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A Short Review on Production of Bio-Diesel from Jatropha Curcas Plant Oil Extract

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Abstract

Biodiesel is renewable and clean burning bio fuel that is made from waste vegetable oils, animal fats, or recycled restaurant grease for use in diesel vehicles. Biodiesel produces less toxic pollutants and greenhouse gases than petroleum diesel. Jatropha is a plant of deciduous type and sheds its leaves during dry season and also under stressful conditions. The leaves are green, smooth, 4-6 lobed and 10-15 cm in width and length. The plant has separate male and female flowers which are organized in clusters, inflorescences. The plant carries more male than female flowers, the male-to-female ratio is 29:1. This review paper delivers the production method of biodiesel from jatropha plant oil extract.

Keywords: bio-diesel, jatropha plant, oil extraction

Introduction

Biodiesel is a form of diesel fuel derived from plants or animals and consisting of long-chain fatty acid esters. It is typically made by chemically reacting lipids such as animal fat (tallow), soybean oil, or some other vegetable oil with an alcohol, producing a methyl, ethyl or propyl ester. Unlike the vegetable and waste oils used to fuel converted diesel engines, biodiesel is a drop-in biofuel, meaning it is compatible with existing diesel engines and distribution infrastructure. Biodiesel can be used alone or blended with petrodiesel in any proportions. Biodiesel blends can also be used as heating oil.

Energy is a vital commodity as it is commonly recognized that access to energy is closely linked with economic development. India is targeting economic growth rate of 8-9% in coming years. It is likely to have a significant consumption of energy resources in future for meeting the targeted growth rate and fulfilling the energy needs of its increasing population. India has developed rapidly during the past decades, so in developing countries the supply of food and energy must be secured; the population needs food for sustenance, and access to modern energy sources is necessary in order to achieve both economic growth and sufficient social and public services. India depends on import of fossil fuels to satisfy energy demand, and with population growth and economic development the demand will continue to increase. Fossil fuels are finite energy resources, and as the amount of new supplies found is decreasing, the resources will eventually be exhausted. Furthermore, the use of fossil fuels has a severe impact on climate change. Increased fossil fuel use thus conflicts with the increasing global pressure to reduce environmental impact and mitigate climate change.

The combustion of fossil fuels in the transport sector leads to an aggravation of the air quality along city roads and highways. Urban air quality is a serious problem nowadays as the number of vehicles increases on a yearly basis. The environmental implications of current energy usage such as GHG emissions, deforestation, land degradation, water and air pollution are of serious concern for policy makers. CO2 is the most important GHG contributing to climate change. All countries are at present heavily dependent on petroleum and Diesel fuels for transportation and agricultural machinery. The fact that a few nations together produce the bulk of petroleum has led to high price fluctuation and uncertainties in supply for the consuming nations. This in turn has led them to look for alternative fuels that they themselves can produce which is renewable and produce less number of carbon and other harmful particles. Crude oil is the largest consumed fossil fuel after coal in India. Known crude oil reserves are estimated to be depleted in less than 50 years at the present rate of consumption. Many countries lacking crude oil resources are facing foreign exchange crisis and high inflation rate mainly due to import of crude oil. It is believed that dependence on imported crude oil, environmental issues and employment in rural areas are reasons for replacement of fossil fuels by biofuels. Among the alternatives being considered are methanol, ethanol, biogas, bio-diesel and vegetable oils. Bio-Diesel have certain features that make them attractive as substitute for Diesel fuels. Biodiesel is an alternative fuel made from renewable biological sources such as vegetable oils and animal fats. Vegetable oils are usually esters of glycol with different chain length and degree of saturation. Biodiesel is a renewable fuel can be used to power any diesel engine. Now accepted by the federal government as an environmentally friendly alternative to petroleum diesel, biodiesel is in use throughout the world. Practically the high viscosity of vegetable oils (30-200 Centistokes) as compared to that to Diesel (5.8-6.4 Centistokes) leads to unfavourable pumping, inefficient mixing of fuel with air contributes to incomplete combustion, high flash point result in increased carbon deposit formation and inferior coking. Due to these problems, vegetable oil needs to be modified to bring the combustion related properties closer to those of Diesel oil. The fuel modification is mainly aimed at reducing the viscosity and increasing the volatility. Bio-Diesel has the characteristics compatible with the CI engine systems. Bio-Diesel are also miscible with diesel fuel in any proportion and can be used as extenders. Moreover, the gases emitted by Bio-Diesel driven vehicles have not an adverse effect on the environment and human health.

