

Title -

An Alternative Fuel: Biodiesel, Synthesized by Jatropha oil

Authors -

Ms. Anuradha Nanewar,

Abstract -

In the present age of depletion of fuels along with the environmental and earth's the search for an alternative fuel which promises a relation with sustainable development energy conservation management efficiency and also environmental preservation has highly become necessary. Especially is the developing country where there is less utilization of resources due to infrastructure and lack of high technology the fuels of bio-origin can provide a feasible solution to the crises? The fuel getting importance in the present scenario is the biodiesel. Biodiesel is the easily manufactured, clear burning diesel replacement fuel which can be manufactured from natural renewable sources such as new and used vegetable oils and animal fats. Bio diesel has 0% sulphur and other very good environmental friendly characteristics. So our aim is to produce an environmental friendly alternative fuel i.e. biodiesel by **Jatropha oil** (Ratanjyot) which has no economically significant use and hence can be come an ideal raw material for the manufacture of Bio diesel. The method we are using here is the two stage method, first is the acid stage and second is the base stage. The chemistry behind is transesterification. We draw the graph between the yield and the molar ratio to show the results of experiment and tested the product for some properties.

Key Words - Biodiesel, Transesterification, jatropha oil

Main Text - Bio Diesel -

Biodiesel is defined as the monoalkyl esters of long chain fatty acids derived from renewable feed stocks, such as vegetable oil or animal fats, for use in common ignition engines. Biodiesel has been found to be as a possible substitute for conventional diesel and is comprised of fatty acid methyl or ethyl esters, obtained from triglycerides by transesterification with methanol or ethanol respectively. Bio diesel is compatible with conventional diesel and both can be blended in different proportions to be used as a fuel in the engines.

Jatropha Curcus, an energy yielding plant:

Jatropha Curcus is a member of the family Euphorbiacial. It is commonly known as Ratanjyat. The non edible oil such as Jatropha, which has no other application of economic significance, is an ideal crop for the production of bio-diesel particularly in Indian conditions.

Botanical features – it is a small tree or shrub with smooth gray bark which exudes whitish colored watery latex when cut. Normally it grows between 3 and 5 meter in height, it can attain a height up to 8 or 10 maters under favorable condition. Fruits are produced in winter when the shrub is leafless or it may produce several crops during the year if soil moisture in good and temperatures are sufficiently high. Each efflorescence yields a bunch of approximately 10 or more fruits.

Ecological requirements: Jatropha Curcus grow almost anywhere – even on gravelly, sandy and saline soils. It can grow even in the crevices of rocks. Climatically, Jatropha Curcus in found in the tropics and sub tropics and like heat, although it does well even in lower temperatures and can withstand a light is frost. Its water requirement is extremely low and it can stand long periods of draught by shedding most of its leaves to reduce transpiration loss. Jatropha Curcus is also suitable for preventing sole erosion and shifting of sand dunes.

Chemical composition of Jatropha Curcus

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

The oil content is 35-40% in the seeds and 50-60% in the kernel. The oil contains 21% saturated fatty acids and 79% unsaturated fatty acids. There are some chemical dements in the seeds which are poisonous and sender the oil not appropriate for human consumption

The results of chemical analysis of Jatropha Curcus oil show that

Acid Value	38.2
Saponification value	195.0
Iodine value	101.7
Viscosity, cp	40.4
Fatty acids composition	
Palmitic acid %	4.2
Stearic acid %	6.9
Oleic acid %	43.1
Linoleic acid %	34.3
Other acids %	1.4

