

PRODUCTION OF BIODIESEL FROM WASTE COOKING OIL BY INTENSIFICATION TECHNIQUES

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Abstract

Energy security and air pollution is the challenging issues now days. Current, globally depleting fossilized fuel reserves, increasing environmental pollution and problems are the key motivating factors to pursue research on an alternative fuel derived from biomass, which can fulfil the ever-increasing energy demand for sustainable development. Biodiesel as a sustainable alternative helps in the protection of the environment due to its non-toxic, renewable, and biodegradable nature and produces less Sulphur emissions and greenhouse gases. It is easy to use as well as clean and safe to handle as compared to gasoline diesel. The present work is mainly motivated on design and development of an environment- friendly, energy-effective and industrially viable process intensification (PI)-based techniques {Ultrasound, Microwave, and Conjoint (microwave + ultrasound technique)} using both homogeneous (potassium hydroxide, KOH) and heterogeneous (calcium oxide, CaO) catalyst to synthesize biodiesel from waste cooking oil (WCO) and blended oils. The outcomes of independently studied ultrasound process observed to have enhanced the biodiesel yield (98 % for KOH and 96.45 % for CaO catalyzed conditions). Biodiesel is an effective alternative fuel. In present study, biodiesel is prepared using waste cooking oil, using intensification techniques such as Mechanical stirring and Microwave Irradiation method is used to draw biodiesel.

Introduction

Energy security is the great concern of the country. Petroleum products are used to fulfil the energy requirement of the nation. Energy security is the great concern of the country. Petroleum products are used to fulfil the energy requirement of the nation. Now day's air pollution is increased up to the alarming situation. The increased number of vehicles make it difficult to the human life. Although there are so many causes of increase in air pollution but among all of them exhaust gases of vehicles is the major issue [3]. Alternative fuels and electric vehicles are the potential solution of this problem. Among all alternative fuels, biodiesel is very effective and potential fuel. It is renewable and can be drawn through various edible and non-edibles oils. WCO is injurious to human health. Hotels and restaurant normally discard it. Therefore, it can be obtained from big hotels and food chains in India. The cost of biodiesel derived from WCO is lower as compared others.

World energy supplies are primarily fulfilled through the use of fossil fuels. It is well known that burning coal and crude based fuel leads to depletion of conventional resources and are associated with environmental concerns such as air pollution, greenhouse effect, waste disposal,

climate change, etc. These primary challenges need full engagement from all the concerned stakeholders. The carbon footprint increased, especially by automobile and allied sectors, plays a vital role in issues of environmental health. Hence, attempts have been made to bring a diversity of renewable fuels used in vehicles. This approach is one of the efficient solutions to counter environmental problems caused by the combustion of non-renewable fuels. Bio diesel plays a significant role in satisfying the demand for sustainable alternative fuel, which will help in reducing the carbon footprint. Biodiesel is a biodegradable and environment-friendly option as compared to non-renewable fuels.

Biodiesel is a renewable resource obtained by the transesterification of triglycerides present in vegetable plant oils or animal fat. It contains insignificant sulfur and aromatic compound as well as have more than 10 % inbuilt oxygen fraction, which supports complete combustion. Biodiesel production improves the environment by reducing particulate matter (by 47 %), and hydrocarbon emissions (by 67 %). The fast growth of the biodiesel industry has created exciting opportunities for several biodiesel enterprises. Biodiesel can be used as it is or blended with gasoline-diesel in the existing diesel engine. The major issues with biodiesel production using conventional biodiesel processing technology are feedstock flexibility, yield efficiency, the ecological influence due to the use of excessive raw materials and cost efficiency.

The selection of feedstock is a critical step in the production of biodiesel, driven by several factors, such as cost, purity, yield, and composition of the produced biodiesel. Thus, availability and source are the key parameters of selecting a feedstock. The selection of a particular feedstock depends on the suitability, ease of availability, oil content, physical properties, chemical composition, and economic aspect. Based on the availability and type feedstock can be categorized in the four generations.

Transesterification Process

Triglyceride reacts with alcohol in the presence of a catalyst to produce esters and glycerol is called transesterification. High viscosity and low volatility of virgin feedstock derived from animal fats and vegetable oils limit their direct usage in diesel engines. The major goals of transesterification reaction are to remove these problems. Stoichiometrically a 3:1 molar fraction of alcohol to oil is necessary to complete the transesterification reaction. Triglyceride and alcohol are two main reactants in this reaction. When methanol is used as a co-reactant, the process is called as methanolysis. Triglyceride has three long-chain fatty acids attached to the glycerin molecule as its base. The structure of fatty acids attached to glycerol determines the characteristics of the oil/fats and in turn affects the characteristics of the biodiesel. Catalyst during transesterification process is used to augment the rate of reaction and improves the produced fuel properties. Nature and catalyst concentration play an important role during the transesterification process to produce biodiesel. Catalysts are generally classified into homogeneous, heterogeneous, and biocatalyst and a detailed sub-classification is shown in Fig. 1.2. It is a well-known fact that in the case of alkaline homogeneous catalyzed transesterification reaction the rate of reaction is 4000 times faster when compared to acid-catalyzed reactions.