One of the crops that have been considered among the most promising for production of biodiesel is Jatropha. *Jatropha curcas* plant is a drought-resistant, perennial plant living up to 50 years and has the capability to grow on marginal soils. It requires very little irrigation and grows in all types of soils, thus making Jatropha a more sustainable choice than other vegetable oils. Its promoters argue that it does not compete directly with food production since the whole plant is toxic and hence non-edible. More importantly, the potential of Jatropha to

grow on degraded soil and its resistance to drought and pests enable cultivation on land that is not suitable for food production. The characteristics of Jatropha have raised expectations for positive environmental and socio- economic impacts from biodiesel production, and a large-scale government programme was launched in 2003 for promotion and implementation of biodiesel production from Jatropha. The plant that is generally cultivated for the purpose of extracting jatropha oil is Jatropha curses. The seeds are the primary source from which the oil is extracted. Owing to the toxicity of jatropha seeds, they are not used by humans. The major goal of jatropha cultivation, therefore, is performed for the sake of extracting jatropha oil. It is significant to point out that, the non-edible vegetable oil of jatropha Curcas has the requisite potential providing a promising and commercially viable alternative to diesel oil since it has desirable physical chemical and performance characteristics comparable to diesel. Cars could be run with jatropha Curcas without requiring much change in design. Oil from jatropha Curcas: There are number of variety of jatropha. Best among these are jatropha Curcas. Jatropha oil is an important product from the plant for meeting the cooking and lighting needs of the rural population, boiler fuel for industrial purpose or as a viable substitute for Diesel. About one- third of the energy in the fruit of jatropha can be extracted as oil that has a similar energy value to Diesel fuel. Jatropha oil can be used directly in Diesel engines added to Diesel fuel as an extender or trans esterified to a bio-diesel fuel. There are some technical problems to using jatropha oil directly in Diesel engines that have yet to be completely overcome. Moreover, the cost of producing jatropha oil as a Diesel substitute is currently higher than the cost of Diesel itself.

It is expected that industrialized countries would contribute finances, technology transfer, and other necessary support for these projects. The increased flow of these resources to developing countries is intended in principle to support their sustainable development, while at the same time reducing the global GHG emissions since it is becoming practically impossible to achieve this in the developed countries. Energy production using Jatropha biodiesel could be a viable project that parties could embark upon to assist most developing countries. since it is glaringly evident that epileptic electric power supply has always being the bane of development in these countries. On the other hand, it is widely believed that widespread adoption of localized power generation systems can play a key role in creating a clean, reliable energy with substantial environmental and other benefits.

Description of jetropha:

Jatropha is a plant of deciduous type and sheds its leaves during dry season and also under stressful conditions. The leaves are green, smooth, 4-6 lobed and 10-15 cm in width and length. The plant has separate male and female flowers which are organized in clusters, inflorescences. The plant carries more male than female flowers, the male-to-female ratio is 29:1. Flowering normally occurs once a year, during rainy season, but in permanently humid areas or under irrigation it flowers throughout the whole year. After pollination by insects, mainly honey bees, approximately ten green fruits having an ellipsoidal shape are formed by each inflorescence. Each fruit is about 40 mm long and contains three seeds. Occasionally a fruit can contain four to five seeds. It takes three to four months after the flowering for the seeds to mature. The seeds are black, measuring on average 18 mm in length, 12 mm in width, and 10 mm in thickness. The seeds weigh between 0.5 and 0.8 grams and the average number of seeds per kg of fruit is 1375.for on average 37 and 63 percent of the total weight, respectively. Oil content of the seeds range from 32 to 40 percent; the average is 34 percent. The seed contains toxins, such as phorbol esters, curcin, trypsin inhibitors, lectins, and phytates, which render the seeds, oil, and seed cake non-edible if not detoxified. Jatropha, is a small tree or large bush belonging to the Euphorbiaceae family. Normally the plant reaches a height of three to five meters but can reach up to eight to ten meters when grown under favourable conditions. It has a life expectancy of up to 50 years, maturing after four to five years, and grows into different shapes, with one stem with no or few branches, or with branches growing from below. The plant initially develops one central deep tap root and four lateral roots. The tap root can stabilize the soil and prevent landslides while the shallower roots are assumed to prevent soil erosion caused by wind and water. Jatropha grows in tropical areas all around the world. Its exact point of origin is still unknown, but located in the Central America and Mexico area. The plant was probably brought to Africa and Asia by Portuguese seafarers via Cape Verde, which is also where its first commercial use was reported during the first half of 20th century. According to current knowledge, Jatropha is an easily established, drought-resistant plant, which grows relatively quickly. It is therefore well-adapted to semi-arid and arid conditions. Its characteristics make it suitable not only for cultivation for oil production, but also for use as a live fence and for reclamation of eroded land.