Oil bearing trees – selection of Jatropha Curcas –

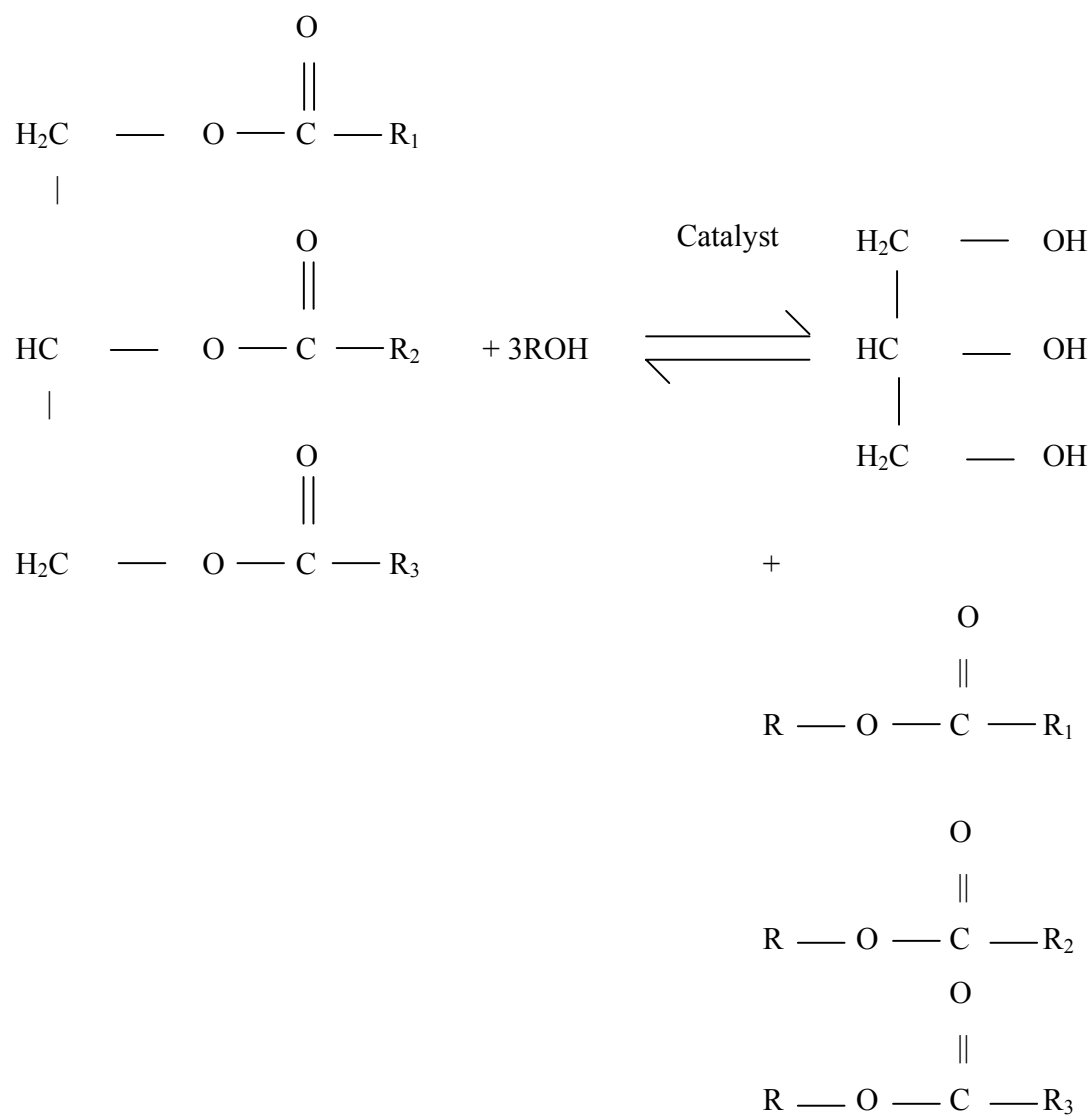
There are many tree species which bear seeds rich in oil having properties of an excellent fuel and which can be processed into a diesel substitute of there some promising tree species have been evaluated and it has been found that there are a number of them such as pongmia pinnata (karanja) and Jatropha Curcas (Ratanjyot) which would be very suitable in our conditions. However, to start, the advantage is clearly in favor of Jatropha because of various reasons, some of them are,

