# PRODUCTION AND CHARACTERISATION OF BIODIESEL FROM SIMAROUBA GLAUCA SEED OIL WITH DIETHYL ETHER AS AN ADDITIVE AND ITS PERFORMANCE AND EMISSION EVALUATION ON SINGLE CYLINDER, FOUR STROKE C.I ENGINE

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**ABBREVIATIONS**

| | |
|---|---|
| BTE | Brake thermal efficiency |
| BSFC | Brake specific fuel consumption |
| EGT | Exhaust gas temperature |
| RPM | Rotation per minute |
| HC | Hydrocarbons |
| $NO_x$ | Nitrogen oxides |
| $CO_2$ | Carbon dioxide |
| CO | Carbon monoxide |
| SGME | Simarouba glauca methyl ester |

## Abstract

*In the present years due to diminishing petroleum reserves and stringent emission norms it is necessary to search for alternative for petroleum, since they are exhaustible. Hence it is very important now to find an alternative which is renewable and environmental friendly, hence various process are employed for production of alternate fuel, one of it is production of biodiesel, which is produced by the transesterification of oil by methanol as an alcohol. In the present paper methyl ester produced from the transesterification of simarouba glauca oil is evaluated in single cylinder, 4 stroke, and direct injection compression ignition engine for its performance and emission characteristic for a simarouba glauca methyl ester and its blend with additive diethyl ether and diesel with varying proportions. The engine was operated at different loads i.e.., 20%, 40%, 60%, 80% and full load condition for the various blends of biodiesel. Performance characteristics of an engine such as brake thermal efficiency, brake specific fuel consumption and exhaust gas temperature were evaluated and emissions such as carbon monoxide, hydrocarbons, nitrogen oxides and carbon monoxide are measured.*

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## 1. INTRODUCTION

Vegetable oils are environmental friendly, produced locally and renewable as well, it is presently a favorable and popular alternate to diesel fuel. They are practically free from Sulphur and also they have got great lubricating property and offer less or no storage difficulty, in addition to the above advantages in the process of photosynthesis the inedible vegetable oil yielding trees absorb more carbon dioxide ($CO_2$) from the atmosphere than they bestow on burning (1). However the vegetable oil cannot be used directly in the diesel engine due to various restrictions or drawbacks of using the vegetable oil directly in the C.I engine the major drawback of the vegetable oil is that it has a viscosity of around ten times greater than that of diesel fuel, which causes many unfavorable condition in the engine such as carbon deposits in the injector, improper atomization and hence incomplete combustion. The above problems have directed to the exploration of various derivatives of oil, fatty acid methyl ester also known as biodiesel derived from triglycerides by transesterification with methanol has received the more attention. The various process used for the production of biodiesel are pyrolysis, dilution, micro emulsion, transesterification as stated before transesterification is used majorly used because of the byproduct glycerol obtained by transesterification which adds to the economic value of biodiesel production (2). In addition to the diminishing reserves of fossil fuel, growing demands for diesel and uncertainty in their availability is said to be significantstart for many initiatives to pursuit for the alternative source of fuels, which can supplement or replace petroleum.

In the present work the biodiesel is produced as of the oil simarouba glauca seed, it is a flowering tree which belongs to the family of *simaroubaceaeaquasia*, it is also recognized as *laxmitaru*, paradise tree, bitter wood, dysentery-bark this tree is inherent to the Florida in the united states of America and now it is found in many parts of India. The kernel obtained from seeds is about 40% and the kernel contains 50-55%of oil (3). The tree issuitable for humid, warm and tropical regions. Its farming depends on rainfall distribution, water holding capability of the soil and sub-soil moisture. It is suitable for temperature range of 10- 40°C. It can produce at altitudes from sea level to 1,000 m. It grows 12 to 15 m tall and has a distance of 7.6 to 9.1 m. It allows yellow flowers and oval extended purple colored heavy fruits (4).
Diethl ether is an organic compound which is commonly known as ethyl ether, ethoxyethane, sulfuric ether.it is usually used as a solvent and it was commonly being used in the field of anesthesia. When diethyl ether comes in contact with air it becomes an explosive mixture, basically it is peroxide forming chemical (PFC) and ether peroxides are explosive when they are borne dry. Diethyl ether has a cetane number of around 85 to 95 and self-ignition temperature of around 160°C and also it is highly volatile and has low flash point, hence it can easily ignite when, and it comes in contact with the hot surface without the aid of spark or flame. Hence it is very important to take-up every possible safety measures while handling the diethyl ether because of its explosive property.