Jatropha curcas Plant

Jatropha curcas Seeds

Jatropha curcas Fruits

Fig: 1 Picture of Jatropha curcas Plant, Jatropha curcas Seeds & Jatropha curcas Fruits

Producing sustem of bio-diesel

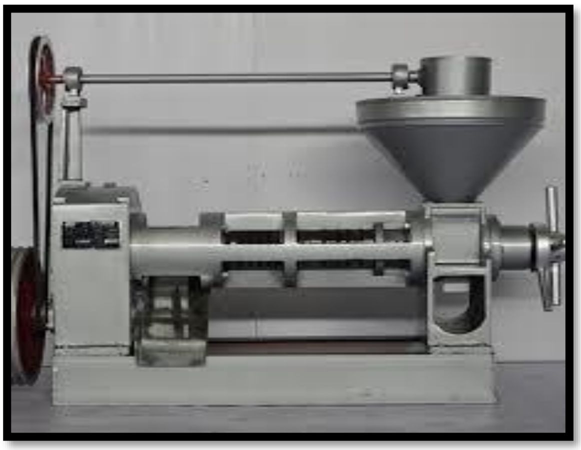
Source of jatropha Oil: The plant that is generally cultivated for the purpose of extracting jatropha oil is *Jatropha curcas*. The seeds are the primary source from which the oil is extracted. Owing to the toxicity of jatropha seeds, they are not used by humans. The jatropha curcus seed have the following chemical compositions.

Moisture: 6.20%
Protein: 18.00%
Fat: 38.00%
Carbohydrates: 17.00%
Fiber: 15.50%
Ash: 5.30%

Oil content in the seed: 25-30%
Saturated fatty acids: 21%
Unsaturated fatty acids: 79%

Oil extraction process:

Oil presses have been used for the purpose of oil extraction as simple mechanical devices - either powered or manually driven. Among the different oil presses that are used for jatropha oil extraction, the most commonly used presses include the Bielenberg ram press. The Bielenberg ram press involves the traditional press method to extract oil and prepares oil cakes. It is a simple device that yields around 3 liters of oil per 12 kg of seed input. Since the recognition of jatropha as an alternative energy sources (namely, biofuel), jatropha oil extraction methods have also gained due importance in the market. Since jatropha oil is the primary ingredient required in the production of biofuels, the development of oil extraction methods and the optimization of existing methods of extracting the oil have become significant. Different kinds of oil expellers are used for the purpose of jatropha oil extraction. The most commonly used ones are the Sayari oil expeller (also called the Sundhara oil expeller) and the Komet Expeller. The Sayari expeller is a diesel-operated oil extraction device that was originally developed in Nepal. It is now being developed for use in Tanzania and Zimbabwe for the purpose of jatropha oil extraction and oil cake preparation. The prototype included heavy parts made of cast iron. The lighter version has the cast iron replaced with iron sheets. A model driven by electricity is also available. The Komet expeller is a single-screw oil expeller that is often used for extracting jatropha oil from the seeds and also for the preparation of oil cakes.



