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Full Length Research Paper

Cosolvent transesterification of *Jatropha curcas* seed oil

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This is paper aimed at characterizing Nigerian *Jatropha curcas* seed oil in terms of % free fatty acid (FFA), viscosity, calorific, acid, iodine and saponification values and cetane number which were found to conform to those in literature. The GC-MS analysis of the raw oil indicated that oil consisted principally of palmitic, oleic, linoleic and stearic acids. The established operating conditions for the efficient cosolvent transesterification of Jatropha oil, using tetrahydrofuran as the cosolvent, were found to be 40°C, 200 rpm, 4:1 methanol-to-oil molar ratio, 1:1 cosolvent-to-methanol volume ratio, 0.5% w/w catalyst concentration and a time duration of 10 min. An optimum yield of 98% was obtained at these conditions and the result of the GC-MS analysis confirms the formation of methyl ester at these conditions. Properties of the biodiesel obtained at these optimum transestrification conditions were compared favourably with the ASTM D 6751-02 Standard B100.

Key words: *Jatropha curcas*, transesterification, cosolvent, biodiesel.

INTRODUCTION

The three dimensional energy threat of climate change, affordability and energy security has lead the world to discover the finite nature of fossil fuels, even though they will continue to dominate the global primary energy mix for several decades to come (World Energy Outlook, 2009; Meda et al., 2009). Growth in world population has resulted into surge in energy demand, and therefore the need for secured energy source that are renewable, environmentally friendly, affordable and above all sustainable has arise. Various feedstocks have been proposed for the production of biodiesesl, one of the contending candidates is the *Jatropha curcas*. This tree is selected due to its numerous advantages over others. *J. curcas* is non-edible as it contains compounds that are highly toxic. It is resistant to drought and pests. Seed yields under cultivation can range from 1,500 to 2,000 kg ha^{-1}, corresponding to extractable oil yields of 540 to 680 L ha^{-1} (58 to 73 US gallons per acre) and they have the potential to get as much as 1,600 gallons of diesel fuel per acre in a year. *J. curcas* tree can also be intercropped with other cash crops such as coffee, sugar, fruits and vegetables.

Biodiesel production through transesterification process involves reaction of the oil with an alcohol (mostly methanol) in the presence of a catalyst resulting into the formation of a diesel equivalent biofuel (mono alkyl ester). This transesterification process is associated with many problems, in which the principal of these problems is that the reactants (oils and alcohols) are not readily miscible because of their chemical structures. Oil disperses in the methanol medium, so the rate of collision of the glyceride and the methoxide (the mixture of methanol and the alkaline catalyst – KOH or NaOH) molecules becomes slower. This lowers the rate of collisions of the molecules and also the rate of reaction causing longer reaction times, higher operating expenses and labour, higher fixed capital investments and consequently higher product costs (Caglar, 2007).

To overcome this difficulty of mixing of the reactants, a single phase reaction is proposed (Boocock et al., 1998). The proposed model involves a cyclic solvent introduced into the reaction mixture which makes both the oil and

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methanol miscible by reduction of mass transfer resistance. This solvent has numerous numbers of solvents with the boiling point up to 100°C (Caglar, 2007). Tetrahydrofuran (THF) (65.8°C) is preferred because of its close boiling point to that of methanol (64.4°C) so that after reaction, both methanol and THF is recycled in a single step to be used again. The addition of THF to create a single phase greatly accelerates the reaction so that 99.89 wt%, whose conversion is almost complete, is achieved in a very short reaction time, such as 10 min (Boocock et al., 1998). The primary concerns with cosolvent transesterification are the additional complexity of recovering and recycling the cosolvent, although this can be simplified by choosing a cosolvent with a boiling point near that of the alcohol being used (Caglar, 2007). Additional concerns have been raised about the hazard level associated with the cosolvents. Several cosolvent are considered to replace THF among which are ethyl acetate, diethyl ether, and 1,4-dioxane (Boocock et al.,1998) each offering a unique set of properties and advantages.

This transesterification process is associated with many principal problems of which the reactants (oils and alcohols) are not readily miscible because of their chemical structures. Oil disperses in the methanol medium, so the probability and the rate of collision of the glyceride and the methoxide (the mixture of methanol and the alkaline catalyst – KOH or NaOH) molecules becomes slower. This lowers the rate of collisions of molecules and also the rate of reaction causing longer reaction times, higher operating expenses and labour, higher fixed capital investments and consequently higher product costs (Caglar, 2007; Behzadi and Mohammed, 2007).

Many researchers have investigated the cosolvent transesterication of various edible vegetable oils, establishing various optimum operating conditions for those oils (Antoline et al., 2002). Out of the available researches, none has neither critically used *J. curcas* oil (which non-edible) for the cosolvent transesterification nor establish the process optimum parameters. This work therefore seeks to cosolvently transesterify Nigerian *J. curcas* seed oil, employing tetrahydrofuran as the cosolvent. Establishing the optimum transesterification conditions was equally an objective this research work was set to achieve.

