Influence of Alkali Catalysts on the Production and Quality of Jatropha Oil Methyl Ester: A Review

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Abstract: **World's economy depends entirely on fossil fuels which are not only rapidly depleting but are also causing environmental degradation. Therefore, in order to replace fossil fuels partially, non-edible vegetable oils (Jatropha, Karanja, Mahua, Cottonseed, Neem, Linseed, Rice bran etc.) may be used for the production of Methyl ester. The yield of the Methyl ester mainly depends on the catalyst used in the transesterification reaction. The present study reports a review on the influence of alkali catalysts such as Potassium hydroxide (KOH), Sodium hydroxide (NaOH), Sodium amide ($NaNH_2$), Magnesium zinc (Mg-Zn), Calcium oxide-Magnesium oxide (CaO-MgO) and Lemna Perpusilla Torrrey Ash on the production yield of Jatropha Methyl ester. This paper also discussed the influence of processing parameters, such as temperature, molar ratio, catalyst % wt., on the quantity and quality of the Jatropha Methyl ester. It was observed that, the KOH very effective than other catalysts and the yield of ester production is 99% at 60 ^{o}C, with a molar ratio 5:1 and 2% wt, as reported in published work. Based on the review, the present authors produced 95% yield of Jatropha Methyl ester using 1% wt. of KOH catalyst, with molar ratio of 9:1 and a reaction temperature of 60 ^{o}C. The fuel properties of different catalysts are also studied and it was observed that, the present sample is meeting the ASTM D 6751 specifications.**

Keywords: **Jatropha Curcas, Methanol, Methyl ester, Transesterification.**

I. INTRODUCTION

Increasing the usage of fossil fuels in day to day life is affecting the environment and causes greenhouse gas emissions resulting in global warming which directly affects the human lives through climate changes [1] and high oil prices and rapid economic growth has led to many efforts being done to establish sustainable development programs and support national researchers in renewable energy such as biofuel, solar, wind etc. The edible oil as generation feedstock due to the biodiesel yield and easy processing with low free fatty acid content [2,3,4,5]. This situation calls for a search for alternative fuels like biodiesel that can be produced from renewable biomass feedstock [6]. Biodiesel, defined as mixture of mono alkyl esters produced from vegetable oils or animal fats, can offer alternative to petroleum diesel **[7].** The consumption of edible oil in India is very high and still the indigenous production does not cope with the consumption and hence considerable amount is imported. There is very little chance of using edible oils for biodiesel production to ensure food security aspect, so there is scope for the non-edible oil resources which can be feedstock for Methyl ester production. There can be grown on waste/semi arid lands under National Biodiesel Programmers of Govt. of India and potential availability of non-edible oils in India is about 1 million ton per year. Jatropha, Karanja, Mahua, Cottonseed, Neem, Linseed, Rice bran etc. been identified as non-edible oil resources, which also includes lot of waste cooking oil obtaining from fast food centers and restaurants in India, will be available for conversion to Methyl ester. Out of the above resources, *Jatropha Curcas* has been considered for present study. The feasibility **o**f non-edible oil especially *Jatropha Curcas* is economical compare to edible oil feedstock [8,9,10,11]. Jatropha oil contain about 14% free fatty acid (FFA), which is far beyond the limit of 1% FFA level that can be converted into biodiesel by transesterification using different alkaline catalyst. Hence by using different alkali catalyst procedure for converting Jatropha oil, which contains high FFA% into Methyl ester, is very much required [12,13,14].This procedure gives different yield for different alkali catalyst.

This paper discusses the outcomes of the experiments carried out by using different alkali catalysts with process variables (Temperature, Molar ratio, % of catalyst, reaction time) effecting the quality and quantity of *Jatropha Curcas* Methyl ester by transesterification reaction to suggest the best alkali catalyst and obtaining corresponding yield of *Jatropha Curcas* Methyl ester.

