PERFORMANCE AND EMISSION CHARACTERISTICS OF A DI DIESEL ENGINE USING BIO-OIL DERIVED FROM WASTE BIOMASS

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Abstract

Bio-oils produced by biomass pyrolysis are substantially different from those produced by petroleum-based fuels and biodiesel. However, they could serve as valuable alternatives to fossil fuels to achieve carbon neutral future The aim of the present review is to study the biodiesel production from transesterification process, effect of reaction parameters on conversion of biodiesel yield and its combustion, performance and emission characteristics. It observes that the base catalysts are more effective than acid catalysts. Biodiesel is a notable alternative to the widely used petroleum-derived diesel fuel since it can be generated by domestic and non domestic sources such as soybeans, coconuts, rapeseeds, Jatropha, Karanja, rubber seed, Mahuaa, waste frying oil, etc. and thus these reduces dependence on diminishing petroleum fuel from foreign sources. The problems with substituting triglycerides for diesel fuels are mostly associated with their low volatilities, high viscosities and polyunsaturated character. The main purpose of the transesterification process is to lower the viscosity of the oil. Over a number of years, the work of exploring different biodiesel as an alternative to diesel fuel has been carried out worldwide.

1.0 INTRODUCTION

Biodiesel is composed of the alkyl esters of fatty acids. These chemicals have a low flash point, a high heating value as well as density and viscosity comparable to those of diesel. Biodiesel has the additional advantages of lubricity, excellent biodegradability, superior combustion efficiency and low toxicity [1]. It is also reported that methyl esters offer low smoke levels, high thermal efficiencies and high heat release rates than normal vegetable oils. Methods such as the transesterification process, blending with diesel and alcohol, dual fueling with gaseous and liquid fuels, the use of additives, and formation of emulsions have been adopted towards reduction in viscosity and improvement in the physical properties like the cetane number [2]. Even though the biodiesel is environmentally compatible, it is subjected to oxidation. In the presence of air or oxygen, there is a possibility that the biodiesel will be hydrolyzed to alcohol and acid. The presence of alcohol will lead to reduction in flash point and presence of acid will increase total acid number. All these effects make biodiesel relatively unstable during storage and residual products of biodiesel such as insoluble gums, total acids, and aldehydes formed from degradation may cause engine problems like filter clogging, injector coking, and corrosion of metal parts [3]. Addition of anti-oxidants will solve the problem of oxidation stability. Pyrolysis is the thermal decomposition of materials in the absence of oxygen or when significantly less oxygen is present than required for complete combustion. Pyrolysis is difficult to precisely define, especially when applied to biomass. The term pyrolysis

often describes processes in which oils are preferred products [4]. In the pyrolysis process, the feed stock is heated in a closed chamber or vessel with an external heat source. The volatile matter that evolves in the vessel is further condensed to get value added products, such as secondary fuels and chemicals that are obtained in the form of liquids, gases and solids [5]. Many attempts have been made to extract mahua biodiesel from the mahua seeds, the same biodiesel was used effectively as an alternative fuel without any engine modifications. They found the performance, emission and combustion characteristics of DI diesel engine was as par with diesel fuel [6]. The seed cake left can be better utilized to produce the liquid fuel called as pyrolytic oil or bio-oil from the pyrolysis of various biomass sources like karanja seed, Rapeseed, Agricultural residues.

FUELS:

In our day-to-day life we see many machines running around us, for running them some form of energy is required which is provided by the help of fuel. A fuel is any material that can be made to react with other substances so that it releases chemical or nuclear energy as which can be utilized directly or can be converted into work. Fossil fuels were rapidly adapted during the industrial revolution because they were cheap and efficient, they have become a major part our society but they have also imputed to pollution. Currently people are more inclined towards usage of renewable fuels such as biofuels. Biofuels are fuels which are derived from biomass, they can be in solid, liquid and gaseous form. Biomass can be used directly for heating or power or it can be processed to get the maximum benefit from it. Biofuel can be produced from any carbonaceous material. Many different plants derived materials are used for biofuel manufacturing. Ethanol is also a biofuel because it is made from corm Biodiesel is vehicle fuel made from vegetable oil.

