International Journal of Mechanical Engineering
ISSN : 2277-7059 Volume 2 Issue 2
http://www.ijmejournal.com/ https://sites.google.com/site/journalijme/

Prospect of Bio-diesel Production from soybean oil and sesame oil: An Alternative and Renewable Fuel for Diesel Engines

Md. Abdullah Al Bari[1]*, Hasan Ali[2], Mizanur Rahman[3], Rakibul Hossain[1]

[1] Department of Mechanical Engineering
Khulna University of Engineering & Technology, Khulna-9203, Bangladesh
[2] Department of Energy Technology
Khulna University of Engineering & Technology, Khulna-9203, Bangladesh
[3] Department of Industrial Engineering and Management
Khulna University of Engineering & Technology, Khulna-9203, Bangladesh

* Email: md.abdullahbari@gmail.com

Abstract. Energy is the prerequisite for modern civilization. Fossil fuel is still the main source of energy. But the endless consumption of fossil fuel has brought its reserve about to an end. As a result, fuel prices are gouging as a consequence of spiraling demand and diminishing supply. So we are always in search of alternative and cost effective fuels to meet our need. Diesel engines are more efficient and cost-effective than other engines. So diesel engines have versatile uses (i.e. automobiles, irrigation, power plants etc.). That is why; consumption of diesel fuel is much higher than other gasoline fuels. This paper estimates the feasibility of **soybean oil and sesame oil** as an alternative fuel for diesel engine. In the present paper, production of biodiesel from soybean oil and sesame oil, its properties and comparison of test results with the results of other biodiesels and diesel have been presented. Biodiesels are produced experimentally from soybean and sesame oils and obtained 89.75% and 82.64% respectively. Calorific values of biodiesels from soybean and sesame oil are obtained 41.57MJ/Kg and 43.67 MJ/Kg and the same for diesel is 44.5 MJ/Kg. The kinematic viscosity of biodiesel extracted from soybean and sesame oils are 2.068*106m2/s and 2.292*106m2/s respectively while the same for diesel is 2.068*106m2/s. Again, flash point of biodiesels from soybean and sesame oil are obtained 96°C & 94°C and the same for diesel is 75°C. The production costs of biodiesels from soybean and sesame oil are Tk. 296.8 and Tk. 370 per liter respectively. These oils or any of its blends could be used as an alternative in case of crisis.

Keywords: Bio-diesel, Blend of bio-diesel, Mustard, Renewable alternative fuel, Trans-esterification process.

1 Introduction

Fuel is defined as a substance that can be burnt or modified by some chemical or nuclear process to produce heat energy. The non-renewable nature and limited resources of petroleum fuels has become a matter of great concern. The economic and political factors are greatly associated with their procurement. The combustion of these fuels in I.C. engines causes environmental pollution. All these aspects have drawn the attention to conserve and stretch the oil reserves by way of alternate fuel research [1]. From the seeking for alternative energy it is found that biodiesel from different plant can be the biggest source of the alternative fuel.

In Bangladesh, diesel is primarily used for transportation, agriculture and power generation. Diesel is becoming scarce and costlier and our reservation of gas is decreasing day by day. For power generation, gas and coal should be used wherever possible to decrease the load on diesel [3]. Transportation of goods and people in Bangladesh is dominated by road transport, which accounts for 80% of all 1,50,000 motor vehicles and 49% of freight. Besides this, the rapid growth of industrialization in Bangladesh demands a much higher level of energy consumption. Thus there is urgent need to take all necessary steps for energy management and conservation.

There are several possible alternative sources of fuels. These are vegetable oils, alcohol such methanol and ethanol; hydrocarbon gases such as compressed natural gas (CNG), liquid petroleum gas (LPG), hydrogen producer gas etc [4]. Among them, vegetable oil presents a very promising alternative to diesel oil since they are renewable and is easily available in rural areas where there is an acute need for modern forms of energy [5].

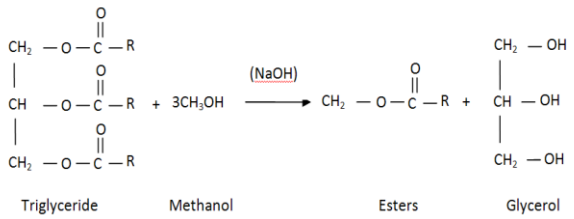
Biodiesel consists of mono alkyl esters produced from renewable resources such as animal fats, waste cooking oils, yellow grease and all kinds of edible and non edible vegetable oils. In 1895, Dr. Rudolf Diesel invented the diesel engine with the intention of running it on a variety of fuels, including vegetable oil. In fact, when he demonstrated his engine at the World Exhibition in Paris in 1900, he used peanut oil as fuel. However, biodiesel and vegetable oil are very different. Raw vegetable oil or recycled greases that have not been processed into esters are not biodiesel [6]. Neat vegetable oil has high viscosity and tendency to polymerize during storage and combustion. All these lead to fuel filter clogging, ring sticking, gum formation, accumulation of oil in the lubricating system, sludge formation, poor atomization in spray system, incomplete combustion and injector choking [7]. Technical aspects of biodiesel are approached; such as the physical and chemical characteristics of methyl ester related to its performance in compression ignition engines.

