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Jatropha Biodiesel: an Alternate Fuel

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ABSTRACT

In 1895,vegetable oil was taken into account for using as a fuel. This concept seems to be insignificant today. Since 1990s, biodiesel or methyl esters have gained much attention because of its ecological merits and it is a product of reaction from renewable and natural resources. Heaps of attempts have gone into the preparation of Jatropha Biodiesel from extraction of oil from seeds to synthesis of biodiesel; to changing its properties by introducing nanoparticles, which has been explored and overviewed in the following article. The article gives detailed explanation of preparation of biodiesel from *Jatrophacurcas*, the obstacles faced during its synthesis, its properties, and quality of methyl esters.

Key Words: Jatropha Oil, Biodiesel, Nanoparticles, Transesterification.

INTRODUCTION

Jatropha, a fast growing, drought resistant native tree of Latin America attracted attention in the field of Research because of its unique ability to grow in any wasteland and almost in any territory, even on soils having gravels, sand and salinity. It doesn't even require pesticide usage due to its pesticidal and fungicidal properties. The seeds of Jatropha contains saturated and unsaturated fatty acids in the ratio of 1:4 on an average, and yields about 25%–40% oil by weight.

A study recently published in the international science journal Earth System Dynamics found that Jatropha plants have wonderful environmental potential; their leaves have capability to absorb high amounts of CO_2, which can help to control effects of climate changes. This concept is termed as "Carbon farming". After keen observation onto qualities of Jatropha, the first step that came to make use of it was extraction of oil from the seeds.

METHODOLOGY

Extraction of Oil

As per the experiments conducted in Malaysia, main operating parameters (solvent type, reaction time, temperature and size of particle) which affect extraction of oil from Jatropha seeds were optimized in order to obtain maximum oil from the seeds.

Figure 1: Jatropha Seeds

Resulted optimized conditions obtained at lab conditions were temperature near about 68°C, reaction time of eight hours, solid to solvent ratio (6:1) and hexane was used as solvent . (3) In comparison to petroleum ether better yield was given by Hexane. The data concurred significantly with the second order standards and kinetics parameters hence the kinetics of the extraction was developed based on the theorization of a second order extraction mechanism. (4)(5).

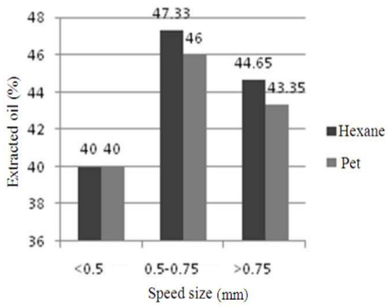

Figure II: Graph showing % of oil extracted from various sized seeds (6).

In another experiment in Egypt, the researchers concluded that for oil extracted from Jatropha seeds Hydrochloric acid, HCl, was more effective than H_2SO_4 and H_3PO_4 in the presence of n– hexane. The optimized result for acid concentration turned out to be at 15%. In extraction process of Jatropha seed oil, the order of kinetics was found to be first when 15% HClcontaing n-hexane was used. The activation energy as per the results calculated was Ea = 26.6763 kJ/mol, and the activation thermodynamic parameters at 60°C were H = 23.908 kJ/mol, S = -239.927 J/mol.K, and G ≠=103.803 kJ/mol. The enthalpy value was H = 0.1586 kJ/mol, and the otherthermodynamic parameters at 60 °C were calculated to be S = 15.275 J/mol.K, and G = -4.928 kJ/mol. H and S was found to be positive, and G was negative concluding that these processes are endoergic, irreversible, and spontaneous. Therefore, it is concluded that usage of hexane in 15% HCl reduced the extraction time and cost as compared to using pure hexane. (7)

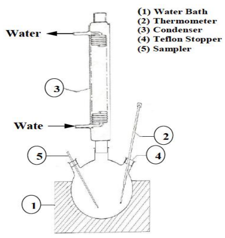

Figure III Extraction Set-up (6)

Synthesis of Bio Diesel

Various methods and techniques were adopted to optimize conditions for production of biodiesel, which could give the maximum yield.

The method that was considered best after various series of experiments was trans-esterification.

1. Preparation by Lipase-Catalyzed Trans-esterification

Out of the three lipases used (*Chromobacterium viscosum*,Porcine pancreas and *Candida rugosa*) for trans-esterification reaction of oil extracted from Jatropha seeds,only one lipase successfully gave the best yield i.e. *Chromobacterium viscosum* . At 40 C, immobilization of lipase on Celite-545 increased biofuel production from 62% to 71% in the time span of 8hours. It was observed that adding water enhanced the yields to 73 and 92%, when added to the free and immobilized enzyme preparations. Immobilized *Chromobacterium viscosum* enzyme lipase thus can be used for transformation of oil. Therefore, it was concluded that adequate amount of bio diesel can be produced by immobilization of lipases in optimized trans-esterification process. (8)

2. Enzymatic production of biodiesel

Feedstock oil and enzyme are mainly associated and responsible for producing an appreciable ratio of biodiesel fuel (BDF). Lipase producing cells of *Rhizopusoryzae* (ROL) were used and immobilized into biomass support particles i.e. as catalyst with a view to reduce tariff concerning BDF yielding, from *Jatrophacurcas* seeds. Comparison was made among commercially available lipases vs ROL's activities. It was observed, that addition of methanol to reaction enhanced the speed of reaction as compared to other alcoholysis regardless of lipases used. It was found that by using Novozym435 in the reaction mixture methyl esters content after 90 hours whereas with ROL, it reached 80 wt. % post 60 hours. However, both lipases yield about 90% after five cycles if used for repeated batches. Results suggested that immobilizing whole-cell ROL on BSP is fruitful for using as biocatalyst for producing biofuel from oil. (9)

Modification Made in Properties of Biodiesel

Catalyzation by Calcium Oxide

Basic strength of calcium oxide (CaO) was found to be greater than 26.5 after dipping in a solution of ammonium carbonate followed by calcining. Reaction was performed to obtain optimize conditions for Jatrophatrans-esterification.

