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BIODIESEL PRODUCTION FROM *JATROPHA CURCAS* OIL

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ABSTRACT

Energy plays an important role in the development of any nation. But with the present rate of consumption, conventional sources of energy like natural gas and petroleum will be exhausted shortly. That's why the concept of using bioenergy is giving attention worldwide. Hence, biofuels appears to be a proven renewable energy option. In this paper, we address the issue of producing vegetable oil from *Jatropha Curcas* seeds, using both mechanical and solvent extraction methods. We are also interested in the production of biodiesel from the raw oil obtained (i.e transesterification or alcoholysis). Results showed that solvent extraction produced high quality oil than mechanical extraction. It was also found that parameters such as oil temperature, reaction temperature, ratio of alcohol to oil and purity of reactants are factors that affect the transesterification process. The use of KOH instead of NaOH as catalyst gave better quality of biodiesel.

Key words: *Jatropha Curcas*, Biodiesel, Solvent extraction, Mechanical extraction.

INTRODUCTION

Energy has a major impact on every aspect of our socio-economic life as it plays an important role in survival and welfare development of any nation. In many developing countries, there is a serious shortage of fuel and therefore, energy crisis is a daily reality for most families. Solution to this problem can be found in the exploitation and the use of renewable energy sources such as biodiesel. In view of substituting diesel for biodiesel, the use of *Jatropha Curcas* to produce biodiesel is an area of priority concern.

What is biodiesel ?

Bio-diesel is defined as the mono-alkyl esters of fatty acids derived from vegetable oils or animal fats. In simple terms, bio-diesel is the product you get when a vegetable oil or

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animal fat is chemically reacted with an alcohol to produce a fatty acid alkyl ester. A catalyst such as sodium or potassium hydroxide is required. Glycerol is produced as a byproduct. Bio-diesel is manufactured from plant oils, animal fats and recycled cooking oils.

Bio-diesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a bio-diesel blend or can be used in its pure form. Just like petroleum diesel, bio-diesel operates in compression ignition (diesel) engine; which essentially require very little or no engine modifications because bio-diesel has properties similar to petroleum diesel fuels. It can be stored just like the petroleum diesel fuel and hence, does not require separate infrastructure. Bio-diesel is considered clean fuel since it has almost no sulphur, no aromatics and has about 10% built-in oxygen, which helps it to burn fully. Its higher cetane number improves the ignition quality even when blended in the petroleum diesel.

About *Jatropha curcas*

Jatropha is a genus of approximately 175 shrubs, a plant tree from the family of *Euphorbioceae*. It was spread as a valuable plant in Africa and Asia by Portuguese traders. The oil from Jatropha can be used for making, biodiesel fuel. The plant can grow in waste land and it yields more than four times as much fuel per hectare as soy-beans and about half as much as corn. A hectare of *Jatropha Curcas* produces 1,892 liters of oil (about 6.5 barrels per acre).

EXPERIMENTAL

Material and methods

Materials (For original protocol)

- 1 Liter of Jatropha oil
- 200 mL of methanol (97% pure)
- Lye catalyst KOH or NaOH-3.5 g of NaOH at 92% pure or 4.9 g of KOH at 92% pure
- Measuring breakers for methanol (CH_3OH) and oil.
- Half liter translucent white HDPE (# 20 plastics) container bung and screw on cap.
- 2 Funnel to fit the HDPE container
- 2 Liter PET bottle for setting
- 2 Liter PET bottle for washing
- Thermometer.

All equipments should be clean and dry.

Methods

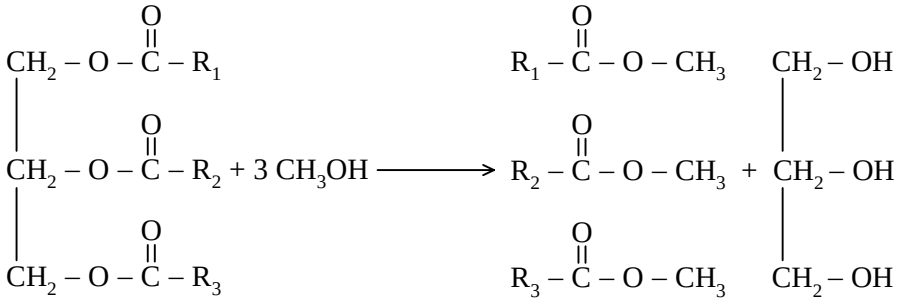
Jatropha oil making

The ripe fruits are plucked from the trees and then sun dried and decordicated manually. They should be heated for several hours or be roasted for 10 minutes (the seeds must not be overheated). This process liquefies the oil and improves the extraction. The oil can be extracted from the seeds by solvent or by pressure. For the mechanical extraction, a screw press is used and for solvent extraction, hexane (C_6H_{14}) is utilized. Solvent extraction of *Jatropha* oil yields maximum and high quality seed oil, but it is found to be costly at small scale The unavailability of hexane and the difficulty of its manipulation explains our choice for mechanical extraction. The oil extracted via the screw press is then purified by sedimentation or by boiling it with water. Sedimentation is easier but it takes about a week or more until the sediments (i.e 25% of the raw oil volume) will settle. The purification process is accelerated tremendously by boiling the oil with water. The boiling should continue until the water is completely evaporated.

