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Research Article

PRODUCTION OF BIO-DIESEL USED IN DIESEL ENGINES

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ABSTRACT

To obtain biodiesel, the vegetable oil is subjected to a chemical reaction termed *transesterification.* Cottonseed oil (CSO) was selected for biodiesel production. In that reaction, the Cottonseed oil is reacted in the presence of a catalyst (sodium hydroxide) with an alcohol (methanol) to give the corresponding methyl esters. Cottonseed is non-edible oil, thus food against fuel conflict will not arise if this is used for biodiesel production. The experiments were conducted in order to evaluate the effects of reaction variable such as methanol/oil molar ratio (1:3.3), catalyst concentration (0.25%), temperature (65^{0}C), reaction time 3.0 hours and stirring intensity (300rpm). The methyl ester yield is (84.3%). The methyl esters of cotton seed oil can be used in existing diesel engines without any modifications.

Keywords: Cottonseed oil, Transesterification, Cottonseed oil methyl esters (COME), Fuel properties

INTRODUCTION

The cottonseed which remains after the cotton is ginned will be used to produce cottonseed oil. Cotton seed oil is a waste product of the cotton industry, so it costs the food manufacturers next to nothing to procure a plentiful supply [1]. The only problem with this is that cotton is not a food crop, therefore is not subject to the same restrictions as to pesticide and fungicide levels. In fact, cotton is one of the most heavily sprayed crops in the world, due to its susceptibility to the threats of insect predators, such as the boll weevil.

It is important to explore the feasibility of substitution of diesel with an alternative fuel, which can be produced with in the country on a massive scale for commercial utilization. At present the potential alternative fuels are Alcohols (Methanol and Ethanol), Liquefied Petroleum Gas (LPG), Compressed Natural Gas (CNG), Hydrogen and Vegetable oils [2, 3]. The cotton seed oil, a non-edible type vegetable oil is chosen as a potential alternative for producing biodiesel and used as fuel in compression ignition engines [5, 6]. Almost all vegetable oils can be directly mixed with diesel oil. Micro-emulsification, pyrolysis and transesterification are the remedies used to solve the problems encountered due to high fuel viscosity. The use of vegetable oils as I.C. engine fuels can play a vital role in helping the developed world to reduce the environmental impact of fossil fuels [7, 8].

EXPERIMENTAL

Materials

A raw cottonseed oil from a local firm (Thiagarajan Oil Mill, Madurai, Tamil Nadu.) was used. Chemicals such as Methanol, sodium hydroxide were purchased from known chemical companies.

Filtering

The cottonseed oil was extracted from the seeds by the mechanized expeller. The extracted oil was very much translucent .Even though the oil was translucent there were some residues of oil cake. These residues were separated out by filtering it. The filtration was done by the Bag filters made from the Canvas cloth. The oil was slightly heated before pouring into the bag. In around 24 hrs .all the residues settle down at the bottom of the filter.

Degumming

In this process the hydratable and non- hydratable phosphatides along with various resinous and mucilaginous materials were separated from the neat oil. The oil was treated with 12-13% volume of NaOH at 80 to 90 deg C. The hydra table portions absorbed and became heavy and the heat helps to coagulate these smaller portions. The soap formation created and separation was achieved through difference in specific gravity, oil being lighter floated on top and soap, gums being heavier settled down. After and before added the NaOH, the oil was washed three times using water at 80- 90 deg C. The non- hydratable portion was separated by increasing the phosphorous concentration by way of mixing with .01% to .02% of phosphoric acid.

Choosing the Catalyst for the Transesterification Process

The transesterification process has to be carried out in the presence of a catalyst. The selection of catalyst is based on pH value of neat vegetable oil. If it is lesser than 7, acid catalyst should be selected and if it is greater than 7, base catalyst should be selected. The wrong selection of the catalyst leads to soap formation. Since the PH value of cotton seed oil is greater than 7, so we had used NaOH (base catalyst) as catalyst for the transesterification process.

Titration –To Determine the Amount of Catalyst

It is necessary to determine the exact amount of catalyst

(NaOH) needed for the transesterification process. Since adding too much or too little catalyst will just result in excessive amounts of bi-product (soap).

The following steps were followed for the titration process:

- Sodium Hydroxide solution was prepared by dissolving 1gm of NaOH in 1000 ml of water.
- Cotton seed oil solution was prepared by dissolving 1 ml. of oil in 10ml. of Isopropyl alcohol.
- NaOH solution was added to the cotton seed oil, one drop at a time. The PH level of the oil solution was checked, after adding each drop.
- An eventual rise in PH level was noticed. This process was continued till the oil solution attained a pH level of 8 to 9.

Fig. 1: Experimental Setup for Producing Biodiesel

Fig. 2: Refrigeration unit for Producing Biodiesel

Transesterification of cotton seed oil

A round bottom flask of 500 ml is used for the present analysis. The cotton seed oil in the flask was heated on a hot plate having magnetic stirrer arrangement is shown in fig.1. The mixture was stirred at the same speed for all test runs. Initially 100ml cotton seed oil is heated to 50^{0}C. Then the methanol 30ml and the catalyst 0.5gms (sodium hydroxide) are mixed. After the methanol and catalyst are mixed, they are poured into a reactor. The temperature maintained for the whole transesterification process is about 65^{0}C.The refrigeration unit (fig.2) is provided to condense the methanol and to get complete reaction. And heat up to three hours and switch off the system until cooled. After the cooling is over, the 'Glycerin' that is present in the vegetable oil is settled down at the bottom of the flask and the 'fatty acid esters' are separated from the Glycerin by using the separating funnel.

