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Production of Biodiesel from Anacaradium Occidentale and Investigating the Properties

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Abstract*: As the rapid increased in the vehicles in transportation in a recent year as leads to increase in petroleum product consumption which leads to fossil fuel depletion and also increased in prices of petroleum product so it is necessity to develop the alternative fuel source, so we found the cashew shell oil as potential feed stock for biodiesel production so cashew shell contain 25 to 30% of oil content by weight so which is good non edible oil source, cashew shell are available at cheap cost at huge quantity3rupees per kg. It contains cardanol as a main constituent and some of free fatty acid composition which help to production biodiesel from transesterification method. FFA of oil is found to be high 11.125, based on FFA% need to select the transesterification process so it is two stage of process called esterification and transesterification method for production of biodiesel. The biodiesel yield 65% is obtained after production of biodiesel and viscosity were found 6.135 cSt which have more than diesel to overcome of the problem we adding additive called diethyl ether. Cashew shell oil it can be used in diesel engine without any major modification.*

Keywords: *Cashew Shell Oil, Biodiesel, Viscosity, FFA%, Transesterification*

1. Introduction

The developing country like India lot of research is going on energy conservation is concerned for better tomorrows, unconventional energy source like utilizing solar energy, biomass energy, wind energy, tidal, geothermal etc. The depletion and raise in crude oil prices are motive to find the alternative fuels sources. Presently in India imports 189.6 million tons of crude oil of worth Rs 6.87 lakh cores India 70.10 million tons of diesel fuel is used for automobiles, agricultural equipment locomotives etc. the alternative fuels must be cost effective, environmental friendly (emission are low), easily available. Biodiesel are clean sources of burning fuels which can reduces the greenhouse emission like CO_2, CO, NO_X [1].

The replacement of diesel oil is biodiesel which is derived from animal fat, vegetable fat, used cooking oil are used nonedible source must be used for replacement of diesel oil. The nonedible oil source like Simroba, ponnagamia pinnta, Jatropha curcus, Calophylum inophylum, Mahua indica, Neem and rubber seed they are nonedible source oil seed which can be used for extraction of biodiesel [2].

The sources which are by product of cashew process industries while deshelling of cashew nut, shell are the waste obtained in deshelling process. The Cashew nut shell is waste has deshelling in cashew processing industries, where the shell weigh about 40% of total weight in India 800 kg/ha of shell available and it contains about 20-30% oil content by weight which promises the reliable feed stock for alternative fuel oil which can have potential to replace the diesel fuel oil. The botanical name of the cashew is "*anacaradium occidentale*". The origin of the crop is Brazil and East Africa but Portuguese peoples are introduced to India in 1600 near. The crop can be cultivated in the almost all type of soils ranging from costal sandy and lateritic soils to red sandy loam soil in plains soils with fertility status. Above the soil area where tell us about the cashew can be cultivated in any waste land (popularized as a waste land crop) The trees will matured in 4th year from plantation and which give more yield in the onward 10th year and more productive in b/w the 10th to 30th year of plantation and climatic condition about 25° north to 23° south latitudes. The crop can withstand the temperature more than 35°c but optimum temperature is about 25°c and the rain fall is may minimum about 100cm but 150cm to 200cm of rain fall is optimum for cashew crop. The global geological distribution of the cashew crop is from origin Brazil from the portuges peoples Main distributor of the world distribution is like viethnum, Tanzania, Mozambique, Indonesia, srilanka, India, Australia and Nigeria. Among them Brazil is maximum producers of cashew nut and the India is have 2nd places in production cashew nut. Local distribution of the cashew crop in India is Kerala, Karnataka, Maharashtra on west coast, Goa, Tamil Nadu, Andhra Pradesh, Orissa and west Bengal on east coast, Tripura and Meghalaya, Assam and Manipur. Among them the Maharashtra is maximum 1186 kg/hectare and 2nd place Andhra Pradesh 544 kg/hectare and 3rd place Orissa 641 kg/hectare. By product of cashew trees are namely cashew nut, cashew apples, cashew nut shell, wood, leaves.

These are all having their own purpose of application as they are all use full where the leaves are used in medicine application in treatment of acne in Kerala, cashew apples are edible i.e. it can be eatable and using the cashew apple preparation of the juice and wine namely 'fenny' (alcohol), cashew nut kernels are also eatable and it can be taken as snacks which are prepared by fried in oil mixed with pepper and salt, and some restaurant are used the cashew kernels for grave and sweet like barfi keru etc [1].