Due to the former favorable effect of glycerol precipitation. Few of the frequently used alkaline homogeneous catalyst for biodiesel production are sodium hydroxide (NaOH), potassium hydroxide (KOH) and sodium methoxide (CH₃ONa). These catalysts have the advantage of providing a faster reaction rate, room temperature is enough for the reaction, requires lesser catalyst amount and fuels produced using them are not corrosive. Despite having advantages, an alkaline catalyst is not suitable for feedstock having high FFA content. FFA decreases biodiesel yield by causing soap and water formation and subsequent gel formation leads to an increase in viscosity as well as, difficulty in separation from biodiesel. Generally, alkali oxides or alkaline earth metals oxides are available in heterogeneous catalysts which are having benefits over homogenous catalysts like easy separation from the product and higher chances of reusability and regeneration along with high biodiesel yield and salt-free glycerol. Among the available heterogeneous catalyst, most of the attention is attracted by calcium oxide (CaO) because of their comparatively high basic strength and generation from cheap sources like limestone and calcium hydroxide but have low solubility in methanol.

The alkaline-catalyzed transesterification reaction has a four-step mechanism. First is the formation of alkoxide and protonated catalyst due to the reaction of base catalyst with the alcohol. During the second step, nucleophilic attack of the alkoxide at the carbonyl group of the triglyceride generates tetrahedral intermediate.

The third stage includes the production of the alkyl ester and the corresponding anion of diglyceride. In the last step, catalyst deprotonation takes place that regenerates the active sites, which is available to react with another alcohol molecule, starting a new catalytic cycle. Diglyceride and monoglyceride follows a similar mechanism and gets converted to produce a mixture of alkyl esters and glycerol.

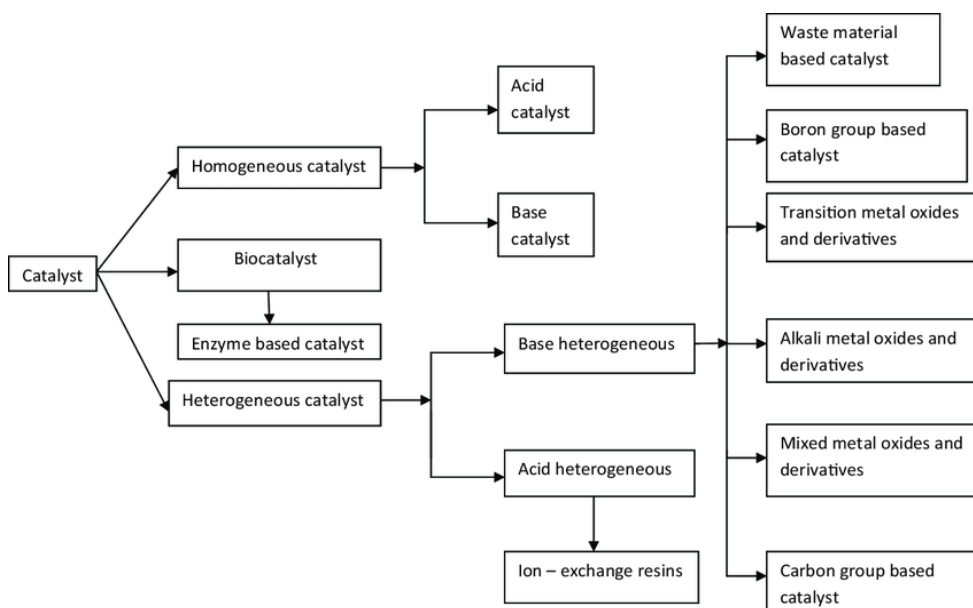


Figure 1 Types of Catalyst

For centuries, the world had relied on non-renewable crude oil for its energy supply. As a result, the International Energy Agency predicts that from now to 2030, world energy consumption will increase by 45 percent (IEA, 2008). With a 2% growth rate, world oil production will rise exponentially from current levels of about 27 billion barrels per year to a maximum of about 55 billion barrels per year in 2037 (Cavallo, 2002), hence oil demand is growing exponentially. It has been widely reported that oil production in 33 out of 48 countries has now peaked and global oil production is approaching an all-time peak. There are various predictions about the decline of oil peaks. The World Energy Forum has predicted the dwindling of oil reserves that in less than 10 decades more; all these energy supplies will be exhausted (Yacob, 2009). Bentley, (2002) suggested that the global peak of all hydrocarbons (oil plus gas) is likely to be in about 10 or more years, etc. OPEC assumption gives the peak production date of world crude oil to be 2008 as shown in Figure.