MATERIALS AND METHODS

Materials

Dried *J. curcas* seeds were obtained from Oil Seed Research unit of the Institute for Agricultural Research (IAR), Ahmadu Bello University Zaria. Tetrahydrofuran (THF), anhydrous methanol, sodium hydroxide, tetraoxosulphate (IV) acid, hydrochloric acid, carbon tetrachloride, potassium iodide, potassium dichromate and Wijs solution were procured from Chemical Stores in Zaria, Nigeria. All the procured chemicals were of analytical grades.

Methods

Oil extraction

The Jatropha seed was weighed, grinded and the chaff separated from the kernel and both were weighed. Then the kernel was grinded and steamed in an oven to reduce the viscosity of the oil after which a mechanical extractor was used to extract the oil from the cake. Respective weights of the cake and the extracted oil were measured.

Oil characterization

The oil was characterized for physical and chemical properties such as viscosity, FFA content, acid, saponification, iodine and calorific values. Others are density and moisture content.

Viscosity determination

The viscosity of the raw oil was measured using Brookfield rotary digital viscometer NDJ-8S at 24.3°C. 200 ml of the oil was poured into a beaker and spindle, No 2 was attached to the viscometer, this was then lowered into the beaker and allowed to attain same temperature with the sample and viscometer was set at a speed of 60 rpm. While the viscometer was on, the reading at 25% shear rate was taken.

Free fatty acid determination

This is the percentage by weight of specified fatty acid in the oil. The method applied for this analysis, is the American Oil Chemists' Society (AOCS) method 5a-40. 1 g of sample was measured in a conical flask and dissolve with 25 ml of isopropyl alcohol. 3 drops of phenolphthalein indicator was added to the solution. The mixture was then titrated with 0.1 N sodium hydroxide solution shaken constantly until a pink colour persisted for 30 s. The percentage FFA was then calculated using the formula:

$$\%FFA = \frac{\text{Titre value} * \text{Normality of NaOH} * 28.2}{weight\ of\ sample} * 100 \quad (1)$$

Acid value determination

This is the number of milligram of KOH required to neutralize the free fatty acid in 1 g of the sample. 1 g of sample was weighed into a conical flask, 25 ml of the sample was poured into the conical flask and 3 drops of phenolphthalein was added and titrated against 0.1 N solution of potassium hydroxide. The acid value was calculated according to the following formula:

$$Acid\ number = \frac{\text{Titre value} * \text{Normality of KOH} * 56.1}{weight\ of\ sample} \text{x}100 \quad (2)$$

Saponification value determination

This is the milligram of KOH required to saponify 1 g of fat or oil. Saponification value is the measure of the molecular weight of the fatty acid. The AOCS method Cd 3-25 was employed. 2 g of the sample was weighed into a 250 ml conical flask and 50 cm^3 of 0.5 N ethanolic KOH (that has stayed overnight) was added to the sample. The mixture was then heated to saponify the oil. The unreacted KOH was then back titrated with 0.5 N hydrochloric acid

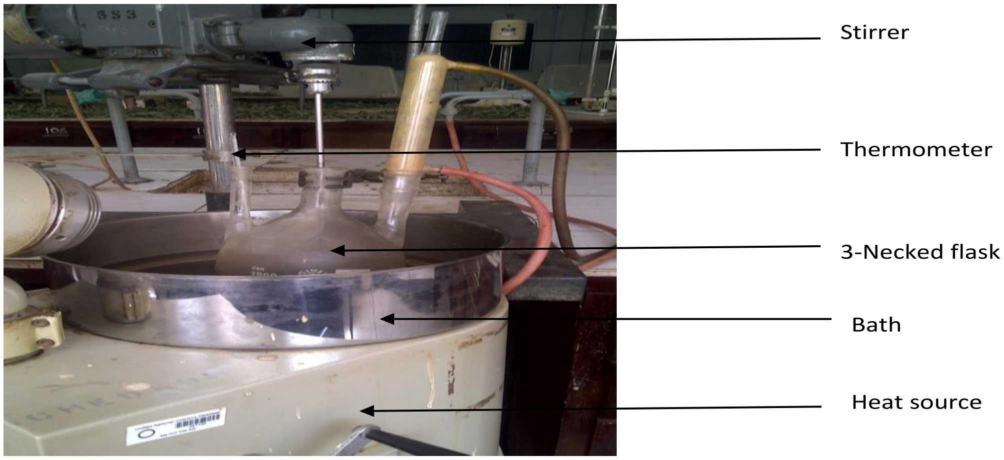

Figure 1. Esterification/Transeterification experimental set up.

using 2 to 3 drops of phenolphthalein indicator. The saponification value was calculated using the formula:

$$Saponification\ value = \frac{\text{Titre value} * \text{Normality of NaOH} * 56.1}{weight\ of\ sample} \tag{3}$$

