

Comparison of Chemical Properties of Diesel and Bio-diesel from Jatropha oil Produced from Bio-reactor Plant and by using Manual Method

Rashi Koul¹ Saurabh Pathak² Rishabh Goel³ Ravi Kumar⁴
^{1,2,3,4}Department of Mechanical and Automation Engineering
^{1,2,3,4}Amity University, Haryana, India

Abstract— Diesel fuel is one of the greatest fuel invention ever in Automobile history. Diesel fuel particularly for diesel engines have certainly helped a lot. Their higher thermodynamics and fuel efficiencies is quite impressive. But diesel fuel are one of the non-renewable resources, which can be replaced by (renewable resource) biodiesel fuels. Biodiesel also called as fatty acid methyl ester (FAME) and can be obtained from any vegetable oil, animal oil, and other seed oils using some specific methods. The objective of this paper is to study the chemical properties of jatropha oil, so as get the clarity upto which extent diesel can be replaced by biodiesel. Energy is one of the most important resources for mankind and its sustainable development. Today, the energy crisis becomes one of the global issues confronting us. A study of various characteristics and chemical properties have been shown using both manual and bio-reactor methods. From our experiments, we have come to know that the various chemical properties are in comparison with the diesel fuel and can easily be replaced.

Key words: Jatropha Bio-Diesel, Energy Crisis, Biodiesel, FAME, Bio-Reactor

I. INTRODUCTION

Jatropha Curcas is multipurpose small shrub, also known as physic nut or purging nut. It is drought resistant shrub belonging to tribe joannesieae in the family Euphrobiaceae which is mostly cultivated in Africa, India, some regions of central and South American [1]. Jatropha is a poisonous, semi green shrub of 4-6m height. Moreover it is resistant to high degree of aridity, which certainly allows it to grow even in desert areas too. This plant can grow in waste lands and almost on any anti-terrain. The plant produces tri-ocular, ellipsoidal fruit, which remains fresh until seed get mature. The seeds are black out 2cm long 1 cm thick [2]. Also seeds of it contains near about 26-38% oil, which can be processed to produce to get high quality biodiesel fuel. Seeds of jatropha curcas contains 6.60% moisture; protein (18.3%); lipid (38.0%); carbohydrates (17.2%); fiber (15.5%), and 4.5% ash [3]. Moreover seeds of jatropha curcas were also reported to be enrich in several macro and micro nutrients such as calcium, phosphorus, potassium and magnesium [4]. Application of jatropha curcas in agriculture, medicine/ health and industries. Also oil of the plant works as potential renewable resources, for various purposes, like lighting, cooking and substitute for diesel fuel [5], also for making soap, cosmetic and dye too. Jatropha curcas plants can also be used bio-insecticides or pesticides since extracts from the plant exhibit molluscicidal properties [6]. Byproduct of this plant cannot be used to feed animal as it has phorbol ester, responsible for its toxicity [7]. For the better utilization of jatropha curcas seeds and byproducts its all characteristics and properties should be known.

Biodiesel is a fuel that can be a direct replacement for petroleum-based diesel in diesel engines. Biodiesel can be produced using titration and trans-esterification [9]. Titration is an initial test to measure the free fatty acid (FFA) content of the feedstock, which determines the amount of catalyst needed to create biodiesel and is a necessary test for waste oil. Trans-esterification is the process in which biodiesel is produced by reacting alcohol, methanol or ethanol, with oil or fat in the presence of a catalyst. After the trans-esterification the liquid needs to settle and separates into glycerin and biodiesel. The glycerin is drained; the biodiesel washed with water to filter out any remaining glycerin or other impurities and then allowed to dry in an open container placed in a well-ventilated area. The end results are biodiesel, glycerin, wastewater, oil and alcohol (the latter two can be recycled or discarded depending upon the quantity and its capabilities).

II. MATERIALS AND METHODS

The materials for making biodiesel are *Jatropha* oil which is obtained from the *Jatropha* plant, KOH, Methanol. There are two methods for producing a biodiesel from Jatropha oil –

- 1) Manual
- 2) Bio- reactor

A. Manual Process

Manual process is one of the cheapest and easiest way to produce biodiesel from jatropha oi, although it takes around 2-4 days.