2. Methodology and materials

2.1Collection of Cashew Shell

Cashew nut shell is waste has deshelling in cashew processing industries, where the shell weigh about 40% of total weight i.e. kernel and shell remaining 60% of weight contain nuts. In India about 800 kg/ha of shell available and it contains about 25 to 30% oil which has anacardic acid, cardanol, cardol as a main constituent. And the cashew shell has thickness of 1/8″ (0.3 mm). Shell has a honeycomb like structure as shown in figure1.Cashew shell collected from cashew nut process industries [1].

Figure. 1 CashewShells

2.2 Extraction Methods of Cashew Shell Oil

The cashew shell oil is extracted by various methods it can be discussed below, which is dark reddish viscous fluid having density of 930 kg/m^3. After extracting cashew shall crude oil from mechanical expeller it is look like dark drown viscous liquid and cake appears like compressed shell [1].

2.3 Thermal Extraction Method

In thermal extraction we have three methods namely roasting, hot bath and solar cooker.in roasting method removes the corrosiveness of cashew nut shell oil and also make shell brittle also called thermal cracking method. Where it operate to maintain the temperature about 180-185ºC, in equipment there is vent for escaping of unpleasant smell. In thermal method 85-90% of oil can be recovered. In oil bath method cashew nut shell are collected in the cylinder. Meanwhile the temperature is maintained about 200-250ºC for 2- 3 minutes of intervals. Cashew nut shell oil was obtained about 7-12% by weight but need to repeatedly. In solar cooker method time interval is 30 minute and temperature about 225-300ºC [2].

2.4 Mechanical Extraction Method

In this research work the oil is extracted using mechanical method. Applying high pressure using hydraulic press / screw press for extraction of raw oil from cashew nut shell as shown in figure 2. The capacity of mechanical expeller is used to extraction of oil is 54-95 kg/hr, and yield of oil about 25-30% [1].

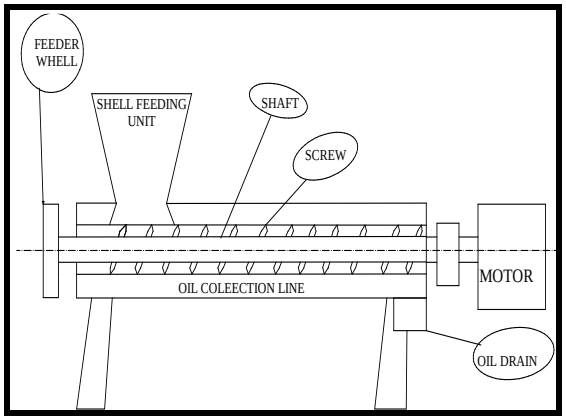

Figure.2. Schematic Arrangement of Mechanical Expeller

2.5 Solvent Extraction Method

In these methods the oil remains in the residue less than 1% by weight. The extraction solvent falls in to two groups; those which are less than water and those which are denser. Commonly used extraction solvent are less denser than water group includes DEE, ethyl acetate, and some hydrocarbons such as propane, hexane etc. the denser solvent such as chlorinated solvents, such as dichloromethane and chloroform, with dichloromethane being the preferred solvent because of its lower toxicity. However, chlorinated solvents do have a greater tendency to form emulsions than non chlorinated solvents [2].

2.6 Biodiesel Production Methodologies

The production of biodiesel is can be done in various methods for edible and non-edible types here in the process the viscosity of the oil, impurities are reduced and also effect volatility which turn effect the atomization of fuel droplets, here all parameters are effect the combustion parameter greatly. We have plenty of methods are available to produces the biodiesel it is explained below [1] & [2].

2.6.1 Micro Emulsification

Where the viscosity of the oil is high and it can be solute in some solvent may be in methanol, ethanol and butanol have been used. The micro emulsion is may be defined as to obtained the equilibrium dispersion optically isotropic liquid microstructure, which means the two immiscible liquid have been merged and show completely isotropic properties for ionic and non-ionic , dimension range may be in 1-150 Nano meter. It will increase some properties like spraying for vaporization of fuel for low boiling constituent of fuel. The maximum lowering of viscosity for diesel engine fuel can be achieved by using butanol, hexane and octonal. And alcohol is having more significant to increase the cetane value also for without diesel fuel [1].