- Oil yield per hectare is among the highest of tree borne oil seeds.
- It can be grown in areas of low rainfall and in problematical soils. In high rainfall and irrigated areas too it can be grown with much higher yields. Therefore it can be grown in most parts of the country.
- Jatropha is easy to establish, grow relatively quickly and is hardy.
- Jatropha seeds are easy to collect as they are ready to be plucked before the rainy season and as the plants are not very tall.
- It can be established in waste land, or on borders of farmer's fields as a boundary fence or live hedge.
- Jatropha is not browsed by animals.
- Being rich in nitrogen, the seed cake is an excellent source of plant nutrients.
- The plant starts giving seeds in a maximum period of 2 years after planting
- Like all trees, Jatropha removes carbon from the atmosphere stores it in the woody tissues and assists in the build up of soil carbon. It is thus environmental friendly.

Transesterification -

Transesterification is the chemical reaction between triglycerides and alcohol in the presence of catalyst to produce mono-esters and glycerol. The long and branched chain triglyceride molecules are transformed to monoesters and glycerin. The transesterification process includes three consecutive reversible reactions. First one fatty acid chain is broken off the triglyceride molecule and bonds with alcohol to form an alkyl ester molecule and a diglyceride molecule i.e. two chains of fatty acids bounded by glycerin. Then a fatty acid chain is broken off the diglyceride molecule and bonds with alcohol to form an alkyl ester molecule and a diglyceride molecule i.e. two chains of fatty acids bounded by glycerin. Then a fatty acid chain is broken off the diglyceride molecule and bonds with alcohol to form another alkyl ester molecule and a monoglyceride molecule. Finally, the monoglycerides are converted to alkyl esters.

The overall chemical reaction of the transesterification process is given as.



Where R_1 , R_2 and R_3 are long chain hydrocarbons which may be same or different and R is alkyl mostly CH_3 or C_2H_5 .

Raw Materials -

The raw materials required for producing biodiesel are -

1. Vegetable oil or waste vegetable oil such as used cooking oil, animal fats. Vegetable fats required can be any of the different oils available. Here we are using Jatropha oil

2. **Alcohol:** Methanol, ethanol, propanol, Butanol. But most preferred are methanol and ethanol. Of this, we are using methanol as it is cheap and easily reacts with hydroxides.

3. **Catalysts** - There are different types of catalysts used depending on the type and the quality of the oil used. Mainly there are three types of catalysts.

- a) **Basic catalysts** - This include catalysts such as sodium hydroxide, potassium hydroxide, sodium methoxide etc. But most often used catalyst is sodium hydroxide and potassium hydroxide. Of this, more common is sodium hydroxide as it is cheaper, easily available and requires less quantity than potassium hydroxide.
- b) **Acid catalysts** - This are needed when the oil contains a high amount of free fatty acids. Some of the catalysts are sulfuric acid phosphoric acid, hydrochloric acid etc. The most common is the sulfuric acid, because of its easy availability.
- c) **Bio Catalyst** - This include lipase catalyst. They are to be chosen so to best suit the alcohol used depending on the type of alcohol used.

4. **Washing:** Washing of biodiesel is done at the last to get pure biodiesel after removal of soaps. It is done to improve the quality of biodiesel for washing of biodiesel one requires -

- i) Vinegar
- ii) Water

There above mentioned substances are required according to the quantity of oil taken and the yield desired for the product i.e. biodiesel.

The method used to manufacture the biodiesel here is called two stage methods.