Iodine value determination

This is the measure of the degree of unsaturation in relation to the amount of fat or oil. Iodine value is defined as the gram of iodine absorbed per 100 g sample. When unsaturated oil is heated, polymerization of the triglyceride occurs which leads to gum formation. Also, unsaturated compounds are susceptible to oxidation when exposed to air, thereby degrading the oil quality. Hence, the higher the iodine value, the greater the degree of unsaturation. The method employed was AOCS method 1b-87. 2 g of the sample weighed into a 250 ml conical flask, 10 cm^3 of CCl_4 was then added to dissolve the sample by swirling, 20 cm^3 of Wij's solution was added and stoppered immediately, then swirled and the mixture was allowed to stand in the dark at ambient temperature for 30 min. 15 cm^3 of 10% KI solution was then added with 100 cm^3 of distilled water to rinse the flask and the solution was then titrated with a solution of sodium thiosulphate using starch indicator. A blank sample was prepared and back titrated accordingly. The iodine value was calculated using the formula:

$$Iodine\ value = \frac{(\text{Sample titre} - \text{blank titre}) * \text{Normality} * 12.69}{weight\ of\ sample} \tag{4}$$

Specific gravity determination

A clean dried density bottle of 25 ml capacity was weighed (Wo), it was then filled with the oil, stopper was inserted and reweighed (W1), the oil was then substituted with water and weighed. The specific gravity was calculated using the following formula:

$$Specific\ gravity = \frac{\text{mass of substance}}{mass\ of\ equal\ amount\ of\ water} = \frac{\text{W1} - \text{W0}}{W2 - W0} \tag{5}$$

Moisture content determination

The moisture content of the raw oil was also determined using oven drying method. The oil was heated at 130°C for 1 h and filtered using muslin cloth to drive off the water and remove the solid particles respectively.

Oil pre-treatment

The oil extracted contain water and some solid particle, it was heated at a temperature of 130°C for 30 min to boil out the water (Singh, 2009), it was then allowed to cool and settle over night, and further, filtered with fine filter mesh to remove the solid particles. The removal of water from the oil is necessary because water content of above 0.5% facilitate saponification.

Oil esterification

The oil had an FFA content of 14.8%, and therefore, there is need for reduction below 0.5%, otherwise there will be high saponification (Van Gerpen, 2005). This reduction was achieved via esterification of the oil with methanol and using tetraoxosulphate (VI) acid as the catalyst. 50 g of the oil was measured and place into three neck round bottom flask and placed in a water bath and heated to a temperature of 60°C. 5% w/w acid was mixed with 20% w/w methanol and also heated to a temperature of 60°C and mixed with the oil. A suspended mechanical stirrer was inserted into the oil via one of the necks, the flask was equipped with a reflux condenser and a thermometer was dipped into the mixture via the remaining neck of the flask. The mechanical stirrer was set at 700 rpm and timing was started at this point. A picking pippeted was used to withdraw samples at one hour interval (1, 2, 3, 4 and 5 h) and was titrated against 0.1 N solution of KOH to determine the %FFA level. The experimental setup is shown in Figure 1.

Oil transesterification

The esterified oil was transesterified in 50 g batches to establish the optimum conditions for the reaction by varying the time at 10, 20, 30, 40, 50 and 60 min, and the temperature at 30, 40, 50 and 60°C. The methanol to oil molar ratio and the Methanol-to-Cosolvent (THF) volume ratio were varied at 3:1, 4:1, 5:1, 6:1 and 1:1, 1:2, 1:3 respectively. The effect of stirring speed was also investigated by varying it at 100, 200, 300, 400, 500, 600 and 700 rpm. The transestrification was carried out in the same set-up used for esterification (Figure 1).

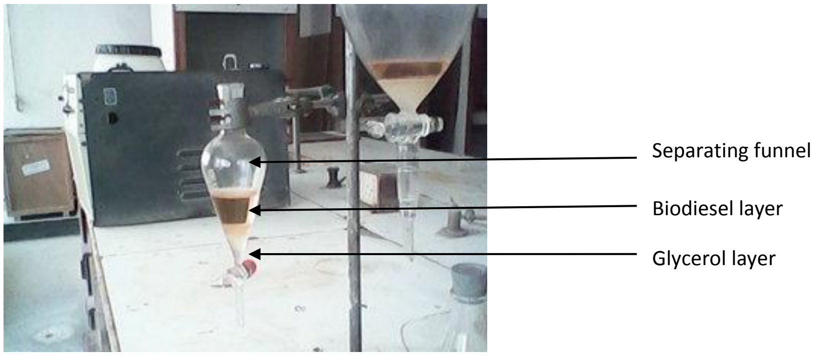

Figure 2. Separation set up.

Table 1. Fatty acid composition of the raw *J. curcas* oil.

