



A study of bio-diesel production and its characterization by using homogeneous catalyst

Remya D S^{1*}, Salin Raj S S², Yardily A³

¹ Department of Chemistry, All Saints' College, Trivandrum, Kerala University, Kerala, India

² Department of Chemistry, Stella Marys College of Engineering, Aruthenganvilai, Kanniyakumari, Tamil Nadu, India

³ Department of Chemistry, Scott Christian College, Nagercoil, Tamil Nadu, India

Abstract

Biodiesel has been defined as the mono-alkyl esters of long chain fatty acids, preferentially methyl and ethyl esters, derived from renewable feed stocks, such as vegetable oils or animals fats. Combustion of biodiesel in diesel engines results in energy and CO₂, which is absorbed through the plant growth. In this study, transesterification method is adopted for synthesizing biodiesel using homogeneous catalyst. The newly synthesized biodiesel is subjected to study its acid value, molecular weight through saponification value. In addition its viscosity, Flash Point and Fire points were determined.

Keywords: Biodiesel, homogeneous catalyst, flash point, viscosity, fire point

Introduction

Diesel engines have been supporting modern society over a century through transport and construction, for example since Rudolf Christian Karl Diesel invented the internal combustion engine at the end of 19th century. Diesel engines with high thermal efficiency have many advantages [1]. While powerful gasoline engines require many cylinders and high revolutions, powerful diesel engines are achieved by increasing the volume of each cylinder, resulting in simple and durable internal combustion engines. Diesel engines are more efficient than gasoline engines of the same power; a common margin is 40% more miles per gallon for an efficient turbo diesel engine. This means that diesel engines consume less fuel and produce less carbon dioxide (CO₂) per unit distance. Biodiesel is the name given to any diesel equivalent to bio-fuel which can be used in an unmodified diesel engine vehicle.

Recently, advances in production and changes in the political climate have increased the availability and awareness of biodiesel, an alternative to petroleum - derived diesel fuel with a much lower net - sum of CO₂ emissions, due to the uptake of CO₂ by the plants used to produce the fuel [2]. Biodiesel is in a broad sense, composed of higher fatty acid derivatives such as fatty acid esters made from triglycerides or higher fatty acids in plant materials or animals fats. Plants convert solar energy into plant materials such as higher fatty acid and triglycerides and consume CO₂. Triglycerides and higher fatty acids present in plant seeds cannot be directly combusted in modern diesel engines; therefore these are converted into biodiesel using chemical processes that consume energy [8]. At present, the need of energy is increasing continuously, because of increase in industrialization as well as human population. Basic source of energy is petroleum, natural gas, coal, hydro and nuclear energy. In general biodiesel is most commonly made with a mixture of vegetable oil, animal fats and methanol/ ethanol [3]. It is there for essential for the

production of environmentally benign Biodiesel production using homogeneous catalyst such as KOH/ NaOH.

Biodiesel is clean burning alternative renewable fuels made from natural sources, which is derived from renewable feed stocks by transesterification process and have low toxicity, renewability and completely biodegradable natural energy source alternate to petro- diesel. Present studies involve the synthesis of biodiesel from palm oil through catalyst (KOH) by changing the reaction parameters such as temperature, pH changes and characterized by various physico- chemical properties [9]. Biodiesel is the mono-alkyl esters of long-chain Fatty acids derived from vegetable oils as well as animal fats, Biodiesel synthesized from the triglycerides in vegetable oils by transesterification reaction with alcohol. In this reaction, the oil reacts with an alcohol in a number of consecutive, reversible steps to form esters and glycerol. Generally Biodiesel has a higher density, viscosity, cloud point and octane number and a lower volatility and heating value compared to commercial grades of diesel fuel. Biodiesel can be used neat or blended in existing diesel engines without significant modification to the engine. In 2005, Malaysia and Indonesia produced nearly 80% of 35 million tones total world production of Palm oil.

Experimental

Materials and methods

Anala R grade chemicals of potassium hydroxide, ethanol, HCl, Calcium chloride and Phenolphthalein were purchased from sigma Aldrich. Palm oil purchased from shop. The solvents are not further purified and used as received. The purity of the reagents & chemicals are 99%.

Instruments

Cleave Land Flash and Fire Point apparatus, Red wood Viscometer, Separating funnel, Thermometer, Water Condenser.