II. JATROPHA CURCAS

The *Jatropha Curcas* as second generation feedstock has been promising to substitute petrol diesel due to the availability, sustainability and lower feedstock price in the market [15,16]. The name Jatropha is derived from latin words Jatros (doctor) and trophe (food) as it has many medicinal values. *Jatropha Curcas* is a small tree or large shrub up to 5-7m tall belonging to the Euphorbiaceace family. The Jatropha plants have average life span up to 50 years. The fruit is a kernel which contains three seeds each. Depending upon the variety, the oil content of decorticated seed ranges from 30 to 50 % by weight and kernel ranges from 45 to 60 % [3,8]**.** The pictures of *Jatropha Curcas* pods and Seeds as shown in Figure 1

(a) Jatropha Curcas pods (b) seeds

Figure 1. Pictures of Jatropha Curcas

III. METHODS OF EXTRACTION OF OIL

Oil can be extracted from the Jatropha seed by using any one of the extraction methods as discussed in the Table 1. They are: 1. Solvent extraction, 2. Mechanical extraction and 3. Super critical extraction. Mechanical press and solvent extraction are the most commonly used method for commercial oil extraction. The seeds can be dried in oven at 105 ^{0}C or open sun before extraction, has moisture content has a significant effect on oil yields. Mechanical expellers or press can be fed either with whole seeds with kernels or mixture of both, but the whole seeds are normally preferred. For chemical extraction only kernels are used [9]. Crude Jatropha Curcas oil properties and its fatty acid composition are tabulated in Table 2 and Table 3.

Table 1. Extraction methods

Extraction method	Basic Principle	Merits	Demerits	% of oil recovery
Solvent extraction	Organic solvents (like benzene, cyclohexane, hexane, acetone and chloroform) mixed with finely powdered seeds/ micro algal biomass, used to extract the oil	Solvents used are relatively inexpensive and can be recycled	The solvents are mostly flammable and toxic and required in large quantities	60–70
Mechanical press	The seeds is pressed under high pressure to release the oil	Easy to use with no need of solvent	Large quantities of seeds is required with slow rate of oil recovery	70–75
Supercritical fluid Extraction	There are two principles of extraction: (i) Based on the solvating power, the solvent is raised above its critical temperature and pressure (ii) Produces highly purified extracts free from potentially harmful solvent residues	Non-toxic solvent, non- flammable and simple in operation	(i) Highly energy intensive (ii) Difficult to scale up	100

Table 2. Properties of crude Jatropha Curcas oil [19]

Property	Value
Cetane Number	45
Density@ 15 °C	0.92 g/cm^3
Calorific Value	39.66 MJ/kg
Flash Point	240 °C
Pour Point	8 °C
Viscosity @ 40°C	49.5 mm^2/s
Carbon Residue	0.44 %
Iodine Value	93 g of I_2 /100g
Water content	822 mg/kg
Acid Value	2.81 mg of KOH/g

Table 3. Fatty acid composition of crude Jatropha oil [18]

Fatty Acid	Acronym	Amount %
Lauric acid	12:0	0.31
Palmitic acid	16:0	13.38
Patmitoleic acid	16:1	0.88
Stearic acid	18:0	5.44
Oleic acid	18:1	45.79
Linoleic acid	18:2	32.27
Others	------	1.93
Total		100.00

IV. PRODUCTION OF JATROPHA CURCAS METHYL ESTER

The crude Jatropha Curcas oil has high free fatty acids (FFA) contents (>1%) and unsuccessful to convert Jatropha Methyl ester directly using alkaline catalyzed transesterification process. This is due to the emulsification (FFA can react with alkali catalyst to form soap) which leads to gel formation and increases the viscosity of Jatropha Curcas Methyl ester. Therefore, two step transesterification process is one of the best and efficient methods that has been used to transesterify crude Jatropha Curcas oil that contains high FFA. Acid catalysed step is often chosen when high FFA content present in the oil. The role of acid catalyst is used to reduce the amount of FFA content to less than 1% in esterification reaction (first step). Alkaline catalyst is used to transesterify the triglycerides in Jatropha Curcas oil into Jatropha Curcas Methyl ester (ME) in transesterification (second step). The flow chart is of the process is shown in Figure 2.The advantage of using this process is that to overcome the problems of slow reaction rate with acid catalyst and eliminate the soap formation by using alkaline catalyst [17].

