RESEARCH PAPER

Biodiesel production from cotton seed oil using alkali catalyst and its characterization

R. SUMATHI AND R.S. MEERABAI

Department of Plant Biology and Plant Biotechnology, P.S.G.R. Krishnammal College for Women, Peelamedu, COIMBATORE (T.N.) INDIA
Email : sumi_eswar@yahoo.co.in

Biodiesel production has received considerable attention in the past as a biodegradable and non-polluting fuel. The production of biodiesel by transesterification process employing alkali catalyst has been widely accepted for its high conversion and reaction rates. In India, edible oils like sunflower, mustard, palm, cotton seed oil, groundnut oil etc., are available in abundance, which can be converted to biodiesel. In the present study, biodiesel has been prepared from cotton seed oil. As the acid value is less than two, it is easily converted to biodiesel by transesterification process. The experimental work revealed the suitability of sodium hydroxide / potassium hydroxide and methanol as solvent for maximum methanolysis at 60-70°C in 45 minutes. Properties of biodiesel are in concordance with international standards.

Key words **:** Biodiesel, Cotton seed oil, Transesterification, Renewable energy

How to cite this paper **:** Sumathi, R. and Meerabai, R.S. (2012). Biodiesel production from cotton seed oil using alkali catalyst and its characterization. *Asian J. Bio. Sci.*, **7** (1) : 84 - 87.

INTRODUCTION

Biodiesel, an alternative diesel fuel, is made from renewable biological sources such as vegetable oils and animal fats. Its biodegradable and non-toxic, has low emission profiles and so it is environmentally beneficial. Vegetables oils are potentially in exhaustible source of energy with an energetic content close to diesel fuel. The vegetable oil fuels were not acceptable because they were more expensive than petroleum fuels. However, with recent increases in petroleum prices and uncertainties concerning petroleum availability, there is a renewed interest in vegetable oil fuels for diesel engines.

Biodiesel is alkyl esters made from the transesterification of both vegetable oil and animal fats which are chemically triglycerides in which three fatty groups are ester bonded to one glycerol molecule. Transesterification is the process of reacting triglyceride of the vegetable oils with solvents such as butanol, ethanol and methanol in the presence of catalyst *viz.*, sodium hydroxide / potassium hydroxide to produce fatty acid methyl esters and glycerol. There is a decrease in viscosity and improvement in fuel properties of the product fatty acid alkyl esters through the process of transesterification. Biodiesel can be used in the pure form or as blends on conventional petrodiesel in automobiles without any major modifications. This paper deals with preparation of alkali catalyzed methyl ester from cotton seed oil and its properties to ascertain its suitability as biodiesel.

RESEARCH METHODOLOGY

Transesterification process:

Transesterification of cotton seed oil to obtain biodiesel consist in replacing the glycerol of triglycerides with a short chain alcohol in the presence of a catalyst. In this method, according to the free acids present in oil, the amount of catalyst was selected. The catalyst (sodium hydroxide / potassium hydroxide-1g) was dissolved in 45ml of alcohol (Methanol/ Ethanol/ Butanol/ Isopropyl alcohol) under low temperature using 100ml of oil. In this process glycerol and methyl esters (biodiesel) are obtained and separated in two different immiscible phases, distributing amongst them an excess of added alcohol and catalyst.

Optimization of process parameters:

From the alkali catalyst thus identified, the optimum quantity required for maximum yield of biodiesel was found

HIND INSTITUTE OF SCIENCE AND TECHNOLOGY

out by using 300, 350, 400, 450, 500, 550 and 600mg per 100ml of cotton seed oil.

Since the ratio of alcohol to vegetable oil is one of the important factors that affects the yield as well as production cost of biodiesel, the ratio of suitable alcohol identified was varied from 20, 25, 30, 35, 40, 45 and 50ml per 100ml of cotton seed oil used with optimum quantity of catalyst.