Synthesis

Synthesis of Biodiesel

Transesterification process

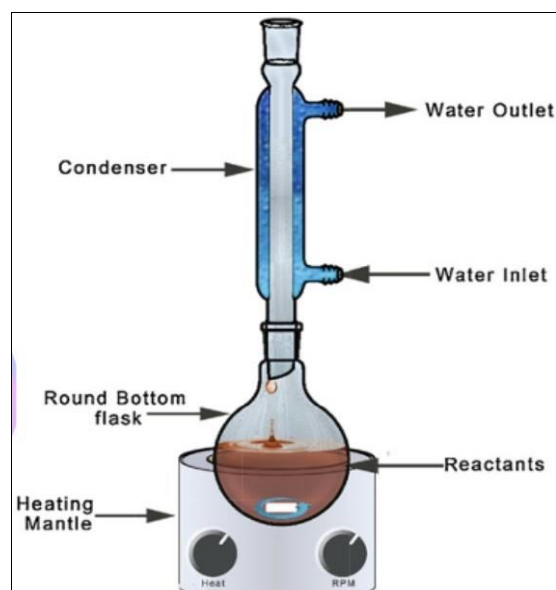


Fig 1: Preparation of biodiesel

Transesterification of Biodiesel consists of following ways. Take the weight of Palm oil and Ethanol in 1:6 ratios and the weight of the catalyst KOH is 1%. Initially ethanol and KOH is mixed homogeneously, and then the required amount of Palm oil is taken in a RB flask and the homogeneous alcoholic KOH is added to the flask [16]. This solution is kept at 60°C and refluxed using water condenser [Fig. 1], the heating is stopped till the formation of ethyl ester. After the specific duration of the reaction finished, heating and agitation were stopped and the reaction product was allowed to settle over a night [Fig. 2]. The reaction's result was two distinct liquid phases; the first was the Palm oil ethyl ester or the biodiesel on the top and the second was the denser phase of glycerol. Ethyl ester phase was applying to a separation process and showered by cold or warm deionized water several times until becomes clean. Excess ethanol and water in ethyl ester was removed by an evaporation process under atmosphere pressure conditions. The resulted ethyl ester was dried using CaCl₂. The previously dried ethyl ester was filtered using filter paper; finally we get pure form of biodiesel. The yield of the biodiesel was we found out [Fig 3].



Fig 2: Separation of Biodiesel using separating funnel

Result and Discussion

Determination of acid Value

About 1 gram of palm oil was titrated against standard potassium hydroxide solution (0.01N), using phenolphthalein as the indicator and the acid value of the palm oil which is also measure of free fatty acid content [3], was determined using the formula [4, 5] given below,

$$\text{Acid Value} = \frac{\text{Eq. Wt. of KOH} \times \text{Titre Value} \times \text{Strength of KOH}}{\text{Wt. of Palm oil}}$$

Determination of Saponification Value

Saponification value was defined as the number of mgs of KOH required to saponify 1 gm of fat or oil [6]. This

indicates the length of fatty acid chain in the given oil. A known amount of oil was treated with excess standard alcoholic KOH [7]. The excess alkali was determined by titrating against the standard alkali [8].

Determination of Flash and Fire Point

Biodiesel taken in the Cleave land Flash and Fire point apparatus is heated by in electric heater [9, 10]. A thermometer is placed inside the cup with its bulb in contact with the fuel [11]. When a particular temperature is reached, the evaporation rate is sufficient to cause a flash, which is the Flash Point of Biodiesel.

On continuous heating, the evaporation rate increases and the fuel burns continuously and the temperature is noted as the fire point ^[12].

Determination of Viscosity of the Biodiesel

Biodiesel is taken in a Red Wood Viscometer, and the temperature of the Viscometer was maintained at 40°C ^[13], ^[14]. Using stop watch the rate of flow of the Biodiesel was found out. It is denoted as (mm²/sec) ^[15].

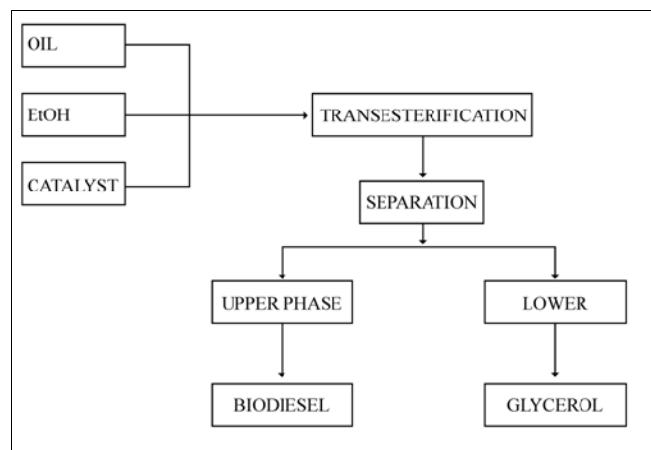


Fig 3: Flow Chart of Biodiesel Production

Conclusion

Biodiesel as an effective alternative fuel for fossil fuels is acquiring momentum now-a-days due to its eco-friendly and renewable nature. Our current world is highly dependent on oils, petrol, diesel and natural gas as our major energy sources of fossil fuels are finite and depleting rapidly due to uncontrolled consumption. Biodiesel is clean burning alternative renewable fuels made from natural sources, which is derived from renewable feed stocks by transesterification process and have low toxicity, renewability and completely biodegradable natural energy source alternate to petrol-diesel.