2.6.2 Pyrolysis

It can be defined as the converting one kind of substance to other kind of substance by means of applying heatin the absence of oxygenwith adding of catalyst so it brake the bondage into small molecules, the heat application for the purpose of is about 140ºC at one hour of time, also at 280ºC temperature and vacuum pressure of 7-8 mm of hg [1] & [2].

2.6.3 Dilution

The dilution of the vegetable oils is possible method of using vegetable oil by dilution of crude oil into petroleum diesel by volume i.e. it cannot be used completely dilute which means the vegetable oil is blended at start from 5-10 % of vegetable oil in to diesel directly without any pre-treatment in optimum case 50:50 proposition of vegetable oil and diesel. in these method used in 1980's to directly vegetable oil to diesel but it cannot be used satisfactory so it create problem like carbon deposit in engine cylinder, and also to form gel and gum and insoluble in side engine and form a nozzle blocking also [1] & [2].

2.6.4 Transesterification

The transesterification is method of producing the biodiesel (methyl ester) by adding some catalyst and alcohol. And obtained the reaction product as glycerin and methyl ester. Improvisation of the methyl ester yield is more when we use excess of alcohol for reaction complete and also yield of biodiesel [1].

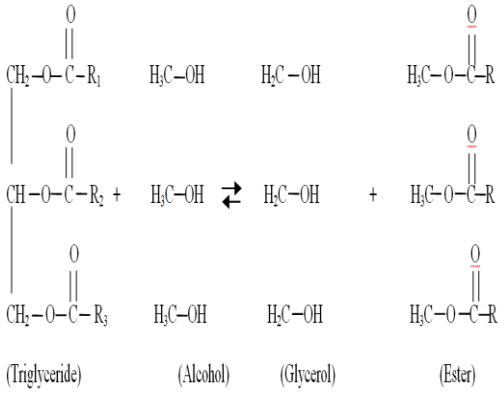

Figure. 3 Transesterification Reactions

The whole reaction is reversible so it can be conversion of triglycerides contents in mono ester, mainly alcohol are short chain hydrocarbon so 1-8 carbon in a shot chain, coming to process initially the vegetable oil are reacted in reactor with alcohol and catalyst which improvise the process to easily complete, the main alcohol compound used for these purpose is ethanol, methanol and butanol etc. the catalyst used may be NaOH, KOH and mgOH also some carbonate compounds,Lipases is use as bio catalyst, if the more it contain FFA we used the catalyst is sulphuric acid, sulfonic acid and hydrochloric acid. [1][2]. The proposition of alcohol and triglyceride is about 3:1 so the equilibrium shift toward the reaction completion but popular catalyst are for acid is sulphuric acid and base catalyst is NaOH, base reaction is more faster than acid catalyst process, out all methods here we considering the transesterification method for production of biodiesel. The reactions of transesterification as shown in Figure 3.

3. Production of Biodiesel

The FFA % indicated that need to perform two stage reactions i.e, esterification and transesterification. Selection of catalyst and alcohol is done in initial stages of biodiesel production. Homogenous catalyst (H_2SO_4) sulphuric acid is used for esterification processand NaOH (sodium hydroxide) for transesterification, alcohol used is methanol (methyl alcohol). And equipment required for production of biodiesel is given in table.1.

Table.1 Material and Equipment Required for Production of Biodiesel.

Sl no	Equipment's and materials	No. of unit
1	Three neck borosilicate rector(2 litter)	1
2	Condenser for avoiding methanol evaporation	1
3	Condenser for methanol recovery	1
4	Separating funnel (1litter)	1
5	Pipette(15 ml)	1
6	Magnetic stirrer with hot plate (2000rpm)	1
7	Thermometer (110º-200ºC)	1
8	Heating mental(100kw)	1
9	Beakers (100ml,500ml,1000ml)	1
10	Electronic weighing equipment(500gram)	1
11	Methanol(99% purity, 2000ml)	1
12	H_2SO_4 (99% pure,200ml)	1
13	NaOH(100gram)	1
14	Cashew shell oil(15litter)	1
15	Glass cork (9/12)	2

Well-equipped lab is needed for production of biodiesel is necessary so that it has a sure to produce the biodiesel (methyl ester) table 1 shows the equipment list which used in production of biodiesel.

3.1 Esterification Process

Esterification process is also alcoholysis process; catalyst used is acid for purpose of improvising the result and it enhances the reaction process as shown in figure 4. For esterification process H_2SO_4 must added has catalyst based on the standard chart available for dosage for FFA 11.125 we have 2.75 ml of H_2SO_4 is to be added along with 150 ml of methanol should be added to reactor for biodiesel production.