In the manual process following procedure is followed for producing the biodiesel-

- a) Take 100 ml of Jatropha oil and heat it up to 60°C with the help of magnetic stirrer heater and add 0.5 gm of KOH (as catalyst) and 20 ml of CH₃ OH.
- b) Cover the whole mixture with aluminum foil so that the vapours of methanol should not leave the container. Maintain temperature at 60°C.
- c) After 2-3 hours due to trans-esterification reaction, whole solution will be divided into 2 layers, glycerol and biodiesel. Glycerol will settle down at the bottom of the container because of its high density whereas the bio-diesel will be present in the upper layer.

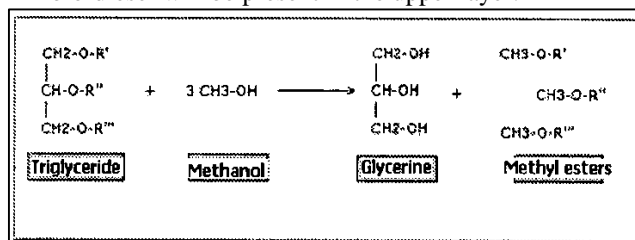


Fig. 1: Chemical reaction of biodiesel

- d) This bio- diesel obtained contains impurities which can be removed by the washing process. In funnel, the

biodiesel obtained from trans-esterification is mixed with water thoroughly and is kept for 2-3 hours, undisturbed. The bio-diesel being lighter will be on the upper side and impurities will settle down at the bottom of the funnel. This process of removing the impurities from the bio- diesel is known as *washing of bio-diesel*. It is done 3-4 times in order to obtain the pure bio-diesel.

B. Bio- Reactor Plant

The bio- reactor is basically an automated machine to produce the bio-diesel. The procedure involved in this case is as following-

- Set the temperature of the reactor at 60°C. Pour the *Jatropha* oil (2lt), maintaining the temperature at 60°C and then add the mixture of methanol (400 ml) and KOH (10 gm.).
- In this stirrer is already there which will rotate and mix the whole mixture for 2-3 hours and the speed of stirrer should not exceed the value 100rpm. It should be maintained between 80-100 rpm. During the process, there is continuous supply of water to the condenser of the main chamber so that the evaporated methanol can be poured back to the main chamber.
- After completion of the mixing process, take about 500 ml of the mixture from the outlet nozzle at the bottom of the reactor drum, to check whether the reaction is completed or not. The colour changes from dark yellow to transparent yellow. If yes, then the mixture is kept for some time until the glycerol settles down and bio- diesel with impurities is obtained. Then again the washing is done of this impure bio-diesel to obtain the pure bio-diesel.



Fig. 2: Bio-reactor machine

III. CHEMICAL ANALYSIS OR CHEMICAL PROPERTIES

There are various chemical properties of bio- diesel like density, viscosity, acid value, calorific value, flash point, and fire point, which can be obtained using several methods and different apparatus.

A. Density

- Mass per unit volume.
- Formula- Mass/Volume

- It was calculated manually.
- The density obtained is 0.86 Kg/l.

B. Viscosity

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress.

It is calculated with the help of equipment name Ostwald's viscometer. This is first done for water (water being the standard fluid) and then for oil. Avg. time for water is calculated and Avg. time for oil is calculated.

$$\text{Formula: - } \frac{\text{Viscosity of water}}{\text{Viscosity of oil}} = \frac{d_1 * t_1}{d_2 * t_2}$$

Where,

d1, d2 =Density of water and oil.

t1, t2 = Average time of water and oil

Viscosity obtained = $5.7 * 10^{-3} \text{ mm}^2 / \text{s}$.

C. Acid Value

It is the actual mass of Sodium Hydroxide (NaOH) in milligrams that is required to neutralize one gram of chemical substance.

It is calculated with the help of titration using the below mentioned formula

$$\text{Formula: - } \frac{56.1 * 1 * \text{Vol. of NaOH used}}{10 * \text{wt. of oil used}}$$

Result: 0.374 (acid value).

D. Flash Point and Fire Point

Flash point is the temperature at which first flame is obtained of the bio- diesel. And the *fire point* is the temperature at which it begins to fire or at which it gives continuous flame. These both can be determined with the help of **Pensky Martens apparatus**.

The flash point calculated of oil is 99°C .

Fire point of bio-diesel is 120°C.

