Biodiesel Production from Jatropha Curcas Seed Oil in a Modified Batch- Reactor Using Sodium-Hydroxide as Catalyst

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DOI: 10.29322/IJSRP.8.6.2018.p7843
http://dx.doi.org/10.29322/IJSRP.8.6.2018.p7843

Abstract- Jatropha seed oil was used to produce biodiesel using a modified batch reactor. A two stage esterification process was adopted. A 114 liters cylindrical batch reactor was modified and locally fabricated, all the required reagents were also locally sourced. Sulphuric acid (H_2SO_4) to oil ratio of 1%w/w and methanol(CH_3-OH) to oil ratio of 60%w/w were used to ensure less than 4% free fatty acid (FFA) content. 753ml of alcohol (methanol) and 30grams of sodium hydroxide (NaOH) was vigorously mixed for about 35mins to achieve a homogenous solution. 3500ml of the acid treated Jatropha curcas seed oil was trans-esterified. A reactor mixing speed of 300rpm using four paddles (arms) and a horizontally placed baffle was maintained for 57minutes at a reaction temperature of 60^0C. The resulting solution was left undisturbed in a gravity flask. After 24 hours the solution produced a slightly cloudy golden brown liquid on the upper part of the mixture (methyl ester) accounting for about 89% and a yellowish brown liquid (glycerol) on the lower part accounting for about 11% of the entire mixture. This translates to about 98% methyl ester production from the experiment.

Index Terms- Biodiesel, Jatropha Curcas, Batch, Reactor, Catalyst, Esterification,

I. Introduction

Oil exploration and coal mining have being the major source of energy for industrial and domestic purposes. The diminishing petroleum reserves and environmental consequences of exhaust gases from petroleum-fuelled engines have triggered the search for an alternative fuel source. The use of biological based sources as a possible alternative fuel source is increasingly gaining global acceptance.[1]

Biodiesel, which is a plant and animal based renewable and biodegradable sources, consist of the simple alkyl esters of fatty acids [2]. Biodiesel contains very little sulfur, polycyclic aromatic hydrocarbons, and metal, Petroleum –derived diesel fuel can contain up to 20% polycyclic aromatic hydrocarbon [3]. For an equivalent number of carbon atoms, polycyclic aromatic hydrocarbons are up to three order of magnitude more soluble in water than straight chains aliphatic. The fact that biodiesel does not contain polycyclic aromatic hydrocarbons makes it a safer alternative for transportation and storage. As a future prospective fuel, biodiesel has to compete economically with fossil diesel. High production cost of the biodiesel at commercial quantity has being a major challenge. One way of reducing the biodiesel production cost is to use simple production method and less expensive feedstock, such as, non-edible oils, animal fats, and waste food oil and by product of the refining vegetable oil [4].
Most inedible vegetable oils produced by seed –bearing trees and shrubs have been found to meet the need for a biodiesel feedstock with adequate treatment. These, inedible feedstock in addition to providing clean renewable energy, have zero food competition. The poisonoussubstances (cursine, deterpine, tannins, saponin, lectinphytate) found in Jatropha curcas notwithstanding, the high oil yield of it's seed of up to 200 gallons per acre [5] among other qualities has encouraged its use as choice feed stock in biodiesel production.To keep in check the saponification process which usually occur when feed stocks with high free fatty acids contents (FFA) are used, acid treatment is encouraged to reduce the FFA of the feedstock to a manageable level.

This paper will discuss the approach adopted to achieve high biodiesel yield from Jatropha curcas using sodium hydroxide as catalyst in a batch rector.

II. MATERIALS

A locally fabricated 114 liters cylindrical batch reactor was used and all the required reagents were locally sourced. The reactor was lagged with fiber glass coated with aluminum foil for adequate heat conservation. The reactor as shown in Fig 1 and Fig 2 consist mainly of four stirring arms, a horizontal baffle and 1.5kW electric coil as heat source. The supplied heat was regulated by means of a thermostat. Some of the key modifications on the batch reactor include the introduction of additional two upper stirring arms, a horizontal baffle inside the reactor and the double coats lagging of the reactor body. Among other materials used were; digital weighing balance and various sizes of mixing bowls.

