A REVIEW PAPER ON BIODIESEL: A PROMISING ALTERNATIVE FUEL

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Abstract: Biodiesel has become more attractive recently because of its environmental benefits and the facts that it is made from renewable resources. These concerns have increased the interest in developing second generation biofuels produced from non-food feedstocks such as no edible oils which potentially offer greatest opportunities in the longer term.

This paper presents a brief review on the current status of biodiesel production and its performance and emission characteristics as compression ignition engine fuel. This study is based on the reports on biodiesel fuel published in the current literature by different researchers. Biodiesel can be produced from crude vegetable oil, non-edible oil, waste frying oil, animal tallow and also from algae by a chemical process called transesterification. Biodiesel is also called methyl or ethyl ester of the corresponding feedstocks from which it has been produced. Biodiesel is completely miscible with diesel oil, thus allowing the use of blends of petro-diesel and biodiesel in any percentage. Presently, biodiesel is blended with mineral diesel and used as fuel. Biodiesel fueled CI engines perform more or less in the same way as that fueled with the mineral fuel. Exhaust emissions are significantly improved due the use of biodiesel or blends of biodiesel and mineral diesel.

I. INTRODUCTION

The most harmful effect of our present day civilization is global warming and environmental pollution. With rapid industrialization and urbanization we are also making our planet unsafe for us and for the generations to come. We are now all well aware of the lethal effects of pollution. India is already the fifth largest greenhouse gas emitter of the world and is expected to become the third largest GHG emitter by the year 2015 with China topping the list. International pres-sures have already started mounting on India to curb its GHG emission. Transport sector contributes significant amount of GHG emission. The vehicle population throughout the world is increasing rapidly; in India the growth rate of automotive industry is one of the largest in the world. It is quite evident that the problem cannot be solved with the conventional fossil fuels, however stringent the emission control norms may be. This demands the search for a suitable alternative to conven-tional fossil fuels.

Biodiesel is an alternative fuel for diesel engines that is produced by chemically reacting a vegetable oil or animal fat with an alcohol such as methanol. The reaction of biodiesel require catalyst as a strong base, such as sodium or potassium hydroxide ,it produces new chemical compounds called methyl esters, this esters are known as biodiesel (Vangerpen, 2005). Dr. Rudolph diesel designed the original diesel engine to run on vegetable oil. He used peanut oil to fuel one of his engines at the Paris exposition of 1900 (Demirbas, 2003).

II. Biodiesel characteristics

Biodisel is a cleaner-buring diesel replacement fuel made from natural renewable sources such as new and used vegetable oils and animal fats. The biodiesel was characterized by determining its density, viscocity, high heating value, cetane index, clod and pour points, characteristics of distillation and flash and combustion points according to Iso norms.

Advantages of biodiesel

A number of technical advantages of biodiesel fuel.
1. It prolongs engine life and reduced the need for maintenance (biodiesel has better lubricating qualities than fossil diesel)
2. It is safe to handle, being less toxic more biodegradable and having a higher flash point.
3. It reduces some exhaust emission. (Warale, 2003) Biodiesel is safe for use in all conventional diesel engines, offers the same performance and engine non-flammable and non-toxic and reduces tailpipe emissions, visible smoke and noxious fumes and ordors.

Disadvantages of biodiesel

Biodiesel/fossil diesel blends include problem with fuel freezing in cold weather, reduced energy density and degradation of fuel under storage for prolonged periods.

III. Biodiesel production

Researchers are trying to find several ways to make biodie-sel from different feed stocks like edible and non-edible vege-table oils, waste cooking oil, animal tallow, algae etc. Most of the researchers prepared biodiesel by transesterification process from the raw feedstocks using a base catalyst. Sharma and Singh [1] developed biodiesel from non-edible feedstock, i.e. karanja, mahua and a hybrid mixture (50:50 v/v) of the two. They followed a two step reactions compris-ing of acid esterification to lower the free fatty acid (FFA) to a desired limit followed by alkaline transesterification for con-version of oil to fatty acid methyl esters.