Transesterification

Vegetable oils are triglycerides containing glycerine. The biodiesel process turns the oils into esters, separating out the glycerine. The glycerine sinks to the bottom and the biodiesel floats on top and can be siphoned off. This process is called transesterification or alcoholysis, which substitutes alcohol for the glycerine in a chemical reaction using lye catalyst. The molecular weight of *Jatropha curcas* oil is taken to be 900 g. As per the transesterification reaction, 3 moles of methanol were required to react with the vegetable oil. Hence (32 x 3) g of methanol was required for the transesterification of 1 mole (900 g) of *Jatropha* oil.

Equation of transestetification reaction



The process

First the required amount of NaOH (3.5 g + x) was dissolved into the methanol, shaken or swirled until all the lye has dissolved. This may take 10 min. and it is normal that the temperature rises. This mixture is called methoxide. Pour the *Jatropha* oil in a vessel large enough, preferably with a valve at the bottom. It was preheated at about 60^{o}C (138^{o} F), then the heating was stopped and the prepared methanol mixture was carefully added into the oil. It was mixed well for 20 to 30 min. As soon as the process is completed, the mixture was poured into the 2 liters PET bottle for settling. It was allowed to settle for 12 – 24 hrs.

Dark – coloured glycerine by-product will collect in a distinct layer at the bottom of the bottle with clear line of separation from the pale liquid above, which is the biodiesel. The biodiesel varies some what in colour according to the oil used (and so does the byproduct layer at the bottom), but usually it is pale and yellowish. If the reaction went well and the biodiesel is clear, it can be used straight, although, its quality may be inferior because of impurities. Water can remove most of the impurities.

RESULTS AND DISCUSSION

Table 1: Catalyst type and purity

Lye catalyst	Purity	Amount needed
NaOH	at least 97% pure	3.5 g
KOH	99% pure (rare)	4.9 g
	92% pure	5.3 g
	90% pure	5.5 g
	85% pure	5.8 g

Mixing the methoxide with NaOH can take from overnight to a few hours to as little as half an hour with lots of swirling. Mixing KOH is much faster, it dissolves in the methanol more easily than NaOH and can be ready for use in ten minutes but NaOH is easier to get and cheaper to use. It is essential to remove water in the oil, because it interferes with the lye catalyst, especially if there is too much lye and one may end up with a batch of gelly. During storage, oil is likely to react with atmospheric oxygen and other element from the environment; this may lead to change in oil quality particularly increase in FFAS.

It is also essential to titrate the oil to find out how much free fatty acid (FFA) it contains, so we can calculate exactly, how much extra lye will be required to neutralize it

(X) ? This means determining the pH and it was found that X = 1 mL. Working on different samples, and varying some parameters, the following results are obtained.

Table 2: Titration result

Batch No.	Vol. of NaOH added to 1 mL of oil	pH
1	0.4 mL	8.0
2	0.7 mL	8.0
3	0.9 mL	8.9
4	0.95 mL	8.6
5	1.0 mL	8.8

The different quantities of oil, lye and methanol are, 20 mL of oil (3.5 g + 1 mL) NaOH and 4 mL methanol (i.e. 20%). The process works as explained above.

Batch 1: The amount of biodiesel before washing is 17 mL, that is -

$$100/20 \times 17 = 85\%$$

Batch 2: Without heating

The amount of biodiesel obtained before washing is 4.8 mL, that is -

$$100/20 \times 4.8 = 24\%$$

Batch 3: With heating (60^oC)

The amount of biodiesel obtained before washing is 18 mL, that is -

$$100/20 \times 18 = 90\%$$

Batch 4: Without heating

The amount of raw biodiesel obtained is 12 mL before washing, that is -

$$100/20 \times 12 = 60\%$$

Batch 5: With heating (60^oC)

The amount of biodiesel obtained before washing is 18 mL, that is -

$$100/20 \times 18 = 90\%$$ with less amount of glycerin

Out of all batches done, batches 3 and 5 with heating steps provide the best result with 90% of oil to free fatty acid ratio. Also the ratio of alcohol to oil is another important parameter affecting the transesterification process. The *Jatropha* oil used in the work is a crude form with minimum filtration; with well processed oil, the ratio of oil to free fatty acid can increase to somewhere around 95% (purity of reactants).

CONCLUSION

The transesterification works well when the input oil is of high quality. However, quite often low quality oils are used as raw materials for biodiesel preparation. In cases where the FFA content of the oil is above 1%, difficulties arise due to soap formation. If the FFA content is above 2%, the process becomes unworkable. Therefore, in this work, the major concentration laid towards the most favorable parameters that can support better esterification; these are: Reaction temperature, purity of reactants, ratio of alcohol to oil, intensity of mixing, catalyst type and concentration.

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