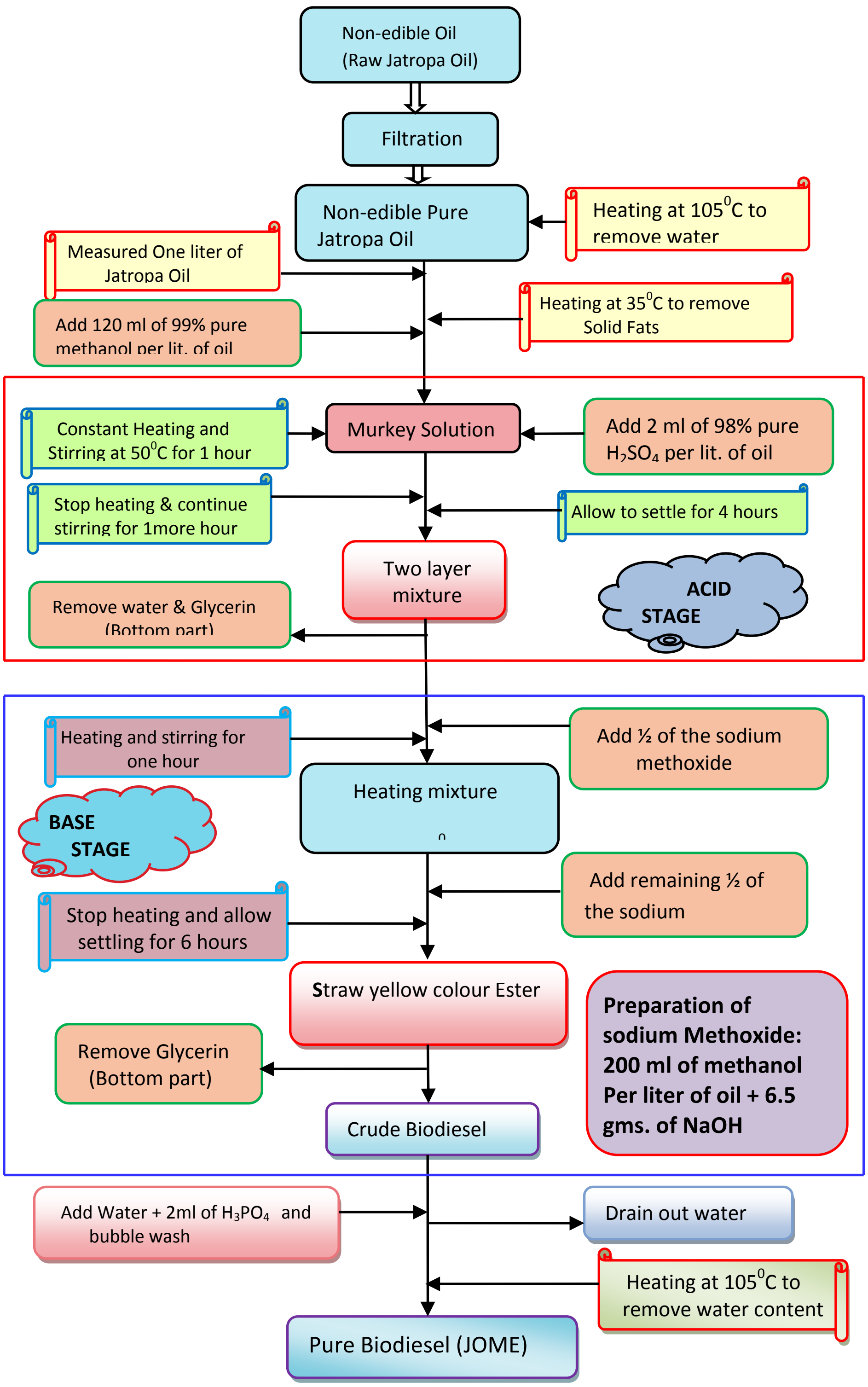

Fig. 5 Process Chart for Jatropa Oil Methyl Ester (JOME)