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# Experimental investigation of advanced nano materials additives on combustion characteristics of biofuels

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## Abstract

Due to the depletion of fossil fuels, renewable and cleaner fuel is now required for diesel engines. The researchers are looking into different kinds of bio-based fuels. It is anticipated that biodiesel will compete with diesel fuel. Pure biodiesel can be used in diesel engines, but due to some drawbacks, including higher density, a lower cetane number, and a lower calorific value, it cannot completely replace conventional diesel. As a result, using biofuel blends in diesel engines is preferred. The role of nanoparticles in biofuel production and the impact of nanoparticles in biodiesel-diesel fuel blends on diesel engine performance, combustion analysis, and emission characteristics are covered in this paper in two different ways. This review study compiles a wide range of findings from earlier research studies on the potential and applications of nanoparticles in the production of bioethanol as well as the impact of their addition to diesel fuel at various biofuel ratios. There are numerous techniques for improving engine performance. Nanoparticles can be used as catalysts in chemical reactions and feedstock pretreatment processes to produce biofuels. According to the overall findings, adding nanoparticles significantly reduced the amount of fuel used for brakes by 20% to 23% when compared to biodiesel-diesel blends with and without the addition of alcohol. In addition to improving the combustion process and boosting the brake power by 2.5% to 4%, nanoparticles have a high thermal conductivity. Emission results revealed that while HC, CO, and PM emissions all significantly decreased in most reviews, NO emissions increased by up to 55%. According to the study's findings, adding nanoparticles to biodiesel and its blends as fuel can make diesel engines run more efficiently, deliver better performance, and produce emissions that are effectively regulated.

## Introduction

Diesel engines are the most widely used fuel in the current scenario. Its primary selling points are ruggedness in build, ease of use and maintenance. However, due to the scarcity of fossil fuel, we might be unable to use it for a while [1], [2], [3]. Because of this, efforts are being done globally to develop unconventional fuels for use in diesel engines. Similar to this, the automobile industry has been driven to manufacture engines with new technology as a result of the focus on how to reduce fuel consumption. New combustion systems have now been developed as a result of this. A lot of research is being done to address the aforementioned problems [4].

The geometry of the combustion chamber, the location and size of the injection nozzle hole, the fuel spray pattern, and the air swirl are some of the variables that influence the performance and emissions of diesel engines. A great number of experimental studies on diesel engines have been carried out in order to enhance the efficiency of their operations and lower the amount of pollution they produce. In order to study how these adjustments will impact the performance of the direct injection diesel engine, its injection pressure is currently being altered. The fuel that was utilised was a combination of diesel and biodiesel, with the specific ratios varying from use to use [5], [6], [7]. This is an effort to determine the injection pressure that will produce the best results in terms of power, efficiency, and specific fuel consumption. Specifically, the goal of this endeavour is to find the optimal pressure.

There is a great deal of interest in developing alternative fuels as a result of the petroleum crisis brought on by the quick depletion of fossil fuels and the environmental damage caused by their combustion. For humans, internal combustion engines are a necessary component of both transportation and mechanized farming systems.Thermodynamic studies on engine performance evaluation established that it is possible to use a variety of alternative fuels, such as hydrogen, compressed natural gas (CNG), alcohols, biogas, producer gas, and various vegetable oils. These alternative fuels include: In addition, the viability of utilising a wide variety of other alternative fuels was established as a result of these studies. Diesel engines in India are able to operate on biodiesel that is produced from edible as well as non-edible oil seeds [8].

Fuel made from vegetable oil is not only non-toxic and biodegradable, but it also significantly cuts down on pollution. According to the findings of a study that looked at the effect of using biodiesel in diesel engines, emissions of SO2, CO, smoke, noise, and particles all decreased significantly. On the other hand, waste resources such as wild or inedible seeds can be used to produce biodiesel in the country's wastelands. Biodiesel has been developed in various countries from buckwheat, sunflower, peanut, grape seed, linseed, Vegetable oil has a viscosity that is 10 to 20 times higher than that of water, and because it has a low viscosity index, it sprays differently. This results in a variable heat release pattern and emission characteristics. Large droplets, poor atomization, and high spray jet penetration can all be attributed to high viscosity. Loss can achieve these outcomes in poor combustion. Pure plant oils pose little environmental threat, particularly to groundwater [9]. Vegetable oil's water dangers are increased by esterification. The molecules of vegetable oils are much larger, sometimes up to four times larger than the molecules of diesel fuel. A mixture of biodiesel and diesel derived from petroleum should be handled in the same manner as diesel derived from petroleum.