S/No.	Component	Composition (Wt %)	Molecular weight
1	Palmitic acid (16:0)	15.86	256.42
2	Linoleic acid (18:2)	37.24	280.45
3	Oleic acid (18:1)	37.13	282.46
4	Stearic acid (18:0)	9.76	284.48
Total		99.99	
Average molecular weight (g/mol)			1103.81

Table 2. Properties of the raw *J. curcas* oil.

S/No.	Property	Unit	Value
1	FFA	%	14.8
2	Saponification value	mg KOH/g oil	202.34
3	Iodine value	g of Iodine/100g of sample	100.56
4	Cetane number	-	50.65
5	Density	Kg/m^3	874
6	Calorific value	MJ/Kg	81.90
7	Viscosity at 25°C	mPa.s	151.4
8	Acid value	%	29.6
9	Moisture content	%	0.4

Ester purification

In each case the mixture was neutralized by addition of 1 drop of 0.6 N H_2SO_4 cooled in an ice bath and poured into a separating funnel to separate the fatty acid methyl ester (FAME) from the glycerol by gravity. The experimental setup is shown in Figure 2. The glycerol, which settled at the bottom, was drained off while the methyl ester was washed with hot distilled water and dried.

Ester characterization

Upon establishing the optimum conditions, the oil produced at the optimum conditions was characterized for fatty acid methyl ester using GC-MS and other properties were also measured in accordance with the standard methods to see if the biodiesel produced had comparable properties with ASTM D 6751-02 standard B100.

RESULTS AND DISCUSSION

Characterization of the raw *J. curcas* oil

Tables 1 and 2 respectively present the compositional analysis and properties of the raw *J. curcas* oil. It can be observed from Table 1 that the oil consisted principally of 15.86, 37.24, 37.13 and 9.76% w/w palmitic, linoleic, oleic and stearic acids respectively. The fatty acid

Table 3. Results of esterification.

S/No.	Time (min)	FFA (%)
1	0	14.8
2	60	8.23
3	120	6.55
4	180	5.43
5	240	2.55
6	300	0.4

composition of the crude *J. curcas* seed oil used in this work is comparable to those reported by Makkar et al. (1997). This indicates that the oil contained more unsaturated fatty acids (linoleic acid and oleic acid) than the saturated fatty acids (palmitic acid and stearic acid). The oxidative stability of biodiesel is a function of the fatty acid composition of the parent oil. The higher the amount of saturated fatty acid in the parent oil the greater the oxidative stability of the oil and vice versa.

Properties of the raw *J. curcas* oil presented in Table 2 were found to be within the literature values (Alptekin and Canakci, 2008). These include; saponification value (202.34 mgKOH/g oil), iodine value (100.56 g of iodine/100g of oil), cetane number (50.6484), density (874Kg/m^3), viscosity (151.4 mPa.s at 25°C) and moisture content (0.4%). The calorific value of the raw *J. curcas* oil was found to be 37.23 MJ/Kg. However, the free fatty acid content of the raw Jatropha oil was found to be 14.8% which was not within the ASTM specified limit of ≤0.5% for biodiesel production. Therefore the raw *J. curcas* oil needs to be neutralized, through esterification.

Results of estrification

As stated previously, the free fatty acid content of the raw *J. curcas* oil was not within the specified ASTM standard for biodiesel production; therefore, there was the need to neutralize the FFA through esterification by reacting the oil with the methanol in the presence of tetraoxosulphate (IV) acid. Table 3 shows the obtained esterification results at various reaction times ranging from 0 to 300 min. This was done with the view of reducing the oil's FFA content to enable us carry out the transesterification on the oil. It can be observed from the Table 3 that at zero minute, the FFA content of the oil was 14.8%. This value decreased to 8.23% after the first 60 min of the reaction, 6.55% after 120 min of the reaction and 5.43% at 180 min of the reaction, this further dropped down to 2.55% at 240 min before it finally came down to 0.4% after 300 min of reaction, which is within the specified limit of ≤0.5% for transesterification process (Singh, 2009).

Optimizing the transesterification process

Having reduced the FFA of the raw oil, transesterifaction process was carried out on the oil with a view to establishing the optimum operating conditions for the biodiesel production. The variables optimized included reaction time, temperature and agitation. Others are the methanol-to-oil ratio, methanol-to-cosolvent ration and the catalyst (NaOH) concentration. It should be noted that in this research work THF was chosen as the cosolvent.

