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Jatropha Biodiesel as a Fuel for Future- A Review

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Abstract- In India, demand for fuel in spite of an increase in prices and extensive air pollution in metropolitan cities encourages in discussing the present status and future scope for biodiesel as an alternative fuel.Biodiesel is clean burning fuel, it can be producedfrom 100% renewable resources and also it possesses environmental benefits. It is necessary for our India to go for some alternative and eco- friendly fuel such as jatropha that can be cultivated in the barren lands of the country. According to the peak oil theory, the demand for oil will exceed the supply and the gap between the demand and supply will continue to grow, triggering an energy crisis by 2024. Bio-dieselwhich is produced from different sources, maybe considered as a supplementary fuel to the diesel fuel in CI engine applications. In addition, it also promises employment to rural people through the opportunities of cultivation of vegetable oil–bearing plants, and this may help improve the domestic economy.India's first biofuel-powered flight that aims at reducing the costs of air travel by replacing the costly aviation fuel, made a successful test run recently.

Keywords-Bio diesel, J. curcas L,transesterification, economics.

I. INTRODUCTION

Growing interest is being shown towards biofuels as engine fuels, be itfor electricity production, transport or agricultural mechanization in both developing and industrialized countries[1]. There are many reasons for this revival in interest, but the main ones include:

- Declining petroleum resources and increasing energy consumption.
- The search for solutions to replace petroleum-based products.
- The virtually global commitment to reduce greenhouse gas emissions (GGE).
- The development of local resources: support to companies and small-scale producers, well-being and added value.

Diesel engines are widely used in the transport, electricity generation and shaft power [2]. These sectors are heavy consumers of petroleum oils which can be partially or totally replaced by vegetable oils and their derivatives which are derived from agriculture and thus of renewable origin [2, 3]

The consumption of diesel fuel in India is approximately six times that of gasoline fuel, as shown in table 1[4] .The table predicts a rising cost of oil-derived fuels caused by severe shortages of oil because of growing energy demand. So it is necessary that an appropriate policy decision is made in the country so that the future demand for diesel fuel is fulfilled in compliance with stringent emission norms[5]. Renewable fuels, particularly biodiesel, should get more attention in India because of the many promises it offers. Researchers are trying to find several ways to make biodiesel

from different feedstock such as edible oil, non-edible oil, waste vegetable oil, algae, animal tallow and fats, etc. [6]

Table 1. Comparison of diesel consumption with that of gasoline

Year	Gasoline Demand (MMT)	Diesel Demand (MMT)
2001-2002	7.02	39.81
2002-2003	7.62	42.15
2003-2004	8.20	44.51
2004-2005	8.81	46.97
2005-2006	9.42	49.56
2006-2007	10.07	52.33
2011-2012	12.85	66.90

*****MMT-Million Metric Tonnes*

Jatrophacurcas (J. curcas *L)*, a shrub of about 3–4 m in height, belongs to thefamily of Euphorbiaceae. Jatropha can be cultivated in tropical parts of the world with an annual rainfall of 300–1000 mm. It occurs mainly at lower altitudes (0–500 meters above sea level) with an average annual temperature well above 20^0C, but it can also be cultivated at higher altitudes and adverse climatic conditions with an inferior quality of the soil. Also, it requires very few nutrients to survive and, therefore, can be grown on less fertile land. It is one of such non-edible oils, which has an estimated annual production potential of 200 thousand metric tonnes in India. [7] The oil content of jatropha varies from 35–40% of the seed mass. The root of thejatropha plant is used as an antidote for snakebite, and the latex obtained from jatrophahas anti-cancerous properties. Also, its cultivation, seed collection, oil extraction, and biodiesel production can generate large-scale employment.[8]The harvesting of jatropha is easier and also hasa much shorter gestation period (about 2–3 years).[9] Fig1.shows the pictures of a jatropha plant and its seeds.

(a) ***(b)*** ***(c)***

Fig. 1 (a) Jatropha plant with fruits,(b) Fresh jatropha seeds, (c)Dried Jatropha seeds

1.1 Few characteristics of Jatropha plant

- Good agronomic traits[10]
- Hardy shrub which grows in semi-arid conditions and poor soils
- Can be intercropped with high-value crops such as sugar, coconut palm, various fruits and vegetables, providing protection from grazing livestock and phyto-protection action against pests and pathogens
- It is easy to establish and grows relatively quickly.
- Yields around 4 tonnes of seed per hectare in unkept hedges are achievable

- Has low nutrient requirements
- Requires low labour inputs.

Multi-purpose plant

- Protective hedges around fields
- Reclaims marginal soils
- Non-edible and therefore does not compete with food supply when used for biodiesel production
- Is energy crop that produces seeds with high oil yields

1.2 Properties of Jatropha oil

Few properties of Jatropha oil are listed in table 2. [11]

Table 2. Properties of Jatropha oil

Property	Value
Cetane Number	45
Density at 15 ^{0}C	.92 g/cm^3
Calorific Value	39.66 MJ/Kg
Flash Point	240 ^{0}C
Pour Point	8 ^{0}C
Viscosity at 40 ^{0}C	49.5 mm^2/s
Carbon Residue	.44%
Iodine Value	93 g of I_2/100g
Water Content	822 mg/kg
Acid Value	2.81 mg of KOH/g
Free Fatty Acids	38%

1.3The disadvantages of Jatropha

Seeds and leaves are toxic to human beings and animals Toxicity is based on several components (phorbol esters, curcains, trypsin inhibitors and others) which make complete detoxification a complicated and difficult process. Competes with food production for land use.

