International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
International Conference On Emerging Trends in Mechanical and Electrical Engineering (ICETMEE- 13th-14th March 2014)

RESEARCH ARTICLE OPEN ACCESS

Use of Karanja Oil for Biodiesel Production

Sanjay Mohite[1], Amit Pal[2], Sagar Maji[3], Sudhir Kumar[4]

[1]Head of the Department, Department of Mechanical Engineering, Manmohan Memorial Polytechnic, Morang, Nepal

[2]Associate Professor, Department of Mechanical Engineering, Delhi Technological University, New Delhi, India

[3]Professor & Dean (IRD), Department of Mechanical Engineering, Delhi Technological University, New Delhi, India

[4] Professor & Head of the Department, Department of Mechanical Engineering, National Institute of Technology, Kurukshetra, Haryana, India

ABSTRACT

Demand of engine fuels is increasing tremendously, due to steep rise in the transportation activities. Fossil fuels are being used conventionally but their use results in high global warming, acid rain, ozone depletion and many other problems related to climatic changes and diseases. It is therefore required to find out the alternative fuels to substitute fossil fuels, which shall be eco-friendly and also reduces import of fossil fuels. In various western countries, edible vegetable oils have been used as an alternative fuel. In India, it will be very costlier affair to use edible oils as an alternative fuels in place of diesel. Mass production of Non-edible oils can be suitably planned in India, because of availability of large area of waste lands. In this experimental study, the potential of biodiesel production from Karanja oil is investigated. Biodiesel was prepared from Karanja oil by transesterification process with methanol in the presence of KOH as catalyst. A maximum conversion of 70% was achieved at 70^0C with optimum parameters for molar ratio of 6:1 at atmospheric pressure & reaction time 120 to 150 minutes.

Keywords: Biodiesel, Karanja Oil, Vegetable oils, Transesterification

I. Introduction

The vegetable oils can not be used directly in diesel engine because of its high viscosity and low volatility which leads to problem such as poor fuel atomization. This type of problem may cause engine failure such as injector coking, formation of carbon deposits and piston ring sticking etc. [1] Transesterification is the most efficient method to reduce the viscosity of vegetable oils. [2] Biodiesel is derived from vegetable oils or animal fats and it is actually monoalkyl esters of fatty acids. Vegetable oils react chemically with alcohol in the presence of catalyst i.e. Sodium hydroxide or Potassium Hydroxide to produce biodiesel. [3] Alcohol such as Methanol or Ethanol can be used for the production of biodiesel; If Ethanol is used, biodiesel produced is called ethyl ester and if methanol is used, the biodiesel is called methyl ester. [4] Tranesterification process and the type of vegetable oils used influences the properties of Biodiesel produced. [5] India imports 70% of the total petroleum fuel required, which costs about Rs.80, 000 crore every year. Rs.4000 crore can be saved by mixing 5% biofuel to diesel fuel in our country every year. [6] There is a large utilization of diesel fuel in transport, commercial, agriculture, and industrial sectors for the generation of power and if small fraction of diesel is replaced by biodiesel, it will have a significant effect on economy and the environment. [7] Subramanian et al. (2005) mentioned that diesel consumption is nearly five times higher than petrol consumption. It was also observed that there were increased in the cost of diesel fuel due to hike in crude oil prices and desulphurization processing cost in order to meet stringent emission norms. Biodiesel and ethanol can be considered as supplementary fuels to diesel in India. Biodiesel can also generate employments for rural people through plantation for vegetable oils. The Biodiesel blending can solve the problem of Indian diesel which has generally low flash point about 35^0C in comparison to world average of 52^0C and high sulphur content.[8]

It is stated that existing agricultural land can not be used for cultivation of vegetable oils used for biodiesel production. In our country, we have more than 100 Mha of waste and degraded land which can be utilized for the cultivation of non-edible vegetables used for biodiesl production. [9] Karanja oil can yield 900 to 9000 kg per hectare. It has a potential of 135000 million tonnes per annum and 6% is only being utlised. [10] Biodiesel is 100% renewable but when we use

fossil alcohol usually methanol in the transesterification, then there will be some percentage decrease in the renewability of biodiesel.[11] CL Peterson et al stated that there would not be addition of CO_2 in the atmosphere as CO_2 emitted will be recycled by the plant while using biodiesel in engines. [12]

There are various processes of biodiesel production among which high level of conversion of triglycerides is obtained by transesterification using alkali as catalyst in short duration.

