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Research Article

Production of Biodiesel Using Bombaxy Ceibia Seeds

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Abstract

The present study focuses on production of biodiesel from Bombax Ceibia seed oil. The oil seeds were crushed in mechanical oil expeller to obtain the oil. 1 L of oil was obtained from 7.1 kg of seeds. Transesterification reactions were conducted in electrically heated reactor. Parameters affecting the yield of biodiesel such as molar ratio of methanol to oil ratio, % KOH, temperature of reaction and reaction time were optimized. The fuel properties of biodiesel were measured and found to comply with ASTM D-6751 standards.

Keywords

Bombax Ceibia, Biodiesel, Transesterification, Alternative fuel.

Declaration of Conflicting Interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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1.Introduction

The fact that petroleum based fuels will neither be available in sufficient quantities nor at reasonable price in future has revived interest in exploring alternative fuels[1]. Biodiesel is produced from both edible oils and non-edible oils such as jatropha, pongamia, mahua, cottonseed, rice bran, neem, sunflower, rapeseed, palm etc. [2]. In this regard, the Bombax ceibea seed oil could be a potential alternative source for biodiesel production. Bombax Ceibea is a type of cotton tree which belongs to the kingdom Plantae and order Malvales. Bombax Ceibea trees grow to an average of 20 m and the old trees in wet tropical region grow up to 60 m. The seeds are long, ovoid, grey or black in colour packed in white cotton. The tree is widely planted in south-eastern Asian countries like Vietnam, Malay, Indonesia, South China, Hong Kong and Taiwan. In India it is widely planted in parks and on roadsides there because of its beautiful red flowers which bloom in March/April. This tree is quite common in New Delhi although it doesn't reach its full size of 60 m there because of the semi-arid climate. Due to subtropical climate and heavy rainfalls, it's found in dense population throughout the Northeast India[3]. Biodiesel blends increases engine life and decreases the frequency of engine part replacement by increasing lubricity. Also in order to use blends there is no modification in engines are required and there is no special handling of fuel is needed[4].

Direct use of vegetable oils or animal fats as fuel can cause numerous engine problems like poor fuel atomization, incomplete combustion and carbon deposition formation, engine fouling and lubrication oil contamination, which is due to higher viscosity. Hence the viscosity of vegetable oils can be reduced by several methods which include blending of oils, micro emulsification, cracking/pyrolysis and transesterification. Among this transesterification is widely used for industrial biodiesel production. Biodiesel is produced through a chemical reaction known as transesterification[4]. For transesterification process methanol is commonly used, because methanol is cheaper than ethanol and the recovery of unreacted methanol is easier .In the case of base catalyst potassium hydroxide (KOH) or sodium hydroxide (NaOH) are used, because it is less expensive and easy to handle in storage and transport. High free fatty acid (FFA) content of oil samples needs two stages Esterification and transesterification. These two steps approach is also known as acid catalysis followed by alkali catalysis [5].

Hence due to the rise in demand of alternative fuels, everywhere extraction of biodiesel is being carried out using new feeds. Our research was based on optimization of extraction of biodiesel from Bombax Ceibea oil.

2. Material and Methods

2.1 Raw materials

Bombax Ceibia seeds were collected from local market and the oil was expelled in a mechanical expeller (**Figure.1 and 2**). After extraction, the oil was allowed to settle for two days. 1 L of oil was obtained from 7 kg of seeds (**Figure.3**). The physical properties of Bombax Ceibia oil(BCO) were determined as per ASTM procedures.

2.2 Experimental set up

The experiment was carried out using three-necked round bottom flask on magnetic stirrer cum heater. The three-necked round bottom flask was filled with oil and pre-heating up to 50ºC. Mixture of methanol-potassium hydroxide as per the stiochiometric calculations were introduced using the third neck in the round bottom flask. In one of the openings thermometer was installed for observing temperature, middle opening was attached with a spiral condenser and last opening was closed with the help of glass stopper.

Figure 1 Mehanical oil expeller

2.3 Transesterification Experiments

100 g of BCO was transferred to reactor and preheated to desired reaction temperature. Known quantity of KOH dissolved in calculated amount of methanol was added to it and time of reaction and microwave power were set in control panel. Following the reaction, the contents of reactor were transferred to and allowed for phase separation for 7 h, resulting into separation of two layers. The top layer consists of mainly DSO methyl esters while the lower layer comprises of glycerol as a major component. The excess methanol in both layers was recovered by distillation. The upper biodiesel layer was washed twice with warm distilled water (10%, v/v) and dried. The Fatty acid methyl esters content (FAME content) of biodiesel was measured.

2.4 FAME analysis

Agilent 7890B equipped with HP-5 column (30.0 m x 0.32 mm x 0.25 μm) was used with FID detector. The injector and detector temperature was set at 250oC and N2 was used as carrier gas at a flow rate at 2 ml/min. The oven temperature was programmed to start at 60oC and increased to 175oC at a rate of 25oC min-1 and then to 240oC at a rate of 4oC min-1 and held constant for 20 min-1.1 mg of internal standard solution of methyl heptadecanoate was added. The analysis was performed by injecting 1 ml

Figure 2 Bombaxy seeds

Figure 3 Bombaxy Ceibia oil

of sample solution into the gas chromatograph. FAME was quantified by comparing the peak areas between the samples with those of the standard compounds. The percentages of each peak/FAME were calculated, and based on these values, the FAME conversion was calculated.

3. Results And Discussions

3.1 Physical properties of BCO

Physical properties of BCO are listed in **Table 1**. It can be seen that, the acid value 0.847 mg KOH/g oil, which indicated that, acid catalyzed esterification experiments are not required and directly Transesterification experiments can be conducted.