## 2. METHODOLOGY:

**Materials:** Simarouba glauca seeds, diethyl ether, methanol, and NaOH catalyst. The simarouba glauca seeds were collected from the Indian institute of horticultural research, Hesaraghatta, Bengaluru, Karnataka.

**Transesterification and separation:** The transesterification of simarouba glauca oil was conducted in a thousand millilitre, three-neck flat bottom flask equipped with water-cooled condenser, thermometer and magnetic stirrer. 500ml of simarouba glauca oil is taken in the flask and is heated to a temperature of 65°C.Simultaneously dissolve the 2%wt/v NaOH catalyst pellets in methanol to oil molar ratio of 6:1 in a beaker, the obtained solution is poured in to the flask. The reaction is continued at 65˚C and carried out for three hours. Once the transesterification process is completed, the mixture is transferred to the separating funnel and allowed to settle overnight. After settling two layers of liquids is formed the top layer being simarouba glauca methyl ester (biodiesel) and the bottom layer being glycerine, the biodiesel is separated from the glycerine and is washed and dried to remove the dissolved catalyst, soap, and moisture.

## 3. BLENDING OF BIODIESEL:

The biodiesel was then blended with diethyl ether and diesel, the biodiesel blends used for engine test is given below.

| | | |
|---|---|---|
| • | B100 | - pure biodiesel. |
| • | B20 | - 20 pure biodiesel and 80% pure diesel. |
| • | B19 | - 19pure biodiesel, 1% diethyl ether, 80%pure diesel. |
| • | B19.5 | - 19.5pure biodiesel, 0.5% diethyl ether, 80%purediesel. |
| • | B99 | - 99%pure diesel, 1% diethyl ether. And |
| • | 100pure diesel | |

The blend was prepared by stirring the mixture in magnetic stirrer for 30minutes.

**Engine test rig**:The engine which was used in this study is a vertical, single cylinder, compression ignition engine, model TAF 1 produced by Kirloskar Oil Engines. This engine has a compression ratio of 17.5:1. It has a power rating 4 KW at 1500rpm, 5.7 KW at 1800rpm and 6.2 KW at 2000rpm.

## 4. RESULTS AND DISCUSSION:

**Fuel properties:** The properties of the biodiesel produced from simarouba glauca oil shown in Table-1 are well within ASTM standards. It indicates that biodiesel produced from the simarouba glauca oil can be utilized as alternative fuel for Compression ignition engine.

**Performance characteristics:** The experiments were conducted on a single cylinder, 4-stroke, direct injection C.I engine for various load(break power) and for various blends of biodiesel i.e.., B19, B19.5, B20, B99, B100 and pure diesel (proportions of biodiesel, diesel and diethyl ether as mentioned in the topic of blending of biodiesel). Performance characteristics of the engine such as brake thermal efficiency, brake specific fuel consumption, and Exhaust gas temperature are calculated for various loads. Emission characteristics like Emissions like carbon monoxide (CO), Hydrocarbon (HC), Nitrogen oxides (NOx), carbon dioxide ($CO_2$) were analyzed. The biodiesel which is used in the experiment was well within ASTM standard, the experiment was carried out without any modification of engine. The experiment was carried out at a constant compression ratio (17.5:1) and fuel injection pressure (200 bar) by varying the Load (Break Power).