Vegetable oils are triglycerides and highly viscous. Vegetable oil can be converted into lighter molecular weight substances by cracking or transesterification. Biodiesel may be produced in several ways, but the most common technique is transesterification. In this process, glycerides in the fat or oil are reacted with an alcohol in the presence of a catalyst to produce esters and glycerin. Specifically, the oil and fat are most often reacted with methanol or ethanol in the presence of a catalyst like sodium hydroxide or potassium hydroxide to form methyl or ethyl esters and glycerin. Biodiesel when used as a pure fuel is known as B100. Biodiesel is a fuel that can be blended easily with fossil diesel fuel and offers several advantages over

diesel fuel. The blend is designated "BXX" where XX is the percentage of biodiesel in the blend.

2 Catalytic conversion of vegetable oil into biodiesel

Vegetable oils are carboxy-esters. The physical properties of these carboxy-esters are only moderately sensitive to the free-fatty acid they are made from, and the resulting biodiesel contains little of the free fatty acids or oxidation products which the vegetable oils are made from. These properties make the resulting carboxy-ester a much more uniform product than the feedstocks (vegetable oil). Making biodiesel is a feedstock "upgrading" technology. Biodiesel is produced by the process called transesterification or esterification where vegetable oil chemically reacts with alcohol in presence of a catalyst. From this reaction Carboxy ester and glycerol are produced as biodiesel and byproduct respectively. The reaction can be performed in four different processes. Among them the mostly used and effective one is alkalicatalyzed process. The catalyst for this reaction is KOH or NaOH. Three moles methanol react with one mol triglyceride. The reaction of catalytic conversion of vegetable oil into biodiesel is given below:



Here R is long hydrocarbon chains, sometimes called fatty acid chains

3 Production of biodiesel

The schematic diagram for the production of biodiesel from vegetable oil is shown in Fig.1.

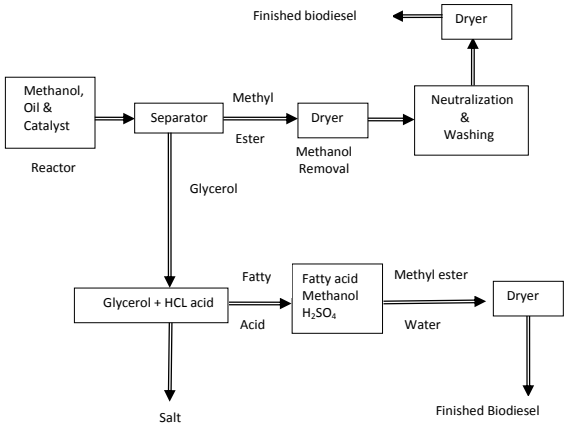


Figure 1: Schematic representation of Biodiesel processing

A solution is produced by stirring the mixture of vegetable oil, alcohol and catalyst. The solution is kept at 45-55 °C for 1 to 8 hours. After those two layers are formed- the upper one is biodiesel and the lower one is glycerol. Biodiesel is separated from the glycerol by gravity separation method. To remove alcohol (if present any) from biodiesel, the separated biodiesel is boiled at the boiling temperature of alcohol for the time being. Again, to wash the catalyst from raw biodiesel water is mixed for formation of soap. Finally the pure biodiesel is produced after removing water by boiling at 100°C.

4 Results & Discussion

Table 1: Biodiesel extracted from vegetable oil

No. of obs.	Quantity of vegetable oil (ml)	Biodiesel Extracted from soybean oil			Biodiesel Extracted from sesame oil		
		Pure biodiesel (ml)	Percentage of extracted pure biodiesel	Average percentage of extracted pure biodiesel	Pure biodiesel (ml)	Percentage of extracted pure biodiesel	Average percentage of extracted pure biodiesel
1	60	53	88%		50	83.3%	
2	60	54	90%	89.75%	52	86.6%	82.64%
3	60	55	91%		50	83.3%	
4	60	54	90%		48	80%	

Table 2: The observed properties of biodiesels and Diesel & their comparison

The density of biodiesel extracted from soybean oil is 0.683 g/cm^3 and the density of biodiesel extracted from sesame oil is 0.6979 g/cm^3. They are quite close to the density of diesel (0.82 g/cm^3). The heating values of biodiesel extracted from soybean and biodiesel extracted from sesame oil are 41.57 MJ/kg and 43.67 MJ/kg respectively. The heating value of diesel is 44.50 MJ/kg. The kinematic viscosity of biodiesel extracted from soybean and biodiesel extracted from sesame oil are 2.068*10^{6}m^2/s and 2.292*10^{6}m^2/s respectively while the kinematic viscosity of diesel is 2.068*10^{6}m^2/s. From above data of the properties of the biodiesels it is obvious that the biodiesel extracted from the sesame oil is more suitable as an alternative of diesel.