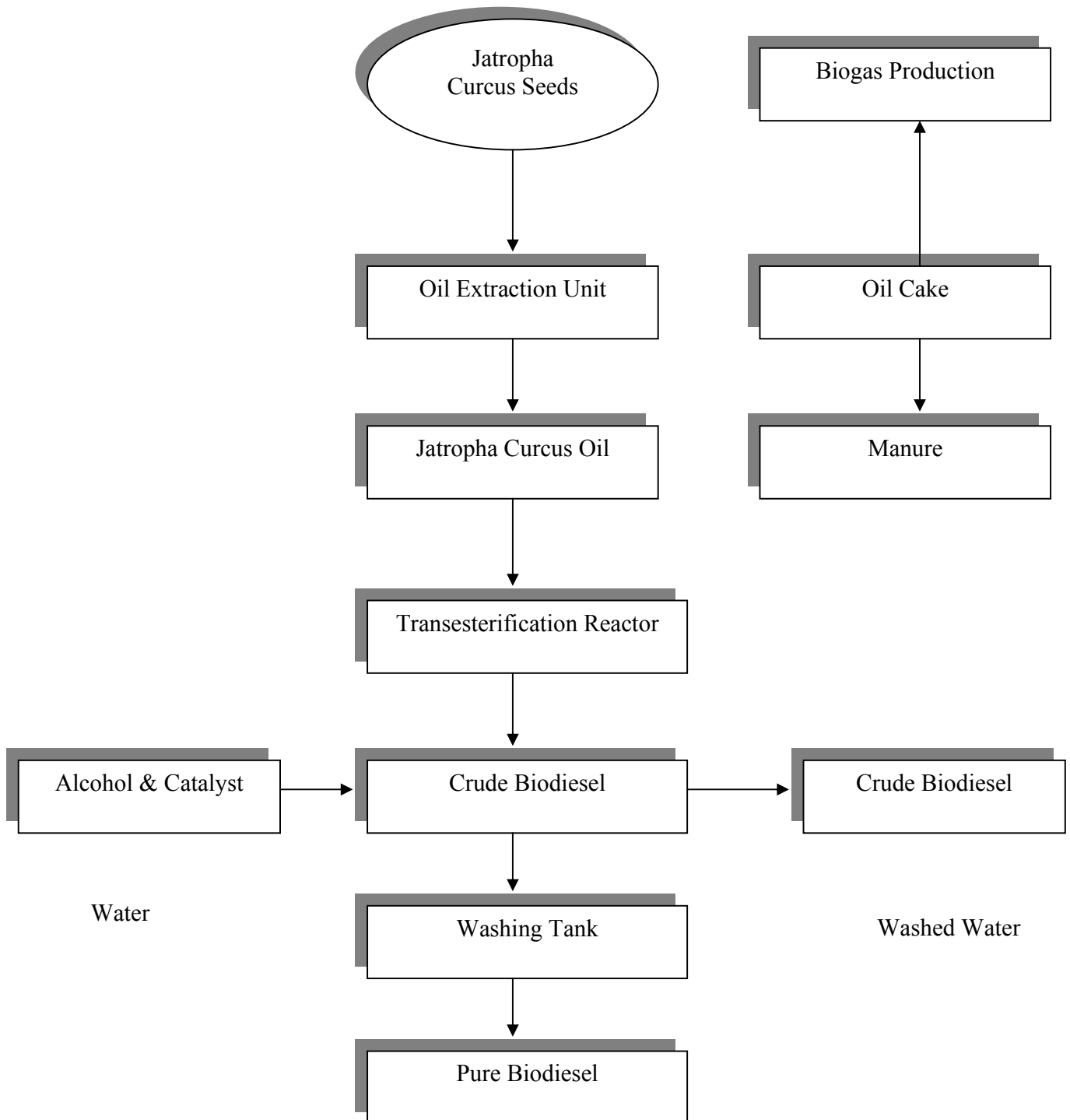
Two stage method: - The two stage method is used for the oil with high free fatty acid content. It involves two stages, first is the acid stage and second is the base stage.

