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GREEN SYNTHESIS OF BIODIESEL FROM VARIOUS VEGETABLE OIL AND CHARACTERISATION BY FT-IR SPECTROSCOPY

P. V. TEKADE*, O. A. MAHODAYA, G. R. KHANDESHWAR and B. D. JOSHI

Department of Chemistry, Jankidevi Bajaj College of Science, Jamnalal Bajaj Marg, Civil lines, WARDHA – 442001 (M.S.) INDIA

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ABSTRACT

Vegetable oil is a renewable starting material as it is derived from growing plants, rather than irreplaceable material like the earth's petroleum and natural gas supplies. We have performed experiments, for the synthesis of biodiesel from different vegetable oils such as soybean oil, groundnut oil, mustard oil, sesame oil, coconut oil and jawas oil. Biodiesel is methyl or ethyl ester of vegetable oil. Confirmation of the biodiesel was done on FT-IR spectrometer. The IR value ranges from 1741 to 1743 cm^{-1}, which clearly indicates carbonyl group of ester in biodiesel. Boiling point of biodiesel was determined in open capillary. The byproduct glycerol i.e. (propane 1, 2, 3 triol) was also confirmed by special tests. The reaction is catalyzed by NaOH making this process economically viable for the industrial scale production of biodiesel. Biodiesel is an excellent product as it is environmentally friendly. These experiments demonstrate the key principles of green chemistry.

Key words: Biodiesel, Green chemistry, FT-IR spectroscopy.

INTRODUCTION

The Green Chemistry program supports the invention of more environmentally friendly chemical processes which reduce or even eliminate the generation of hazardous substances. Biodiesel name itself suggest the synthesis of biodiesel naturally i.e. from vegetable and animal oil or triglycerides. Synthesis of biodiesel has done with the help of green chemistry i.e. very less hazardous substances were use in the synthesis of biodiesel. Chemically, triglycerides consist of three long-chain fatty acid molecules joined by a glycerin molecule.

Biodiesel is a diesel fuel that is made by reacting vegetable oil (cooking oil) with other common chemicals. Biodiesel may be used in any diesel automotive engine in its pure form or blended with petroleum-based diesel. No modifications are required, and the result is a less-expensive, renewable, clean-burning fuel. Research conducted during last 15 years has indicated that vegetable oil derived fuel can used in diesel engine to reduce some engine exhaust emission components such as unburned fuel, total hydrocarbon, carbon monoxide & particulate matter. Esterified vegetable oil contains oxygen which can contribute to lower level of particulate matter[1,2]. Biodiesel is methyl or ethyl ester of vegetable oil[3].

Available online at www.sadgurupublications.com
*Author for correspondence; E-mail: pradiptekade@gmail.com

Interesterification, transesterification, esterification and alcoholysis are all names given to the chemical process of transforming the triglyceride and an alcohol into ester and glycerol. Biodiesel has been known to break down deposits of residue in the fuel lines where petro diesel has been used[4]. In 2005, Chrysler released the Jeep Liberty CRD diesels from the factory into the American market with 5% biodiesel blends, indicating at least partial acceptance of biodiesel as an acceptable diesel fuel additive[5]. In 2007, Daimler Chrysler indicated its intention to increase warranty coverage to 20% biodiesel blends if biofuel quality in the United States can be standardized[6]. The Volkswagen Group has released a statement indicating that several of its vehicles are compatible with B5 and B100 made from rape seed oil and compatible with the EN 14214 standard. The use of the specified biodiesel type in its cars will not void any warranty[7]. Starting in 2004, the city of Halifax, Nova Scotia decided to update its bus system to allow the fleet of city buses to run entirely on a fish-oil based biodiesel. This caused the city some initial mechanical issues, but after several years of refining, the entire fleet had successfully been converted[8,9]. In 2007, McDonalds of UK announced it would start producing biodiesel from the waste oil byproduct of its restaurants. This fuel would be used to run its fleet[10]. A technical research paper[11] describes laboratory research and field trials project using pure biodiesel and biodiesel blends as a heating fuel in oil-fired boilers. Research into the use of transesterified sunflower oil, and refining it to diesel fuel standards, was initiated in South Africa in 1979. By 1983, the process for producing fuel-quality, engine-tested biodiesel was completed and published internationally[13]. Percentage Composition of some oils and fats are as follows:

Groundnut oil : Oleic acid (46-72), linoleic acid (13-38), palmitic acid (6-14)

Soybean oil : Oleic acid (20-50), Linoleic acid (36-65), palmitic acid (7-12)

Coconut oil : Oleic acid (13-44), linoleic acid (33-58), palmitic acid (17-29)

Mustard oil : Oleic acid (8-40), linoleic acid (10-29).

EXPERIMENTAL

This experiment demonstrates the use of groundnut oil as an alternative. The reaction incorporates NaOH as a catalyst in order to achieve high yield and minimize waste. In addition, glycerol the by-product can be reused in order to make glycerin soap.

In this experiment we have synthesized biodiesel from a triester of glycerol (a triacylglycerol or triglyceride). This reaction is known as a transesterification reaction. Transesterification is the process of transforming one type of ester into another type of ester. This reaction incorporates the use of the strong base sodium methoxide. The overall mechanism is catalyzed by the presence of NaOH.

In the first step of the reaction, NaOH reacts with methanol in an acid-base reaction. The product of this reaction is the very strong base sodium methoxide and water.

$$NaOH + CH_3OH \longrightarrow CH_3ONa + H_2O$$

In second step pure groundnut oil was warmed and poured into sodium methoxide solution with continuous stirring. At first the mixture was cloudy, and then two layers were separated. The contents were transferred into the separating funnel. The mixture was separated into two layers. The lower layer is of glycerol and the upper layer was of biodiesel. The system was allowed to settle down for an hour, and then biodiesel was separated with the help of separating funnel.

The same procedure was followed for the other vegetable oils such as sesame oil, mustard oil, coconut oil, jawas oil and soybean oil.

Table 1.

S. No.	Name of oil	FT-IR (cm^{-1})	Colour
1.	Groundnut oil	1743	Yellow
2.	Soybean oil	1742	Yellow
3.	Coconut oil	1741	Colorless
4.	Mustard oil	1743	Yellowish Orange
5.	Sesame oil	1743	Yellowish Orange
6.	Jawas oil	1741	Yellowish Orange

CONCLUSION

The yield of product i.e. biodiesel obtained from soybean, groundnut and jawas oil was More than that of coconut and sesame oil.

Confirmation of the biodiesel was done on FT-IR spectrometer (Bruker Alpha Model). The IR value ranges from 1741 to 1745 cm^{-1}, which clearly indicates carbonyl group of ester in biodiesel.

We performed some test for confirmation of glycerol:

(i) Glycerol + Conc. H_2SO_4 $\longrightarrow$ No Colour

(ii) Glycerol + Conc. H_2SO_4 + Heat $\longrightarrow$ Yellow colour

(iii) Dunstan's Test: Aqueous solution of glycerol is added to borax phenolphthalein (few drops of alcoholic solution were added to very dilute solution of borax) $\longrightarrow$ pink color disappears and reappears on warming.

All the above tests were positive, which confirms presence of glycerol.

Biodiesel is an excellent product as it is environmentally friendly. These experiments demonstrate the key principles of green chemistry.

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