Separation and purification of biodiesel:

After the completion of the reaction, the product was kept over night for separation of biodiesel and glycerol layer. The catalyst and unused alcohol were present in the lower glycerol layer where as a small quantity of catalyst and alcohols were in the upper biodiesel layer. The upper esterified layer was collected and washed with hot distilled water and dried to remove traces of moisture.

Physico chemical properties of FAME:

The fuel properties namely kinematic viscosity, specific gravity, cloud point, pour point, flash point, fire point and ash content (Sudharani, 1998), iodine value and saponification value (William Horowitz,1975) of cotton seed oil biodiesel was determined as per the prescribed methods and compared with that of the conventional diesel as per ASTM / EN standards.

RESEARCH FINDINGS AND ANALYSIS

Sodium hydroxide / potassium hydroxide (alkali catalyst) and methanol (alcohol) were found to be suitable for higher biodiesel yield in the conversion of cotton seed oil to biodiesel by transesterification (Fig. 1a and 1b). The process parameters when optimized suggested that 350mg of sodium hydroxide / Potassium hydroxide and 25ml of methanol per 100ml of cotton seed oil could yield maximum biodiesel (Fig. 1c, 1d, Fig. 2a and 2b). Similar results were obtained by Antolin *et al.* (2002) Ramadhas *et al.* (2005) and Murugesan *et al.* (2008).

The fuel properties of cotton seed oil methyl esters were determined experimentally to ascertain their suitability as diesel fuel by using standard methods and results are presented in Table 1.

A small quantity of free fatty acid (FFA) is usually present in oils along with the triglycerides. The FFA content of cotton seed oil was lesser than the standards.

The absolute viscosity of a fluid oil can be determined by measuring the rate of flow of the oil through a capillary tube kept at a uniform temperature, but in the case of lubricating oils, specific viscosity was generally determined by measuring the time taken for a given quantity of oil to flow through an orifice or jet of standard dimension under standard conditions. High viscosity of vegetable oils and animal fats tends to cause problems when directly used in diesel engines (Bajpai and Tyagi,2006). If the oils and fats are transesterified using short chain alcohols, the resulting mono esters have viscosities that are closer to petroleum based diesel fuel. The viscosity of cotton seed oil biodiesel is higher than the standards.

Densities of biodiesel vary between 0.86-0.90 depending on the feed stock used and that of conventional diesel as per standards. The density of cotton seed oil biodiesel in the present work is within international standards for biodiesel.

The iodine value is the measure of the degree of unsaturation of the fuel. Unsaturation can lead to deposit formation and storage stability problems with fuels. In the present work, the iodine value of cotton seed oil was 119.92. The soyabean oil, sunflower oil and cotton seed oils are used in engines and it was suggested by Ryan *et al.* (1984) that the maximum iodine value should be limited to 135. The iodine value of cotton seed oil biodiesel is within international standards.

Saponification value is the process by which the fatty acids in the glycerides of the oil are hydrolyzed by an alkali. The saponification value of cotton seed oil biodiesel is within the standards.

The flash point is the lowest temperature at which oil on vaporization gives sufficient quantity of vapours that will flash when brought into contact with flame. The fire point of oil is the lowest temperature at which it will give enough vapour, which on rising will begin to produce a continuous flame above

Table 1 : Comparison of cotton seed oil methyl esters (Biodiesel) with standards

Properties	Cotton seed oil	Cotton seed oil biodiesel (NaOH)	Cotton seed oil biodiesel (KOH)	ASTM standards	EN standards
FFA mgKOH/g	1.2	0.4	0.3	-	-
Kinematic viscosity centistrokes	36.88	17.72	17.88	1.9-6	3.5-5
Density kg/m^3	0.9150	0.8729	0.7608	0.82-0.88	0.86-0.90
Iodine value	111.92	66.42	66.01	125.5	120
Saponification value	180.30	158.40	149.40	180	-
Flash point (^oC)	308	164	172	130	120
Fire point (^oC)	328	172	186	-	-
Cloud point (^oC)	3.0	1	1	-3 to 12	-
Pour point (^oC)	-4	-2	-2	-15 to 10	-