Fig 1.Isometric Drawing of Biodiesel Reactor

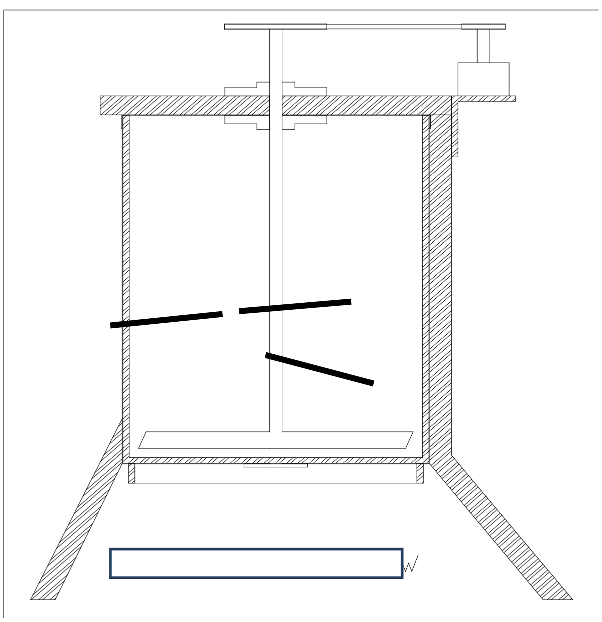

Fig. 2 sectional view of reactor

III. METHOD

Jatropha curcas seed oil has free fatty acid content of about 15%. To minimize the process of saponification, a two-step process was adopted [6]. The acid esterification is to reduce the FFA level followed by base esterification which produces a separable mixture of methyl ester (biodiesel) and glycerin.

The acid esterification was carried out using 400ml of Jatropha curcas raw seed oil. The oil was preheated to 50^0C in a container, 1% based on oil weight of solution of concentrated H_2S0_4 acid in methanol was slightly heated and added to the Jatropha oil in the preheated state . The heating was continued for the entire mixture and maintained at 50^0C. After 60 minutes of steady heating and stirring, the solution was allowed to settle for 120minutes undisturbed in a gravity flask clamped on a stand. Water layer was found to settle on top of the solution and this was carefully siphoned out. The remaining treated oil was used for the transesterification stage.

Transesterification is also called alcoholysis [7]. It is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis. Methanol is used for this purpose because of its availability, cost effectiveness and shorter reaction time. Ethanol, and higher alcohols such as isopropanol, and butanol can also be used with higher molecular weight alcohols to improve the cold flow properties of the biodiesel, but this may reduce the efficiency of transesterification process.

3500ml of treated sample of the oil was pre heated to 50^0C and stirred at a constant speed of 300rpm in the reactor. 753ml of alcohol and 30grams of sodium hydroxide (NaOH) was vigorously mixed for about 35mins to achieve a homogenous solution. While still stirring the pre heated Jatropha curcas oil, the methoxide solution was gently and slowly added to avoid explosive reaction. The temperature was slightly raised to 60^0C and stirred for 57minutes. After which the mixture was left undisturbed in a decanting glass tube mounted on a standing clamp for 24hours.

IV. RESULTS.

After 12 hours in an undisturbed state, the sample had a yellowish brown liquid on the upper part and a dense brown liquid on the lower part. After 24 hours in an undisturbed state, the sample separation was distinct having a slightly cloudy golden brown liquid on the upper part of the mixture accounting for about 89% and a yellowish brown liquid on the lower part accounting for about 11% of the entire mixture. There were also no further significant changes after 36 hours. Physical tests carried out revealed that, the thick whitish substance above the mixture was soapy and jelly like in nature while further physio-thermal tests carried out on the golden brown liquid are presented in Table 1.

Table 1.Thermo-Physical Properties of the Biodiesel

Fuel type	Fuel Parameters				
	Relative density at 15°C	Boiling point (T_1) °C	Distillation point (T_{50}) °C	Cetane values	Heat of combustion kJ/kg
B_{100}	0.879	262	310	50.51	40,733.57
B_0	0.860	265	293	45.67	41,518.8

The analytical values obtained from this experiment for pure biodiesel (B100) compared favorably with that obtained from fossil diesel (B0) as shown in Table 1, and Fig 3.