**Table-1:** comparison of fuel properties of simarouba glauca biodiesel with diesel and ASTM standards

| SL. NO | PROPERTIES | UNITS | EXPERIMENTAL VALUES | | |
|---|---|---|---|---|---|
| | | | BIODIESEL (SGME) | Biodiesel standards (ASTM) | Petro Diesel |
| 1 | Density | $kg/m^3$ | 865 | 850-900 | 805 |
| 2 | Kinematic Viscosity@40˚c | Centistokes | 4.9 | 1.9-6.0 | 2.54 |
| 3 | Calorific Value | KJ/kg | 40610 | ≥37000 | 43500 |
| 4 | Flash Point | ˚C | 179 | >130 * | 54 |
| 5 | Carbon Residue | %w/w | Nil | ----- | 0.05max |

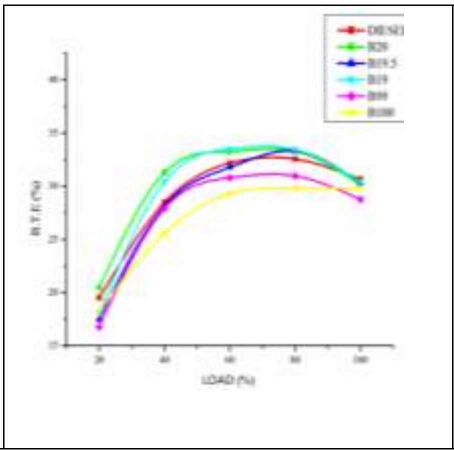

**Figure 1:** Load versus BTE

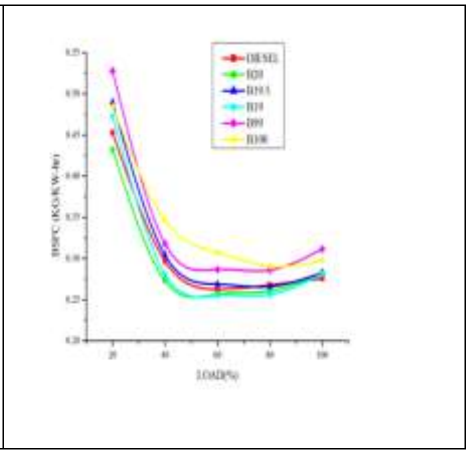

**Figure 3**: Load versus BSFC

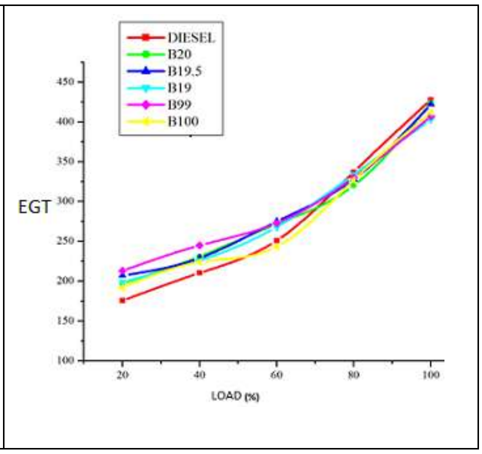


**Figure 3**: Load versus EGT

**Brake thermal efficiency:**Brake thermal efficiency is the energy available at the engine crankshaft to the energy liberated by combustion of fuel inside the engine cylinder. Figure 1 gives the clear picture of variation of BTE versus load, from the above figure it is clear that as the load on the engine increases BTE increases for all the fuels that is because of the fact that at higher load heat losses are minimal. The maximum brake thermal efficiency from the figure is found to be 33.52% for the blend of B19 and 33.32% (B19.5). B19 and B99 have brake thermal efficiency plot almost similar to petro-diesel. From the Figure 1 B19.5 has its plot almost similar to that of diesel plot.

**Brake specific fuel consumption:** specific fuel consumption is the quantity of fuel consumed for producing each unit of brake power per hour. It gives a clear picture efficiency with which the engine has developed from the fuel. The figure 2 gives the clear picture of variation of BSFC versus load for simarouba glauca methyl ester. It is noticed that the trend of plot on decreasing as the load increases, this is because of the fact that at higher load the losses are lesser. From the figure 2 it is seen that BSFC plot for the blends B19.5 and B19 are closer to the plot of petroleum-diesel, but when the simarouba glauca methyl ester is blended with diesel by more than 20% than the BSFC was found to be higher than the petroleum-diesel at all loads. This is because as the blend ratio increases the density of the fuel increases and hence the fuel flow rate increases.