Effect of reaction time

Duration of reaction has been established as one of the critical parameters for biodiesel production. However, it has been found out that incorporation of a cosolvent to the transesterfication alcohol leads to the reduction of the reaction time. To investigate the effect of time on the process, batches of 50 g of the esterified oil were transesterified with a methanol/oil ratio of 3:1, catalyst (NaOH) concentration of 0.5% w/w of oil, 30°C reaction temperature and methanol-to-cosolvent ratio of 1:1% v/v at stirrer speed of 100 rpm. The reaction time was varied at 10, 20, 30, 40, 50 and 60 min. At these conditions, the highest yield of 73.5% was obtained at the 50 min reaction time. However, as can be observed from Figure 3, at the first 10 min, about 73% yield of biodiesel was obtained. Ideally, when optimizing a process, a point with the highest yield is usually considered as the optimum but here, considering the fact that the difference between the yield at 10 and 50 min was just 0.5%, 10 min was chosen as the optimum reaction time. This is in order to save cost of heating that would be required to heat the vessel for 50 min just to attain an extra 0.5% yield of the fatty acid methyl ester (FAME).

Effect of reaction temperature

Temperature is one of the significant factors affecting biodiesel yield. Reaction temperature must be lower than the boiling point of the alcohol in order to ensure that the alcohol will not leak out through vaporization. Having

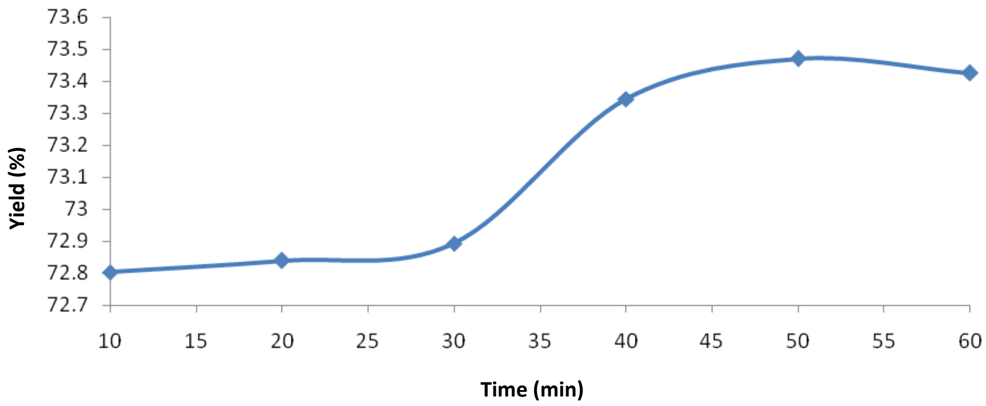

Figure 3. Effect of reaction time on the biodiesel yield.

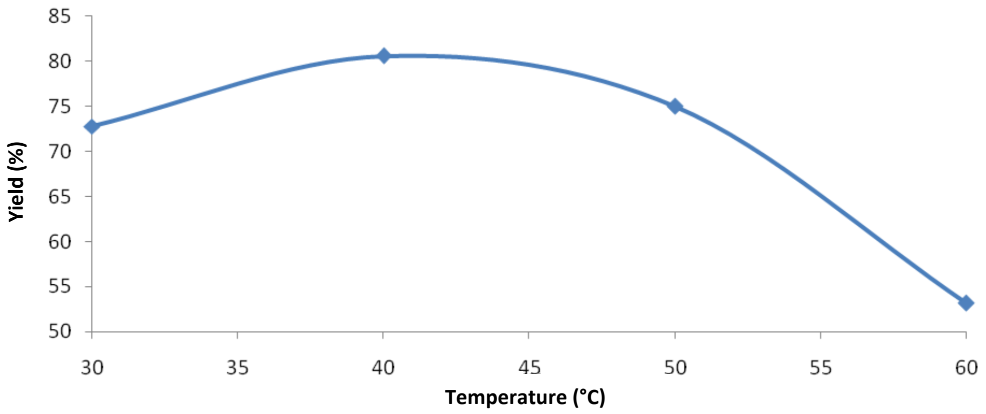

Figure 4. Effect of reaction tempearture on the biodiesel yield.

established 10 min as the reaction time, the oil was transesterified at the earlier stated condition for 10 min under various temperatures of 30, 40, 50 and 60°C. Figure 4 illustrates the effect of reaction tempearture on the biodiesel yield.

As can be observed from figure, the highest yield of 81% was obtained at a reaction temperature of 40°C. Beyond this temperature, the yield decreased drastically. The decrease in yield at temperature above 40°C could be as result of saponification reaction noticed at temperature above 40°C. Therefore, the optimum temperature is 40°C as oppose to the 60°C reported by Demirbas (2009) for conventional transestrification (without a cosolvent)

Effect of methanol-to-oil ratio

Even though theoretically (from the transesterification reaction stoichiometry), methanol-to-oil ratio of 3:1 is required for transestrification reaction. However, researches have indicated that methanol-to-oil ratio significantly affect the yield of biodiesel. Figure 5 shows the effect of Methanol-to-oil ratio on the fame yield. It can vividly be noticed that biodiesel yield is increased when methanol to-oil-ratio is raised beyond 3:1 and reaches a maximum. Increasing the alcohol-to-oil ratio beyond the optimum did not increase the yield; instead it will increase the cost of recovery of the methanol and causes difficulty in glycerol separation consequently resulting in lower yield. When the Methanol-to-oil ratio was varied at 3:1, 4:1, 5:1 and 6:1 the highest biodiesel yield 98% was obtained at 4:1 ratio. Further increase in the ratio resulted into decrease in the yield. Therefore, the optimum methanol-to-oil ratio was chosen as 4:1. It should be noted that, this transesterification stage was conducted at 40°C, methanol-to-cosolvent ratio of 1:1% v/v, stirrer speed of 100 rpm, and catalyst concentration of 0.5% w/w of oil for 10 min.