Bio-diesel extraction machine

Oil expeller

Fig: 2 Bio-diesel extraction machine & Oil expeller

Preparation of Bio-Diesel from Jatropha oil:

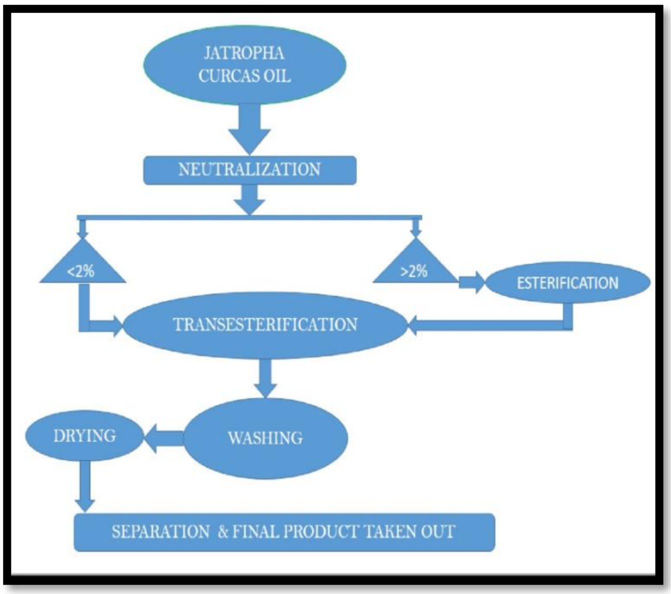


Fig: 3 Flow chart of Bio-Diesel preparation

The main process involves in Bio-Diesel production from jatropha oil are the following

- Neutralization
- Esterification process
- Transesterification process

The Flow chart describes the steps, processes and methods used to produce biodiesel product. To produce biodiesel its need three steps namely acid catalyse esterification,

Fig: 4 Followed by base catalyse transesterification and washing process.

Neutralization:

The vegetable oil contains about 14-19.5 % free fatty acids in nature, it must be freed before taken into actual conversion process. The presence of about 14% of free fatty acid makes Jatropha oil inappropriate for industrial biodiesel production. The dehydrated oil is agitated with 4 % HCl solution for 25 minutes and 0.82 gram of NaOH was added per 100 ml of oil to neutralize the free fatty acids and to coagulate by the following reaction.

$$RCOOH + NAOH \rightarrow RCOONa + H_2O$$

The coagulated free fatty acid (soap) is removed by filtration. This process brings the free fatty acid content to below 2 % and is perfect source for biodiesel production.

Esterification process:

Esterification process was purpose to reduce the free fatty acid (FFA) by converting it into esters. After titration was performed and the feedstock is more than 2%, esterification process will be performed. Theoretically, esterification also will be increase the yield of biodiesel. In this process methanol and sulphuric acid (H2SO4) was used as chemical reaction. This process used the alcohol and acid catalyst based on the ratio. The ratio of alcohol and acid catalyst based it used as in previous to reduce FFA. The ratio of methanol to oil is 16:1 and the catalyst is 1%. In this study, the pre-treatment step was carried out by following the esterification reaction. Firstly, the JCO was heated in the three neck flask reactor. The solution of sulphuric acid (H2SO4) in methanol at 1 % was heated at the specified temperature, and then added into the reactor containing the heated JCO. The ratio of methanol to JCO ratio was used is 16:1 and the time of reaction was at 120 minutes.

Separation needed 3hours to get the top methanol and bottom oil layers of the biodiesel. Two layers could clearly be seen in the successful basic esterification biodiesel. The top

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layer was mainly methanol. The bottom layer was mainly triglyceride product esterification after remove the water. These processes to reduce free fatty acid until below 2%. The density of the methanol is less than the bottom triglyceride. After the reaction was completed, the mixture was allowed to settle down for three hours and the methanol water fraction at the top layer was removed.

Transesterification process:

Transesterification of vegetable oils with alcohol is the best method for biodiesel production. There are two transesterification methods, which are: a) with catalyst and b) without catalyst. The utilization of different types of catalysts improves the rate and yield of biodiesel. The transesterification reaction is reversible and excess alcohol shifts the equilibrium to the product side. The general equation of transesterification reaction. Much different alcohol can be used in this reaction, including methanol, ethanol, propanol and butanol. The methanol application is more feasible because of its low-cost and physical as well as chemical advantages, such as being popular and having the shortest alcohol chains reaction. In this study transesterification was be performed at 120 minutes reaction time at 64.5 degree centigrade with 6:1 am.