4.1 Chemicals Required

Methanol, Sulphuric acid (H_2SO_4) and Potassium hydroxide (KOH).

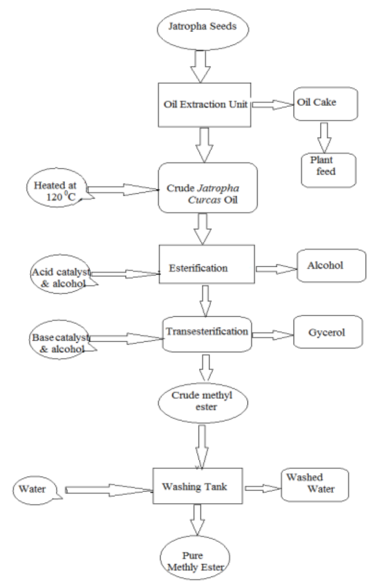


Fig.2 Flow chart for *Jatropha Curcas* Methyl ester production

4.2 Pre treatment process

The Crude Jatropha Curcas oil is taken and 10% of H_3PO_4 to remove FFA (<0.2mg KOH/g) oil, water (<0.1%), phospholipids (<0.04%) and other impurities. This was done to improve the quality of oil before first step. The preheated oil is as shown in Figure 3.

Figure 3. Preheated oil

4.3 Acid catalyzed Esterification

The free fatty acids can be reduced to esters by two processes viz. hydrolysis, methanol with acid catalyst. Generally sulphuric acid, hydrochloric acid, ferric sulphate and phosphoric acid have been used to reduce acid value for high free fatty acids[15]. In this process acid catalyst H_2SO_4 is used for esterification with 9:1 molar ratio of methanol. The refined and moisture free oil was poured into the reactor and heated at temperature 60 ^{0}C to optimize the temperature for maximum yield and maximum FFA reduction. The mixture of concentrated H_2SO_4 and 1% v/v with methanol ratio 9:1 was separately heated at same temperature 60 ^{0}C and then added to heated oil in the reactor. The mixture was heated at that temperature for 2 hours to complete the esterification. After acid-catalyzed step, the mixture was cooled and allowed to settle overnight. This mixture was finally subjected to base catalyzed reaction.

4.4 Base catalyzed transesterification

The esterified oil was poured into the reactor and heated at temperature 60 ^{0}C and mixture of 1% w/w KOH catalyst in methanol 9:1 molar ratio was heated for 5 min and added slowly to the heated oil.the reaction mixture was heated and stirred for about 2 hours. After 2 hours, two distinct layers were formed and the mixture was allowed to settle overnight. The heavier glycerol layer was separated from the lighter Methyl ester layer by separating funnel. Finally the Jatropha Curcas Methyl ester is produced as shown in Figure 4.

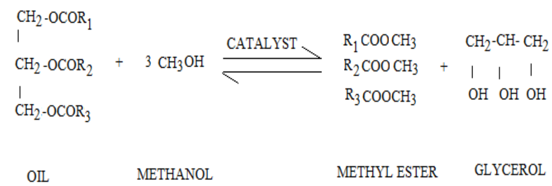
Figure 4. Jatropha Curcas Methyl ester

4.4.1 Transesterification process

Transesterification of triglycerides produce fatty acid alkyl esters and glycerol as shown in Figure 5. The glycerol layer settles down at the bottom of the reaction vessel. Though esters are the desired products of transesterification reactions, glycerin recovery is also important due to its numerous applications in daily products[20]. The overall transesterification reaction is given by three consecutive and reversible equations as shown below. Diglycerides and monoglycerides are the intermediates in this process.

