



## Performance Characteristics of Diesel Engine Using Biodiesel and their Esters as Fuel

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**ABSTRACT:** Biodiesel is one of the available alternative fuels in the market. It is derived from biomass, which is one of the sources of renewable energy. Coconut oil is one of the sources of biodiesel and of all the other sources, it would be best in tropical countries biodiesel done to help the readers become aware of this the performance, emission and combustion characteristics of diesel engine using mahua methyl esters. In the present work, mahua methyl esters and its blends with diesel were used as fuel. Various proportions of mahua methyl ester fuel blends (25% and 50%) were used for conducting the performance tests at varying load conditions. Various parameters such as thermal efficiency, specific fuel consumption, emission of carbon dioxide, carbon monoxide, hydrocarbons and oxides of nitrogen gases in exhaust were recorded. The important properties of mahua methyl esters are compared with diesel standards. can be used in diesel engines without any engine modifications No new experiments have been conducted to prove any theory or hypothesis regarding the Biodiesel production is a very modern and technological area for researchers as an alternative fuel for diesel engines because of the increase in the petroleum price, its renew ability and the environmental advantages. Biodiesel can be produced from renewable sources such as vegetable oil, animal fat and used cooking oil. Currently, the cost of biodiesel is high as compared to conventional diesel oil because most of the biodiesel is produced from pure vegetable oil.

**Key words:** Biodiesel Mahua methyl esters Performance Emission Combustion

### I. INTRODUCTION

The transport sector plays a major role in the economic development of the country. The motor vehicle population in India is about 80 million and has also increased tremendously over the last decade; which has further pushed demand for eco-friendly fuels. The various alternative fuel technologies discussed are that they provide reduced emissions. derivative diesel was regarded once more as a potential fuel alternative, as a bio diesel technology known as transesterification was introduced [1]. The methyl esters of oils of 26 varieties were found most appropriate for use as bio diesel [2]. Considering the special effects of methanol fraction, acid concentration and response time to decrease free fatty acid and the period of pretreatment bio diesel fuel Biofuels are drawing increasing attention worldwide as substitutes for petroleum-derived transportation fuels to help address energy cost, energy security and global warming concerns associated with liquid fossil fuels. The term biofuel is used here to mean any liquid fuel made from plant material that can be used as a substitute for petroleum-derived fuel. Biofuels can include relatively familiar ones, such as ethanol made from sugar cane or diesel-like fuel made

from soybean oil, to less familiar fuels such as dimethyl ether (DME) or Fischer-Tropsch liquids (FTL) made from lignocellulosic biomass. A relatively recently popularized classification for liquid biofuels includes “first-generation” and “second-generation” fuels. There are no strict technical definitions for these terms. The main distinction between them is the feedstock used. A first-generation fuel is generally one made from sugars, grains, or seeds, i.e. one that uses only a specific (often edible) portion of the above-ground biomass produced by a plant, and relatively simple processing is required to produce a finished fuel. First-generation fuels are already being produced in significant commercial quantities in a number of countries. Second-generation fuels are generally those made from non-edible lignocellulosic biomass, either non-edible residues of food crop production (e.g. corn stalks or rice husks) or non-edible wholeplant biomass (e.g. grasses or trees grown specifically for energy). Second-generation fuels are not yet being produced commercially in any country. the substitutability of various biofuels for common petroleum-derived fuels. Alcohol fuels can substitute for gasoline in spark-ignition engines, while biodiesel, green diesel and DME are suitable for use in compression ignition engines.