Advantages and disadvantages of bio diesel:

At present, Biodiesel fuel is about one and a half times more expensive than petroleum diesel fuel. It requires energy to produce biodiesel fuel from soya crops, plus there is the energy of sowing, fertilizing and harvesting. Another biodiesel fuel disadvantage is that it can harm rubber houses in some engines.

2.0 LITERATURE REVIEW:

Agarwal [7] In their study to performance, emission, and combustion characteristics of karanja oil as a blend with diesel in a diesel engine at various loading conditions and a constant engine speed of 1500 rpm. They reported a decrease in HC, CO and smoke emissions at 20-50% (v/v) karanja oil content in the test fuels. They showed a significant increase in combustion duration at lower karanja oil concentrations in the test fuels. Amol Bharat Varandal **[8]** The scarcity of petroleum reserves and the problems of environmental pollution have led to the search for more environmentally friendly and renewable fuels. In this study, the use of atrophy biodiesel blends as an alternative fuel for diesel engines is investigated. Ashok et al. **[9]** Evaluated the experimental parameters of Carlo strain methyl ester and its mixtures in a diesel engine they observed that the brake thermal efficiency of Calophyllum inophyllum methyl ester has slightly decreased. They also observed that the reduction in CO and HC emissions with a significant penalty in nitrogen oxides emissions. Aydin **[10]** He investigated the

use of blends of pure vegetable oil and diesel fuel in a zirconium oxide coated diesel engine. He thermally insulated the surfaces of the piston, exhaust and intake valves to reduce heat transfer through the walls during combustion. He found that the thermal barrier coating did not cause major problems during long-term operation. Aydin **[11]** They tested biodiesel from cottonseed residual cooking oil in coated and uncoated internal combustion engines. They applied a 400 μm thick thermal barrier coating to the piston crown and valves. They found that engine power, exhaust manifold temperature, and engine noise increased with coated engine operation, and brake-specific fuel consumption decreased. They found that the shorter ignition delays due to less heat transfer through the ceramic-coated combustion chamber resulted in a reduction in engine noise. Ayodele **[12]** They studied the biodiesel production phases of C. ion phylum using a solid acid catalyst to replace the conventional catalyst. They prepared the solid acid catalyst by asphyxiating polycyclic aromatic carbon from pyrolysis of microcrystalline cellulose. Bhojraj N. Kale **[13]** The increasing demand for petroleum and its availability are inversely related. This opens a new field for researchers to find a solution to this problem. A cottonseed oil-biodiesel blend is investigated as a fuel for variable compression ratio diesel engines. The combustion characteristics in terms of mass of burned fraction are investigated for different compression ratios. Emission characteristics are also studied in comparison with diesel fuel without any engine modification. The results are comparable to petroleum diesel.

3.0 Materials and methods

The plastic waste such as household waste, hospitals, blood bank, nursery, autopsy centres, laboratories and minor sources such as clinics dental clinics, home cares, institutions, cosmetic shops etc. In their study to planned to use solid plastics waste **[14].** These wastes are treated and subjected to pyrolysis process to extract oil.

Materials

In their study to Waste oil and grease can be collected from restaurants to produce biodiesel. Whereas the processing costs of this urban source are higher per gallon than the processing costs of virgin vegetable oils. The waste polystyrene used for packing electronic goods was also collected from local scrap vendors. The two feed materials used for this study are complete industrial waste products. The NDC was dried in open atmosphere for more than 15 days and then oven dried at approximately 60°C for 12 hours. The waste polystyrene collected for this study is 95% air with high volume. In order to reduce its volume, the material was shredded and then dried at 100°C.