Triglyceride (TG) + ROH ↔ Diglyceride (DG) + $RCOOR_1$

Diglyceride (DG) + ROH ↔ Monoglyceride (MG) +$RCOOR_2$ Monoglyceride (MG) + ROH ↔ Glycerol +$RCOOR_3$



Where R_1, R_2, R_3 are hydrophobic rest of acids

Figure 5. Chemical reaction of transesterification

This step wise reactions are reversible and a little excess of alcohol is used to shift the equilibrium towards the formation of esters. In presence of excess alcohol, the forward reaction is pseudo-first order and the reverse reaction is found to be second order. It was also observed that transesterification is faster when catalyzed by alkali [21].

V. EFFECT OF ALKALI CATALYSTS IN THE PRODUCTION OF JATROPHA CURCAS METHYL ESTER

5.1 Lemna perpusilla Torrey Ash Catalyst

Lemna perpusilla Torrey is a very small aquatic weed which grows naturally in the water surface of ponds and other water accumulating bodies throughout India and most parts of Asia and Latin America. The Lemna perpusilla Torrey plants (about 3 months old) required for this study were collected from a pond of depth 1.1 m located in Sipajhar (Longitude 91.88 E, Latitude 26.40 N) Assam, India using specially made thread net. These were dried in open sunlight for three days to remove the initial moisture and were stored in polyethylene bags. Further, these were carried to the laboratory and dried in an oven at 50 ^{0}C for 72 hours. The moisture content was determined from the green sample and found to be 95.5% of the original mass. After complete drying these were burnt in open air to produce ash. These ashes were further calcined in a furnace at 550 ± 5 ^{0}C temperature for 2 hours. After the calcinations these ashes were stored as catalyst in corked glass vessel. Catalyst surface area, pore size and pore volume were measured using the BET surface area analyser. It is suitable due to the non-corrosive, environmentally benign and present fewer disposal problems. It can be easily separated from the biodiesel prepared from the refined *Jatropha Curcas* oil. *Jatropha Curcas* Methyl ester is produced using Lemna perpusilla Torrey ash (5%) with 9:1 molar ratio at 65± 5 ^{0}C in 5 hours which gives 89.43% of yield. The catalyst could be reused upto 3-times but there is a reduction of efficacy by about 25% for 3rd consecutive batch reaction [22].

5.2 Calcium and Magnesium oxide (CaO–MgO) mixed alkali Catalyst

Calcium oxide and Magnesium oxide are known metals. The preparation of catalyst by co-precipitation method is a mixture of required amounts of $Ca(NO_3)_2 \cdot 4H_2O$ and $Mg(NO_3)_2 \cdot 6H_2O$ were dissolved in de-ionized water. The two precursor solutions were mixed homogeneously and allowed to precipitate using a basic solution of NaOH and Na_2CO_3 at a constant pH of 10. After completion of precipitation, it was filtered and washed with water thoroughly. The resultant catalyst mass was dried at 100 °C for overnight and calcined at 800 °C for 6 hours. Production of Jatropha Methyl ester achieved an optimum level of 93.55% biodiesel yield at the following reaction conditions with methanol/oil molar ratio is 38.67:1, reaction time is 3 hours and 44 minutes, catalyst amount is 3.70 wt.%, and reaction temperature of 115.87 °C and the yield of 93.55% is reported [23].