The following experimental procedure was adopted for the production of biodiesel:

Some 200 ml. of Jatropha oil was taken in a round bottomed flask. A water cooled condenser and a thermometer with cork were connected to the side openings on the either side of the round bottomed flask. The oil is heated to 35°C and 8% by volume of methanol is added to it and mixed for about 5 min. Then we added 0.2 ml. of 95% sulfuric acid to oil and mixed it gently keeping the temperature at 35°C. The temp. was maintained for an hour and then the heating was stopped but stirring was continued. The mixture was stirred for another hour (total 2 hr) and then stopped mixing. The mixture was allowed to settle for at least 8 hour. Then for making sodium methoxide solution we took 24 ml. by volume of methanol and 0.8 gm of sodium hydroxide for the first batch and 1.0 gm. for the second batch of the experiment and mixed it completely. After the oil mixture has settled for 8 hrs we added half of the methoxide solution to the unheated oil and mixed for five min. Then in the second stage we heated the

mixture to 55⁰C and maintained it and added the second half of methoxide solution to the heated mixture and mixed it. When a straw yellow color comes in the mixture, the heating and mixing is stopped. The mixture is allowed to settle and then it is separated then the biodiesel is washed.

Fig.1 Process schematic of biodeisel



Results and Discussion -

The results in tabular form are:

Temp = 50°C

i) For NaOH = 0.8 gm

Table 1

S.No.	Type of oil	Quantity taken (ml)	Amount of methanol (ml)	Karanja ester (ml)	% yield
1	Jatropha	200	20	100	50
2	Jatropha	200	26	116	58
3	Jatropha	200	32	128	64
4	Jatropha	200	40	140	70
5	Jatropha	200	45	144	72
6	Jatropha	200	50	144	72