II. PRODUCTION OF JATROPHA BIO DIESEL

2.1 Raw materials required

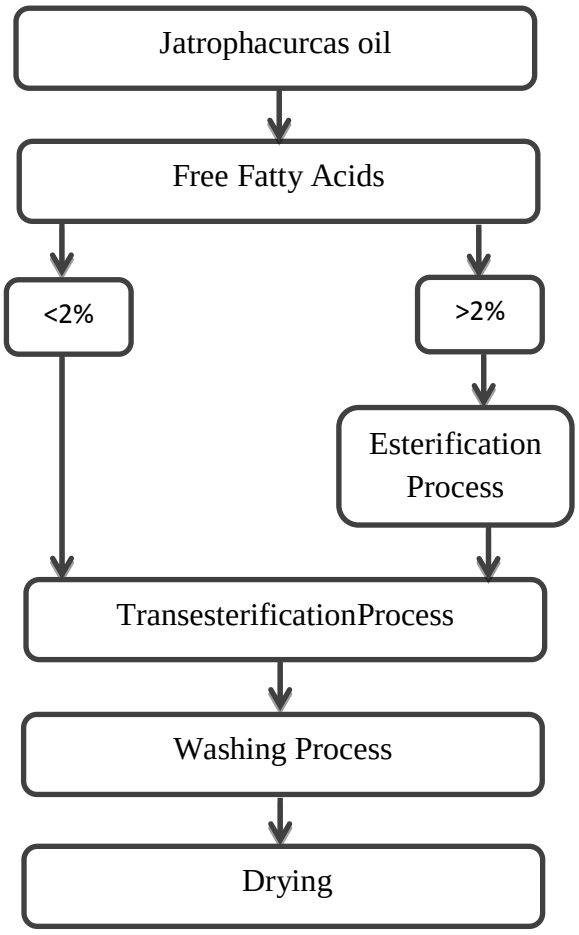
- Jatropha oil
- Methanol
- Potassium hydroxide
- Isopropyl alcohol
- Distilled water
- Phenolphthalein solution
- Vinegar
- Water

2.2 Procedure

Crude jatropha oil is poured into a conical flask and heated to a temperature of 50^0C. A mixture of concentrated H_2SO_4 with methanol heated separately (at 50^0C), and then added to the heated oil in the flask. The mixture is stirred for some time and allowed to settle.

Step by step approach used in the production of the biodiesel is given below.

i. A measured quantity of jatropha oil is measured and poured into a conical flask and heated to a temperature of 50^0C.
ii. A quantity of methanol is poured in a round bottom flask and soxhlet apparatus, and the heater is turned on. This is done in order to purify methanol.
iii. Potassium hydroxide pellet is placed in the weighing balance to get exactly the required amount.
iv. A solution of potassium methoxide is prepared in a beaker using the weighed (i.e. catalyst concentration of 0.5%) of potassium hydroxide pellet and methanol (1:6 ratio). The solution is then properly stirred until potassium hydroxide pellet was completely dissolved.
v. The potassium methoxide solution is then placed in the oven to bring its temperature to 60^0C.
vi. The potassium methoxide solution is poured into the warm jatropha oil and stirred vigorously for around an hour using a magnetic stirrer. The mixture is allowed to settle for around 24 hrs in a separating funnel.
vii. The biodiesel obtained is then poured into a separate beaker, while the lower layer (which comprises of glycerol and soap) is collected from the bottom of the separating funnel.
viii. Warm water is then used to wash the biodiesel to remove any excess glycerol and soap that remain in the funnel. This is done until the clear water is seen below the biodiesel in the separating funnel.
ix. The washed sample is then dried by placing it on a hot plate and excess water still in the biodiesel was removed.
x. The quantity of biodiesel collected is measured. The process flow is as shown in fig. 2



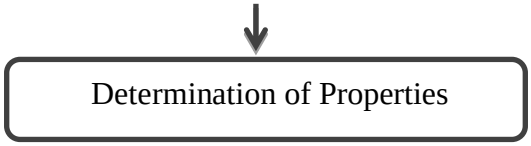


Fig 2. Process flow in the production of biodiesel from jatropha oil

III. FUEL PROPERTIES OF JATROPHA BIODIESEL

The fuel properties ofjatrophabiodiesel are summarized in comparison with jatropha oil and diesel in table 3[7].

