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A Review on Biodiesel Production and Performance

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ABSTRACT: The purpose of this paper is to evaluate the research on biodiesel manufacturing, combustion, efficiency, and emissions. This research is based on the results of about 130 scientists who published their findings between 1980 and 2008. As fossil fuels deplete, there is a pressing need to develop an alternative fuel to meet the world's energy demands. Biodiesel is one of the finest accessible options for meeting the global energy needs. More than 350 oil-bearing crops have been discovered, with some only being evaluated as possible diesel engine alternative fuels. Several oils and their mixes with diesel were used in the experiments by the scientists and researchers. Short-term engine experiments utilizing vegetable oils as fuels were extremely promising, according to the vast majority of scientists, but long-term test results revealed increased carbon buildup and lubrication oil pollution, culminating in engine failure. Vegetable oils, either chemically changed or mixed with diesel, were shown to be effective in preventing engine failure. Biodiesel has been shown to have comparable combustion properties as diesel, with shorter ignition timing, greater ignition temperature, higher ignition pressure, and higher overall heat release in blends. The power output of the engine was found to be comparable to that of diesel fuel. Furthermore, it was discovered that base catalysts and enzymes are more effective than acid catalysts and enzymes.

KEYWORDS: Acid Catalyzed, Base Catalyzed, Biodiesel, Enzyme Catalyzed, Supercritical.

1. INTRODUCTION

As coal and oil deplete, there is a pressing need to develop an alternative fuel to meet the world’s largest energy demands. Biodiesel is one of the finest accessible options for meeting the world's energy needs. Petroleum fuels are critical to the development of industrial expansion, transportation, the agriculture industry, and many other fundamental human requirements. However, since use is quickly growing, these fuels are finite and decreasing day by day. Furthermore, their usage is causing serious environmental issues in society. As a result, scientists are on the lookout for alternate fuels [1]. India imports more than 80% of its gasoline and spends a significant amount of foreign currency for it. Due to the finite nature of fossil fuel supplies, biodiesel is growing in popularity as a viable alternative fuel. The goal of the esterification reaction procedure is to reduce the oil's viscosity.

Vegetable oil's major disadvantage is its high viscosity and low volatility, which results in poor combustion in diesels [2]. The process of eliminating glycerides and mixing oil esters of vegetable oils with alcohol is known as esterification reaction. This procedure lowers the viscosity to a level similar to diesel, resulting in better combustion. When compared to diesel, biodiesel produces less pollutants across the whole range of air–fuel ratios. Biodiesel may be made utilizing a variety of methods, including ultrasonic cavitation, hydrodynamic cavitation, microwave irradiation, response surface technology, and the two-step reaction process. Tests on several kinds of combustion have been carried out [3]. The findings of a spherical combustion chamber were found to be superior to those of other types of combustion. The researchers examined a variety of fresh

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and processed vegetable oils, including rapeseed oil, sunflower oil, palm oil, and soybean oil. The findings of a few studies have been compared and presented in this article [4].

The steep rise of demand of petroleum-based fuel is because of rapid and fast industrialization of automotive sector. There are limited reserves for petroleum-based fuels. These limited reserves are located in the certain regions of the world. Therefore, the countries those are not having the sufficient stock of petroleum-based fuel, are facing the problems of increase cost of fuel which mainly due to the cost involved in the import of the petroleum-based fuel. Hence it is required to find out and investigate the other resources of the alternative fuels, which can be produced from nearby and locally available sources such as Alcohol, Biodiesel, Vegetable oil etc. Methyl or ethyl esters of fatty acids produced from vegetable oil or an animal fat is called biodiesel. Non edible oil or animal fats are the main recourses for production of biodiesel such as Jatropha, Palm, Marine fish oil, Soybean, Cottonseed etc. Biodiesel blends are prepared in any proportion with diesel to use in a conventional diesel engine. By using biodiesel in an engine there is a significant reduction in the harmful pollutants in the environment. This paper reviews the production, properties, performance and emission analysis of different feedstock of blends of biodiesel and experimental work carried out in the various parts of the world.

