International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN : 0974-4290
Vol.6, No.7, pp 3672-3676, Sept-Oct 2014

Complete Utilisation of Pongamia Pinnata: Preparation of Activated Carbon, Biodiesel and its purification

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Abstract: This work is a compilation of studies related to preparation of Biodiesel, Activated Carbon and their inter linking. Karanja oil was converted into biodiesel through base catalyzed transesterification in an Oscillatory Baffled Reactor. After separating the glycerol, the crude methyl esters were purified using activated carbons produced from residual Karanja seed cake. The structure and composition of the Karanja seed cake AC were studied to better understand its properties as an adsorbent. Yield and fuel properties of the produced biodiesels were compared with those purified by conventional method namely water washing method. Crude methyl esters were transferred into a column of 10 cm height, packed with Activated Carbon, and allowed to pass through the adsorbent bed with a flow rate of (15 drops/min). The study revealed that using activated carbons for the purification of biodiesel resulted in higher yield and flow properties of biodiesel have been improved by passing through Karanja Cake adsorbent.
Keywords: Pongamia Pinnata,Activated Carbon,Biodiesel,Karanja,Adsorbent.

1. Introduction

Biodiesel is an excellent alternative for petroleum diesel substitution. It presents important characteristics as non-toxicity, biodegradability, high energy content and absence of sulfur [1–3]. The global tend on reducing the dependence on fossil fuels, associated to an increasing environmental concern has motivated the searches for alternative energy source [3]. The main chemical process to produce biodiesel is the alkaline transesterification with methanol and KOH, where the alcohol reacts in the presence of the catalyst to form alkyl esters (biodiesel) and glycerin [4]. As raw materials it is possible to use vegetable oils and animal fats. The focus has been mainly on oils like soybean, rapeseed, sunflower and safflower, which are essentially edible in nature. Few attempts have been made for producing biodiesel from non-edible sources like used frying oil, greases, tallow and lard. In India, with abundance of forest resources, there is a number of other non-edible. Among these, Karanja (Pongamia glabra) and Jatropha (Jatropha curcas) have been successfully proved for their potential as biodiesel [5]. Solid waste disposal has become a major problem in vegetable oil mill / refinery and biodiesel plant. Either it has to be disposed safely or use for the recovery of valuable materials. Therefore, AC has been prepared from Karanja cake which is thrown out as a waste from Karanja oil mill and biodiesel plant have no further use after seed removal [6].After the glycerin removal, biodiesel can shows traces of alcohol, catalyst, glycerin and water. Beside these products, traces of unreacted glycerides (mono-, di- and tri-acylglycerides) can also be found [6]. With the objective to attend the international specification for commercialization, it is fundamental the use of a purification step. Biodiesel purification process with water is normally used due its capacity to solubilize the glycerin, methanol and catalyst, allied to its abundance and low cost. However, the use of water can cause some problems as emulsion formation, preventing the separation of the esters and allowing the formation of free fatty acids and soaps [7, 8]. The purity level of the biodiesel has strong influence on its fuel properties. Especially, the amount of glycerides and triglycerides present in the fuel can cause serious problems in application. Thus, it is necessary firstly to purify with a slightly acid solution (normally with H3PO4) to neutralize the system and prevent the hydrolysis of esters and the consequent soap formation. Therefore, it is possible to obtain a biodiesel with good quality but with the disadvantage of generating high volumes of liquid effluent. This fact obliges the implementation of a treatment of waste water station beside the biodiesel industry. The use of adsorbents turns the process more rapid and there is not a formation of aqueous residues [9].

In this study, the production of biodiesel from Karanja oil through base catalyzed transesterification was investigated. After separating the glycerol, the crude methyl esters were purified using activated carbons produced from Karanja seed cake. Properties of the produced fuels were measured and compared with those purified using other methods. Thus the study shows complete usage of Karanja seeds in an environment friendly and economically feasible way [10, 11].

2. Experimental

2.1 Evaluation of Feedstock:

The various properties of Karanja Oil, taken as feedstock for Biodiesel preparation, were evaluated.

Table 1 The physiochemical properties of raw Karanja oil

Sr. No.	Property	Test value
01	Colour	Dark brown
02	Kinematic viscosity	35.325 cSt at 40 °C
03	Acid value	5.3295 mg of KOH / gm of oil
04	Saponification value	178.1176
05	Molecular weight	944.881
06	Specific gravity	0.9345 gm/ml at 30 °C
07	Flash point	184°C by Cleveland Open Cup Apparatus
08	Fire point	189°C by Cleveland Open Cup Apparatus.

Based on the properties of Karanja oil the Methanol required for biodiesel preparation was calculated.

2.2 Biodiesel preparation from Karanja Oil:

The preparation of biodiesel was carried out in a specially designed Oscillatory Baffled Reactor (OBR) to reduce the time required for its preparation.