Table 2.Dosage of H_2SO_4 for Esterification.

FFA(of oil)	H_2SO_4 (in ml)
1	0.25
2	0.5
3	0.75
4	1.00
5	1.25
6	1.50
7	1.75
8	2.00
9	2.25
10	2.50
11	2.75
12	3.00
13	3.25
14	3.50
15	3.75
16	4.00

Where H_2SO_4 and methanol must be added separately before adding into reactor the reaction time is about 1hr 30mintemperature 55º C, speed is 500 rpm. after the reaction give time for settling in settling funnel, after settling in funnel for minimum 8hr. The reactant product are precipitation and acid layer, where something like whitish brown is bottom layer and some amount of acid i.e. in thin brown colour separate both bottom and top layer and take middle layer for farther production procedure.
Precipitant can be observed from figure4 the separation of whitish brown precipitation in bottom layer so it must be removed from funnel by releasing valve of separating funnel.

In second stages of reaction check FFA once again for these stage we have FFA 8.121 therefore we need make anther stage of esterification H_2SO_4 dosage can be determined by table 2, so we have 2 ml of theH_2SO_4 along with 150 ml of same procedure can be followed for second stage. It can be observe from figure 5 the separation of whitish brown precipitation in bottom layer so it must be removed from funnel by releasing valve of separating funnel.

Figure. 4 Three Neck Reactor with Magnetic Stirrer with Hot Plate

After compilation of second stage separate the oil and unwanted precipitation. Determined FFA is about 6.23 so still need to esterification process, H_2SO_4dosage can be taken from the table 2 along with 150 ml of methanol, so reaction need to repeat the same procedure as first stage.

Figure. 5 Stages of Esterification Process

After compilation of third stage separating of oil and unwanted precipitation must be separated and take middle layer oil. Determined FFA value after this stage is about 4.5. So still need to perform the esterification process, H_2SO_4dosage can be taken from the table 2 Along with 150 ml of methanol, so reaction is repeating the same procedure as first stage.

After the fourth stage of reaction separate oil and unwanted precipitation must be separated and take middle layer oil and determined FFA is about 1.25 the esterification process is stop here because of FFA<4 .

3.2 Transesterification Process

Transesterification process is also an alcoholysis process which reaction occurs for oil and methanol with homogenous catalyst (NaOH), initially oil having triglyceride which reacts with methanol gradually after reaction change in methyl ester and glycerine (by product) [3].

Figure. 6. Separation of Methyl Ester and Glycerine

After the last stage of reaction we get the product methyl ester and by product as glycerine, the glycerine is separated by layer from bottom it can be seen from using more intensify focus light. Because of it has a short chain molecule in the oil we can get very little amount of glycerine/ litter. Figure 6 shows transesterified sample of Cashew shell oil after 8hr of settling we can observe the separation of glycerine and biodiesel in the separating funnel.

3.3 Methanol Recovery

Methanol recovery is the optional process is done with help of 3 neck flask , methanol recovery condenser, thermometer, 19/26 glass cork and heating unit as magnetic stirrer as shown in figure 7 and the temperature is maintained for this process is about 65º-70ºC, about 1hr.

Figure. 7 Methanol Recovery Process

Methanol can evaporate at this temperature in atmosphere condition. And the cooling water circulation will condense the evaporated methanol in methanol condenser, after the condensation of methanol we can collect it and can be reused. This is an optional process which recover a very little amount of methanol per litter of biodiesel for 1 litter of biodiesel we get 25ml of methanol recovery process is shown in figure 7 [4].

3.4 Water Washing Process

After separating of glycerine some small portion of the glycerine and impurities may occur to remove those impurities we must wash the biodiesel with hot water temperature about 55º-65ºC so the sludge of glycerine is dissolved in warm water and settled in bottom of separating funnel it can be observed in figure 8 after clear steeling of foam water we can separate the those water with help of relieving valve of separating funnel [4].

Figure.8 Water Washing process of Biodiesel

3.5 Drying

The drying process is done because of remove the moisture content in biodiesel using open beaker, heating unit as heating mantle or magnetic stirrer**,** thermometer, holding stand for thermometer. In open beaker pour the biodiesel and heat up to 100º-105ºC, about 1hr so that moisture and methanol if any it can be easily removed and then gradually cool the biodiesel as shown in figure 9 and then collected the biodiesel is pure it can be test for properties it must meet ASTM standard [4].