Table 3. Properties of Jatropha oil, Jatropha diesel and Diesel

Property	Unit	Jatropha Oil	Jatropha diesel	Diesel
Density at 15 ^{0}C	Kg m^{-3}	940	880	850
Viscosity at 15 ^{0}C	mm^2 s^{-1}	24.5	4.80	2.60
Flash point	^{0}C	225	135	68
Pour point	^{0}C	4	2	-20
Water content	%	1.4	0.025	0.02
Ash content	%	0.8	0.012	0.01
Carbon residue	%	1.0	0.20	0.17
Acid value	Mg KOH g^{-1}	28.0	0.40	-
Calorific value	MJ kg^{-1}	38.65	39.23	42

3.1. General comparison between petroleum and biodiesel

- Where on one hand, diesel is one of the major air pollutants in the world and causes many heart ailments and lung problems, biodiesel on the other is a 75% cleaner fuel and is hence safer than diesel in many ways.
- Another difference between the two is that petroleum diesel is a fossil fuel and releases a lot of carbon dioxide in the air when burnt but biodiesel releases a much (about 78%) lower amount of carbon dioxide in the air. This is the reason why biodiesel is an efficient fuel for managing global warming whereas diesel is a fuel which is responsible for global warming.
- Biodiesel consists of a solvent which helps to clean off deposits of petroleum diesel from pipes and tanks. It thus serves as a super lubrication agent and its combustion leaves very few such particles behind. On the other hand, petroleum diesel possesses no such property.
- Engines which run on biodiesel are known to start very smoothly and run better with clear emissions. This is so because this fuel has a higher cetane number due to the presence of oxygen. But diesel again possesses no such quality and has a lower cetane number.
- Diesel is known for high sulfuric acid emissions which can be very harmful to the environment but biodiesel produces lesser amounts of carbon monoxide, unburned hydrocarbons and sulfur dioxide and is thus safer for the environment.
- Biodiesel is helpful and effective in removing crude oil from water but with diesel, there is no such possibility or scope.
- Another difference or point of comparison between these two fuels is that where on one hand, biodiesel is not yet used widely, diesel is sold worldwide and in huge quantities on

an everyday basis. There are only 19 national biodiesel boards which supply biodiesel in the United States.

- Biodiesel is definitely environment-friendly but its highlight feature is that it is highly economical as well. This is so because it does not incur any import costs. Diesel, on the other hand, is an imported product for most nations and is the less economical out of the two.

IV. ECONOMICS OF BIODIESEL UTILIZATION

The major hindrance in use of the biodiesel as an alternate fuel is its higher cost of production compared to mineral diesel. The estimated cost for biodiesel production was much lower in 2003, as reported by the Planning Commission of India[12]. The cost of biodiesel was estimated as Rs. 16.59–14.98 per liter. The details of the cost components have been provided in Table 4[12]. Nowadays the cost of production is much more. Actually, the cost of production depends on the scale of production. In most cases, it also depends on government policies as well. Sustained commitment from the government regarding budget allocation, coordination between different sectors, and incentives for the producers, processors, and consumers are the need of the hour for successful implementation of biofuel programs[13].From another point of view, the biofuelindustry increases employment opportunities, indigenous energy sufficiency, and savings of foreign exchange. To date, the production of biofuel crops is hit by a lack of research and development work and price support for farmers. As a protection measure for domestic producers, the Biodiesel Association of India has advocated for an increase in the import duty of biodiesel by 100%. On the basis of the current market survey, the cost analysis of biodiesel production based on the latest data of Kumar and colleagues[14]has also been shown in Table 5 [14]. They estimated the unit price on a per liter basis in 2012 as Rs. 46.45.

Table 4. Cost ofbiodiesel production in 2003

Cost of components	Rate (Rs./kg)	Quantity (kg)	Cost(Rs.)
Seed	5.00	3.280	16.40
Cost of Collection and oil extraction	2.36	1.050	2.48
Less cake produced	1.00	2.230	2.23
Trans esterification cost	6.67	1.000	6.67
Less cost of glycerol produced	40-60	0.095	3.8 to -5.70
Cost of biodiesel per kg	-	-	19.52- 17.62
Cost of biodiesel per liter(Sp. Gravity 0.85 at 15^0C)	-	-	16.59- 14.98

Table 5. Cost of biodiesel production in 2012

Cost components	Rate (Rs/kg)	Quantity (kg)	Cost (Rs)
Seed	16.00	3.280	52.48

Cost of collection and oil extraction	2.36	1.050	2.478
Less cake produced	1.00	2.230	2.23
Transesterification cost	6.67	1.000	6.67
Less cost of glycerol produced	50.00	0.095	4.75
Cost of biodiesel per kg	-	-	54.65
Cost of biodiesel per liter (Sp. Gravity 0.85 at 15^0C)	-	-	46.45

V. CONCLUSION

Biodiesel has become moreattractive as an alternative to fossil diesel because of its environmental benefits and the fact that it is made from renewable resources. *J.* curcasL. is a promising source of biodiesel since its seeds contain a high amount of oil and the species has good agronomic traits. These properties of *J.*curcasL. have attracted a lot of projects developers. Biodiesel seems to be a realistic fuel for the future. Also, the climatic condition of India is very much suitable for the cultivation ofjatropha plants, thereby canceling the import charges and providing employment to our people. The major challenges of biodiesel are its cost and limited availability of fats and oil resources. The cost of raw materials itself accounts for 60 to 75 percent of the total cost of biodiesel fuel[15].

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