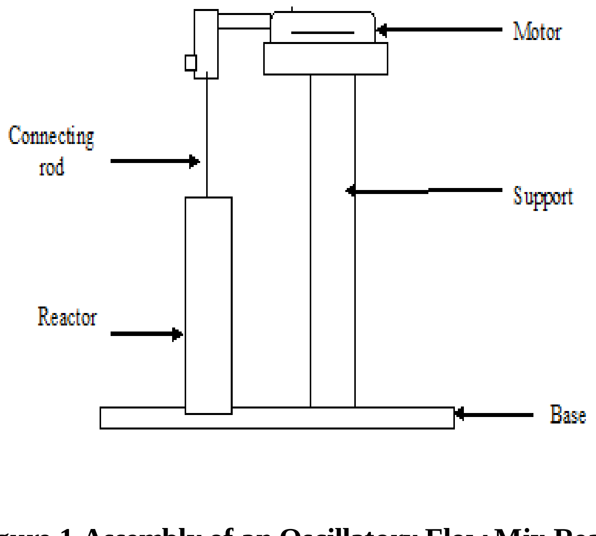


Figure 1 Assembly of an Oscillatory Flow Mix Reactor for Biodiesel Production

Since the FFA contents of Karanja oil collected is high, a two step process, i.e., acid catalyzed esterification, followed by based- catalyzed transesterification process, is selected for converting it into methyl ester. This is to avoid the problem of saponification. The first step, i.e., acid catalyzed esterification is for the reduction of FFA, which is mainly a pretreatment process. The process used sulphuric acid as acid catalyst. Once the FFA contents in Karanja oil reduce to 1-2%, the base catalyst transesterification is applied to get biodiesel.

2.3 Preparationof Activated Carbon

a) Impregnation:-

Impregnation of karanja cake were done with (0.25, 0.5, 1.0, 1.5, 2.0) N phosphoric acid. 2 gm of sample is impregnated with appropriate volume of phosphoric acid of different concentration. The impregnation process was performed at temperature 30ºC for 24 hrs in a Petri dish. The impregnated sample was washed with distilled water till we get 7 pH. The sample was dried in an oven at 100ºC for 8 hrs.

b) Carbonization:-

After drying, the samples were placed in crucibles and into a high temperature furnace for carbonization. The carbonization temperatures used were, 500-800°C.

2.4 Flow Properties optimized via adsorption on Karanja adsorbent:

Biodiesel obtained was then treated with adsorbent.A bed of 10 cm height was packed with 5 grams of Activated Carbon.Next, crude methyl esters were transferred into the column and allowed to pass through the adsorbent bed with a flow rate of (15 drop/min).The samples were then collected after passing through the bed.The viscosity of sample was then calculated using Ostwald's D type viscometer.

2.5Properties assessment of the purified biodiesels:

The Viscosity and Density before passing and after passing were assessed. The percentage decrease in Viscosity and Density, percent product yieldand percent conversion were calculated using below equation.

- % decrease in density = $\frac{\text{initial density - final density}}{\text{Initial density}} \times 100$
- $\%\ \text{Product Yield} = \frac{\text{Wt Of Product}}{\text{Wt of Raw Oil}} \times 100$
- $\%\ \text{Conversion} = \frac{\text{initial acid value} - \text{final acid value}}{\text{initial acid value}} \times 100$

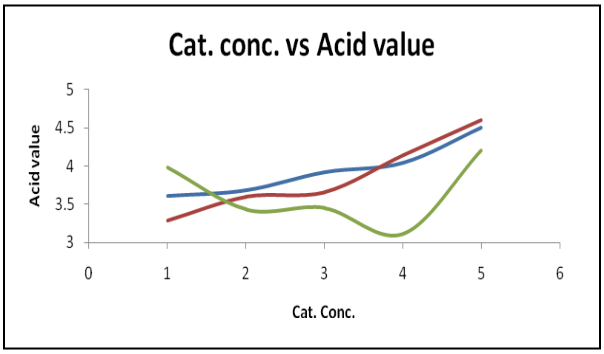
3. Results and Discussion

3.1 Calculation for First Stage:

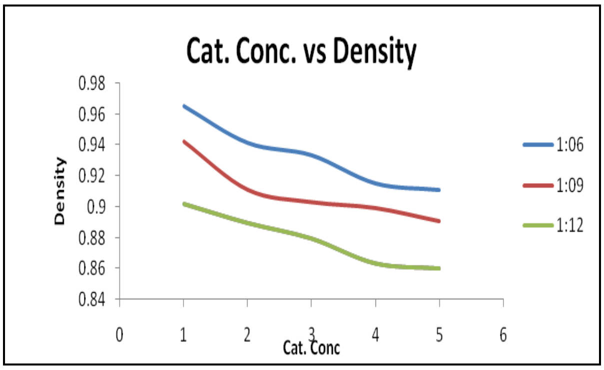
The reaction time in all the run studied in this works was taken as 10 min for the feed stock Karanja oil in an Oscillatory Baffled Reactor under the optimum conditions for biodiesel production are 1:6, 1:9, 1:12oil to alcohol ratio, catalyst concentration 1-5 vol % sulphuric acid, reaction time of 10 minutes for first stage.