3.2 Effect of molar ratio of methanol to oil on yield of biodiesel

Initially %yield of biodiesel increased with increase in moles of methanol but 7 moles of methanol/mole

S.No	Fuel property	Value
1.	Acid value (mg KOH/g oil)	0.846
2.	Density @15oC (g/ml)	0.913
3.	Kinematic viscosity@40oC (mm2/s)	31.41
4.	Flash point (oC)	298
5.	Pour point (oC)	13

Table 1 Physical properties of Bomaxy Ceibia oil

of oil %yield start to decrease because the reaction start to shift backwards also if excess methanol is used, the separation between glycerol and biodiesel will be improper. Amount of biodiesel obtained for different trails is shown in **Figure.4**.

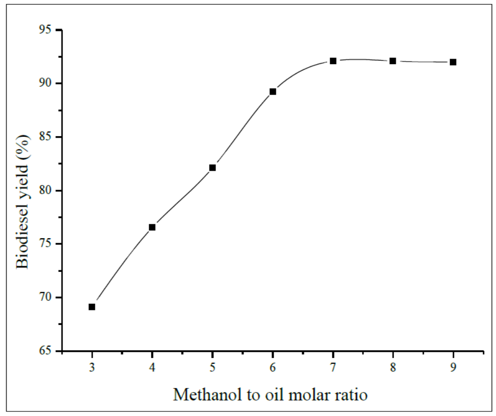

Figure 4 Effect of molar ratio of methanol to oil on yield of biodiesel

3.3 Effect of KOH concentration on yield of biodiesel

Transesterification is catalyzed either by base or by enzymes. For experiments KOH was used as catalyst. The quantity of catalyst used affects the yield of biodiesel. The amount of catalyst is varied in the range of 6-14 g/L. The result shows that the % yield increased with increase in catalyst concentration. Further increase in catalyst quantity after 12 g/L, resulted in decrease of %yield of biodiesel due to presence of soaps which prevents biodiesel from layer separation. Amount of biodiesel obtained for different trails is shown in **Figure.5**.

3.4 Effect of reaction time on biodiesel yield

The time of reaction is an important parameter because the transesterification reaction is a reversible reaction. For obtaining maximum biodiesel, reaction time must be optimized. For the experiment, trails were carried out for 20, 30, 40, 50, 60, 70, 80, 90 min. After 60 min there is very less rise in yield with time. In laboratory it is feasible but on industrial scale a lot energy will be spent for rise of just 1% yield. Amount of biodiesel obtained for different trails is shown in **Figure.6**. It can be seen that after 60 min, no significant changes occurred in biodiesel yield.

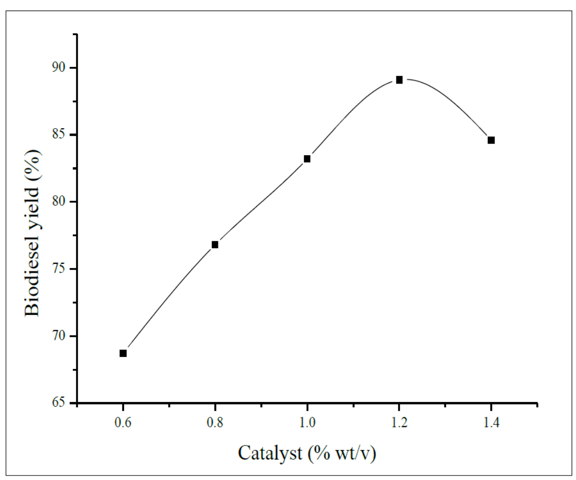

Figure 5 Effect of KOH concentration on biodiesel yield

3.5 Effect of reaction temperature on biodiesel yield

Reaction temperature is an important parameter in transesterification reaction. Various trails were conducted at 40 ºC, 50 ºC, 60 ºC and 65 ºC. The yield of biodiesel increased continuously with rising temperature and highest biodiesel yield of 92.1 % was observed at 65oC (**Figure 7**).

3.6 Fuel Properties of Bombax Ceibea biodiesel

The fuel properties of Bombax Ceiba biodiesel are depicted in **Table 2**. All the properties complied with ASTM D 6751 standards. Thus, the Bombax Ceiba biodiesel can be a potential for blending with diesel.

S.No	Fuel property	Test procedures	BCO biodiesel	ASTM D 6751 specifications
1.	Acid value (mg KOH/g oil)	ASTM D 664	0.35	0.5 max
2.	Density @15oC (g/ml)	ASTM D 287	0.875	0.86-0.9
3.	Kinematic viscosity@40oC (mm2/s)	ASTM D445	4.2	3.5-6
4.	Flash point (oC)	ASTM D93	138	Min.100
5.	Higher heating value (MJ/kg)	ASTM D 240	43.1	-
6.	Pour point (oC)	ASTM D 97	4	-
7.	Cloud point (oC)	ASTM D2500	2	-

Table 2 Fuel properties of Bomaxy Ceibia biodiesel

Biodiesel was successfully produced from Bombax Ceibea oil using base catalyzed transesterification. The parameters influencing the transesterification reaction (molar ratio of alcohol to oil, reaction time, catalyst concentration and temperature) were optimized. Varying the parameters illustrated the optimum conditions for biodiesel production of Bombax Ceibea oil to be 12 g/L catalyst, methanol to oil molar ratio 7:1, reaction time 60 min and reaction temperature 60oC at constant stirring rate 600 rpm. It could be concluded form the result of present investigation that Bombax Ceibea oil as non-edible oil can be converted into biodiesel with yield (92.2%) under an optimized conditions. Important fuel properties of biodiesel like kinematic viscosity, flash point, density, pour point, cloud point, ash content, carbon residue and calorific value of were found to be within the limits of biodiesel ASTM standards.

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