E. Calorific Value

It is defined in terms of the number of heat units liberated when unit mass of fuel is completely burnt in a calorimeter under specified conditions. Higher calorific value of fuel is the total heat liberated in kJ per kg .The calorific value of the bio-diesel was determined with the Isothermal **Bomb Calorimeter**. The sample of fuel was ignited electrically. The water equivalent of bomb calorimeter was determined by burning a known quantity of bio-diesel and heat liberated was absorbed by a known mass of water. The heat of combustion can be calculated with the help of

$$\text{Formula: - } H_c = W_c T / M_c$$

Where,

H_c = Heat of combustion of the fuel sample, kJ/kg

W_c = Water equivalent of the calorimeter assembly, kJ/ °C

T = Rise in temperature, °C

M_c = Mass of sample burnt, kg.

Chemical Properties	Biodiesel	Diesel
Density(Kg/L)	0.86	0.838
Viscosity(mm ² /s)	$5.7 * 10^{-3}$	$5.2 * 10^{-3}$
Acid value	0.374	Max-0.5
Flash Point (°C)	99	75
Fire Point(°C)	120	120-130
Calorific Value(Kj/Kg)	40	40-45

Table 1: Desirable Chemical Properties of Biodiesel and Diesel

IV. RESULT AND DISCUSSION

Jatropha curcas oil is successfully converted into Jatropha biodiesel using both manual and bioreactor method.

All the desirable chemical properties of Biodiesel are in comparison with the diesel.

Bio- diesel is a viable substitute for our future needs in automotive industry.

V. CONCLUSION

Production of bio-fuel from plant materials is a major step toward harnessing one of the world's most-prevalent, yet least-utilized renewable energy resources. The main aim of the present investigation was to produce bio-diesel from jatropha oil by using different methods. The resulting biodiesel has almost the same chemical structure as traditional diesel and burns the same way in diesel engines. This comparison helped us to figure out that with certain modifications in the chemical properties of the bio-diesel, it can replace the existing endangered diesel fuel completely so as to use it as 100% in CI engines.

India, with its huge waste/non-fertile lands, has taken a well noted lead in the cultivation. Since the knowledge-base/expertise for jatropha has been inadequate in India, there is an ardent need for setting up specialized extension service centres for its cultivation and propagation.

REFERENCES

- [1] Schmook, B., Seralta-Peraza, L., 1997. Jatropha curcas: distribution and uses in the Yucatan Peninsula of Mexico. In: Gubitz M, Mittelbach M, Trabi M, editors. GM. Biofuels and Industrial Products from Jatropha curcas, pp. 53- 57. DBV Graz. 53-57. DBV Graz.
- [2] Heller, J. (1996). Physic Nut: Jatropha Curcas L. Promoting the conservation and use of Underutilised and Neglected Crops. I. Institute of Plant Genetics and Crop Plant Research, Gatersleben/ International Plant Genetic Resources Institute, Rome.
- [3] Gubitz, G. M, Mittlebach, M and trabi, M. (1999). Exploitation of the tropical oil seed plant Jatropha curcas L. Bioresource Technology 67:73-82.
- [4] El - Diwani, G I, Sh. A. El Rafei and Hawash, S.I. (2011). Ozone for the Phorbol Esters Removal from Egyptian Jatropha Oil seedcake. Advances in Applied Science Research, 2011, 2(4):221-232.
- [5] Ishii, Y, Takeuchi, R. and Tokida, K. (1987). Transesterified curcas oil as a farm diesel engine fuel. In proceedings of the International Symposium on Agriculture Mechanization and International Co-operation in a High Technology Era .Pp. 239. University of Tokyo, 3rd April.
- [6] Liu, S.Y., Sporer, F., Wink, M., Jourdane, J., Henning, R., Li, Y.L., Ruppel, A., 1997. Anthraquinones in Rheum palmatum and Rumex dentatus (Polygonaceae), and phorbol esters in Jatropha curcas (Euphorbiaceae) with molluscicidal activity against the schistosome vector snails Oncomelania, Biomphalaria and Bulinus. Tropical Medicine and International Health 2, 179-188.
- [7] Adolf, W. Opferkuch, H.J. and Hecker, E. (1984). Irritant phorbol derivatives from four Jatropha species. Phytochemistry 23:129-132.
- [8] Raina, A.K., Gaikwad, B.R., 1987. Chemobotany of Jatropha species in India and further characterization of 'curcas oil'. Journal of Oil Technology, India 19, pp. 81-85
- [9] Rashi Koul, Emission Characteristics of a single cylinder diesel engines fuelled with 1-octane diesel blends, International Journals of latest trends in Engineering & Technology, 2015: ISSN:2278-621X, 302-305.