Extraction and Production of Biodiesel from Jatropha Curcas Seed Oil

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Abstract—Jatropha curcas is an agricultural product with a variety of applications and enormous economic potentials for its seed oil. It contains high amount of oil in its seeds which can be converted to biodiesel- an alternative to petro-diesel. In this study, extraction of oil from Jatropha seeds using n-haxane and production of biodiesel from the oil was performed. The physicochemical characteristics of the oil extracted gave oil yield 42.19%, density 880kg/m^3, iodine value 121.82 gI_2/100g, acid value 1.178 mgKOH/g, free fatty acid value 0.59 mgKOH/g and saponification value 84.15 mgKOH/g. The result obtained from the biodiesel showed that the properties determined closely conformed with biodiesel standard. This indicate that the oil can be used as a source of energy.

Key Words — Extraction, Oil, Characterization, Biodiesel

1 Introduction

Jatropha Curcas seed have attracted considerable attention as a possible renewable energy source of a substitute for petroleum base diesel. Jatropha Curcas seed are well known for their high oil contain. The proximate analysis of Jatropha seeds revealed that the percentage of crude protein, crude fat and moisture were 24.60, 47.25 and 5.54% respectively [1]. The seeds of the Jatropha contain 30 - 40% oil that can be easily expressed for processing (transesterification) and refinement to produce biodiesel [1], [2], [3].

The fact that the oil of Jatropha Curcas cannot be used for nutritional purposes without detoxification makes its use as an energy source for fuel production very attractive. The by-products of the biodiesel processing plant are nitrogen-rich press cake and glycerol, which are said to have good commercial value as fertiliser and as a base for soap and cosmetics, respectively.

Jatropha Curcas is traditionally used for medicines and as hedges to protect fields and gardens since animals do not eat it [2], [4], [5], [6]. The leaves, root and bark also have potential for numerous other industrial and pharmaceutical uses. A number of enzymes such as protease, lipase and esterase with good properties for use in biotechnology have also been extracted and purified from Jatropha Curcas [7].

Transesterification is the process of converting vegetable oil to its corresponding fatty esters and thus biodiesel. For several years, the transesterification of vegetable oil to form esters, most especially methyl ester, has been greatly considered. Transesterification of vegetable oil by chemical catalysis have been extensively investigated and processes were also patented by many workers [8], [9]. Biodiesel is a methyl or ethyl ester of fatty acid made from renewable biological resources such as vegetable oils (both edible and non-edible), recycled waste vegetable oil and animal fats [10], [11], [12].

Molar ratio of alcohol, oil, catalyst concentration, purity of reactants as well as reaction time and temperature are some of the agents that could affect the rate of transesterification and biodiesel yield. In biodiesel production a temperature ranging between 45°C and 65°C have been tested with desirable result obtained under some restrictions at 50°C and 60°C respectively optimal alcohol to oil molar ratios of 5:1 [13], the type and concentration of catalysts employed are also important.

This research work focused on extraction of oil and production of biodiesel from Jatropha seed considering its abundance in Nigeria. The oil and the produced biodiesel were

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also characterized for physical and chemical properties.

2. Materials and Methods

2.1 Sample collection and preparation

Jatropha Curcas seed were collected from Jatropha Curcas plant in Vel town, Pankshin Local Government Area of Plateau State, Nigeria. The seeds were sun dried, cracked and the shell carefully removed. The kernel from the seeds were pulverized.

2.2 Extraction of oil

200 g of the pulverized sample was wrapped in a filter cloth and inserted into a soxhlet extractor. 200 mL of N-haxane was poured into a round bottom flasks attached to the lower part of the soxhlet extractor, and heated at a constant temperature of 20^{o}C. The extraction process was carried out for 8 hours and thereafter the N-hexane was recovered using the soxhlet extractor. The oil extracted was then placed in a water bath to evaporate the water and remaining N-hexane molecule present in the oil extracted [14]. The oil was then cooled, transferred to a plastic bottled and sealed. The extraction was done twice due to the size of the soxhlet extractor, and each extraction of 100 g of the sample 50 mL of oil was extracted. The oil obtained was weighed and the percentage oil content was calculated. The extracted oil partly was characterized and partly used for the production of biodiesel.

2.3 Transesterification reaction

0.25 g of KOH was mixed with 250 mL of methanol and mixed with a magnetic stirrer for 3 mins to ensure a homogenous mixture. 50 ml of the oil was then pre-heated and place on a magnetic stirrer. The mixture KOH and CH_4OH was then poured into the beaker containing 50 g of oil making it at the ratio 5:1 of methanol to oil which gives a golden colour, and was heated for 1 hour while stirring at a speed of 700 rpm also at the temperature of 60^{o}C. The mixture is then poured in a separating funnel and left over. Two layers were formed; the upper layer consist mainly of the methyl ester, whereas the lower layer consist of glycerol. The methyl ester containing layer was separated and analysed.

2.4 Physicochemical Analysis of oil and biodiesel

The extracted oil was characterized for density, iodine value, acid value, saponification value and percentage yield while the biodiesel was analyzed for viscosity, cloud and pour points, free fatty acid, flash point and density. The physicochemical analysis of the oil and biodiesel obtained from Jatropha Curcas seed oil was carried according to ASTM methods.

3. Results and Discussion

The physicochemical characteristics of Jatropha Curcas seed oil and biodiesel determined are shown in Tables 1 and 2 respectively. Table 3 shows standard specifications of Jatropha oil, biodiesel and petrol diesel.