The Fischer-Tropsch process can produce a variety of different hydrocarbon fuels, the primary one of which is a diesel-like fuel for compression ignition engines. While there is much attention on biofuels for the transport sector, the use of biofuels for cooking is a potential application of wide relevance globally, especially in rural areas of developing countries. In all cases, combustion of biofuels for cooking will yield emissions of pollutants that are lower (or far lower) than emissions from cooking with solid fuels. Some 3 billion people in developing countries cook with solid fuels and suffer severe health damages from the resulting indoor air pollution [1, 2]. Thus, biofuels could play a critical role in improving the health of billions of people. It is noteworthy that the scale of biofuel production needed to meet cooking energy needs is far smaller than that for meeting transportation fuel needs. One estimate [3] is that some 4 to 5 exajoules<sup>2</sup> per year of clean cooking fuel would be sufficient to meet the basic cooking needs of 3 billion people. This is the equivalent of about 1 per cent of global commercial energy use today. Many industrialized countries are pursuing the development of expanded or new biofuels industries for the transport sector, and there is growing interest in many developing countries for similarly “modernizing” the use of biomass in their countries and providing greater access to clean liquid fuels. Biofuels may be of special interest in many developing countries for several reasons. Climates in many of the countries are well suited to growing biomass. Biomass production is inherently rural and labour-intensive, and thus may offer the prospects for new employment in regions where the majority of populations typically reside. Restoration of degraded lands via biomass-energy production may also be of interest in some areas. The potential for producing rural income by with mahua oil is prepared [3]. Nuclear magnetic resonance test can be done to establish the bio diesel alteration [4]. Bio diesel is an esterified version of vegetable oil. This could be edible or non-edible oils. Oils having high free fatty acids (FFA) need a different treatment from that Bio diesel is an esterified version of vegetable oil. This could be edible or non-edible oils. Oils having high reefatty acids (FFA) need a different treatment from that procedure has been generally used to decrease the viscosity of triglycerides. The reaction is conducted The carbon monoxide emission depends upon at temperature close to the boiling point of methanol, 60-70°C, at atmospheric pressure. The mahua oil chemically reacted with alcohol in the presence of a catalyst to produce methyl esters. After completing the of low FFA oils High viscosity and FFA and Gum cause clogging and injector nozzle plugging. in corroding engine parts, increases viscosity and tends to increase deposit Blending of vegetable oils with diesel fuel would resolve such troubles of diesel engine

[6] and results in low CO, HC and smoke emission and higher thermal efficiency [7]. Bio diesel is eco friendly and renewable in nature. Numerous researchers carried out with dissimilar types of non edible oils in their customized and clean forms [8-11]. In the present investigation, blends were used as fuel and the performance was compared with diesel. The mahua oil used for biodiesel production must be moisture free because each molecule of water destroys the active sites of catalyst; thus; decreasing its concentration. The FFA content of the oil is supposed to be less than 1% when methanol was used; Potassium hydroxide was used as the catalyst for transesterification. This the oxygen content and cetane number of the fuel. The biodiesel has more oxygen content than the diesel fuel. So the bio diesel blends are involved in complete combustion process. The maximum carbon monoxide emission was observed at full brake power of the engine. Bio energy is one of the so-called renewable energies. It's is the energy that is contained in living or recently living biological organisms. (6) Bio-energy is obtained from organic matter, either directly from plants or indirectly from commercial, domestic or agricultural products and waste. The use of bio energy is generally classed as a carbon-neutral process because the carbon dioxide released during the generation of energy is balanced by that absorbed by plants during their growth. (7) The term bio-energy really covers two areas: bio-fuel which is the transformation of plant materials into liquid fuel, and bio-mass, where solid plant materials are burnt in a power plant and this process creates energy, which can then be for immediate use or stored. (8) Advanced and efficient conversion technologies now allow the extraction of bio fuels besides the traditional use of bio energy; ‘Modern bio energy’ comprises bio fuels for transport, and processed biomass for heat and electricity production.

## II. BIODIESEL DEFINED

The use of vegetable oil as a fuel source in diesel engines is as old as the diesel engine itself. However, the demand to develop and utilize plant oils and animal fats as biodiesel fuels has been limited until recently. The technical definition of biodiesel is: “The mono alkyl esters of long fatty acids derived from renewable lipid feedstock such as vegetable oils or animal fats, for use in compression ignition (diesel) engines” (National Biodiesel Board, 1996). In simple terms, biodiesel is a renewable fuel manufactured from methanol and vegetable oil, animal fats, and recycled cooking The term “biodiesel” itself is often misrepresented and misused. Biodiesel only refers to 100% pure fuel (B100) that meets the definition above and specific standards given by the American Society of Testing and Materials (ASTM) International (D 6751).

