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Biodiesel from Algae Oil as an Alternative Fuel for Diesel Engine

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ABSTRACT
Biodiesel has become more attractive recently because of its environmental benefits and the fact that it is made from renewable resources. The world is getting modernized and industrialized day by day. As a result vehicles and engines are increasing. But energy sources used in these engines are limited and decreasing gradually. This situation leads to seek an alternative fuel for diesel engine. Biodiesel is an alternative fuel for diesel engine. The esters of vegetables oil animal fats are known as Biodiesel. This paper discussed about the prospect of making of biodiesel from Algae oil. Algae are generally microscopic organisms, are generally thought of as simple aquatic plants which do not have roots, stems or leave and have primitive methods of reproduction. Aquatic algae are found in both fresh and marine waters. They range in size from large kelp (meters in length) to those visible only under a microscope. Algae vary considerably in size, shape, and growth form. The Algae contain 2-65% oil with different species. In this study the oil has been converted to biodiesel by the well-known transesterification process and used it to diesel engine for performance evaluation.
Key Words: Algae oil, Biodiesel, Transesterification process etc.

INTRODUCTION

As population is growing, transport becomes essential part of life. The biggest problem is the growing population & depletion of fossil fuel. About 90-100 years ago, the major source of energy shifted from recent solar to fossil fuel (hydrocarbons) [3]. Technology has generally led to a greater use of hydrocarbon fuels, making civilization vulnerable to decrease in supply. This necessitates the search for alternative of oil as energy source.

Biodiesel is an alternative fuel for diesel engine [11]. It is made from renewable biological sources such as vegetable oils and animal fats. It is biodegradable and non toxic, has low emission profiles and so is environmentally beneficial [1]. One hundred years ago, Rudolf Diesel tested vegetable oil as fuel for his engine. With the advent of cheap petroleum, appropriate crude oil fractions were refined to serve as fuel and diesel fuels and diesel engines evolved together. In the 1930s and 1940s vegetable oils were used as diesel fuels from time to time, but usually only in emergency situations [10]. Recently, because of increases in crude oil prices, limited resources of fossil oil and environmental concerns there has been a renewed focus on vegetable oils and animal fats to make biodiesel fuels.

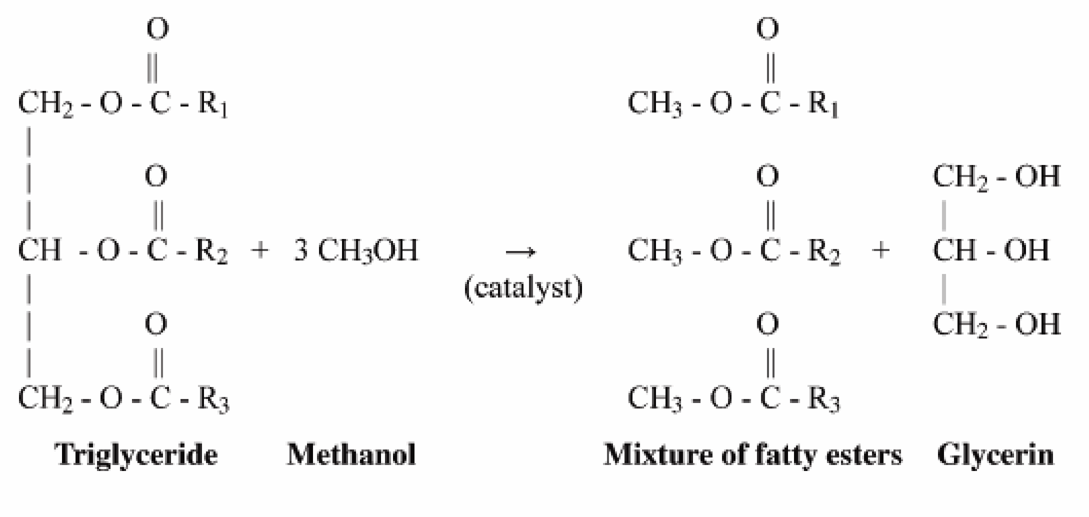
It is a domestic, renewable fuel for diesel engine derived from natural oil like Algae oil. Biodiesel has an energy content of about 12% less than petroleum-based diesel fuel on a mass basis. It has a higher molecular weight, viscosity, density, and flash point than diesel fuel [4]. From Algae, oil can be extracted which have similar properties as diesel but some properties such as viscosity, flash point and ignition point is very high in Algae oil. By some chemical reactions, Algae oil can be converted into biodiesel. Algae oil can also be used directly by blending with diesel. Alternative fuels, other than being renewable, are also required to serve to decrease the net production of carbon dioxide (CO_2), oxides of nitrogen (NO_x), particulate matter etc, from combustion sources [2]. The purpose of this research work is to investigate the fuel properties of Algae oil and production of bio-diesel from Algae oil. Investigate the fuel properties of bio-diesel and performance test diesel engine by using bio-diesel.