The graphs showing responses are below:

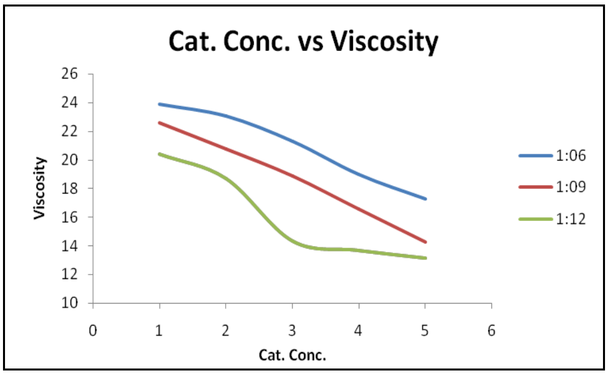
1. **Graph 3.1**



2. **Graph 3.2**



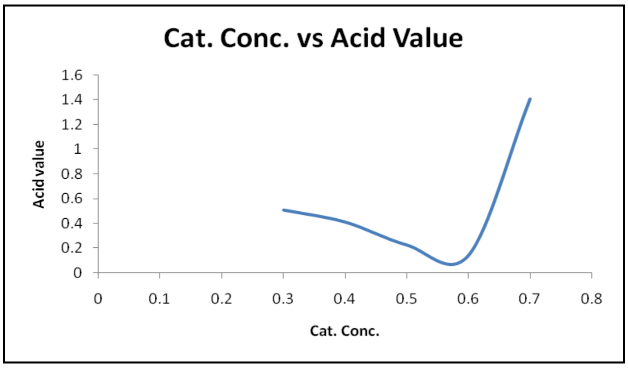
3. **Graph 3.3**



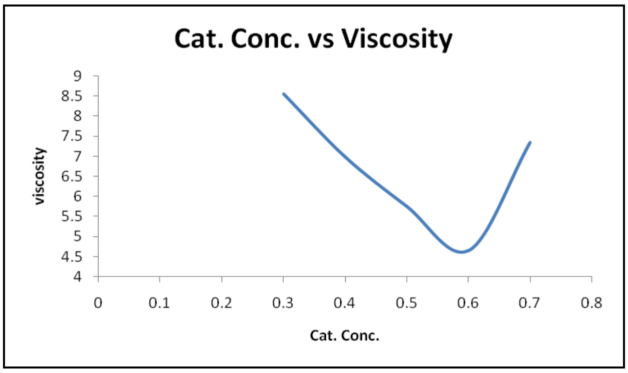
3.2 Calculation for Second Stage:

Experimental work was carried out to study the effect of Cat. Conc. on biodiesel properties, at room Temperature (34-36^{0}c), catalyst concentration= 0.3-0.7 wt%,Reaction time = 10 min. This data are shown in below graphs.

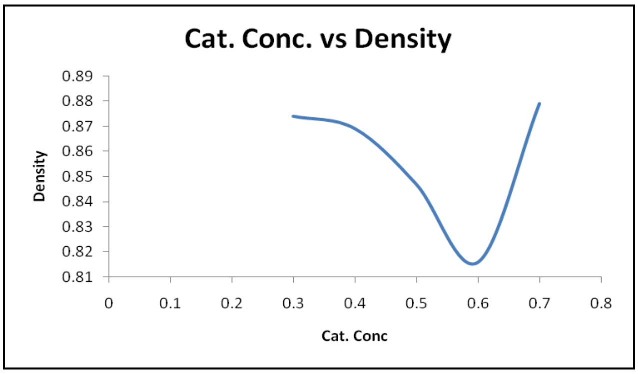
4. **Graph 3.4**



5. **Graph 3.5**



6. **Graph 3.6**



3.3 Calculation for Third Stage:

Table 2 Run Summary for Third stage

Sr. No.	Amount of Biodiesel	Amount of Activated Carbon	initial viscosity	final viscosity	initial density	final density	% decrease in viscosity	% decrease in density
1.	25	5	8.56	5.7933	0.874	0.7588	32.321	13.18
2.	25	5	6.98	5.086	0.8691	0.7188	26.925	17.29
3.	25	5	5.76	4.9455	0.847	0.6658	14.141	21.393
4.	25	5	4.655	3.5325	0.816	0.6596	24.1138	19.1667
5.	25	5	7.342	6.499	0.879	0.7026	11.482	20.064

Table no. 2 shows percentage decrease in viscosity and density after passing biodiesel throughKaranja cake activated carbon.

4. Conclusion

Karanja cake Activated Carbonwas successfully used as an adsorbent for purifying biodiesel from Karanja oil showing efficiency in increasing the flow properties of biodiesel. The main advantage of using the Karanja cake Activated Carbon as an adsorbent is that it facilitates complete utilisation of Pongamia Pinnata besides contributing to waste management. The study showed that in general, using activated carbons for biodiesel purification resulted in higher yields and better fuel properties.

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