Figure. 9 Drying of Biodiesel

1. 4. Properties

After the two stage of reaction namely esterification and transesterification the properties of crude oil (after process it is called as biodiesel also methyl ester) is changed, the properties of biodiesel is varies from crude oil because of catalyst and methanol, the properties like viscosity, density, flash and fire point shown in table 3. It must evaluate by different apparatus. It must be evaluated because it must suit the ASTM standards requirement [5].

Table.3 Properties of Crude Oil and Biodiesel.

Properties	Diesel	B100	Crude oil
Calorific value in kJ/kg	43500	36484.818	-
Viscosity in cSt	4.1	6.135	17.2
Specific gravity	0.840	0.880	0.930
Flash point in° c	52	195	252

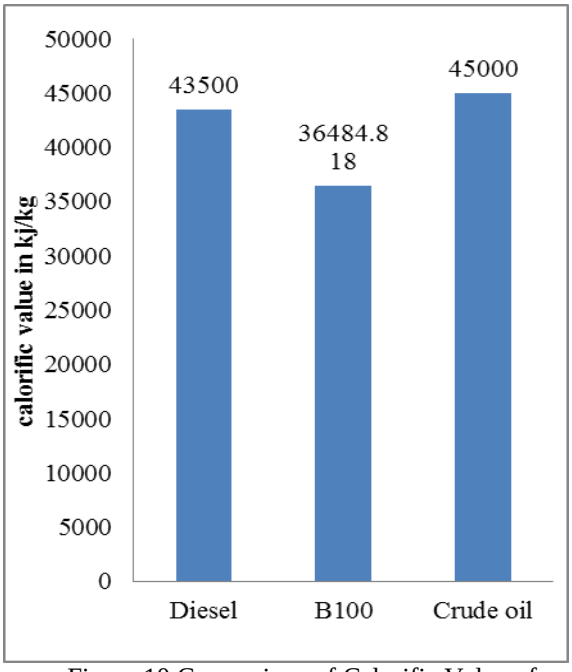

Figure.10 Comparison of Calorific Value of Diesel, Biodiesel and Crude Oil.

Calorific value determined by isothermal bomb calorimeter and the figure 10 shows the comparison between the diesel, biodiesel and cashew shell crude oil. And the crude oil has more calorific values but it can't use completely and directly in diesel engine so that crude oil is subjected to transesterification process will produces the biodiesel.

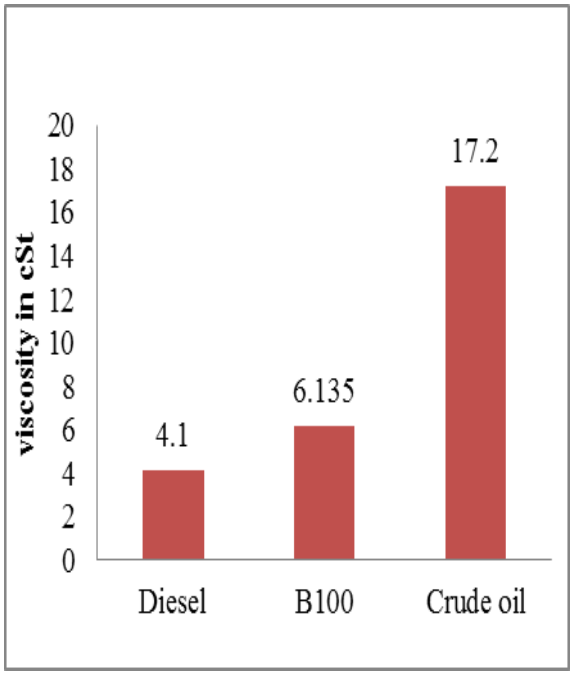

Figure.11 Comparison of Viscosity of Diesel, Biodiesel and Crude Oil.

The viscosity is determined in cannon franske apparatus. The figure 11 shows the comparison of viscosity between the diesel, biodiesel and the crude oil. The viscosity is more in crude oil about 17.2cSt, biodiesel is about 6.135cSt, and diesel as usual 4.1cSt.