2. DISCUSSION

1. *Production of biodiesel:*

Researchers and scientists have devised several ways for biodiesel production from various biofuels. Here is a quick rundown of these techniques. The majority of the researchers stated that the generation of biodiesel increased when a catalyst was included in the process. To make biodiesel, Ahn et al. used a two-step reaction method. Canola methyl ester (CME), rapeseed methyl ester (RME), linseed methyl ester (LME), beef tallow ester (BTE), and sunflower methyl ester (SME) were produced using this technique in a bioreactor using sodium hydroxide, potassium hydroxide, and sodium methoxide as catalysts. Cvengro and Povaz reported biofuel synthesis utilizing two-stage low-temperature esterification of cooler rapeseed oil with methanol at temperatures as high as 70ºC. Masaru et al. established a new enzymatic technique for synthesizing methyl esters from plant oil and methanol in a solvent-free reaction system. Uosukainen et al. provided a statistical and analytical methodology to assess the dependence of process factors in enzymatic esterification reaction in the same year. The alcoholysis of rapeseed oil methyl ester was also investigated by the authors (biodiesel). Fangrui and Hanna looked into how biodiesel is made.

The effects of pretreatment of immobilized Candida antarctica lipase enzyme (Novozym 435) on methanolysis for biodiesel fuel generation from soybean were studied by Samukawa et al. Ikwuagwu et al. looked into how rubber seed oil might be used to make biodiesel. Crabbe et al. investigated the impact of three main factors on the yield of acid-catalyzed synthesis of methyl ester (biodiesel) from crude palm oil: molar ratio of methanol to oil, quantity of catalyst, and temperature. Saka and Kusdiana studied the transesterification of rapeseed oil in supercritical methanol without using any catalyst. Yuji Shimada et al. investigated enzyme alcoholysis for the manufacture of biodiesel fuel. Pizarro and Park investigated the manufacture of pure biodiesel from waste activated bleaching earth containing vegetable oils. Using response surface technology, Shieh et al. improved soybean biodiesel. According to Zhang et al. the acid-catalyzed waste

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cooking oil process has proven to be more technologically possible and less complicated than the alkali-catalyzed waste cooking oil process. Kojima et al. investigated the manufacturing of fatty acid methyl ester (FAME) from waste enabled decolorization earth discarded by the primitive oil refining industry, using fossil fuel as a solvent in the esterification of triglycerides.

2. *Combustion of biodiesel:*

The next paragraphs go through the combustion properties of different biodiesel fuels, such as ignition latency, ignition temperature, and spray penetration. Zhang and Van Gerpen explored use of soybeans oil methyl esters and diesel in a turbocharger, four-cylinder, direct-injection diesel engine modified with a bowl in the piston and a medium swirl type. They discovered that the mixes had a shorter ignition delay and burning parameters that were comparable to diesel Radwan et al. used a pulse tube test rig to examine the impact of jojoba methyl ester ignition, delay time by changing variables such as equivalency ratio, ignition heat, and ignition pressure. They found that jojoba methyl ester had a shorter ignition delay time, but the ignition temperature and pressure were greater. Yusuf et al. investigated the in-cylinder temperature parameters of a six-cylinder, direct injection, 306 kW diesel engine utilizing methyl tallowate esters as fuel in the same year. The peak rate of heat release for a mix of diesel methyl tallowate and diesel was discovered to be lower. Yu et al. compared the combustion properties of waste cooking oil to diesel as a fuel in a direct injection diesel engine. Tashtoush et al. studied the burning properties of waste vegetable oil ethyl esters. When comparing straight rapeseed oil to methyl ester of vegetable oil, Nazar et al. discovered that the duration of combustion is longer for straight vegetable oil. The combustion properties of rice bran oil in transport diesel engines were studied by Sinha and Agarwal, Usta et al. studied the combustion properties of sunflower oil. When water is emulsified with diesel, according to Lif and Holmberg, combustion efficiency improves. Using modeling methods, Saikishan et al. tried to determine the cetane number based on the characteristics of biodiesel. They investigated the impact of different fuel characteristics, such as density, viscosity, flash, and fire points, on the carbon content of biodiesel and its blends Dagaut et al. investigated the kinetics of rapeseed oil methyl ester (RME) oxidation in a jet-stirred reactor for the first time. Biodiesel may affect the fuel injection and ignition processes, according to James et al, whether it was used plain or in a mix[2].