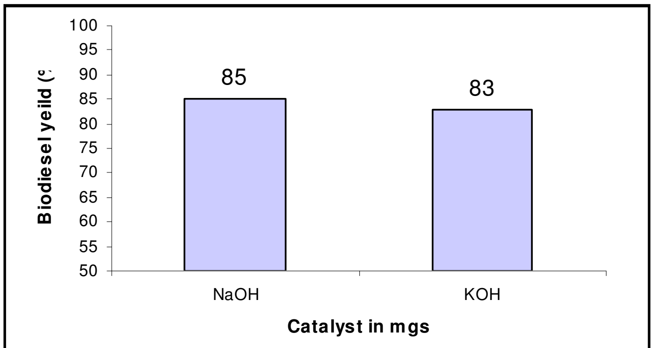

Fig. 1 a : Biodiesel production using chemical catalyst

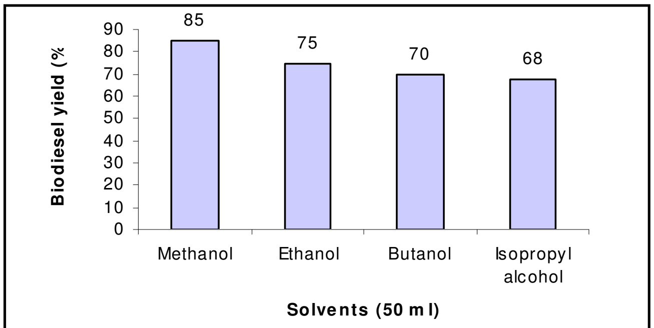

Fig. 1 b : Biodiesel production using different solvents

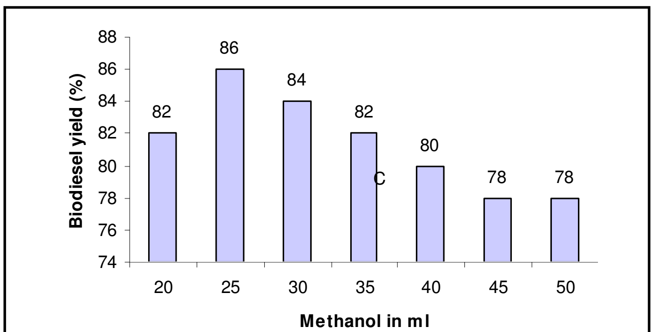

Fig. 1 c : Biodiesel production using different concentrations of methanol (NaOH)

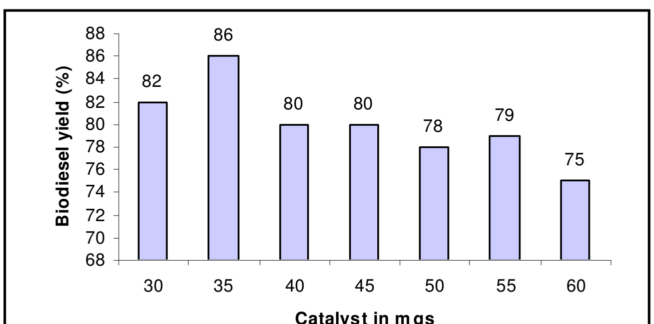

Fig. 1 d : Biodiesel production using different concentrations of sodium hydroxide

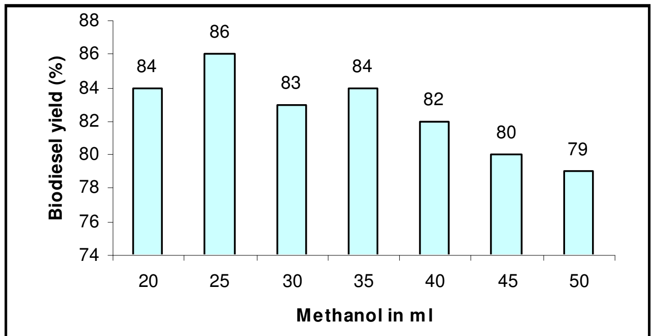

Fig. 2 a : Biodiesel production using different concentrations of methanol (KOH)