Separation

After the reaction is completed, the products are allowed to separate into two layers by using the separating funnel. Gravity is used to separate the two products, since they have different densities. Glycerin is the denser of the two products. We can separate the biodiesel (product) and glycerol. The lower layer contains impurities and glycerol. This top layer (ester) is separated.

Washing

The purpose of a water wash is to remove un-reacted alcohol, catalyst, or glycerin in the biodiesel. Two step wash is carried out using hot water washing and another one is salt water washing. This top layer (ester) is separated and purified using distilled water. Hot distilled water is sprayed over the ester and stirred gently and allowed to settle in the separating funnel. The lower layer is discarded and upper layer (purified biodiesel) is separated. And washed top layer of ester is rewashed with sodium chloride (Nacl). Un-reacted alcohol decreases the flashpoint of biodiesel. Biodiesel with 0.2% alcohol does not meet ASTM fuel Standards [4].Water wash will also remove any soap in the biodiesel.

Drying

The final product of purified ester was heated to 106^{0}C under vacuum to remove residual moisture. Around three hours to heat by using oven. Then the final biodiesel is got. Many of the parts in the diesel fuel injection system are made of high carbon steels; thus, they are prone to corrosion when in contact with water. Many diesel engines are equipped with water separators that cause small water droplets to coalesce until they are large enough to drop out of the fuel flow where they can be removed. There are some reports that these water separators are not effective when used with biodiesel.

RESULTS AND DISCUSSION

Calculation of Percentage Yield (% yield)

Percentage yield was calculated using the following formula: 548 Milliliters of methyl esters produced by 650Milliliter of oil taken for reaction. The yield Percentage of methyl esters was 84.3% Yield of methyl ester = (Milliliters of methyl esters produced/Milliliter of oil taken for reaction) ×100

Fuel properties of cottonseed oil methyl esters

The properties of COME are summarized in Table1 and compared with raw cotton seed oil and diesel.

Cetane number

The cetane number, which is a dimensionless descriptor of the tendency of the fuel to self ignite when the fuel is injected into the combustion chamber, was determined using an Ignition Quality Tester (IQT). The cetane number of cottonseed oil methyl esters was determined as 51.

Kinematic viscosity

Viscosity is a key fuel property because it influences the atomization of a fuel upon injection into the combustion chamber and eventually the formation of soot and engine deposits. The viscosity of the cottonseed oil methyl esters and diesel was measured by redwood viscometer. The raw cottonseed oil Kinematic viscosity was 50.7 is reduced to 5.20 at 40^{0}C. The Kinematic viscosity of cottonseed oil methyl esters is nearer to that of diesel.

Density and Heating value

The density of cottonseed oil methyl esters (COME) was 0.8752 g/cc at 15^{0}C.It is obvious that the density measurement of COME is quite lower than that pure cottonseed oil. Higher heating value is a measure of the energy produced when the fuel is burnt completely, which also determines the suitability of biodiesel as an alternative to diesel fuels. Table 1 shows that the gross calorific value of COME produced were 10142 Kcal/Kg. It is always desirable for the cottonseed oil methyl esters to have a calorific value nearer to that of diesel.

Table 1: Typical Property of Diesel, Cotton Seed Oil Methyl Ester and Cotton Seed Oil

Property	Diesel	Cotton seed oil methyl ester	Raw cotton seed oil
Density @15 C g/cc	0.8218	0.8752	0.9169
Kinematic viscosity@40C	3.01	5.2	50.7
Flash point (°C)	53	171	316
Fire point (°C)	61	182	322
Cloud point (°C)	8	14	l3
Pour point (°C)	Below -13	8	2
Specific gravity @15/15C	0.8225	0.8745	0.9176
Water content	nil	nil	nil
Gross caloric value kcal/kg	10,713	10,142	9981
Sediments %	nil	nil	0.001
CetaneNumer	52	51	49

Important temperatures

Pour point and cloud point are important for cold weather operations of the I.C. engine. For satisfactory working, the values of both should be well below the freezing point of the oil used. The cloud point (CP) and pour point (PP) observed for COME were 14 °C and 8 °C, respectively (Table 1). The Flash point and fire point observed for cottonseed oil methyl esters were 171 °C and 182°C, respectively (Table 1). Flash point is an important temperature from a safety point of view.

CONCLUSION

Cotton seed oil is chosen as a potential non-edible vegetable oil for the production of biodiesel. Here the biodiesel was prepared from cotton seed oil by transesterification process. Viscosity and density of methyl esters of cotton seed oil are 5.20 mm2/s and 0.8752 g/cc, which are very close to that of diesel. The calorific value of biodiesel is found to be slightly lower than that of diesel. The flash point of biodiesel is 1180C higher than that of diesel. The important properties of biodiesel produced from cotton seed oil are quite close to that of diesel. The methyl esters of cotton seed oil can be used in existing diesel engines without any modifications.

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