ii) For NaOH = 1.0 gm

Temp = 50°C

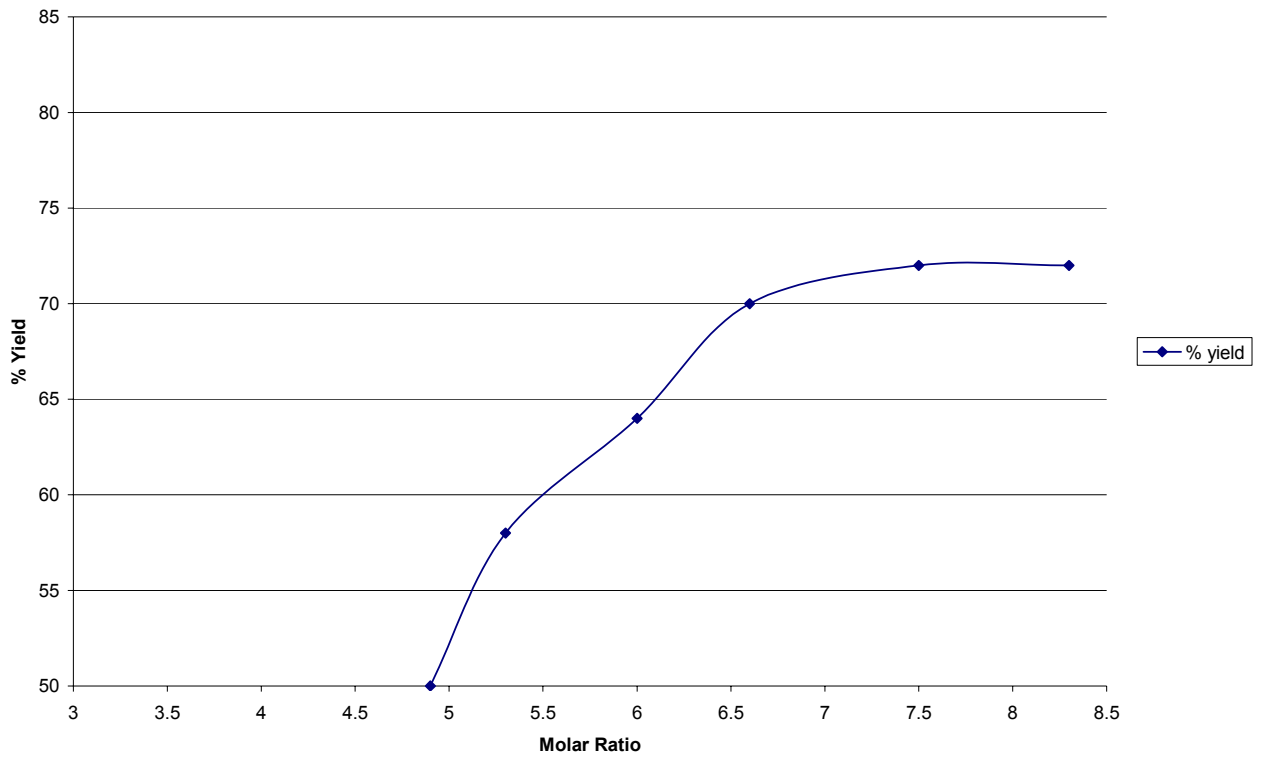
Table 2

S.No.	Type of oil	Quantity taken (ml)	Amount of methanol (ml)	Karanja ester (ml)	% yield
1	Jatropha	200	20	106	53
2	Jatropha	200	26	118	59
3	Jatropha	200	32	132	66
4	Jatropha	200	40	144	72
5	Jatropha	200	45	146	73
6	Jatropha	200	50	146	73

