

## Mahua oil methyl ester as Biodiesel-preparation and emission characteristics

R.Venkateslu<sup>1</sup>, M.SuriyaPrakash<sup>2</sup>, K.Mythili<sup>3</sup>, R.velayutham<sup>4</sup>, M.Muthu<sup>5</sup>

<sup>1</sup>(chemical engineering,/periyar university ,india)

<sup>2</sup>(Thermal engineering,Bharathidasan college/Anna University, india)2,3,4

<sup>1</sup>(cad/cam,Jayalakshmi college,Anna university ,india)

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**Abstract:** There is an increasing interest in many countries to search for suitable alternative fuels that are environment friendly. Although straight vegetable oils can be used in diesel engines, their high viscosities, low volatilities and poor cold flow properties have led to the investigation of various derivatives. Biodiesel is a fatty acid alkyl ester, which can be derived from any vegetable oil by transesterification. Biodiesel is a renewable, biodegradable and non-toxic fuel. In this study, Mahua oil was transesterified with methanol using sodium hydroxide as catalyst to obtain mahua oil methyl ester. This biodiesel was tested in a single cylinder, four stroke, direct injection, constant speed, compression ignition diesel engine to evaluate the performance and emissions.

**Keywords:** Biodiesel; Renewable energy; Transesterification

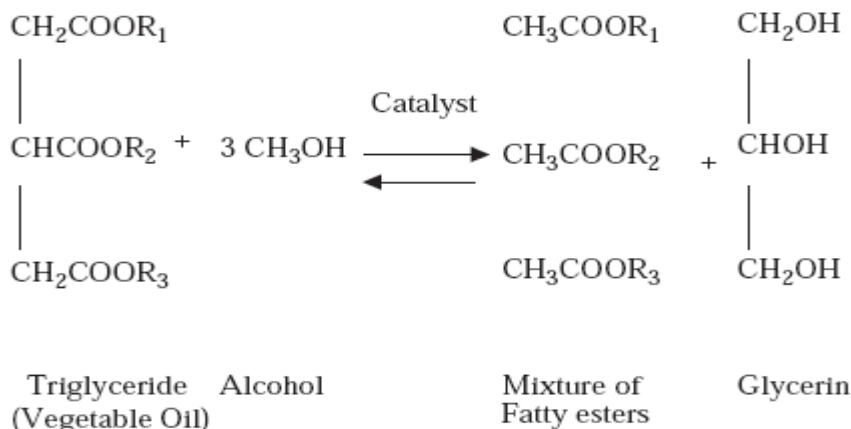
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### I. Introduction

Biodiesel is made from renewable biological sources such as vegetable oils and animal fats. Research on vegetable oils as diesel fuel was conducted at least 100 years ago but interest lagged because of cheap and plentiful supplies of petroleum fuels. Periodic increase in petroleum prices due to more demand, stringent emission norms, feared shortages of petroleum fuels due to rapid depletion and net production of carbon dioxide (CO<sub>2</sub>) from combustion sources have rekindled interest in renewable vegetable oil fuels. Since the oil price increased of the 1970s, various alternative fuels have been investigated with the goal of replacing conventional petroleum supplies. The initial interest was mainly one of fuel supply security, but recently more attention has been focused on the use of renewable fuels in order to reduce the net production of CO<sub>2</sub> from fossil fuel combustion sources. Renewable fuel like vegetable oils take away more carbon dioxide from the atmosphere during their production than is added to it by later combustion. Therefore, it alleviates the increasing carbon dioxide content of the atmosphere [1]. Many investigations revealed that crude vegetable oil as fuel in diesel engine created various problems [1,2]. Problems were encountered in the early stages because of excessive deposits and thickening of lubricating oil in diesel engine. The high viscosity of the vegetable oil was largely responsible for these problems. So improving the viscosity of vegetable oil by blending, pyrolysis and emulsification does not solve the problem completely [1]. The alternate way to make use of vegetable oil in the existing diesel engine is their derivatives called monoester and it has been proved that transesterification is the best way to produce ester from vegetable oil [2]. Transesterification is a process of producing a reaction between a triglyceride and alcohol in the presence of a catalyst to produce glycerol and ester. The molecular weight of a typical ester molecule is roughly one third that of typical oil molecule and therefore has a very low viscosity. To complete a transesterification process stoichiometrically, 3:1 molar ratio of alcohol to triglycerides is needed. However in practice higher ratio of alcohol to oil ratio is generally employed to obtain biodiesel of low viscosity and high conversion [4,5]. Alcohols are primary and secondary monohydric aliphatic alcohols having 1–8 carbon atoms. Among the alcohols that can be used in the transesterification process are methanol, ethanol, propanol, butanol and amyl alcohol. Methanol and ethanol are widely used and especially methanol because of its low cost, its physiochemical advantages with triglycerides and sodium hydroxide (NaOH) is easily dissolved in it [5]. Physiochemical property of methanol includes molecular weight (32.04), boiling temperature (64.7 °C) and specific gravity (0.792). As the molecular weight is low compared to other alcohol, less amount of methanol is required on mole basis for reaction. Since boiling temperature is also low compared to other alcohol, less energy required for reaction. Apart from alkali other catalysts such as acids, enzymes can be used for transesterification. Some of the alkalis include NaOH, potassium hydroxide (KOH), carbonates and corresponding sodium methoxide, sodium ethoxide, sodium propoxide and sodium butoxide. Sulphuric acid, sulphonic acids and hydrochloric acid are usually used for acid catalysis. Alkali catalyzed transesterification is much faster than acid catalyzed transesterification and is most often used commercially [5]. Transmethylation occur approximately 4000 times faster in the presence of alkaline catalyst than those catalyzed by the same amount of acid catalyst [1]. Biocatalysts such as Lipases can be used as catalysts in transesterification reaction [6,7]. The other important parameter is stirring speeds, which play a vital role in transesterification process [8].