**Exhaust gas temperature:** The importance of studying the exhaust gas temperature is that it is the representation of quality of combustion inside the cylinder (6). From the figure 3 it is evident that there is not much change in the plot of exhaust gas temperature of clean biodiesel, diesel, biodiesel-diesel and biodiesel-diesel-diethyl ether blend with variations in load, and it also shows that as the load on the engine increases the trend of exhaust gas temperature increases for all the blends. At 60% loading condition the exhaust gas temperature for B19, B19.5, B20 and B99 are almost same and maximum but for clean diesel and clean biodiesel the exhaust gas temperature is minimal. At full load we can notice that there are very small variations in exhaust gas temperature for all the blends.

**Emission characteristics:**In today's world of stringent emission norms it is very important to study the emissions of the fuel. Since emissions from the engine leads to various environmental threats like ozone layer depletion, global warming, and photochemical smog and in turn it produces wide range of air pollution, which causes various health related issues for human beings and animals hence automobiles emissions are placed under stern and all possible methods is triedto decrease the emissions (5).

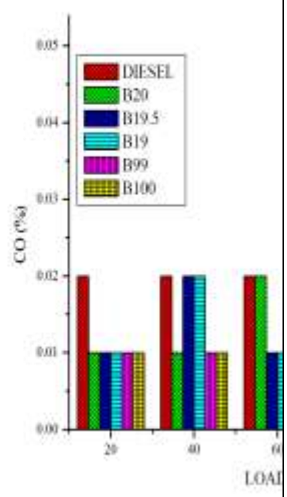


**Figure 4:** Load versus carbon monoxide

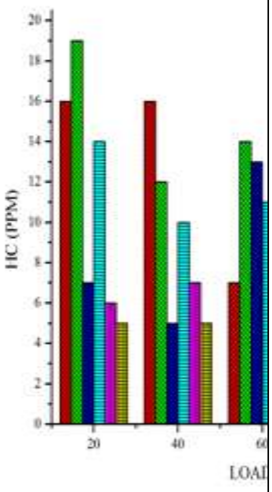


**Figure 5**: Load versus Hydrocarbons

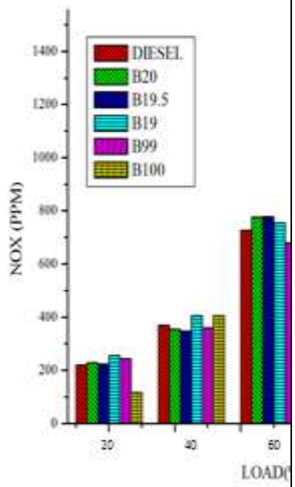


**Figure 6:** Load versus $NO_x$

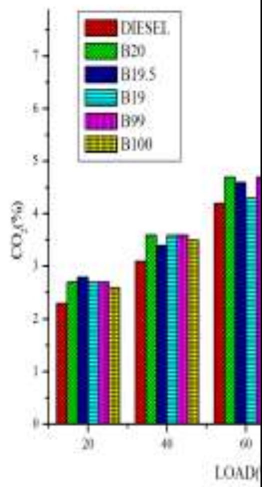


**Figure 7:** Load versus $CO_2$

**Carbon monoxide:**carbon monoxide emissions are the result of incomplete combustion of fuel inside the engine cylinder. The CO emissions are higher at the higher loads this can be credited to the higher rate of injection of fuel at higher loads (7). from the figure 4 it is clear that the CO for all the loads all most all blends have lower CO emission compared to the conventional petroleum diesel, this is because of the fact that the oxygen content in the biodiesel is more and hence with increasing the blending ratio of biodiesel in the diesel CO emission decreases. From figure 4 it can be seen that at full load there is drastic increase in the carbon monoxide emission compared to when engine was running at partial load for all the fuels and the maximum emission is found to be for B19.5 at full load. Diesel, B20, B19.5 has comparably higher carbon monoxide emissions.