However, it is often used to describe blends of biodiesel with petroleum diesel. Such blends are generally referred to as “B2,” “B5,” “B20,” etc., where the number indicates the percent of biodiesel used. The most common method to produce biodiesel is through a process called “transesterification,” which involves altering the chemical properties of the oil by using methanol (Fangrui and Hanna, 1998). Transesterification of plant oils with methanol is a relatively simple process that yields high conversions with only glycerin as a byproduct. One hundred pounds of plant oil is reacted with 10 pounds of methanol to yield 10 pounds of glycerin and 100 pounds of biodiesel. While the process is relatively straightforward, due to quality concerns, legal liability, and vehicle warranty restrictions, we strongly recommend that individuals not try to produce biodiesel fuels. The properties of biodiesel differ depending on the source of plant oil/fat source. This is mainly related to their chemical structure, such as the number of carbons and the number of double bonds in the

hydrocarbon chain. For an explanation of these differences, see the Purdue Extension publication “Biodiesel Quality: Is All Biodiesel Created Equal.”

**Benefits of Biodiesel :** There are several significant advantages and limitations of using biodiesel to replace petroleum-based diesel.

**Gallons of Biodiesel per Acre of Soybeans:** The gallons of biodiesel an Indiana soybean grower can produce per acre is based on two factors: 1) average yield (bushels per acre) and 2) percent oil content. Because soybean yield and oil content are influenced by both genetic and environmental factors, we may see significant year-to-year variability (Table). Fortunately, the relationship between pounds of oil produced per acre and pounds of biodiesel produced per acre is 1:1. This simple relationship allows us to make reasonable estimates as the soybean growing season progresses biofuels for use in helping to understand technology-related implications of biofuels development.

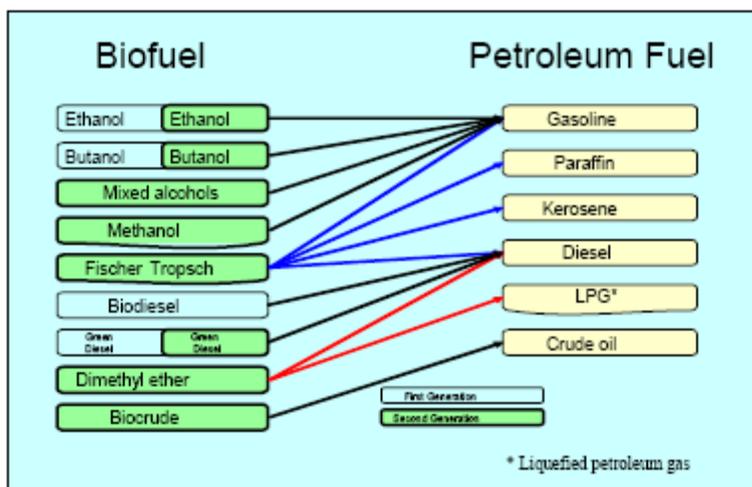


Fig. 1. Substitutability of biofuels with common petroleum-derived fuels.

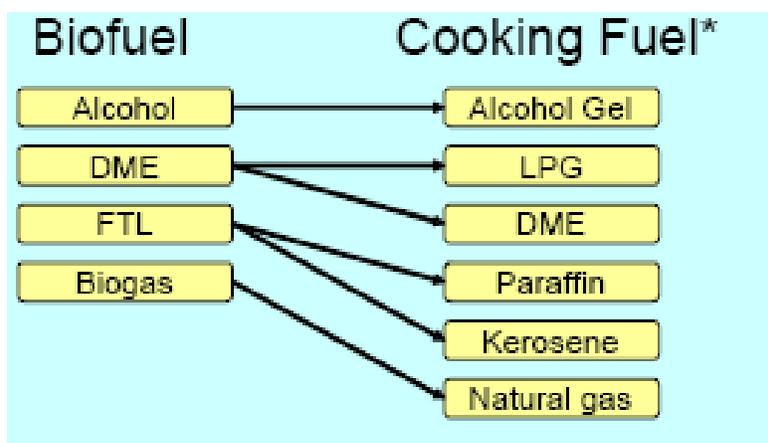


Fig. 2. Substitutability of biofuels for clean fossil fuels used for cooking.