The degree of homogeneity (emulsification) of alcohol in the triglyceride phase is of great importance in the transesterification process [9]. After transesterification process the ester can be separated from glycerol by gravity and the ester has to be washed with slightly acidified water to remove traces of alkali [10].

## II. Experimental



Scheme 1. Schematic representation of transesterification processes.

### Transesterification

A 500 ml 3-necked round bottom flask equipped with mechanical stirrer, thermometer and condenser with guard tube to prevent moisture entering into the system, was heated to expel residual moisture. On cooling, 200 ml (180 g) of Mahua oil (crude grade) was added to the flask. The oil was stirred and heated in a silicon oil bath to 60 °C at which recently prepared sodium methoxide (40 ml methanol and 1 g NaOH) was added rapidly under stirred condition and the reaction continued for two hours at the same temperature. Two layers were observed clearly on cooling. The top layer was biodiesel and the bottom denser layer was glycerin. The top layer was neutralized by diluted acetic acid and washed with distilled water.

### Engine Test

The performance of prepared MOME was studied in comparison with diesel fuel. The compression ignition engine used for the study was Kirloskar, single cylinder, four stroke, constant speed, vertical, water cooled, direct injection. The engine was coupled to a swinging field separating exciting type DC generator and loaded by electrical resistance bank. Exhaust gas temperature was measured by an iron-constantan thermocouple. A mercury thermometer measured cooling water temperature. Carbon monoxide (CO), nitrous oxide (NOx) and hydrocarbons (HC) were measured by MRU air fair emission monitoring systems ‘‘DELTA 1600-L and MRU OPTRANS 1600’’. Fuel consumption was measured by a U-tube manometer. The Smoke particulate number was measured by TI diesel tune, 114-smoke density tester. The engine was started on neat diesel fuel and warmed up. The warm up period ended when the liquid cooling water temperature was stabilized. Then the fuel consumption, exhaust gas temperature and exhaust emissions of NOx, HC, CO and smoke were measured and recorded for different loads. Similar procedures were repeated for the MOME fuel.

### Engine Performance

The brake specific fuel consumption (BSFC) of each fuel is shown in Fig. 1. The term ‘‘brake specific’’ is used to designate quantities that have been normalized by dividing by the engine’s power, thus the BSFC is equal to the fuel flow rate divided by the engine’s power. Fig. 1 shows that BSFC for MOME is higher than diesel. This is due to the fact that ester has lower heating value compared to diesel; so more ester-based fuel is needed to maintain constant power output.

property	Methyl ester
Acid value[mgKOH/g]	0.5
Moisture content %	0.03
Appearance	clear
colour	Dark yellow

Table 2 Properties Of Mahua Methyl Ester

Fuel properties	Diesel	MOME
Lower heating value[MJ/Kg]	42	36.9
Specific gravity	0.82	0.865
Kinematic viscosity@40 C	2.4	5.2
Cetane number	46	51
Flah point C	70	127
Fire point C	70	136
Cloud point C	-10to-15	5