Here the biodiesel is prepared using homogeneous catalyst such as KOH with ethanol or methanol and palm oil. The transesterification process is performed at 80°C using a condenser. Studies shows that some of the acceptable fuel data viz. acid value (0.1), saponification value (191), molecular weight (881), Viscosity (1.9) Flash point (123°C) and Fire point (165°C) are found. This study shows that it requires mild reaction condition and the yield is very high.

References

1. Mohamed chaker Ncibi, Mika Sillanpaa. Recent research and developments in biodiesel production able bioresources, Recent patents in chemical engineering,2013:6:184.
2. Daming, Haining Zhou, Lin lin, Biodiesel: An alternative to conventional fuel, Energy procedia,2012:16:1874-1885.
3. Fei-ling Pua, Zhen Fang, Sarani Zakaria, Feng Guo, Chin-hua Chia. Direct production of biodiesel from high-acid value Jatropha oil with solid acid catalyst derived from lignin, Biotechnology for Biofuels, Article number,2011:4:56.
4. Crabbe E, Nolasco-Hipolito CN, Kobayashi G, Sonomoto K, Ishizaki A. Biodiesel production from crude palm oil and evaluation of butanol extraction and

fuel properties. Proc Biochem,2001:37:65-71. 10.1016/S0032-9592(01)00178-9

5. Berchmans HJ, Hirata S. Biodiesel production from crude Jatropha Curcas L. seed oil with a high content of free fatty acids. Bioresour Technol,2008:99:1716-1721. 10.1016/j.biortech.2007.03.051.
6. Panel Jan CJ. Bart, Natale Palmeri, Stefano Cavallaro Biodiesel Science and Technology, From Soil to Oil, Woodhead Publishing Series in energy, 6 - Emerging new energy crops for biodiesel production, 2010, 226-284.
7. George Wypych. Handbook of Plasticizers (Third Edition), 3 - Typical Methods of Quality Control of Plasticizers, 2017, 85-109.
8. Vinoth Thangarasu R. Anand Advanced Biofuels Applications, Technologies and Environmental Sustainability, Woodhead Publishing Series in Energy Chapter 17 - Comparative evaluation of corrosion behavior of Aegle Marmelos Correa diesel, biodiesel, and their blends on aluminum and mild steel metals, 2019, 443-471.
9. Dario Alviso, Emir Saab, Pascal Clevenot, Silvia Daniela Romano. Flash point, kinematic viscosity and refractive index: variations and correlations of biodiesel–diesel blends, Journal of the Brazilian Society of Mechanical Sciences and Engineering, Article number,2020:42:347.
10. Agarwal AK. Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines. Prog Energy Combust Sci,2007:33(3):233–271.
11. Romano SD, Sorichetti PA. Dielectric spectroscopy in biodiesel production and characterization. Springer, Berlin, 2010.
12. Alviso D, Rolon J, Scoufflaire P, Darabiha N. Experimental and numerical studies of biodiesel combustion mechanisms using a laminar counter flow spray premixed flame. Fuel,2015:153:154–165.
13. Esteban B, Riba J-R, Baquero G, Rius A, Puig R. Temperature dependence of density and viscosity of vegetable oils. Biomass Bio. Energy,2012:42:164–171. doi: <https://doi.org/10.1016/j.biombioe.2012.03.007>
14. Fasina OO, Colley Z. Viscosity and specific heat of vegetable oils as a function of temperature: 35 C to 180 C. Int J Food Prop,2008:11(4):738–746. doi: <https://doi.org/10.1080/10942910701586273>
15. Raghavan V, Rajesh S, Parag S, Avinash V. Investigation of combustion characteristics of biodiesel and its blends. Combust Sci Technol,2009:181(6):877–891. doi: <https://doi.org/10.1080/00102200902900409>
16. Mumtaz MW, Adnan A, Mukhtar H, Rashid U, Danish M. Clean Energy for Sustainable Development, Comparisons and Contrasts of New Approaches, 2017, 465-485. Chapter Fifteen - Biodiesel Production Through Chemical and Biochemical Transesterification: Trends, Technicalities, and Future Perspectives