It seeks to (a) provide some context for understanding the limitations of first-generation biofuels; (b) provide meaningful descriptions accessible to non-experts of second-generation biofuel technologies; (c) present salient energy, carbon, and economic comparisons

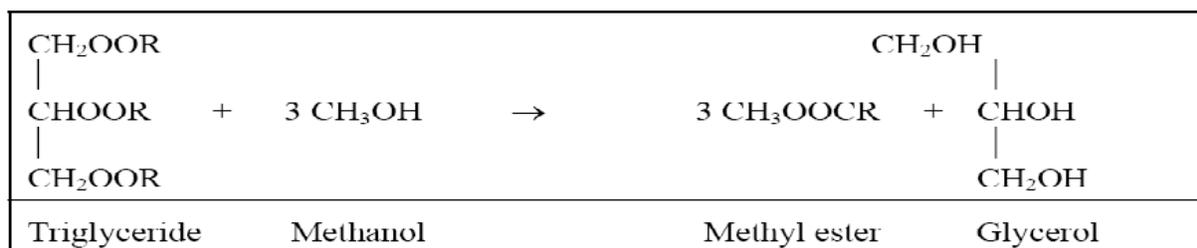
between first and second-generation biofuels; and (d) finally, to speculate on the implications for trade and development of future expansion in global production and use of biofuels.

**Table 1. Biofuel classification.**

First-generation biofuels (from seeds, grains or sugars)	Second-generation biofuels (from lignocellulosic biomass, such as crop residues, woody crops or energy grasses)
<ul style="list-style-type: none"> <li>• Petroleum-gasoline substitutes               <ul style="list-style-type: none"> <li>– Ethanol or butanol by fermentation of starches (corn, wheat, potato) or sugars (sugar beets, sugar cane)</li> </ul> </li> <li>• Petroleum diesel substitutes               <ul style="list-style-type: none"> <li>– Biodiesel by transesterification of plant oils, also called fatty acid methyl ester (FAME) and fatty acid ethyl ester (FAEE)                   <ul style="list-style-type: none"> <li>▪ From rapeseed (RME), soybeans (SME), sunflowers, coconut, palm, jatropha, recycled cooking oil and animal fats</li> </ul> </li> <li>– Pure plant oils (straight vegetable oil)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Biochemically produced petroleum-gasoline substitutes               <ul style="list-style-type: none"> <li>– Ethanol or butanol by enzymatic hydrolysis</li> </ul> </li> <li>• Thermochemically produced petroleum-gasoline substitutes               <ul style="list-style-type: none"> <li>– Methanol</li> <li>– Fischer-Tropsch gasoline</li> <li>– Mixed alcohols</li> </ul> </li> <li>• Thermochemically produced petroleum-diesel substitutes               <ul style="list-style-type: none"> <li>– Fischer-Tropsch diesel</li> <li>– Dimethyl ether (also a propane substitute)</li> <li>– Green diesel</li> </ul> </li> </ul>

**Vegetable oils:** Most vegetable oils are triglycerides (TGs; triglyceride = TG). Chemically, TGs are the triacylglyceryl esters of various fatty acids with glycerol. Some physical properties of the most common fatty acids occurring in vegetable oils and animal fats as well as their methyl esters are listed in Table. Besides these fatty acids, numerous other fatty acids occur in vegetable oils and animal fats, but their abundance usually is considerably lower. Table lists the fatty acid composition of some vegetable oils and animal fats that have been studied as sources of biodiesel. Structure of triglycerides and principle of the transesterification reaction (shown for methyl esters;  $R = (CH_2)_x CH_3$  or unsaturated rests according to the fatty acids listed in Table). [6] The most common derivatives of TGs (or