Optimum conditions obtained were: temperature of 900°C for catalyzed calcination, reaction febricity of 70°C, duration 2.5 hours, catalyst %as 1.5%, and methanol in oil was used in the ratio as 9:1 and yield obtained of biodiesel was 93%. Decalcination was explored in order to purify biodiesel and make it calcium free. Best results for decalcination came up with citric acid with yielded refined biodiesel having properties of foreign standards. (10)

Response surface methodology

Response surface methodology, abbreviated as RSM is an analytical and statistical technique used to enhance a variable, which is influenced by many other free in constants. Hinge on CCRD (Central Composite Rotatable Design), the following reaction variables like amount of methanol, concentration of acid and duration of reaction for reduction of Free fatty acids of the oil (<1%) as compared to methanol quantity and time for executing trans-esterification of the previously treated oil. To envision acid content value and trans-esterification, quadratic polynomial equations were obtained using this methodology. Both the predicted models were validated by verification experiments. It was found that optimum condition for scaling down the Free Fatty Acid value of Jatropha oil to about or less than 1% were H_2SO_4acid catalyst content=1.43% v/v, alcohol (methanol)-to-oil ratio to be 0.28 v/v, appropriate duration of reaction was 88mins at 60 °C as compared to taking 0.16 v/v which was taken in previously treated oil. This process gave more than 99% yield on an average, which was appreciable. The product obtained i.e. biodiesel from Jatropha was found to have properties equivalent to that of diesel (conventional), confirming to the American and European standards. (11)

Introduction of Nano sized base catalyst

Hydrotalcite-derived particles i.e. magnesium aluminum hydroxyl carbonate having Mg/Al molar ratio of 3:1 were synthesized by a co-precipitation method (used for magnetic nanoparticles synthesis) using a precipitating agent, urea, eventually with microwave-hydrothermal treatment (MHT), and followed by calcination for 6 hours at a temperature of 773 K≈499.85 °C. These particles were Nano-sized oxides as per calculations from X-ray Diffraction (XRD) data. These nanoparticles were basic in nature and were brought into the reaction procedure as catalyst after pretreatment of oil. With use of this solid basic catalyst, the reactions under different conditions were brought about in Ultrasonic Reactor. Using this catalyst, that can be reused 8 times, attained the maximum production (95.2%), moreover its properties were close to those of the German standard. (12)(13)

Table-I. Jatropha vegetable oil characteristic

Properties	Values
Moisture % weight	0.0326
Ramsbottom Carbon Residue	0.22
Viscosity (cSt)	34.5
Sulfur Content %	0.0094
Gross Calorific Value (kJ/g)	46.024
Acidity	2.19
Density (kg / m^3)	935.0

Properties	B5	B10	B100
Moisture % weight	0.0441	0.079	0.2765
Cetane Number	45.8	45.6	43.3
Ramsbottom Carbon Residue	0.08	0.12	0.39
Flash Point (°C)	51	52	100
Pour Point (°C)	0	3	-3
Viscosity (cSt)	3.43	3.61	9.02
Corrosive Corrosion	1a	1a	1a
Sulfur Content %	0.0929	0.0887	0.0170
Gross Calorific Value (kJ/g)	45.434	45.409	44.844
Acidity	0.48	0.66	0.75
Initial Boiling Point/Final Boiling Point °C	141/372	142/373	290/350
Density (kg/m$^{3)}$	855.2	858.2	898.1
Lubricity (mm)	174	176	185

CONCLUSIONS

Certain tests carried out by experimentalists gave the following results given in Table 1. After combining results of various experiments published in many articles, the following observation was made regarding characteristics of JME (Jatropha methyl ester).

Studies on biodiesel are of uttermost importance for an emerging country like ours as when biodiesel blend becomes economically viable, it would mean saving trillions of rupees. A boundless repository of information on all aspects of biodiesel is accessible which make room for diverse feedstock, its characteristics, production practice, as well as execution of alternative diesel in various engines. (14) Now it has been universally accepted that biodiesel is an inexhaustible and biodegradable fuel, which is alternative and suitable for Compression-Ignition engines.

It significantly reduces the emissions of CO, HC and particulate matter. Although specific fuel consumption of biodiesel is slightly greater than petrol due to its lower heating capacity and higher density. In many countries, various blends and virgin biodiesel is on front burner.

Standard quality of biodiesel is available now. B5, B20 and B100 blends have been used in few countries like France, USA, Austria and Germany. In many other countries, environmentally susceptible areas such as schools, hospitals, etc. have been marked first for endorsement of biodiesel. Many countries offer regional tax exemption and incentives for usage of biodiesel. Through research, enactment of finer feedstock, surpassing productivity and better technology, cost is fated to get reduced to attain analogy with conventional diesel.

Keeping in view of growing consumption of diesel (near about 50 m-tones/year in India) and environmental concerns, it is the need of hour to make out all possible efforts to not only produce but also to use appropriate blends of biodiesels in India. The country has about 130 m-ha of degraded lands. Presently, the most encouraging feedstocks are Jatropha, Karangia, Mahuva, etc. Although, in future, other feedstock including 'used frying oil' need to be considered for usage at large scale. In states like Punjab and Haryana provision of incentives and finance support to the farmers to enhance productivity of oil seeds and use these crops has been opted. The dream of paving the way in the second green revolution can be realized only when adequate sum of energy for production and post-production is accessible on the farm.(15)

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