MATERIALS AND METHODS

The use of biodiesel is an effective way of substituting diesel fuel in the long run. One important conclusion that can be drawn from the work done earlier is that the vegetables oils can't be used directly in the diesel engine [6]. Several problems crop up if unmodified fuel is used and viscosity is the major factor. It has been found that transesterification is the most effective way to reduce the viscosity of vegetable oils and to make them fit for their use in the present diesel engines without any modification. One of the most promising processes to convert vegetable oil into methyl ester is the transesterification, in which alcohol reacts with triglycerides of fatty acids (vegetable oil) in the presence of catalyst [7]. The catalyst for this reaction is KOH or NaOH. Three mol methanols react with one mol triglyceride which produces mixture of fatty esters and glycerin.

The primary input is assumed to be oil that has previously been extracted from Algae by oil expeller method. To accomplish the transesterification reaction described above, the oil, methanol, and catalyst are mixed together in a stirred reactor. 55-60 ° C temperatures will cause the reaction to reach equilibrium more rapidly; in most cases the temperature is kept below the normal boiling point of the methanol (65ºC) so the reactor does not need to be pressurized [13]. As shown in the reaction equation below, three moles of methanol react with one mole of triglyceride. In practice, most producers will use at least 100% excess methanol (6:1 molar ratio) to force the reaction equilibrium towards a complete conversion of the oil to biodiesel [12]. The reaction is slowed by mass transfer limitations since at the start of the reaction the methanol is only slightly soluble in the oil and later on, the glycerin is not soluble in the methyl esters.

Since the catalyst tends to concentrate in the glycerin, it can become unavailable for the reaction without agitation. A common approach to overcome this issue is to conduct the transesterification in two stages [8]. First, the oil is combined with 75% to 90% of the methanol and catalyst and this mixture is allowed to react to equilibrium. Then, the glycerin that has formed is separated by gravity separation and the remaining 10% to 25% of the methanol and catalyst is added for a second reaction period. At the conclusion of this second reaction period, the remaining glycerin is separated and the biodiesel is ready for further processing [9]. The glycerin separation steps are usually accomplished by gravity settling or with a centrifuge. After the biodiesel is separated from the glycerol, it contains 3% to 6% methanol and usually some soap. If the soap level is low enough (300 to 500 ppm), the methanol can be removed by vaporization and this methanol will usually be dry enough to directly recycle back to the reaction. Methanol tends to act as a co-solvent for soap in the biodiesel, so at higher soap levels the soap will precipitate as a viscous sludge when the methanol is removed [11].



Scheme-1

After the methanol has been removed, the biodiesel needs to be washed to remove residual free glycerin, methanol, soaps, and catalyst. This is most frequently done using liquid-liquid extraction by mixing water with the biodiesel and gently agitating them to promote the transfer of the contaminants to the water without creating an emulsion that might be difficult to break [8]. The washing process is usually done multiple times until the wash water no longer picks up soap. Although the gray water from later washes can be used as the supply water for the earlier wash steps, the total amount of water will typically be one to two times the volume flow rate of the biodiesel [15].

When oils and fats with high free fatty acids are to be used for biodiesel production, an acid catalyst such as sulfuric acid can be used to esterify the free fatty acids to methyl esters as shown in the following reaction-

$$\text{Fatty Acid} + \text{Methanol} \xrightarrow{\text{Sulphuric Acid}} \text{Methyl Ester} + \text{Water}$$

Then, the Methanol with the Free fatty acids converted to methyl esters, a conventional alkali-catalyzed process can be used to transesterify the triglycerides in the feedstock. While acids can be used to catalyze the transesterification reaction, the reaction is very slow at the 50° to 60°C reaction temperature the two-step approach of acid-catalyzed esterification followed by base-catalyzed transesterification gives a complete reaction at moderate temperatures [13].