Pyrolysis Process: Pyrolysis is the thermal decomposition of biomass occurring in the absence of oxygen. It is the fundamental chemical reaction that is the precursor of both the combustion and gasification processes and occurs naturally in the first two seconds **[15].** The products of biomass pyrolysis include biochar, bio-oil and gases including methane, hydrogen, carbon monoxide, and carbon dioxide. Depending on the thermal environment and the final temperature, pyrolysis will yield mainly biochar at low temperatures, less than 4500C, when the heating rate is quite slow, and mainly gases at high temperatures, greater than 8000C, with rapid heating rates. At an

intermediate temperature and under relatively high heating rates, the main product is bio-oil **[16].**

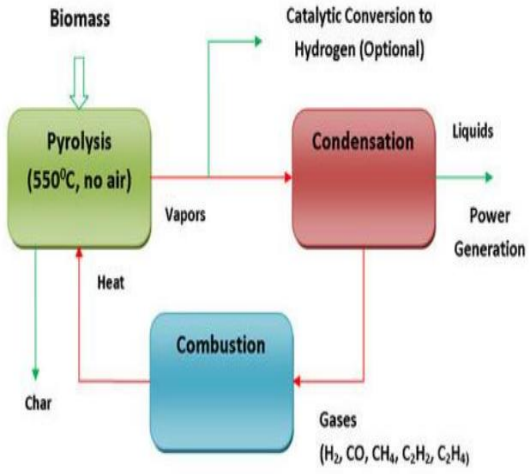

Fig: Plastic waste liquification via pyrolysis

Challenges Using Pyrolysis Oils in Compression Ignition Engines/Diesel Engines

Better suitable for running in low-speed large engines and moderate speed engines

Highly tolerable to low grade fuels; blended and upgraded fuels more resistant to high mechanical and thermal stresses and have potential to be used in high-speed smaller engines

Injection system will require some modifications using pyrolysis oils to achieve comparable Combustion efficiency between diesel fuel and pyrolysis bio-oil **[17].**

- Preheating and fuel filtering is required. Cold start up can be an issue when dealing with high viscous oils but can be overcome using a pilot fuel for initial ignition. Increased compression ratio can help assist ignition issues.
- High CO, NOx and UHC emissions are expected, however, and oxidized catalyst can help reduce NOx.
- Very limited studies demonstrated success of using pyrolysis oils and reporting stable engine performance, hence this remains an area of interest.
- Unless the fuel injection system is modified to be suited for use with such heavy oils, it will remain a challenge to successfully operate on 100% pyrolysis oil.

4.0 Biodiesel characterisation process:

Biodiesel meets both the biomass-based diesel and overall advanced biofuel demand of the Renewable Fuel standard. Biodiesel is a liquid fuel usually stated as B100 or neat biodiesel in its pure, un homogenised form. Like petroleum diesel, biodiesel is used as fuel in compression-ignition engines. How well biodiesel performs in weather condition depends on the blend of biodiesel The smaller the proportion of biodiesel within the mix, the better it performs in cold temperatures

Biodiesel is made by reacting vegetable oil or animal fat with an alcohol (methanol or ethanol) and a catalyst. This process separates the glycer in from oil or fat. Thus, resulting in biodiesel which is thinner than the original oil or fat and works better in diesel engine [18]. Biodiesel production is the method of producing the biofuel, biodiesel, through the chemical reactions such as transesterification and esterification. This involves vegetable or animal fats and oils being reacted with short chain alcohols (typically methanol or ethanol). The alcohols used should be of low relative molecular mass, ethanol is most commonly used because of its low cost, however greater conversion into biodiesel can be done using methanol [19]. The method of production is base catalysed transesterification, this process is chosen

because it consumes less time and also the cost of catalyst is low. This process is cheaper than the acid esterification [20]. However alkaline catalyst has the disadvantage of high sensitivity to both water and fatty acid present within the oil.