Material Collection and Analysis

Biodiesel is produced from vegetable oils, yellow grease, used cooking oils, or animal fats. The fuel is produced by transesterification—a process that converts fats and oils into biodiesel and glycerin. Here waste cooking oil (WCO) is used for the production of bio diesel. The waste cooking oil was collected from local restaurant in Madurai. WCO was filtered to remove the suspended food particles. Methyl alcohol or ethyl alcohol, calcium oxide (CaO), and calcium carbonate (CaCO₃) powder (purity 99 %) Potassium hydroxide (KOH), Sodium hydroxide (NaOH) were collected from chemical store.

Biodiesel Production

Samples are prepared taking Waste Cooking Oil (WCO) 100-gram, Ethyl Alcohol 50 ml, Catalyst (NaOH) 0.5 g.

Step: 1 First of all impurities are removed by filtration process of WCO.

Step: 2 After filtration process oil is heated to remove the moisture contents. After removal of moisture contents oil is cooled up to the room temperature.

Step: 3 Now required quantity of Ethyl alcohol and NaOH are stirred together.

Step: 4 This mixture is stirred with WCO with the help of mechanical stirrer. During mixing temperature is kept around 45-60 ° C.

Step: 5 Mechanical stir ration continues, after some time period, transesterification reaction takes place Step:6 After completion of transesterification reaction, biodiesel is transparent and lighter as compared to glycerol. Biodiesel is appeared in upper layer while glycerol settled down in the container.

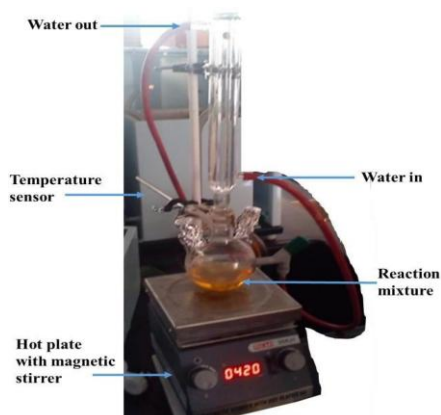


Figure 2 Mechanical Stirring (MS) Reactor Unit used for Biodiesel Production



Figure 3 Biodiesel Production by MS Technique

Post-Treatment on Transesterification Reaction Mixture

The post-treatment for the separation of biodiesel and glycerol after the transesterification reaction. In NaOH catalyzed condition upon completion of the reaction, two layers of the reaction mass were observed, i.e., a bottom layer of glycerol and a top layer of biodiesel with a trace amount of unreacted oil and methanol. Similarly, for CaO catalyzed condition, upon completion of reaction formation of the three layers was observed i.e., a bottom-most layer of catalyst, a middle layer of glycerol, and the topmost layer of biodiesel with a trace amount of unreacted oil and ethanol.

Upon separation of glycerol layer and methanol recovery, biodiesel produced from NaOH catalyst was rinsed three times with deionized water to remove bits of NaOH catalyst. CaO catalyst was separated using a high-speed centrifuge (1200 rpm), and after drying, reused without pre-treatment or regeneration. Excess ethanol was separated from the remaining liquid product. The biodiesel rich phase was further washed with deionized (DI) water to remove traces of unreacted oil and heated up to 80 °C in a rotary evaporator to remove any traces of moisture.

Result

Table 1 FFA Analysis Data on Waste Cooking Oil Properties of Waste Cooking Oil

S.No	PROPERTIES	RESULT
1.	Acid Value	0.218 NaoH/ gram of oil
2.	Density 0.875 gm/cc	0.875 gm/cc
3.	Flash point by PMCC method	189°C
4.	Fire point by PMCC method	202°C
5.	Moisture content	0.021%
6.	Cloud Point	8°C
7.	Pour Point	2°C
8.	Calorific value	8522.978 Cal/g

Conclusion

Used cooking oil as raw material with a FFA value of 0.11% can be converted into biodiesel using the transesterification method directly without going through the esterification process. Magnetic stirring is very effective methods for the biodiesel production. Waste cooking oil can be a good source of biodiesel production. This technique provides more biodiesel yield. Thus, the Biodiesel obtained from Waste Cooking Oil by Mechanical Stirring technique has a yield of about 95.3 %.

References

1. Refaat AA, Attia NK, Sibak HA, El-Sheltawy ST, El-Diwani GI. Production optimization and quality assessment of biodiesel from waste vegetable oil, *Int. J. Environ. Sci. Tech.* 5(1) December(2008) 75-82.
2. Eevera T, Rajendran K, Saradha S. Biodiesel production process optimization and characterization to assess the suitability of the product for varied environmental conditions, *Renewable Energy* 34(3) March(2009) 762–765.
3. Noiroj K, Intarapong P, Luengnaruemitchai A, Jai-In S. A comparative study of KOH/Al₂O₃ and KOH/NaY catalysts for biodiesel production via transesterification from palm oil, *Renewable Energy* 34(4) April(2009) 1145–1150.
4. Abubakar, H.G., Abdulkareem, A.S., Jimoh, A., Agbajelola, O.D., Okafor, J.O., Afolabi, E.A., 2016. Optimization of biodiesel production from waste cooking oil. *Energy Sources, Part A Recover. Util. Environ. Eff.* 38, 2355–2361.