5.3 Aluminium modified Magnesium-Zinc oxide Catalyst (MgZnAlO)

MgZnAlO modified catalyst was prepared by co-precipitation using the nitrate of the metals. Based on 20g of salt, 50 ml of mixed salt solution containing 0.66 M of $Zn(NO_3)_2 \cdot 6H_2O$, 0.41 M of $Mg(NO_3)_2 \cdot 6H_2O$ and 0.27 M of $Al(NO_3)_3 \cdot 9\ H_2O$ were prepared and placed in a 250 ml conical flask continuously stirred at 800 rpm with magnetic stirrer. The metals were precipitated using 9.61 ml NH_4OH equivalent to 5 M solution. The mixture was aged to 80 ^{0}C under this condition for 6 hour until complete homogenized milky solution was obtained. Basic strength was determined by the indicator method which gives a value of 8-9. This was maintained throughout all the catalyst preparation. The solution was filtered and gradually dried initially at oven temperature of 70 ^{0}C for 8 hours for ease of handling from the filter paper into a glass dish. Thereafter, the catalyst was dried at 100 ^{0}C for 6 hours. This was followed by thermal treatment at 461 ^{0}C for 4 hours 25 minutes.

The transesterification reaction with methanol to Methyl ester yielded 94% in 6 hours with methanol–oil ratio of 11:1, catalyst loading of 8.68 wt.% at 182 °C. In the range of experimental parameters investigated, it showed that the catalyst is selective to production of Methyl ester from oil with high free fatty acid [24].

5.4 Sodium amide ($NaNH_2$) Catalyst

Its molecular formula is $NaNH_2$. The cost of $NaNH_2$ is higher than that of NaOH, the main merit of $NaNH_2$ is its excellent base and it rarely serves as nucleophile. $NaNH_2$ was used to reduce both reaction time and by-products. It is widely used in industries and it can be recycled easily.

The highest Jatropha Methyl ester yield produced by conventional heating system process was 95.6% when 1 wt% of a $NaNH_2$ catalyst, a methanol to oil molar ratio of 8:1, a reaction time of 90 minutes, and at temperature of 65 ^{0}C [25].

5.5 Sodium hydroxide (NaOH) Catalyst

Also known as caustic soda is an inorganic compound with molecular formula NaOH. It is a white solid and highly caustic metallic base and alkali salt which is available in pellets, flakes, granules, and as prepared solutions at a number of different concentrations. Sodium hydroxide is solublein water, ethanol and methanol. This alkali is deliquescent and readily absorbs moisture and carbon dioxide in the air. It is also economical due to low priced. Esterification was performed using acid catalyst (5% H_2SO_4) and methanol (20% of oil) while, transesterification reaction was carried out for 2 hours keeping molar ratio of methanol to oil at 6:1 and Sodium hydroxide concentration of 0.7 weight percentage of oil and obtained yield is 97% [26].

5.6 Potassium hydroxide (KOH) Catalyst

This colorless solid is a prototypical strong base with molecular formula KOH. It has many industrial applications; most applications exploit its reactivity towards acids and its corrosive nature. Even at high temperatures, solid KOH does not dehydrate readily. This is reliably cheap.

Transesterification reaction with methanol (0.16 v/v) to produce Methyl ester in 24 minutes of a reaction at a temperature of 65 ^{0}C with 2 wt% KOH gave a yield of *Jatropha Curcas* Methyl ester above 99% [27].

5.7 Present study

From the above literature KOH as alkali catalyst produced higher yield compared to other catalysts for the production of *Jatropha Curcas* Methyl ester. So, in the present study KOH is used as alkali catalyst transesterification was carried out for 2 hours at a temperature of 60 ^{0}C with 9:1 molar ratio and the obtained yield was 95 % .

VI. EFFECT OF DIFFERENT PARAMETERS ON PRODUCTION OF METHYL ESTER

The most important variables that influence the transesterification reaction are as follows

6.1 Reaction temperature

The rate of reaction is strongly influenced by the reaction temperature. However, given enough time, the reaction will proceed to near completion even at room temperature. Generally, the reaction is conducted close to the boiling point of alcohol at atmospheric pressure. These mild reaction conditions require the removal of free fatty acids from the oil by refining or pre-esterification. Further increase in temperature is reported to have a negative effect on the conversion. The rate of reaction is strongly influenced by the reaction temperature. Further increase in temperature is reported to have a negative effect on the conversion. Literature Studies have indicated in Table 4 that given enough time, transesterification can proceed satisfactorily at ambient temperatures in the case of the different alkaline catalyst [28].