Effect of catalyst concentration

Investigating the effect of catalyst concentration (NaOH)

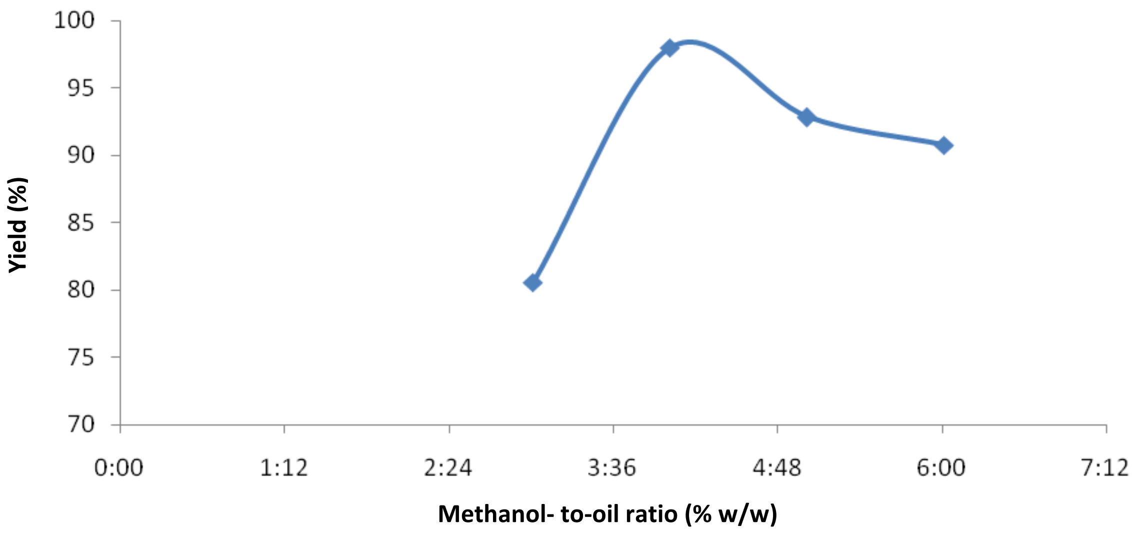

Figure 5. Effect of methanol-to-oil ratio on the biodiesel yield.

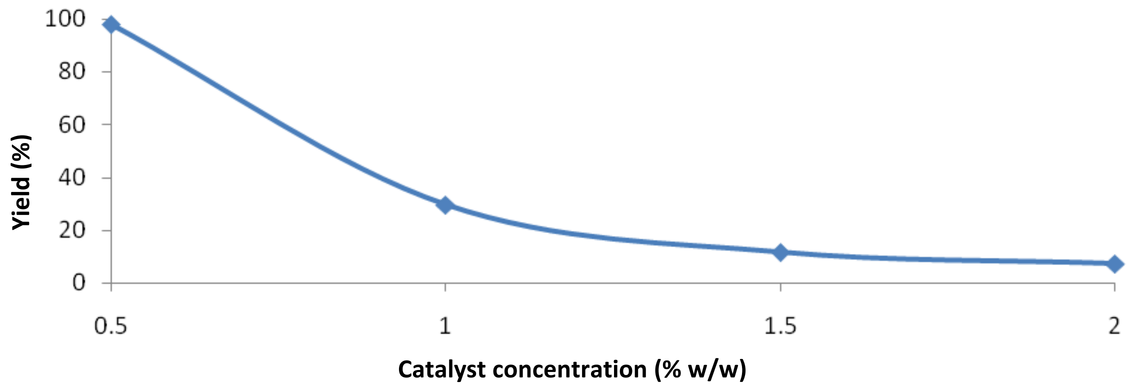

Figure 6. Effect of catalyst (NaOH) concentration on the biodiesel yield.

on the yield of biodiesel was carried out by varying the concentration of NaOH at 0.5, 1.0, 1.5 and 2.0% w/w of oil and keeping the other variables stated above constant. The result shown in Figure 6 indicates that the optimum catalyst concentration was 0.5% w/w. Further increase in concentration of catalyst beyond this facilitated saponification reaction and caused difficulty in the biodiesel separation from glycerol (Shay, 1993). This resulted in lowering the yield of the biodiesel at higher catalyst concentration. This finding corroborates with the findings of Encinar et al. (2010) that the introduction of a cosolvent to the transesterification alcohol reduces the amount of catalyst required.