3. *Emissions from biodiesel:*

Carbon monoxide, carbon dioxide, nitrogen oxides, sulphur oxides, and smoke are the major pollutants released by biodiesel. These contaminants produced by biodiesel have been briefly reviewed. In a single cylinder engine, Barsic and Humke investigated the effects of combining peanut oil and sunflower oil with diesel fuel. When contrasted to 100% diesel fuel, they found that increasing the quantity of vegetable oil in the mix increased the level of carbon deposits on the injector tip. They discovered that the bulk heat capacity of vegetable oil fuel mixes was lower than that of diesel fuel[5].

Murayama et al. found that vegetable oils and rapeseed oil's methyl ester produced less smoke and nitrogen oxides (NOX). Hemmerlein et al. studied the exhaust emissions and durability aspects of utilizing plain rapeseed oil as a fuel. Carbon monoxide, nitrogen oxides (NOX), and smoke emissions were marginally lower for soybean ester than diesel, according to Scholl and Sorenson but HC emissions were reduced by 50% compared to diesel. Ali et al.investigated the usage of various methyl tallowate and ethanol mixes with gasoline as a fuel in a Cummins 522 kW six-cylinder turbo direct injection engine. Carbon monoxide emissions decreased, but carbon dioxide and hydrocarbon emissions remained unchanged, according to the testing. NOX and smoke emissions were comparable to those of diesel. The 80:13:7 (diesel:methyl tallowate:ethanol) mix produced the greatest results and the lowest emissions. Unburnt hydrocarbon emissions were reduced when rapeseed methyl ester was used, according to Nwafor and Rice. Schumacher et al. investigated heavy-duty exhaust fumes emissions utilizing methyl ester soybean oil/diesel fuel mixes. The impact of exhaust gas recirculation on diesel engine emissions was studied by Ladommatos et al. They observed a significant decrease in NOX emissions at the cost of increased particle and unburned hydrocarbon emissions. Desantes et al. evaluated the rapeseed oil methyl ester and diesel mix in a direct injection diesel engine. They found that increasing the intake air temperature from ambient reduced carbon monoxide, NOX, and smoke emissions significantly[6].

Yoshimoto et al. studied the combustion characteristics of spent frying oil in a single cylinder direct injection engine with a 30% water emulsion. With the introduction of hydrogen, Senthil Kumar et al. found a decrease in smoke, hydrocarbon, and carbon monoxide emissions. However, owing to greater combustion rates, NOX emissions rose. The emission characteristics of a stationary diesel engine running on sunflower oil methyl ester/diesel blends were studied by Kalligeros et al. Particulate matter, carbon monoxide, hydrocarbon, and nitrous oxide emissions were also reduced.[7] The usage of methyl ester of used olive oil as fuel in a direct injection diesel engine was investigated by Dorado et al. Carbon monoxide, carbon dioxide, oxides of nitrogen, and sulphur dioxide emissions fell by 59 percent, 8.6 percent, 32 percent, and 57 percent, respectively, while smoke emissions were minimal, according to the researchers. They came to the conclusion that olive oil's methyl ester might be utilized as a fuel. In a gasoline engine direct injection diesel engine, Raheman and Phadatare. evaluated karanja methyl ester and its blends with diesel from 20% to 80% by volume and found that carbon monoxide, smoke, and NOX emissions were reduced. Turrio-Baldassarri et al. investigated the chemical and toxicological properties of emissions from an urban bus engine powered by a diesel and biodiesel mix. The authors also looked at how the fuels they were looking at affected the size distribution of particulate matter (PM)[8].