The overall morphology, availability, and combustion properties of mahua oil and its mixes with diesel oil that are being tested are described here, in addition to the density, viscosity, flash point, and fire point of each of these substances. An intensive search for alternative fuels has been prompted by a number of factors, including the rapidly diminishing supply of petroleum around the world, rising prices, and the growing risk of environmental damage caused by these fuels. The use of Mahua oil, which comes from the Madhuca Indica plant, as a diesel replacement in compression ignition engines has recently become more common. This can be attributed to the large population and rapid growth of these countries. Because hydrocarbons are in such high demand everywhere, mahua oil has the potential to easily replace them, which would result in significant savings for the country in terms of foreign currency. As a consequence of this, it is of the utmost importance to devise techniques for enhancing the fuel efficiency of compression ignition engines and to investigate whether or not Mahua oil is appropriate for use in diesel engines [10]. Diesel engines have the potential to become the most in-demand types of engines in the future [11], [12], provided that they are able to operate on more environmentally friendly fuels such as honge oil and mahua oil. Current researchers are looking at a wide variety of non-edible seed oils, and one of those oils is mahua oil.

It is possible for it to use ethanol or methanol that is extremely close to being pure. Glycerol does not become isolated from the reaction mixture when water is present because, similar to oil, water has an effect on the conversion rate.

Although sodium or potassium hydroxide can be purchased, the price is exorbitantly high for either. The best grades of potassium hydroxide contain 14–15% water and 85% potassium hydroxide [13], [14], [15]. This ensures that the product will produce the desired results. Because carbonate is an ineffective catalyst that can cause the finished ester to become cloudy, the carbonate content should be kept to a minimum [16], [17], [18]. The excellent results that the sodium hydroxide pellets produced were made possible by the fact that very little catalyst was used and that high-quality catalysts could still be used despite their high cost.

Because of the high concentration of saturated fatty acids that it contains, tallow has a melting point that is higher than the temperature of the surrounding air, making it the animal fat that is being investigated the most for its potential use in biodiesel [19], [20].



## Section snippets

### Mahua tree

India is home to two species each of the genera Madhucaindica and Madhucalongifolia. Mahua, also known as It is a plant that thrives in deserts and arid environments. The seeds of the tree are referred to as the Indian butter tree. Mahua oil had a specific gravity that was 9.11% higher than diesel. At 40°C, the kinematic viscosity of mahua oil was 15.23 times that of diesel [21], [22]. The kinematic viscosity of mahua oil was significantly reduced by adding more diesel fuel to fuel blends and

### Ways to make biodiesel from mahua oil

According to studies, using non-edible oil neat is conceivable but not recommended. Non-edible oils have a high viscosity and low volatility, which impairs fuel atomization and spray patterns and causes severe carbon deposits, incomplete combustion, injector choking, and piston ring sticking. The transesterification process, which combines a variety of fatty acid chains depending on the particular oil being used, is one of them and is frequently employed in the commercial production of clean,

## Testing

The qualities of the blended biodiesel and regular diesel have been tested, and they are.

## Variable compression ratio setup

A single-cylinder diesel engine equipped with a variable compression ratio (VCR) is shown being loaded by an eddy current dynamometer in Fig. 1. By employing a tilting cylinder block arrangement that was specifically designed for this purpose, it is possible to alter the compression ratio without having to either stop the engine or alter the geometry of the combustion chamber. The crank angle and combustion pressure can both be accurately measured with the instruments that come with the kit.

## Result & discussion

Fig. 2 depicts the variance in brake thermal efficiency for B100 to MME with regard to braking power. As can be observed, B0 and B20 have nearly identical values. Diesel and B20 have maximum braking thermal efficiencies at full load of 32.0021 % and 30.897 %, respectively. It should be noted that B100 has a reduced thermal efficiency for the brakes under all loads. The brake thermal efficiency for B100 is lower than diesel fuel at both no load and full load condition. This may be due to

## Conclusion

The expeller method was found to be suitable for extracting Mahua oil at 350ml per kg of Mahua seed. Using titration technique, the free fatty acid content of mahua oil was found to be 18% which was reduced to less than 2% by acid esterification in which 5% of concentrated sulphuric acid and methanol were added. The base catalyzed transesterification with sodium hydroxide and methanol at a molar ratio of 1:6 was found to be very effective which yielded 89 % of biodiesel. The biodiesel

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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