Triglyceride + Alcohol ↔ Alkyl Ester + Glycerol

Transesterification is a mixture ester and alcohol to produce methyl ester. In this experiment methanol was used because if lower cost and easily available compared to other alcohol like ethanol and butanol propanol. For the catalyst, sodium hydroxide (NaOH) will be used. This catalyst has been choosing because safe to use and fastd 9:1 molar ratio. According to two differences catalyst with three differences molar ratio and five of properties test, the total of samples that have been prepared 18 samples. These samples were test based on the biodiesel standard. The apparatus needed in this process is digital weight scale, three neck flasks, retort stand, water tube, condenser, thermometer, hot plat stirrer, magnetic stirrer, beaker, filter funnel and the pot.

Transesterification process and any methanol evaporation the resultant biodiesels were left to lie for at least 8 hours. Separations were used to separate the top (methyl ester) and bottom (glycerol) layers of the biodiesel samples. Two layers could clearly be seen in the successful basic transesterification biodiesel samples. The top layer was mainly composed of free fatty acid methyl esters. The bottom deposit was mostly made up of glycerol, salts, soap, other impurities and excess methanol as it is a very polar compound i.e. it partitions more with polar glycerol as opposed to the non-polar methyl esters.

Procedure:

The base catalysed transesterification is selected as the process to make biodiesel from Jatropha oil. Transesterification-ion reaction is carried out in a batch reactor. For transesterification process 500 ml of Jatropha oil is heated up to 70ºC in a round bottom flask to drive off moisture and stirred vigorously. Methanol of 99.5 % purity having density0.791 g/cm³ is used. 2.5 gram of catalyst NaOH is dissolved in Methanol in bi molar ratio, in a separate vessel and was poured into round bottom flask while stirring the mixture continuously. The mixture was maintained at atmospheric pressure and 60°C for 60 minutes. After completion of transesterification process, the mixture is allowed to settle under gravity for 24 hours in a separating funnel. The products formed during transesterification were Jatropha oil methyl ester and Glycerin. The bottom layer consists of Glycerine, excess alcohol, catalyst, impurities and traces of unreacted oil. The upper layer consists of biodiesel, alcohol and some soap. The evaporation of water and alcohol gives 80-88 %pure glycerin, which can be sold as crude glycerin is distilled by simple distillation. Jatropha methyl ester (biodiesel) is mixed, washed with hot distilled water to remove the unreacted alcohol; oil and catalyst and allowed to settle under gravity for 25 hours.

The biodiesel fuel that has been separated from glycerin was sieved by adding warm water to eliminate the remnants of catalyst or soap. Then, it was dried and kept. This is the last process in order to get the pale yellow colour of biodiesel and same concentrate as petro-diesel. There are many ways to wash biodiesel like bubble washing and mixing with water. In this study the used mixing with warm water. This process was performed after esterification and transesterification process. First of all, water was heated to washing. After that, water was poured into the biodiesel in the beaker. Then, mixture is stirred using mechanical stirring at slow speed until two phases formed. At the bottom phase is warm water and above phase is biodiesel. It is shown the biodiesel has a lower specific gravity than water, the water was eventually separate and settles to the bottom and the biodiesel was remained at the top. In this point separation was took place between water and any impurities was removed from beaker. PH paper was used for the checking PH value. This process was stopped until PH paper show 7 or natural condition. For the final step in washing process is the sample oil biodiesel waste heated at 100 ºC. This step vaporized the water in the oil into the air. After washing process for get the pure biodiesel, fatty acid methyl ester (FAME) must heat for 5 hours or above at 100 degree centigrade in oven. There are many factors that could affect the yield of biodiesel. The factor such as types of feedstock, content of free fatty acid, the amount of alcohol, molar ratio, types and concentration catalyst use, reaction time and reaction temperature. In this study, the molar ratio was used as a constraint on JCO to produce the biodiesel.

Conclusion:

Biodiesel is renewable and clean burning fuel that is made from waste vegetable oils, animal fats, or recycled restaurant grease for use in diesel vehicles. Biodiesel produces less toxic pollutants and greenhouse gases than petroleum diesel. It can be used in pure form (B100) or can be blended with petro-diesel in the form of B2 (2% biodiesel, 98% petroleum diesel), B5 (5% biodiesel, 95% petroleum diesel), B20 (20% biodiesel, 80% petroleum diesel) and B100 (pure biodiesel). Biodiesel has helped several countries in reducing their dependence on foreign oil reserves as it is domestically produced and can be used in any diesel engine with little or no modification to the engine or the fuel system.

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