The generation of hydrogen-rich gas from catalytic engine exhaust aided rapeseed methyl ester fuel reforming has been explored experimentally as a method to supply the necessary hydrogen for the reduction of biodiesel emissions. Suryawanshi and Deshpande investigated the effects of exhaust gas recirculation and injection timing delay on pongamia methyl ester-fueled diesel engines. They found that injector time retardation and exhaust gas recirculation reduced nitrogen oxide emissions when compared to normal circumstances. The emission properties of mahua oil methyl ester as biodiesel were investigated by Sukumar Puhan et al. Usta investigated the exhaust emissions of a diesel engine running on methyl ester of tobacco seed oil. The findings indicated that adding methyl ester of tobacco seed oil to diesel fuel decreased CO and SO_2 emissions while marginally increasing NOX emissions. Ramadhas et al. investigated the emission characteristics of a diesel engine running on methyl esters of rubber seed oil [9].

4. *Performance of biodiesel:*

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Various biodiesels' performance characteristics, such as power output, specific fuel consumption, and brake thermal, were examined. Yarbrough et al. investigated the performance of a diesel engine running on six different types of sunflower oil. They discovered that degummed and dewaxed vegetable oil avoids engine failure and that refined sunflower oil provides acceptable results. They also came to the conclusion that although raw sunflower oil cannot be utilized as a fuel, processed sunflower oil may be used in diesel engines. Bettis et al. looked at the usage of sunflowers, safflower, and rapeseed oils as liquid fuels. They discovered that engine power output was comparable to diesel fuel, but long-term durability testing revealed significant carbonization issues. Strayer et al. looked into whether degummed canola oil and high erucic rapeseed oil might be used as diesel fuel replacements in small and large diesel engines. They found that these oils had greater specific fuel consumption and particulate matter, and that the engine performance was better with degummed canola oil when compared to crude canola oil after 25 hours of operation.

Pryor et al. used plain soybean oil in a small diesel engine to perform short and long-term engine testing. Short-term experiments using soybean oil revealed performance comparable to diesel, but long-term testing was impossible owing to power loss and carbon build-up on the injectors. They came to the conclusion that soybean oil is only suitable for short-term use. The injection and combustion characteristics of various vegetable oils, including peanut oil, cottonseed oil, sunflower oil, and soybean oil, were studied by Ryan et al. Laforgia and Ardito examined the performance parameters, emission characteristics, and heat release of biodiesel. Nwafor and Rice investigated the use of rapeseed oil blends as fuel in an air-cooled, 300 cm3 indirect injection diesel engine. It was discovered that the power output of plain rapeseed oil was lower and rose as the percentage of rapeseed oil in the mix increasedAccording to Sapaun et al., the power output of a palm oil and diesel mix was comparable to that of diesel. Short-term experiments with palm oil revealed no indications of combustion chamber wear, carbon deposits, or lubricating oil contamination. Radu and Mircea [108] tested a three-cylinder, 33-kW DI diesel engine with a sunflower oil/diesel mix. With adjusted fuel injection, a cooking oil mix has been shown to be superior for power development. Niemi et al. used mustard oil to test a turbocharged 4 direct injection diesel engine. Their testing revealed that the engine produced power comparable to that of a diesel engine. They did, nevertheless, come to the conclusion that long-term testing should be conducted.[10]

3. CONCLUSION

Despite the fact that 350 oil-bearing crops have been discovered, only a handful are suitable for biodiesel production, such as sunflower, rapeseed, palm, and jatropha. Its been discovered that biodiesel has comparable burning properties to gasoline, and that the base catalyst outperforms acid catalysts and enzyme. The high viscosity oil produced injectors coking and polluted the lubricating oil, implying that the engine performance was worse while utilizing vegetable oil/diesel mix. The results of the testing using refined oil blends showed a significant increase in efficiency. Unburned hydrocarbon emissions from the engine were found to be higher on all fuel mixes than on diesel. When comparing all fuel mixes to diesel, the emissions of nitrous oxides from engines was found to be greater.

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