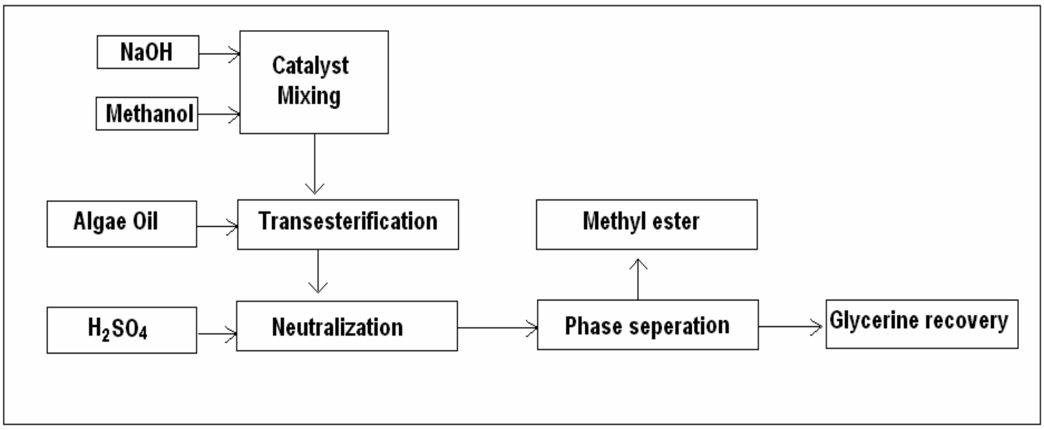


Fig.-1: Schematic diagram of Biodiesel Production from Algae oil

A problem with this approach is that the water produced by the esterification reaction should be removed before the base catalyzed process begins so that soap formation is not excessive. This can be done by settling or centrifuging the methanol-water-acid layer that separates after the esterification has reached equilibrium [5]. The additional equipment required for the acid-catalyzed pretreatment raises the processing cost, but this approach allows the use of feed stocks containing up to 100% free fatty acids. Finally after drying the found methyl ester is converted to the required biodiesel. Hence, it is seen that 450 ml biodiesel is produced from 500 ml of Algae oil [14].

Fig.-2: Wet Algae

Fig.-3: Dry Algae

Table-1: Engine Specification

Model	SF
Serial No	11833
CEX No	12158
Type	S
Optimal utilization of engine speed (RPM)	1500
BHP	5
Kilo watt	3.73
Specific fuel consumption in	GMS/BHR/HR 195
Method of starting	By using starting motor

Fig.-4: Layer Separation

Fig.-5: Biodiesel from Algae Oil

Engine Test

The final product of biodiesel from Algae oil is used as an alternative fuel to operate diesel engine in the Heat and Mass Transfer Laboratory of Department of Chemical Engineering, College of Engineering & Technology, Akola. The tested engine specification is shown in Table-1 and photograph is shown in Fig. 6. The engine has been run using biodiesel and required data are collected to calculate the engine performance parameters.

Fig.-6: Diesel Engine

RESULTS AND DISCUSSION

From the analysis of exhaust gas it is observed that % of CO_2 gas of biodiesel is very lower than the diesel and also from the mixture of 20% biodiesel & 80% diesel and 50% biodiesel & 50% diesel. The % of O_2 of biodiesel is very higher than the diesel and nearly with mixture of 50% biodiesel & 50% diesel. And the % of CO is zero for biodiesel & one for other three compositions.

Table-2: The observed properties of fuels

S.No	Properties	Biodiesel	20% Biodiesel & 80%Diesel	50% Biodiesel & 50%Diesel	Diesel
1	Density	0.940	0.42	0.60	0.84
2	Viscosity	3.46	1.53	2.22	3.28
3	Flash point	49^0C	53^0C	59^0C	55^0C
4	Fire Point	78^0C	79^0C	83^0C	80^0C
5	Pour point	-10.5^0C	-	-	-
6	Cloud point	-11.5^0C	-	-	-

Table-3: The exhaust Gas analysis by ORSAT apparatus

S.No	% of Sample gas	Biodiesel	20% Biodiesel & 80%Diesel	50% Biodiesel & 50%Diesel	Diesel
1	CO	0	1	1	1
2	CO_2	1.12	2	5	9
3	O_2	18.2	6.4	8.6	5

CONCLUSIONS

In the current investigation, it has confirmed that Algae and Algae oil may be used as resource to obtain biodiesel. The experimental result shows that transesterification process is a promising area of research for the production of biodiesel in large scale. Algae could play an important role as a potential feedstock for bio-fuels, as it offers significant advantages in terms of yield and productivity compared to conventional feed-stocks. From the above discussion it is clear that biodiesel from Algae oil is very necessary to us. It reduces green house effect on our environment by reducing CO_2 gas emission. It is very friendly with environment because it increases percentage of O_2 in exhaust gas than the ordinary diesel.

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