1. Availabilities & Properties of Non-edible oils in India

The forest of India has wide range of non edible plants and oilseeds. The Indian economy can be improved by using these non edible oils like Neem, Karanja, Kusum, Ratanjyot, Tumba, Pilu, Sal, Mahua, Phulware, Simarouba, Jojoba, Chullu, Kokum etc. Out of the above mentioned non edible plants, Karanja is easily available and may be cultivated easily in many parts of India. Therefore, the properties of Karanja tree is discussed in this paper as given below:-

Karnaja: Karanja is a member of Leguminaceae family. It is a medium size tree with a height of about 18 m and trunk diameter greater than 0.5 m. It can grow under a wide range of agroclimatic conditions and can be grown in coastal areas, tidal forests and on roadsides. It can be grown in environments having annual rainfall of range 500-2500 mm. It is highly tolerant of salinity.[13] The tree is considered to be a native of western ghats and is chiefly found along the banks of streams & rivers or near sea coast in beach & tidal forests.[14] The short duration oilseeds & pulse crops can be grown successfully as intercrops upto 4-5 years after planting without affecting the growth of Karanja plants. [15] Karanja is one such forest based non-edible oil with a production potential of 135000 million tones. [16]

II. Production Methods of Biodiesel

The biodiesel can be produced by the following useful methods:-

1. Micro-emulsions
2. Pyrolysis
3. Transesterification

Out of the above production methods, the transesterification is the most efficient method for the production of biodiesel from non edible oils. In transesterification process, a triglyceride reacts with three molecules of alcohol in the presence of catalyst producing fatty acids alkyl esters and glycerol. Tranesterification is the reversible reaction so excess alcohol is added to increase the yield of alkyl esters and to allow its phase separation from the glycerol formed.

The various parameters which affect the conversion of non-edible oils to biodiesel are given below:-

1. Time of reaction
2. Reaction Temperature
3. Molar Ratio (Molar ratio of alcohol to non-edible oil)
4. Type of catalyst and concentration
5. FFA content of the vegetable oil

1 Time of reaction: It is one of the important parameter. Conversion of non edible oil increases with the increase in reaction time. After a certain time of reaction there is no further increase in the conversion with the increase in reaction time because of the following factors:-

i) Rate of reaction is directly proportional to the concentration of oil in the reaction mixture. The rate of reaction therefore decreases with time as the concentration of oil keeps on decreasing with time.

ii) Transesterification is a reversible reaction and has an equilibrium conversion, which is independent of time. Optimum reaction time to obtain high conversion is 110-120 min.

2. Reaction temperature: The rate of reaction is affected by reaction temperature. The reaction is conducted close to boiling point of methanol (60^0C to 70^0C) at atmospheric pressure. This reaction condition is required for the removal of free fatty acids from the oil by pre-esterification. The maximum yield of ester is obtained at temperatures ranging from 60^0C to 80^0C at molar ratio (alcohol to oil) of 6:1. Negative effect is reported if the temperature is increased further.

3. Reactants Ratio (Molar Ratio of Alcohol to Oil): Molar ratio of alcohol to non-edible oil is also important variable. When 100% excess methanol is used, the reaction rate is the highest. A molar ratio of 6:1 is normally used to obtain methyl ester yields higher than 80% by weight. Higher molar ratio of alcohol to non edible oil interferes in the separation of glycol.

4. Type of catalyst & concentration: Alkali metal alkoxides are the most effective transesterification catalyst compared to the acidic catalyst. Sodium alkoxides and Potassium alkoxides are the most efficient catalysts. Transmethylations occurs approximately 4000 times faster in the presence of an alkaline catalyst than those catalysed by the same amount of acidic catalyst. The alkaline catalysts are also less corrosive to industrial equipments than acidic

catalysts. Therefore alkaline catalysts are preferred for the process. The alkaline catalyst concentration in the range of 0.5 to 1% by weight yields 80% to 85% conversion of non-edible oil into esters. Further increase in catalyst concentration does not increase the conversion and it adds to extra costs.

5. FFA content of the vegetable oil: FFA content signifies the free fatty acid content. Lower the FFA easier the conversion of the vegetable oil to biodiesel. Preferably FFA content must be lower than 2.5%, otherwise we have to adopt the two step transterification process for the conversion of the vegetable oil to biodiesel.

III. Production Process

The following table proposed the required quantities of Methanol and Catalyst (KOH) to mix in Non-edible oils for the production of Biodiesel:-

Molar Ratio Alcohol/ Oil	Quantity of Non-edible oil (gm)	Quantity of Methanol (gm)	Catalyst (KOH)		
			0.5 %	0.75 %	1.0 %
6:1	50	11	0.25 gm	0.375 gm	0.5 gm
4.5 : 1	50	8.28	0.25 gm	0.375 gm	0.5 gm

Experimental Setup

A cylindrical glass jar is taken and mixture is put inside the jar. Digital thermometer is use to take the temperature of mixture. The cylindrical glass jar is put on metallic heater and the magnetic metal piece stirrer is put into the mixture. The magnetic stirrer mixes the mixture properly.

Experimental Procedure

A known quantity of karanja oil (100 gm) was taken inside the cylindrical glass jar and heated about 70^0C. This temperature is maintained throughout the reaction by the thermostat inside the metallic heater. Prior to this the oil was preheated upto 110^0C to remove unwanted moisture in the oil. KOH was used as catalyst to achieve basic medium in transesterification. Catalyst was dissolved in alcohol (Methanol). The catalyst, Potassium Hydroxide (Potash) was dissolved in alcohol using a standard agitator. Alcohol with dissolved catalyst was added to Karanja oil at 70^0C and equilibrium temperature was maintained, alcohol used to vaporize during the reaction. This reaction temperature was maintained as rate of reaction was directly proportional to temperature. Recommended reaction time varies from 120-150 minutes. Excess alcohol is normally used to ensure total conversion of non edible oils to its esters. The solution was kept in separating funnel after the reaction was over. Two phases of different densities were formed during the process of transesterification.