fatty acids) for fuels are methyl esters. These are formed by transesterification of the TG with methanol in presence of usually a basic catalyst to give the methyl ester and glycerol. Other alcohols have been used to generate esters, for example, the ethyl, propyl, and butyl esters. Selected physical properties of vegetable oils and fats as they relate to their use as DF are listed in For esters these properties are [7] Also listed in are the ranges of iodine values (centigrams iodine absorbed per gram of sample) of these oils and fats. The higher the iodine value, the more unsaturation is present in the fat or oil. That vegetable oils and their derivatives are suited as DF is shown by their CNs which generally are in the range suitable for or close to that of DF.

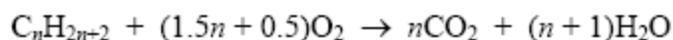


**Table 2. Selected properties of some common fatty acids and esters.**

<i>Trivial (Systematic)name<sup>a</sup>; Acronym<sup>b</sup></i>	<i>Mol. wt.</i>	<i>m.p.<sup>c</sup> (°C)</i>	<i>b.p.<sup>c,d</sup> (°C)</i>	<i>Cetane No.</i>	<i>Heat of Combustion<sup>e</sup> (kg-cal/mole)</i>
Caprylic acid	144.22	16.5	239.3		

**Combustion Chemistry. Emissions. Engine problems and deposits:** Besides the properties discussed above and accompanying operational problems, the question of combustion, emissions, and engine deposits of biodiesel fuels is of extreme significance and will be discussed here. Generally, similar types of compounds are observed in the exhaust emissions of conventional DF and vegetable oil-derived fuels. This is additional proof of the suitability of fatty compounds as DF because there presumably exist similarities in their combustion behavior. Emissions from any kind of engine are the result of the preceding combustion within in the engine. The combustion

process, in relation to the properties of the fuel, [4] and its completeness are responsible for any problems associated with the use of biodiesel, such as formation of deposits, etc. To understand the formation of emissions and deposits, and possibly direct the combustion to suppress undesirable emissions and deposits, it is essential to study the combustion of the fuel. Ideally, the products of complete combustion of hydrocarbons are carbon dioxide (CO<sub>2</sub>) and water according to the equation (shown for alkanes (saturated hydrocarbons))



Combustion in a diesel engine occurs mainly through a diffusion flame and is therefore incomplete (8). This causes the formation of partially oxidized materials such as carbon monoxide (CO), other oxygenated species (aldehydes, etc.), and hydrocarbons. In the case of biodiesel, liberation of CO<sub>2</sub> (decarboxylation), as indicated above, from the ester moiety of the triglyceride or methyl ester occurs besides combustion formation of CO<sub>2</sub> from the hydrocarbon portions of bio diesel. The formation of CO<sub>2</sub>, an incombustible compound despite its high oxygen content (although mistakenly assumed by some that it can serve as [8] a combustion enhancer because of its high oxygen content), shows that one has to be judicious in choosing oxygenated compounds as combustion enhancers because the combustion-enhancing properties will depend on the nature of the oxygen (bonding, etc.) in those compounds. Therefore, the higher oxygen content of bio diesel does not necessarily imply improved combustion compared to conventional DF because of removal of this oxygen from the combustion process by decarboxylation, but CO<sub>2</sub> may contribute to combustion in other ways.

**Waste vegetable oils:** Vegetable oils have many other applications, notably as food ingredients and cooking

oils. Especially the latter use produces significant amounts of waste vegetable oils. These vegetable oils contain some degradation products of vegetable oils and foreign material. However, analyses of used vegetable oils claimed (172) that the differences between used and unused fats are not very great and in most cases simple heating and removal by filtration of solid particles suffices for subsequent transesterification. The cetane number of a used frying oil methyl ester was given as 49 (173), thus comparing well with other materials, but little demand could be covered by this source. Biodiesel in form of esters from waste cooking oils was tested and it was reported that emissions were favorable (174). Used canola oil (only purified by filtration) was blended with DF2 (175). Fuel property tests, engine performance tests and exhaust emission values gave promising results. Filtered frying oil was transesterified under both acidic and basic conditions with different alcohols (methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, and 2-ethoxyethanol) (175). The formation of methyl esters with base catalysis (KOH) gave the best yields. The methyl, ethyl, and 1-butyl esters obtained here performed well in short-term engine tests on a laboratory high-speed diesel engine.