5 Cost Analysis

Table 3: Cost of biodiesel per liter production from soybean oil.

Sl. No.	Component	Amount used	Unit price (Tk)	Cost (Tk)
1.	Soybean	1liter	80/L	**80**
2.	Methanol	250 milliliter	720/L	**180**
3.	NaOH	8gm	800/Kg	**6.4**
	The total cost of 89.75% Biodiesel			**266.4**

The cost of per liter biodiesel extracted from soybean oil is 296.82 tk.

Table 4: Cost of biodiesel production from sesame oil.

Properties	Soybean Oil	Sesame Oil	Jathropa Oil	Diesel	Soybean biodiesel	Sesameb iodiesel	Jathropa biodiesel
Kinematic viscosity, ν at 30^{0}C (10^{6}m^2/s)	32.6	35.5	55	2.6	2.068	2.292	5.34
Density, ρ at 30^{0}C (g/cm^3)	0.9138	0.9133	----	0.82	0.683	0.6979	0.62
Heating Value (MJ/kg)	39.6	39.3	39.5	44.5	41.57	43.67	41
Flash Point (^{0}C)	254	260	-----	65	96	94	-----

Sl. No.	Component	Amount used	Unit price (Tk)	Cost (Tk)
1.	Sesame	1liter	120/L	**120**
2.	Methanol	250 milliliter	720/L	**180**

3.	NaOH	8gm	800/Kg	**6.4**
	The total cost of 82.64% Biodiesel			**306.4**

The cost of per liter biodiesel extracted from sesame oil is 370 tk.

6 Conclusion

Biodiesel is an important new alternative transportation fuel. Its pure form B100 can be directly used in diesel engines without any engine modifications. This report investigates parameters for optimization of biodiesel production by catalytic upgrade by around sixty tests and their properties and compare with those of diesel fuel. The results of this work can be summarized as follows:

- A maximum of 89.75% biodiesels soybean oil and a maximum of 82.75% biodiesel production are found at 25% methanol and 0.8% NaOH from soybean oil.
- The optimum reaction time for maximum biodiesel production from both oil with methanol and NaOH was observed to be around 3-4 hours at 50-55^{0}**C**.
- The cost of the one liter biodiesel produced from this process from soybean oil is approximately 296.82Tk and the cost of the one liter biodiesel produced from this process from sesame oil is approximately 370Tk.

Results show that the biodiesel extract from the sesame oil is more suitable than the biodiesel extract from the soybean oil as an alternative of diesel fuel compared from their properties.

Biodiesel is a new renewable source of energy. It will give mankind the future fuel safety. This report show that biodiesel can economically produce from the vegetable oils. Though the cost of biodiesel is high in present situation, but they can be used as energy source in critical moment effectively. Biodiesel extract from sesame oil and soybean oil can meet up the need of energy in future days and help to build up a pollution free healthy world.

References

1. Singhal, K.C. and Rahman,A., "Plant-Oil as Diesel-Engine Fuel". *National Conference on I.C Engines and Combustion*. pp.55-62,1994.
2. Rahman, M. S., Nabi, M. N. and M. R. A. Beg, 2004,"Performance Study of a Diesel Engine with Diesel-Vegetable oil Blends as Alternative Fuel", *2nd BSME-ASME International conference on Thermal Engineering,* 2-4-January,Dhaka, Bangladesh.
3. Gandhi, K. K.., 1994, " Alternate fuels: A necessity", Science Report. 1994. PP. 13-16.
4. Datta K., 1995, "Plant oil–A Suitable Option for Diesel Engine", Department of Mechanical Engineering, Jadavpur University of Calcutta.700032, PP. 1-3.
5. Rao S.P. and Gopalakrishnan K.V., 1991,"Vegetables oil and their Methyl esters as fuels for diesel engine".Indian Journal of Technology.Vol.29, PP. 292-29.

6. *Alternative Fuels: Biodiesel* , Us.S. Environmental Protection agency EPA420-F-06-044 October 2006
7. Williams, A., Ani, F.N., The Use of Plam Oil as an alternative Diesel Fuel, *Fuels for Automotive and Industrial Diesel Engines, The institute of Mechanical Engineers, London, UK, Nov 20,1990*
8. Nabi, Md. Nurun, Hustad Johan Einar and Kannan Dhandapani, *First Generation Biodiesel Production from Non Edible Vegetable Oil and Its Effect On Diesel Emissions,* Proceedings of the 4th BSME-ASME International Conference on Thermal Engineering; 27-29 December, 2008, Dhaka, Bangladesh