6.2 Ratio of Alcohol to Oil

Another important variable affecting the yield of ester is the molar ratio of alcohol to oil. The stoichiometry of the transesterification reaction requires 3 mol of alcohol per mole of triglyceride to yield 3 mol of fatty esters and 1 mol of glycerol. To shift the transesterification reaction to the right, it is necessary to use either a large excess of alcohol or to remove one of the products from the reaction mixture. When 100% excess alcohol is used, the reaction rate is at its highest. Higher molar ratio of alcohol to oil interferes in the separation of glycerol. With higher molar ratios, conversion increased but recovery decreased due to poor separation of glycerol. It was found that optimum molar ratios depend upon type & quality of oil [29]. Depends up on the alkali catalyst the molar ratio varies from one catalyst to the other catalysts as shown in Table 4.

6.3 Catalyst Type and Concentration

Alkali metal alkoxides are the most effective transesterification catalyst compared to the acidic catalyst. Trans methylations occurs approximately 4000 times faster in the presence of an alkaline catalyst than those catalyzed by the same amount of acidic catalyst. Partly for this reason and partly because alkaline catalysts are less corrosive to industrial equipment than acidic catalysts, most commercial transesterification are conducted with alkaline catalysts. Further, increase in catalyst concentration does not increase the conversion and it adds to extra costs because it is necessary to remove it from the reaction medium at the end. It was observed in literature studies higher amounts of KOH catalyst were required for higher FFA oil [30]. Potassium hydroxide (KOH) is the most efficient catalyst compared to other catalysts in Table 4.

VII. CHARACTERISTICS OF JATROPHA CURCAS METHYL ESTER

7.1 Density

Density influences the efficiency of the fuel atomization for airless combustion system [31]. It has some effect on the break-up of fuel injected into the cylinder. In addition, more fuel is injected by mass as the fuel density increases. All Methyl esters are derived from same feedstock *Jatropha Curcas* oil are less compressible. According to ASTM standards density should be 870 to 890 kg/m^3 and all are within the range as shown in Table 5.

7.2 Kinematic viscosity

It is defined as the resistance of liquid to flow and is the most important fuel features. This factor affects the operation of fuel injection, blending formation and combustion process. The high viscosity interferes with the injection process and leads to insufficient atomization [32]. According to ASTM standards kinematic viscosity should lie between 1.9-6.0 mm^2/s and are compared to Methyl ester which are produced from different alkaline catalyst as shown in Table 5 which are in within the range.

Table 4. Comparison of Jatropha Curcas Methyl ester yields using different alkali catalysts

Sample No	Type of Catalyst	Catalyst amount(wt% of oil)	Type of Alcohol	Molar ratio(Alcohol: Oil)	Reaction Temperature(^{0}C)	Yield of Methyl Ester(%)	Reference
S_1	Lemna perpusilla Torrey ash	1	Methanol	9:1	65	89.43	Chouhan and Sarma 2013
S_2	CaO-MgO	3.7	Methanol	38:1	115	93.55	Lee et al.,2011
S_3	Mg-Zn	8.64	Methanol	11:1	182	94	Olutoye and

							Hameed 2011
S_4	Sodium amide	1	Methanol	8:1	65	95.6	Lin et al., 2014
S_5	NaOH	0.7	Methanol	6:1	65	97	Singh and Saroj Padhi 2009
S_6	KOH	2	Methanol	5:1	60	99	Tiwari et al., 2007
S_7	KOH	1	Methanol	9:1	60	95	Present Study

7.3 Flash point

It is the minimum temperature of the fuel at which the fuel gives flash when it comes to contact with testing flame. It is an important parameter from the safety point of view such as safe for transport, handling, storage purpose and safety of any fuels [33]. According to ASTM standards Methyl ester have a flash Point not greater than 130 ^{0}C. This is higher than petrol diesel which has flash point of 71 ^{0}C. This higher flash point probably due to *Jatropha Curcas* Methyl ester has less volatile impurities which are an important fuel feature for an engine's starting and warning. A fuel with high flash point may cause carbon deposits in the combustion chamber. It is observed that in Table 5. *Jatropha Curcas* Methyl ester produced from Lemna perpusilla Torrey ash as catalyst has flash point 108 ^{0}C [22].