Effect of methanol/cosolvent volume ratio

As opposed to conventional transestrification cosolvent transestrification offers significant reduction in mass transfer resistance (Encinar et al., 2010). At this stage of the work, methanol-to-cosolvent (Tetrahydofuran) ratio was varied at 1:1, 1:2 and 1:3% v/v while keeping other reaction variables constant. Figure 7 presents the influence of methano-to-cosolvent ratio on the biodiesel yield. The figure indicates that for this investigation, the optimum methanol-to-cosolvent volume ratio is 1:1 which gives a yield of 98%. Further increase in the ratio resulted in the decrease of the biodiesel yield. This could probably be as a result of the dilution effect on the reagents.

Effect of agitation

In conventional transestrification reaction, agitation is a significant factor affecting yield of biodiesel. Several works have been conducted to investigate this effect, Vincent (2005) and Antoline et al. (2002) reported 600 rev/min as the optimum impeller speed. The effect of

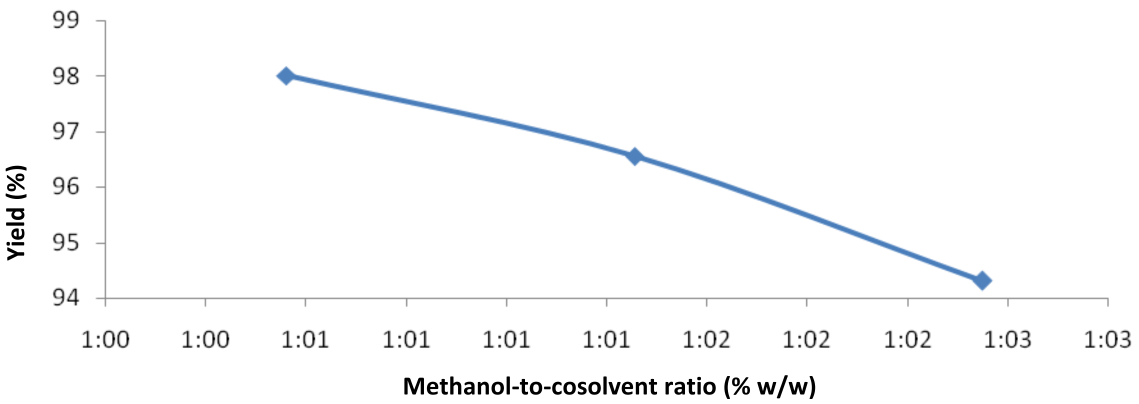

Figure 7. Effect of methano-to-cosolvent ratio on the biodiesel yield.

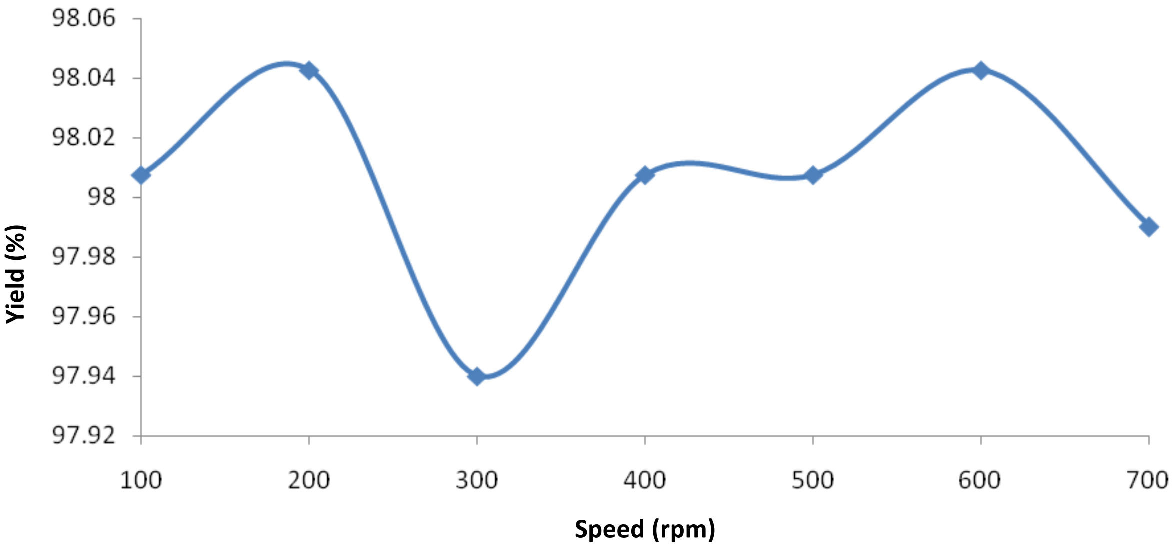

Figure 8. Effect of agitation on the biodiesel yield.