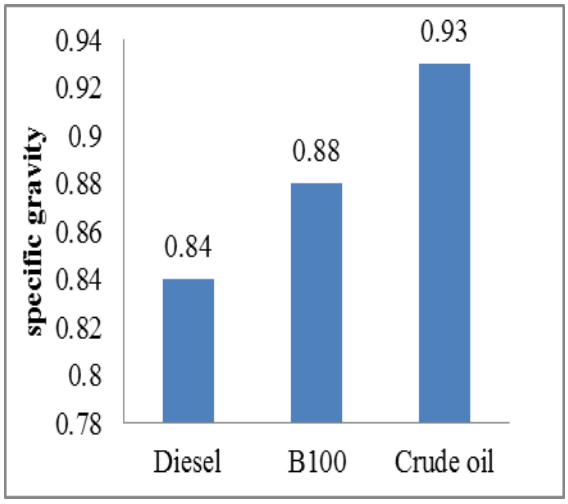

Figure.12 Comparison of Specific Gravity of Diesel, Biodiesel and Crude Oil.

The specific gravity is determined in hydrometer apparatus. The figure 12 shows the comparison of specific gravity between the diesel, biodiesel and the crude oil. The flash point is more in crude oil about 0.93; biodiesel is about 0.88 and diesel as usual 0.84.

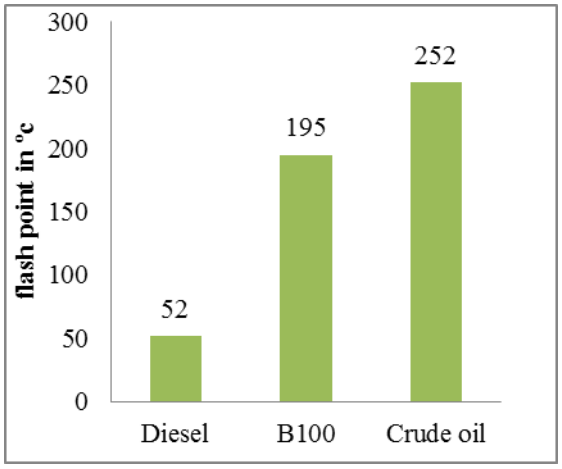

Figure.13 Comparison of Flash Point of Diesel, Biodiesel and Crude Oil.

The flash point is determined in penskey apparatus. The figure 13 shows the comparison of flash point between the diesel, biodiesel and the crude oil. The flash point is more in crude oil about 252ºc, biodiesel is about 195ºc and diesel as usual 52ºc.

4.1 Composition of Free Fatty Acid

The free fatty acid composition of cashew shell oil can be determined by gas chromatography test (GC57) and the composition details are as shown in table 4.

Table.4 Fatty Acid Compositions for Methyl Ester.

Fatty acid composition	In %
Palmitic acid	5.46
Oleic acid	14.96
Linoleic acid	5.77
Linoleinc acid	0.93
Recenoleic acid	47.84
Behenic acid	Nil

5. Conclusion

A waste source is determines for by utilizing the cashew shell oil for The production of the biodiesel initiated with determining FFA% and composition of free fatty acid by GC57 method and % of FFA is determined by chemical titration. FFA % is more than 4% we have to choose the two stage reaction namely esterification (acid catalyst H_2SO_4) and transesterification, in esterification process we need to reduce the FFA to less than 4% than only go for transesterification (base catalyst is NaOH) and alcohol used is methanol. It is concluded that cashew shall oil is possible to produce the biodiesel from above stated methods.

6. References

[1]Raghavendraprasada. S. A, "A Review on CNSL biodiesel as an alternative fuel for diesel engine", in international journals of science and research, July 2014, volume 3, pp 2028-2038.

[2]Ayhan Demirbas "progress and recent trends in biodiesel fuels", in Elsevier publication on energy conversion management , volume 50, October 2008, pp 14-34.

[3] S.G. Bojan, and S.K. Durairaj, "Producing Biodiesel from High Free Fatty Acid Jatropha Curcas Oil by A Two Step Method- An Indian Case Study", in Journal of Sustainable Energy & Environment, 2012, volume 3, pp 63-66.

[4] Y. Zhang, M.A. Dube, D.D. McLean and M. Kates, "Biodiesel production from waste cooking oil: 1. Process design and technological assessment", in Bio Resource Technology Elsevier publication, 2003 volume 89, pp1-16.

[5]S. Radhakirrshnan, C.Thamodharan and N.Senthilnathan "Evaluating performance and emission characteristics of CI engine run by cashew ut shell liquid (CNSL) as a fuel", in international journal of scientific & technology research, April 2014, volume 8, pp13-18.