Separation: Separation was done in separating funnel which takes 4 to 6 hours. The upper layer consisted of biodiesel and lower layer consisted of heavier glycerin with some impurities. The glycerin was heavier and it can be taken out from the bottom of beaker.

Water Wash Process: Biodiesel obtained contains some amount of catalyst and soap. These can be removed by gently washing it with warm water. The biodiesel was mixed with water amounting to 1/3rd by volume of Biodiesel. It was heated gently and then the water was taken out. The biodiesel was again heated to 100-110^0C to remove any traces of water and alcohol. In this way, the biodiesel was produced.

IV. Results

Yield of Biodiesel: The three Karanja oil samples of 100 gm each were taken. In 1st Sample, 100gm oil was mixed with 22gm Methanol and 1gm KOH and the yield obtained was 70%. In 2nd sample, 100 gm oil was taken and mixed with 22gm Methanol and 3gm KOH and the yield obtained was 50%. In the 3rd sample, 100 gm Karanja oil was mixed with 44gm Methanol and 2gm KOH and the yield obtained was 64%.

V. Conclusions

It is concluded that Karanja oil can be used to produce biodiesel. The optimum parameters for molar ratio of 6:1, Quantity of Karanja oil 100gm, Quantity of Methanol 22gm, & 1 gm KOH, Pressure 1 atmosphere, temperature 70^0C, Reaction Time 120 to 150 Minutes with Alkaline Catalyst Method. Further two step process (Acid catalyst followed by Alkaline Catalyst) may be used to achieve higher yield and lower reaction time.

References

[1] Murat Karabektas, Gokhan Ergan, Murat Hosoz, "The effects of preheated cottonseed oil methyl ester on the performance and exhaust emissions of a diesel engine", Applied Thermal Engineering 28 (2008) 2136-2143

[2] Hanbey Hazar & Huseyin Aydin, "Performance and emission evaluation of a CI engine fueled with preheated raw rapeseed oil (RRO) - diesel blends", Applied Energy 87(2010) 786-790

[3] Piyanuch Nakpong, Sasiwimol Wootthikanokkhan, "High free fatty acid coconut oil as a potential feedstock for biodiesel production in Thailand", Renewable Energy 35(2010) 1682-1687

[4] Titipong Issariyakul, Mangesh G.Kulkarni, Lekha C. Meher, Ajay K. Dalai, Narendra N. Bakhshi, "Biodiesel production from mixtures of canola oil and used cooking oil", Chemical Engineering Journal 140(2008) 77-85

[5] Sidharth Jain, M. P. Sharma, "Biodiesel production from Jatropha curcas oil", Renewable & Sustainable Energy Reviews 14(2010) 3144-3147

[6] R. D. Misra, M. S. Murthy, "Straight Vegetable oils usage in a compression ignition engine-A review", Renewable and Sustainable Energy Reviews 14(2010) 3005-3013.

[7] B. K. Barnwal, M. P. Sharma, "Prospects of biodiesel production from vegetable oils in India", Renewable and sustainable energy reviews 9(2005) 363-378

[8] K. A. Subramanian, S. K. Singal, Mukesh Saxena, Sudhir Singhal, "Utilization of liquid biofuels in automotive diesel engines: an Indian perspective", Biomass and Bioenergy 29 (2005) 65-72.

[9] Dutta R, Report on the committee on "Role of NGOs, Financial Institutions, Corporate bodies etc in raising plantation for promotion of biofuels", Planning commission, Government of India, New Delhi.

[10] Bobade S N Khyade V B, "Detail study on the properties of Pongamia Pinnata (Karanja) for the production of biofuel", Research Journal of Chemical Sciences Vol. 2(7), pp16-20, July2012

[11] Magin Lapurta, Octavio Armas, Jose Rodriguez- Fernandez, "Effect of biodiesel fuels on diesel emissions", Progress in Energy and Combustion Science 34(2008)198-223.

[12] Peterson C L, Hustrulid T, "Carbon cycle for rapeseed oil biodiesel fuels", Biomass and Bioenergy 1998:14(2):91-101

[13]. L C Meher, S N Naik & L M Das,"Methanolysis of Pongamia Pinnata (karanja) oil for production of biodiesel" Journal of Scientific and Industrial Research, Vol.63, Nov 2004, pp913-918

[14]. Bringi, N. V., "Non-traditional oilseeds and oils in India", Oxford & IBH Publishing Co. Pvt. Ltd, (1987) New Delhi

[15]. National Oilseeds & vegetable oils development board (NOVOD BOARD), Ministry of Agriculture, Government of India, 2008.

[16]. Srivastava A & Prasad R, "Triglycerides based diesel fuels", Renewable & Sustainable Energy Reviews, 4:111-133, 2000