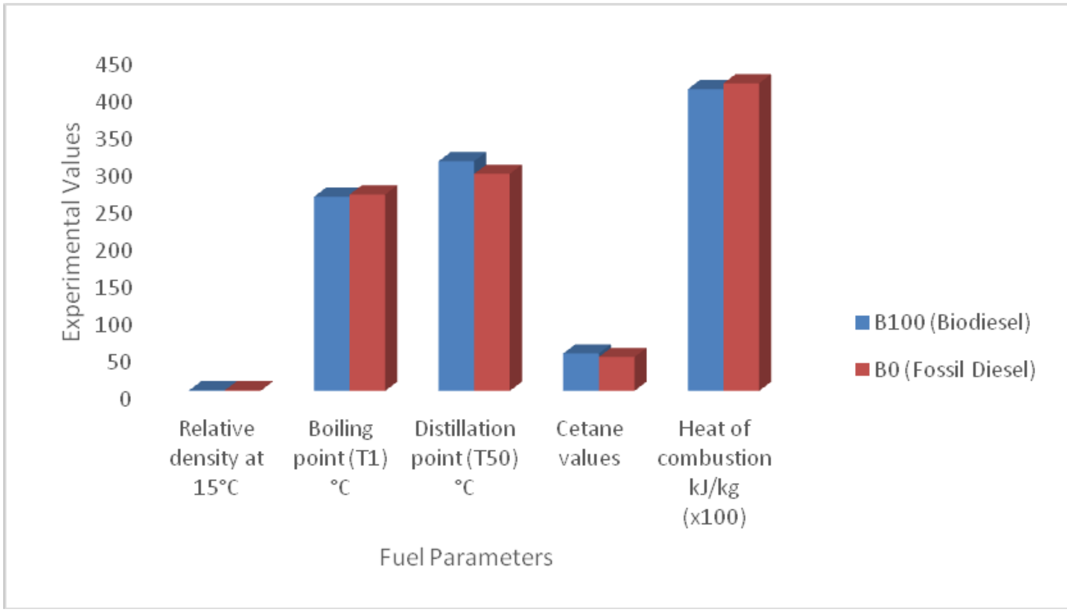

Fig.3, Comparing Some Thermo-Physical Properties of Produced Biodiesel and Fossil Diesel

V. CONCLUSIONS

Biodiesel was successfully produced from Jatropha curcas seed oil using 1: 6 molar ratio of oil to methanol and sodium hydroxide as catalyst. Biodiesel yield of 98% was achieved at a mixing speed of 300rpm using the modified batch reactor. The characterization of the biodiesel was carried out and the results compared favorably to those obtained from fossil fuels. The close range of these results is a confirmation that both fuels can be interchanged in an engine without major modifications.

The produced biodiesel has a cetane number of 50.51, which is higher than that of fossil diesel (46), this is an indication that the green fuel will have a smoother ignition than fossil diesel with less noise when in use. Although, fossil diesel generated slightly more heat of combustion than the biodiesel and its blends, the heat generated by the biodiesel and its blends are within acceptable ranges to power any agricultural machine or heavy duty industrial engines. The drop in combustion heat in biodiesel may be attributed to the high viscosity of the fuel. The high viscosity of biodiesel and its blends is advantageous when it comes to protection of the engine moving parts by reducing frictional wear and tear while in operation.

REFERENCES

[1] Vertes, A.A; M.Inui; H. Yakawa (2006). “Implimenting Biofuels On a Global Scale”. Nature Bio-Technology.

[2] Hanny, J.B and B.Shizuko(2007) - “Biodiesel Production from Crude Jatropha Curcas L. Seed Oil with a High Content of Free Fatty Acids”.Http:www.Science Direct.com. (2012),1716-1721

[3] Palligarnai,T and Vasudevan. Michael Briggs.(2008).Biodiesel Production –Current State of the Art and Challenges. Journal of Industrial Microbiololgy/Biotech. 421-430.

[4] Veljikovic,V.B.,S.H.Lakicevic, S.O.Stamenkovic, L.K.L.Todorovic(2006).Biodiesel Production from Tobacco Weed Oil with High Content of Free

[5] Chilakpu, K.O (2014) "Jatropha Seed Based Biodiesel Production Using Modified Batch-Reactor and Evaluation in a Single-Cylinder Diesel Engine" Unpublished Ph.D Thesis, Federal University of Technology Owerri.

[6] Urratia, C (2016). "Two Step Esterification-Transesterification Process of Wet Greasy Sewage Sludge for Biodiesel Production. Science direct.com.pii. Accessed April 2017.

[7] Rchard, P.W (2008)."Bio-Based Polymer and Composites. Sciencedirect/alcoholysis. Accessed March 2018.

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