Methyl ester is now well proven as a fuel for diesel engines, mixed with mineral diesel or as a complete replacement. [10] Engine power and fuel consumption are largely unaffected, and the fuel has some desirable environmental features: lower smoke, particulate levels and sulphur, and very low toxicity to water life. However, the high cost of rape-seed oil is a major problem. Lower-cost feedstocks are essential to the further growth of the industry. bio-diesel from *Camelina sativa* oil was found to have acceptable properties, with the exception of a high iodine value. Esters of waste cooking oil had more variable properties than those from virgin oil, but still came close to conformity.

### METHODS

Tallow from BSE risk organisms (brain and spinal tissue) was esterified in the laboratory. Free fatty acid content was 15-20%, so esterification using the standard base-catalysed process was not possible. The process was adapted to the esterification of this material by using large excesses of base (+75%) and methanol (+50%), and using water to help with the separation of glycerol. [9] Further process steps to improve yield were explored. Three light vehicles were operated on five bio-diesel blends based on three feed-stocks: camelina oil, waste cooking oil and tallow. Vehicle monitoring included engine lubricating oil condition (methyl ester content, viscosity and wear metals), fuel consumption and practical observations of vehicle behaviour.

### Advantages

1. can be produced from renewable, domestic resources.
2. energy efficient. (The total fossil fuel energy efficiency of biodiesel is 32% vs. 83% for petroleum diesel.) (National Biodiesel Board, 1998)
3. can be used directly in most diesel engine applications.
4. can reduce global warming and tailpipe emissions (-41%) (Hill, Nelson, Tilman, Polasky, & Tiffany, 2006).
5. nontoxic and biodegradable.
6. A good solvent and may clean out fuel line and tank sediments. (Note that this may result in fuel filter clogging during initial use.)

### Limitations

1. contains approximately 8% less energy per gallon.
2. generally has a higher cloud and pour point (will

freeze at a higher temp) than conventional diesel.

3. compatible with some hose and gasket materials, which may cause them to soften, degrade, and rupture.
  4. compatible with some metals and plastics.
  5. may increase nitrogen oxide emissions
- The most common method used to overcome the limitations of B100 is called "blending." Blending biodiesel with diesel to produce B20 (20% biodiesel), B5 (5% biodiesel), and B1 (1% biodiesel) retains many of the advantages of biodiesel while overcoming some of its limitations.

### RESULTS

with respect to load for different blends as is brake specific energy consumption decreases with increase in brake mean effective pressure up to full load. At atmospheric temperature shows lowest It was observed that as bio diesel percentage increases decreases. The variation of exhaust gas temperature with respect to applied loads for different blends as in It is observed that with increase in load exhaust gas temperature also increases. This reveals that the effective combustion is taking place in the early stage of strokes and there is reduction in the loss of exhaust gas energy. When bio diesel concentration is increased, the exhaust gas temperature increases by same value, but for blend low exhaust gas temperature at all loads. The highest exhaust gas temperature is observed at blend at full load. The higher exhaust gas temperature may be because of better consumption of the castor methyl ester as it contains oxygen molecule which helps in proper consumption.

### CONCLUSIONS

The following are the main conclusions arising from this work It is possible to produce bio-diesel of acceptable quality from low-grade tallow, including that from risk organisms. Some modifications and additions to the conventional esterification process are required. Esters of waste oils and fats oils give a performance similar to rape methyl ester in vehicles. Problems of high melting point can be overcome by mixing with mineral diesel. Tallow ester requires careful filtration. Waste oils and fats are available in Ireland and throughout the EU in sufficient quantities to greatly increase bio-diesel production.

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