stirrer speed on the yield of biodiesel was investigated by varying the speed between 100 and 700 rev/min. Figure 8 shows effect of agitation on the *J. curcas* biodiesel yield. It can be observed from the figure that there is no definite trend. However, the highest yield value of 98.04% was obtained both at 200 and 600 rpm. Since actually mixing is only needed to establish one phase, once this is established, there is no need for agitation. In cosolvent transestrification, cosolvent contributes to overcome region of slow rate and therefore agitation becomes insignificant. In this case however, the optimum agitation may be considered as 200 rev/min based on the highest FAME yields obtained at this condition. However, it should be noted that the difference in biodiesel yield between 100 rpm (98.0076%) and 200 rpm (98.0426%) was just 0.035%. So based on the results of this investigation, agitation of the reaction mixture for about 100 to 200 rpm especially for the first few minutes of the reaction could be sufficient.

Characterization of the produced *J. curcas* biodiesel

Sample of the biodiesel produced at the optimum conditions established previously was characterized to ascertain its composition and relevant properties. Table 4 presents the composition of the FAME produced from the *J. curcas* oil as extracted from the obtained various peaks of the GC-MS used. It can be noticed from the table that the produced biodiesel consisted principally of the fatty acid methyl esters of palmitic, linoleic, oleic and stearic acids, hence confirming a high quality product. It can equally be observed that traces of other methyl esters were also observed in the composition of the produced

Table 4. Peak report of FAME produced at the optimum conditions.

Peak number	%area	Component
1	0.17	Myristic acid, methyl ester
2	2.83	Palmitoleic acid, methyl ester
3	20.01	Palmitic acid, methyl ester
4	0.18	Cyclopropaneoctanoic acid, methyl ester
5	0.35	Margaric acid, methyl ester
6	44.95	Linoleic acid, methyl ester
7	17.86	Oleic acid, methyl ester
8	11.51	Stearic acid, methyl ester
9	0.72	Ricinoleic, methyl ester
10	0.79	Arachidic, methyl ester
11	0.24	Bet-monolinolein
12	0.08	Stearic acid diglycerin ester
13	0.12	Docosanoic acid, methyl ester
14	0.18	Lignoceric acid, methyl ester
Total	100.00	FAME

Table 5. Properties of biodiesel produced at the optimum conditions.

S/No.	Property	FAME	ASTM D6751-02	Petrodiesel
1	Cetane number	51.43	47 min	46
2	acid number, mg KOH/g	0.75	0.80 max	0.35
3	Total glycerol, % w/w	0.0	0.24	NIL
4	Water content, % v/v	0.0	0.05	0.02
5	Density, Kg/m^3	869	875-900	850
6	Calorific value, MJ/Kg	38.53	-	42
7	Viscosity at 40°C, mm^2/sec	4.6	1.9-6.0	2.6
8	Saponification value, mg KOH/g oil	200.28	-	NIL
9	Iodine number, g /100g oil	103.2	-	-

biodiesesl. These traces could not affect the quality properties of the fuel as indicated in Table 5.

The produced biodiesel at the optimum conditions was analysed to ascertain its quality with respect to the standard biodiesel and petrodiesel properties. Table 5 shows the comparative properties of the produced *J. curcas* oil biodiesel with respect to the ASTM biodiesl and petrodiesel. It can be observed from the table that the produced biodiesel (FAME) virtually conforms to the properties specified by the American standard (ASTM D6751-02) and most of the properties tally with those of the conventional diesel oil (petrodiesel). The produced oil can therefore conveniently be used in a diesel engine.

CONCLUSIONS

The following conclusions were drawn from this research work:

1. The raw Jatropha seed oil was found to contain basically four major fatty acids namely: palmitic acid, oleic acid, linoleic acid and stearic acid. The unsaturated fatty acids were in higher quantity than the saturated acid and therefore the oil is good for biodiesel production.
2. Properties of the crude *J. curcus* seed oil such as viscosity, saponification value, Iodine value, cetane number, calorific value, flash point etc., were found to have comparable values with those obtained in the literature with the exception of the % FFA
3. The transesterification optimum conditions were found to be 40°C, 200 rpm, 0.5% w/w catalyst concentration, 4:1 methanol-to-oil molar ratio, 1:1 methanol-to-cosolvent volume ratio and time of 10 min.
4. Transesterification proceeds to completion at an even lower impeller stirring speed of 200 rpm as compared to 600 rpm reported for conventional transesterification.
5. Overall, the cosolvent transesterification offers an avenue for reduction in cost of material (in terms of catalyst concentration) and energy (in terms of stirring speed) in biodiesel production as well as significant reduction in time of reaction for a possible continues process of biodiesel production.

6. The biodiesel produced was found to have properties that are within the ASTM standard for biodiesel and have small of the cosolvent used.

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