7.4 Cetane number

Measure of the ignition quality of diesel fuel; higher this number, the easier it is to start a standard (direct-injection) diesel engine. It denotes the percentage (by volume) of cetane (chemical name Hexadecane) in a combustible mixture (containing cetane and 1-Methylnapthalene) whose ignition characteristics match those of the diesel fuel being tested.

7.5 Lower Calorific value

It is a measure of the energy produced when the fuel is burnt completely which also determines the suitability of Methyl ester as an alternative to diesel fuel. The calorific value of Methyl ester is normally lower than diesel due to oxygen content of Methyl ester. The ASTM standard value is 37,318 kJ/kg. From the Table 5 it was noted that calorific value is high for KOH producing Methyl ester [27].

7.6 Molecular weight

The average molecular weight of the Jatropha biodiesel is calculated by considering the weight percent of each fatty acid and their corresponding molecular weights. The Table 5, shows the molecular weight of *Jatropha Curcas* Methyl ester which satisfies the standards.

7.7 Iodine value

Iodine value or iodine number is defined as the number of grams of iodine taken up by 100 g of oil or fat. In this case, addition reaction takes place across the double bonds of unsaturated fatty acids present in the fat by the addition of a halogen, such as iodine. Thus, the iodine number gives the indication of the degree of unsaturation of fats. The average number of double bonds can then be calculated from the halogen consumption, the double bonds in oil sample are halogenated using Wij's solution (iodine monochloride). Excess iodine monochloride is reduced to free iodine in the presence of Potassium iodide. The amount of free iodine is then determined by titrating the solution with Sodium thiosulphate using starch as indicator.

Table 5. Comparison of Fuel properties of Jatropha Curcas Methyl ester

Property	Jatropha Methyl Ester (Chouhan And Sarma 2013) S_1	Jatropha Methyl Ester (Lee et al., 2011)S_2	Jatropha Methyl Ester (Olutoye And Hameed 2011) S_4	Jatropha Methyl Ester (Singh and Saroj Padhi 2009) S_5	Jatropha Methyl Ester (Tiwari et al., 2007) S_6	Jatropha Methyl Ester (Present study) S_7	ASTM (D 6751)
Carbon Chain	C_{14}-C_{20}	C_{14}-C_{22}	C_{14}-C_{22}	C_{14}-C_{22}	C_{14}-C_{20}	C_{14}-C_{24}	C_{12}-C_{22}
Density (kg/m	891	914	879	880	880	880	870-890
Kinematic Viscosity @ 40^0C (cSt)	6.8	5.4	3.2-4.6	4.84	4.80 @15^0c	5.2	1.9-6.0
Flash point (^{0}C	108	235	140-180	162	135	165	130 min.
Cetane Numbe	--	46.3	---	51.6	---	54	48-70
Calorific Valu (kJ/kg)	37,100	---	---	37,200	39,230	39,000	37,518
Molecular Weight	277	281	---	---	277	283	292

VIII. CONCLUSION

The influence of alkali catalysts on the production and quality of Jatropha methyl ester. It was observed that, the catalyst (KOH) is produced highest yield (99%) at a molar ratio of 5:1 with 2% wt. catalyst at 60 ^{o}C. This work also discussed the influence of process parameters on quality and quantity of methyl ester production from *Jatropha curcas*. Based on the information available in the literature, the authors conducted experiments in their laboratory and able to produce 95% yield from *Jatropha curcas* oil, at 9:1 molar ratio with 1% wt. catalyst at 60 ^{o}C and it is meeting the ASTM standard specifications and suitable for direct usage in diesel engines.

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