Table: Review on DI diesel engine using bio-oil derived from waste biomass

Author	Year	Discerption
Z. Wang, K [21]	2021	In pyrolysis, the waste solid particles are transformed into liquid oil by applying heat up to 750°C with maximum liquid yield of 60–70%. the bio-oil produced from biomass materials on the other hand has unstable fuel characteristics compared to mineral oil. the water content in the bio-oil is the main drawback that decreases the energy content of the fuel
M. Mohsin, Q [22]	2019	Many researchers have previously conducted engine performance analysis using various biodiesel and different engine modification systems. conducted engine analysis using different blends of cottonseed oil biodiesel with various percentages of octanol additives along with multiwalled carbon nanotubes. the study showed that 20% blend of biodiesel with 5%, 10%, and 15% octanol consumes lower fuel.
R. R. Appannagari [23]	2017	In their study to fossil fuels in all industrial sectors and transport vehicles are the primary source of these harmful pollutants. The increased thermal efficiency and outstanding drivability of the diesel engine have a propensity to use in transport sector as well as power plants
S. Papari, H. Bamdad [24]	2021	In their study to yields high-quality liquid products due to synergetic effects and can be utilised in internal combustion engines. During biodiesel synthesis process, a bulk quantity (~40%) of solid waste is produced from the oil feedstocks. For example, neem seed is a potential feedstock producing neem seed oil
J. N. Nair [25]	2017	This project deals with study of emission and performance characteristics on diesel engine with blends of Neem oil as biodiesel. Biodiesel is prepared from Neem oil by transesterification pr

		ocess followed by adding 1% v/v H_2SO_4. The tests were performed with B10, B20, B30 blends on a single cylinder, 4-stroke, diesel engine.
S Rathinam [26]	2020	This study focuses on the effect of particle size of cerium oxide (CeO_2) nanoparticle on the emissions characteristics of four-stroke, single cylinder water-cooled diesel engine fueled with neat neem biodiesel (NBD100). Neem oil is transesterified into biodiesel and employed in this work.
K. B. Park, Y. S. Jeong [27]	2018	The present study aims to produce pyrolytic oil from thermoplastics and their different mixtures in order to determine the best performance between these and different mixtures, as well as to characterize the liquid fraction obtained to analyse its use based on said properties. This was carried out in a batch type reactor at a temperature of 400 °C for both individual plastics and their mixtures, from which the yields of the different fractions are obtained.
R. R. N. Bhattacharya [28]	2018	The plastic fuel properties are like commercial non-renewable energy source and they tend to be utilised in diesel engines without adjustment. This investigation audit, execution and outflow attributes of the diesel engine work with the plastic oil. It likewise incorporates the impact of working parameters on the performance and emission qualities of the diesel engine.

Conclusion:

Biodiesel provides energy security as it protects the environment, and also boosts the economy. Today, biodiesel turning as the growing alternative fuel not only in America, but other parts of the world as well. One of the main reasons behind transition to biodiesel fuel is energy security. Is that the nation's dependence on foreign oil get reduced, use of locally available sources is enhanced. Thus, a country finds energy security in biodiesel fuel without a decrease in greenhouse gas emissions. Although the total energy balance is still a debatable issue, but clearly the energy security due to biodiesel fuel is enhanced. It has been observed that properly managed biodiesel fuels have the prospective for strengthening the security of supply and can also help in generating different energies to propose experimentation with the pyrolysis of thermoplastic residues in a temperature range estimated by thermogravimetric analysis to determine the temperature that

generates the highest and best liquid product for the subsequent pyrolysis for the mixtures of said plastics. Additionally, this study presents a comparative analysis of the properties of the product obtained with the prospect of its use as a conventional fuel additive.

Scope for future work:

- The current batch feeding system is to be converted to continuous feeding system with some modification. Better and effective distillation columns should be applied on the plant for refining of the pyrolysis products.
- The non-condensable gases were flared off in the experiment. It would be valuable to collect some of the gases and investigate its composition. The diesel range product should be separated out of the condensed products in the small-scale plant.

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