Table 3 Results Of Fuel Tests On Fuel, Mahua Methyl Esters

### III. Emissions Nox Concentration

Nitrogen oxides are reported by several researchers to be increased with biodiesel [14,15]. However our data shows a reduction in NOx consistently throughout all five tests. The statistical analysis for the test shown in Table 4. The emission of NOx is determined by oxygen concentration, peak pressure, combustion temperature, and time. The availability of oxygen is unclear but the esters may decarboxylate and produce CO2 early in the combustion process. Secondly the heating value of the ester is about 12% less than diesel fuel. In addition, because of the cetane number is high for ester, the ignition delay may reduce which in turn may reduce the peak pressure rise, which occur during the initial portion of the combustion process .

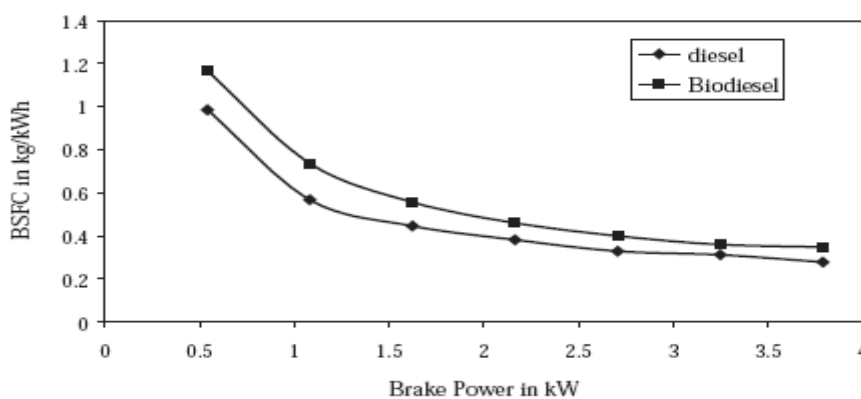


FIG. 1. BSFC VS. BRAKE POWER.

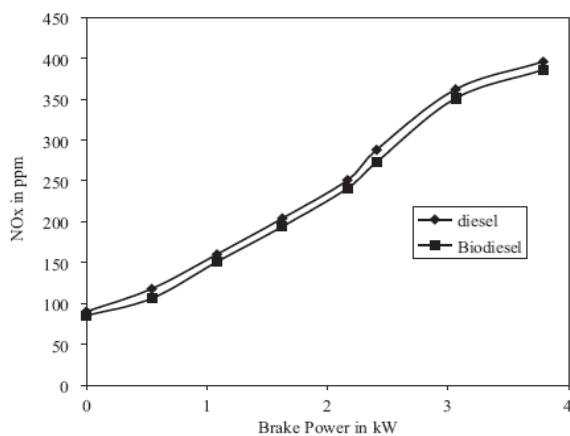


FIG. 2. NOx VS. BRAKE POWER.

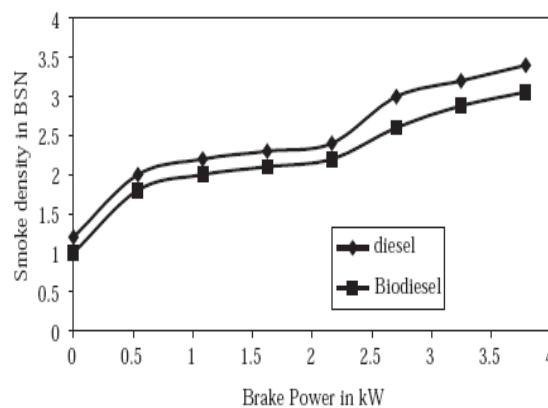


FIG. 3. SMOKE DENSITY VS. BRAKE POWER.

### IV. Conclusion

Mahua oil was transesterified using methanol in presence of alkali and the biodiesel obtained was studied for fuel properties and exhaust emission characteristics. Engine performance test show that MOME as a fuel does not differ greatly from that of diesel. A slight power loss, combined with an increase in fuel consumption, was experienced with MOME. This may be due to the lower heating value of the ester. Emissions of CO, HC are too low for MOME. Oxides of nitrogen were slightly low for ester compared with diesel. The MOME could be used as alternative fuels in a diesel engine instead of diesel fuel.

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