Table 1: Physicochemical properties of Jatropha Curcas seed oil

Parameter	Values
Yield (wt. %)	43.5
Density (kg/m^3)	880
Iodine value (gI_2/100g)	121.824
Acid value (mgKOH/g)	1.178
Free fatty acid (wt.%)	0.589
Saponification value (mgKOH/g)	84.15

From Table 1, the various properties of the Jatropha oil used are within range of the standard as shown in Table 3. The percentage oil yield of Jatropha curcas seed oil determined was 43.5% (wt.%) closely agreed with the yield (42.19 wt.%) [15]. Similarly, the oil content of Jatropha curcas seeds oil in the present studies slightly exceeded the range of some conventional oil seed crops such as, and mustard (24.0-40.0%), soybean (17.0 – 21.0%), safflower (25.0 – 40.0%) and (15.0 – 24.0%) for cotton [16]. Therefore, the relative high oil yield of Jatropha curcas seed oil shows it wide potential in industrial applications.

The iodine value is a measure of the average amount of unsaturation in fats and oils. It is expressed in terms of the number of grams of iodine absorbed per 100 grams of oil sample. The iodine value obtained was 121.82 gI_2/100g (Table 1) and is relatively high compared standard values of 95-107 gI_2/100g [17]. The high iodine value could be due to high content of unsaturated fatty acids and therefore, the oil may be useful in oil paints manufacture and as a dietary supplement [15].

Acid value was 1.178 mgKOH/g and agreed with 1.20 ± 0.065 mgKOH/g reported for Jatropha seed oil [18]. This value indicates a maximum purity and made it suitable for soap production. It is also within acceptable value of 4.0 mgKOH/g for edible oils as recommended by Codex Alimentarus Commission for ground nut but only when it is detoxify [19].

Free fatty acid was 0.59 wt. % and lower than the value (1.8 wt.%) for variety Nigeria (light yellow) reported by Parawira, 2010. The relative low the free fatty acid obtained indicates that the oil may have low deteriorating rate and high edibility [15]. Similarly, the saponification value determined was 84.15mgKOH/g and is lower than the standard specification 188-198 mgKOH/g (Table 3). This shows that the oil is of lower molecular weight and this property is very important because if it is too high the formation of soap will be more prevalent instead of the desired biodiesel [20].

Table 2: Fuel Properties of Jatropha biodiesel

Properties	Jatropha biodiesel
Density (kg/m^3)	831
Viscosity (mm^{2}s^{-1})	2.73
Cloud point (^{o}C)	2
Pour point (^{o}C)	-12
Free fatty acid (wt. %)	0.14
Flash point (^{o}C)	105

Table 3: Standard Specifications of Jatropha Curcas and Petrol diesel

Property	Jatropha oil	Jatropha biodiesel	ASTM Biodiesel Standard	Petrol diesel
Density (kg/m^3)	940	880	-	850
Viscosity (mm^{2}s^{-1})	24.5	4.8	1.9-6.0	2.6
Iodine value (gI$_2$/100g)	90.8-112.5	-	-	-
Acid value (mgKOH/g)	28.0	0.4	<0.8	-
Saponification value (mgKOH/g)	188-198	-	-	-
Pour point (^{o}C)	4	2	-2	-28
Flash point (^{o}C)	225	135	>130	68

The fuel properties of Jatropha biodiesel are summarised in Table 2. Jatropha biodiesel has comparable properties that similar to the ASTM standards for biodiesel. The density of a fuel is an important factor for good engine performance; the higher the density, the more difficult it becomes to pump the fuel. The density of the biodiesel produced is 831kg/m^3; this is well within the range of the standard. Similarly, the high viscosity of vegetable oils leads to problems in pumping and spray characteristics when used in combustion engines. The best way to use the vegetable oils as fuel in compression ignition engines is to convert it into biodiesel.

The pour point of the biodiesel produced is higher than that of the petrol diesel. The pour point is the temperature below which the fuel will not flow. As a result of this higher value, the performance of the biodiesel in cold conditions will be worse than that of petroleum diesel [20]. Another important characteristics of any fuel is its flash point; this is defined as the lowest temperature at which it can vaporize to form an ignitable mixture in air. The biodiesel has a higher flash point of 105^{o}C as compared to that of the petrol diesel (flash point of 68^{o}C). This makes the biodiesel sample safe for use and storage. Also, fuels with lower flash point tend to ignite at lower temperature making it highly dangerous if it is not stored and used properly. Biodiesel can be blended in various proportions with fossil diesel to create a biodiesel blend or can be used in its pure form. It can be used in compression ignition engines with very little or no engine modifications because it has properties similar to mineral diesel [17].

4.0 Conclusions

Jatropha Curcas is a multipurpose species with many attributes and considerable potential. The plant is widely seen to have potential to help combat the greenhouse effect, create additional income for the rural poor and provide a major source of renewable energy both locally and internationally. The oil from its seeds is the most valuable product since it can be converted into biodiesel. From the characterization of the biodiesel, the physical properties of biodiesel from Jatropha oil with methanol were found to be within the ASTM specified limits. The viscosity of Jatropha oil reduces substantially after transesterification and is comparable to diesel. Biodiesel characteristics like density and viscosity are comparable to that of the petrol diesel.

5.0 References

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