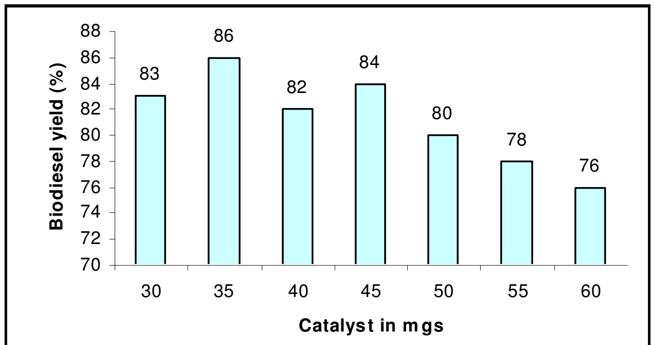

Fig. 2 b : Biodiesel production using different concentrations of potassium hydroxide

the oil. In most cases, the fire points are 5^0C to 40^0C higher than the flash points. The flash points and fire points do not have any bearing with the lubricating property of the oil, but these are important, when oil is exposed to high temperature. A good lubricant should have flash point at least above the temperature at which it is to be used. The flash and fire points of cotton seed oil biodiesel seem to be significantly higher than the standards specified.

The cloud point is the temperature at which the oil will become cloudy in appearance when cooled at a standard rate. The pour point is the lowest temperature which the oil will just cease to flow or pour when cooled under definite prescribed conditions. The cloud and pour point indicates the suitability of lubricants on cold conditions. Lubricant used in machine working at low temperature should possess low pour point; other wise solidification of lubricant will cause jamming of the machine. These properties were almost similar to the prescribed standards. Similar results were obtained by Masjuki *et al*. (1993)

These properties of cotton seed oil biodiesel and the conversion yield of cotton seed oil to biodiesel is upto 95 per cent by the methods employed in the preset investigation ensure the suitability of cotton seed oil biodiesel as a source of biodiesel.

Acknowledgement:

The authors would like to thank authorities of P.S.G.R. Krishnammal College for Women for providing the laboratory facilities for carrying out the above research work.

LITERATURE CITED

Antolin, G., Tinaut, Y., Briceno, V., Castano, C., Perez and A.L., Remirez (2002). Optimization of biodiesel production by sunflower oil transesterification. *Bioresour. Technolol.,* **83** : 111-114.

Bajpai, Divya and Tyagi, V.K. (2006). Biodiesel : source, production, composition, properties and its benefits. *J. Oleo Sci.*, **55**(10): 487-502.

Masjuki, H.,.Zaki A.M. and Sapuan, S.M. (1993). Methyl ester of palm oil as an alternative diesel fuel. In : *Fuels for automotive and industrial diesel engines*. Institution of Mechanical Engineers, LONDON 129 pp.

Murugesan, A., Srinivasan, P.S.S., Subramanian, R. and Neduzchezhian, N. (2008). KOH-catalyst production of maximum yield biodiesel fuel from pongamia oil. *Indian J. Engg. Sci. & Technol.*, **2**(1) : 22-26.

Ramadhas, A.S., Jayaraj, S. and Muraleedharan, C. (2005). Biodiesel production from high free fatty acid rubber seed oil. *Fuel.,* **84** : 335-340.

Ryan III, T., Dodge, L.G. and Callahan, T.J. (1984). *J. Am. Oil. Chem. Soc.*, **61** : 1610-1613.

Sudharani (1998). *Laboratory manual on engineering chemistry.* Dhanpat Rai Publishing Company (P) Ltd., NEW DELHI (India).

William Horowitz (ed) (1975). *Official methods of analysis*, AOAC Association of Official Analytical Chemists WASHINGTON 12th Ed, 490 pp.

Received : *01.02.2012;* **Revised :** *28.02.2012;* **Accepted :** *10.03.2012*