**Hydro carbon emission:**Hydro carbon emission from the engine indicates the presence of completely unburnt fuel particles or partially unburnt fuel particles in the emission. Hydrocarbon emission from the C.I engine usually occurs due to the misfire, lean air-fuel mixture or when only the part of air fuel mixture burns (7). The figure 5 shows the variation of hydro carbon emission versus load. From the figure it is clear that the hydrocarbon emission for B100 is lower than the other blends at all most all loading condition this is because of the presence of excess oxygen content in the clean biodiesel which aids in the combustion of fuel. But at 60% loading the hydrocarbon emission for B99 is lesser than the B100 where the biodiesel is blended with 1% diethyl ether. The hydrocarbon emission for diesel, B20 and B19.5 is found to be higher than the other blends. It is reported from the figure 5 at few loading conditions B20 fuel gives more hydro carbon emissions than diesel. A noticeable reduction in hydrocarbon emission is observed from the addition diethyl ether in 0.5% as well as in 1% addition.

**Nitrogen oxide emission:** Nitrogen oxides are extremely hostile for the living beings. Since it creates various health related hazards, hence it is very necessary to control the nitrogen oxides emission from the engine. $NO_x$ emissions usually depend on the temperature range of working gas, equivalence ratio, presence of oxygen and also humidity in the cylinder caused by combustion of fuel. Generally $NO_x$ emission takes place at very high temperature of around 1500 and at regions in the cylinder where there is stoichiometric ratio (8). The figure 6 indicates the variation of nitrogen oxide emission with varying load, it is seen that the plot follows the trend of increasing nitrogen oxide emission with increase in load for all blends of fuel and diesel. That is because as the load on the engine increases the combustion chamber temperature increases due to the combustion of more fuel, due to the existence of added oxygen content and high temperature during the combustion of B100, $NO_x$ emission is maximum for it. And from figure 6 it is interesting to see that at partial and full load B99 has minimum $NO_x$ emission where 1% diethyl ether is blended with 99% of pure biodiesel.

**Carbon dioxide emission:** Carbon monoxide emission from the engine indicates the efficiency of combustion of fuel inside the engine cylinder. Figure 7 shows the variation of carbon dioxide emission for the various blends of simarouba glauca methyl ester versus the load on engine. The trend of the plot shows increase in carbon dioxide emission as the load increases, this show that the combustion efficiency of biodiesel and its blends higher compared to pure petroleum diesel. And also as the load increases the more fuel is injected in to the engine and increases the combustion rate hence the carbon dioxide emission is more for all the fuels at 100% load compared to partial and full load.

## CONCLUSION

The following conclusions are made by the production of biodiesel from the simarouba glauca oil by the method of transesterification and experimenting the biodiesel in a compression ignition engine, by blending it with diesel and diethyl ether at different proportion of B19, B19.5, B20, B99, and B100 for studying the performance characteristics and emission characteristics of biodiesel-diesel-diethyl ether blends.

- The simarouba glauca methyl ester produced from the transesterification process was found to be well within ASTM limits.
- The existing compression ignition engine performs satisfactorily with the simarouba glauca methyl ester and its blends without any modification to the engine.
- The brake thermal efficiency of B19 and B99 have efficiency plot almost similar to the diesel. B20 and B19 has thermal efficiency greater than diesel at partial load, with which load most of the engine run.
- The brake specific fuel consumption was found to be decreasing with increase in load for all the blends, B19.5 and B19 has plots almost similar to the diesel plot of B.S.F.C.
- Nitrogen oxide emission which is major problem in biodiesel fueled engine, is found to be reduced when B19.5 and B19 are used at higher loads, the $NO_x$ emission for these blends is found to be less than the diesel at higher loads.
- Emissions such as HC andCO are reduced. But carbon dioxide emission is increased which is a good sign of complete combustion, for biodiesel blends.

However, it should be noted that the above conclusions are for a single compression ratio, constant speed, constant injection pressure and some eccentricities are more likely under different operating condition.

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