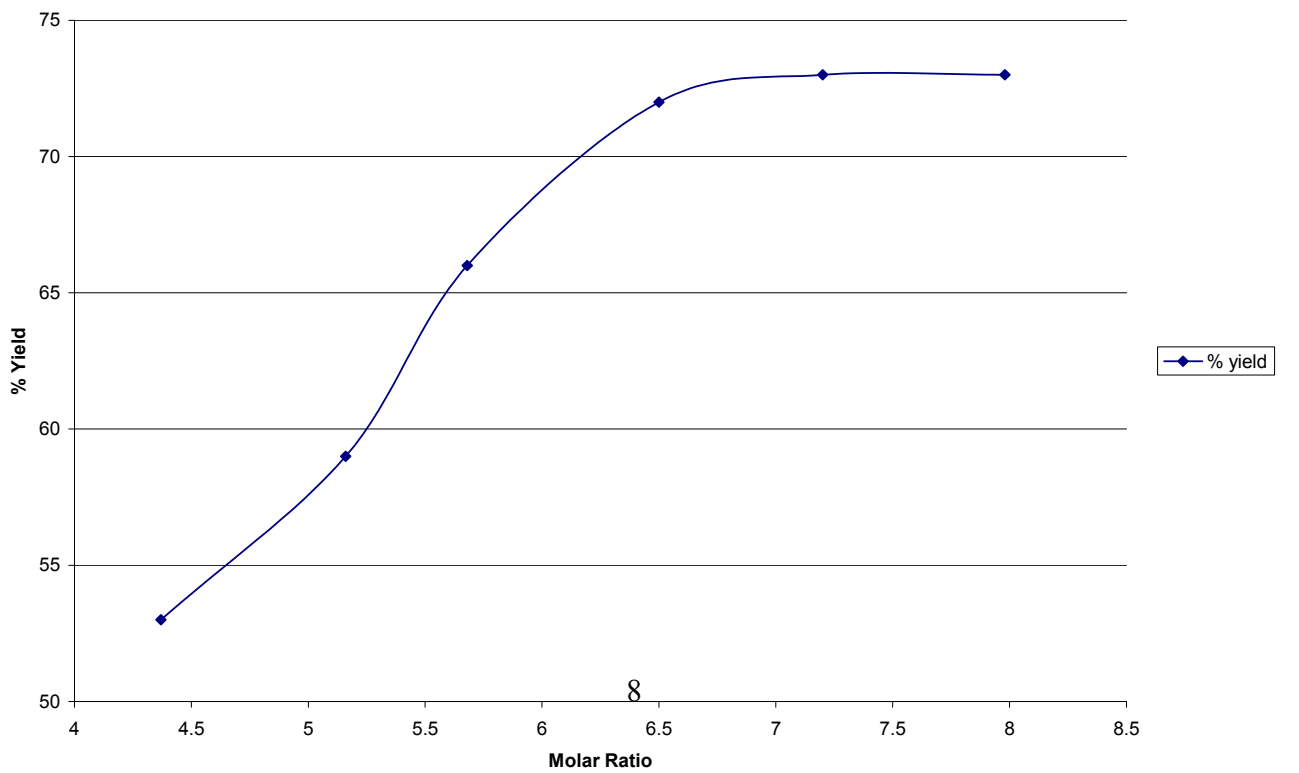
Table 3

Sr.No.	Property	Jatropha Ester	
1	Specific gravity	0.872	
2	Flash point °C	130	
3	Fire point °C	138	
4	Viscosity at 40°C mm ² /s	5.2	

For Fig.2



For Fig. 3



A. Effect of Alcohol to oil molar ratio

The molar ratio of alcohol to oil is one of the important factors that affect the yield as well as the production cost. The percent yield or conversion is defined as the yield of the process expressed in terms of percentage. Molar ratio is defined as the ratio of the number of moles of alcohol to the number of moles of glycerides in the oil. Theoretically, the transesterification reaction requires three moles of alcohol for each mole of oil. But in practice the molar ratio should be higher in order to shift the reaction forward. The molar ratio was changed and the conversion changed accordingly. It is shown in fig 2 that with increase in molar ratio the conversion increased .the maximum conversion was obtained near the molar ratio of 6.5:1 and with further increase in the molar ratio there is only a slight increase in conversion or percentage yield.

A. Effect of catalyst amount

The amount of catalyst used in the reaction also affects the percentage yield of the process, though not to large extent. The catalyst amount was taken as 0.4 and 0.5 % of oil. The affect of catalyst amount is shown in the graph. With the increase in the catalyst amount the yield was increased. Also, addition of excess amount causes the formation of soaps. For the catalyst amount of 0.5% by volume fraction of oil, the yield was maximum.

B. Effect of temperature

The reaction was performed at constant temperature. It was seen that oils gave a better product when the temperature was maintained around 50°C. But, if the temperature was increased the product led to the formation of soap and gels with a poor product quality.

Some physical properties such as specific gravity, flash point, fire point and viscosity were also measured using suitable instruments.

Appendix -

		Page No.
	Abstract	1
	Key words	1
	main text	1
List of figures	Process schematic of biodiesel	6
	Graph 1	8
	Graph 2	8
List of tables	Table 1	7
	Table 2	7
	Table 3	7

References -

1. C. Carraretto, A. Macor, A. Mirandola, A. Stoppato, S. Tonon; Biodiesel as an alternative fuel : Experimental analysis and energetic evaluations. *J. Energy*, 2003; 29 (2004), pg. 2195-2211.
2. K. Pramanik, properties and use of jatropha oil and diesel fuel blends in comparison ignition engine. *J of Renewable Energy* 28 (2003) pg. 239-248.
3. Properties of jatropha by Satish Lele.
4. Fcuge RO, Gros AT, Modification of vegetable oils, VII Alkali catalyzed transesterification of pea-nut with ethanol. *J. Am Oil Chem. Soc.* 1949, 26(3) Pg. 97.
5. Freedman B. Pryde BH, mounts TL, variables affecting the yields of fatty esters from transesterified vegetable oils, *J. Am oil chem Soc.* 1984; 61 (10) pg. 1638-43.
6. M.A. Kalam, H.H. Masjuki, Biodiesel from palm oil an analysis of its properties and potential *Biomass and Bioenergy*. 23 (2002) pg. 471-479.
7. S.L. Dmytryshyn, A.K. Dalai, S.T. Chaudhari, H.K. Mishra, M.J. Reancy synthesis and characterization of vegetable oil derived esters: evaluation for their diesel additive properties *J. Bioresource. Technology* 2002, 92 (2004) pg. 55-64.
8. Y. Zhang, M.A. Dube, D.D. Mclean M. Kates; Biodiesel Production from waste cooking oil; 2. Economic assessment and sensitivity analysis. *J. Bioresource Technology* 2002; 90 (2003) pg. 229-240.