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For esterification reaction, H2SO4 is added as a catalyst and for transesterification KOH is added as the catalyst with metha-nol. Methanol is chosen as the alcohol as it takes a lower reac-tion time and costs are also low. Ilkılıç et al. [2] produced biodiesel from safflower oil by tran-sesterification process using NaOH as a catalyst. They used H2SO4 as a depolarizer after getting the biodiesel from neat safflower oil. A supercritical methanol biomass conversion system has been employed to produce biodiesel from rapeseed vegetable oil without addition of any catalyst by Saka and Kusdiana [3]. Venkanna and Reddy [4] produced biodiesel from honne oil through a three stage transesterification process with methanol which comprised of acid esterification, alkali transesterification and post treatment. The acid esterifi-cation were conducted with H2SO4 as a catalyst, alkali transes-terification were conducted with KOH as a catalyst. The post treatment consisted of gentle water wash thrice using distilled water. Biodiesel production from Eruca Sativa Gars (ESG) vegeta-ble oil studied by Li et al. [5] on lab scale basis through tranes-terification process with methanol. Transesterification of ESG oil was catalyzed by a heteropolyacid salt. Production of bio-diesel from rubber seed oil through a two stage method of transerterification with methanol, which comprised alkali es-terification by using H2SO4 as a catalyst and transesterification with methanol by using NaOH as a catalyst studied by Ra-madhas et al. [6]. Biodiesel production from inedible animal tallow was studied by Oner and Altun [7]. Biodiesel was pre-pared by base-catalyzed transesterification of tallow with me-thanol in the presence of NaOH as catalyst. Ghadge and Raheman [8] produced biodiesel from mahua oil having high free fatty acids in it. Firstly, the FFA content was determined by a standard titrimetry method, after that there was a pre-treatment method for lowering the higher acid value, thereaf-ter the transesterification reaction was done with methanol using KOH as an alkaline catalyst.

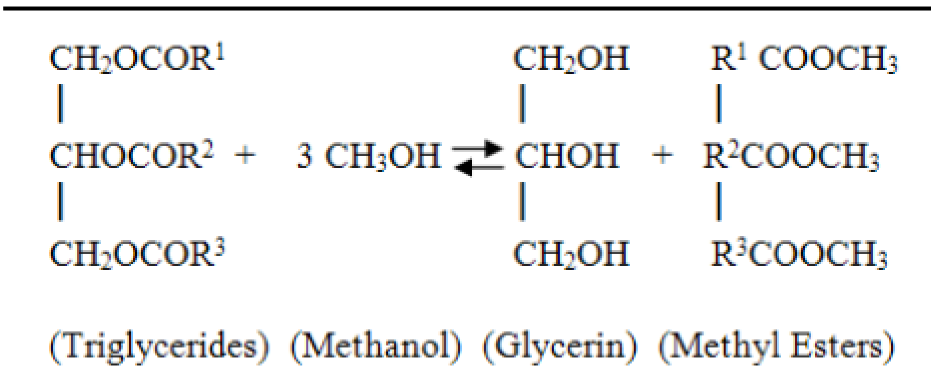

Fig. 1 Chemical structure of biodiesel

Nabi et al. [11] studied that for biodiesel mixtures of cotton seed oil. The emissions of CO and PM were found to be lower than that of pure diesel fuel and NOX level was higher, be-cause biodiesel mixtures contain some extra oxygen in their molecule that resulted in complete combustion of the fuel and supplied the necessary oxygen to convert CO to CO2, this ad-ditional oxygen also responsible for higher NOX emission compared to neat diesel fuel. A mixture of 30% biodiesel and 70% petro diesel reduced CO emissions by 24%, PM emission by 24% and 10% increase in NOX emission. The reduction of NOX with biodiesel may be possible with the proper adjust-ment of injection timing and using exhaust gas recirculation (EGR) technique. With the 10% biodiesel mixture the smoke emission reduced by 14%. For both 100% biodiesel and 100% petroleum diesel a narrow range of reductions (about 10%) of emissions were observed for NOX, HC and CO when burning biodiesel by Zou and Atkinson [12]. For CO2, emissions from using biodiesel and diesel were at similar levels.

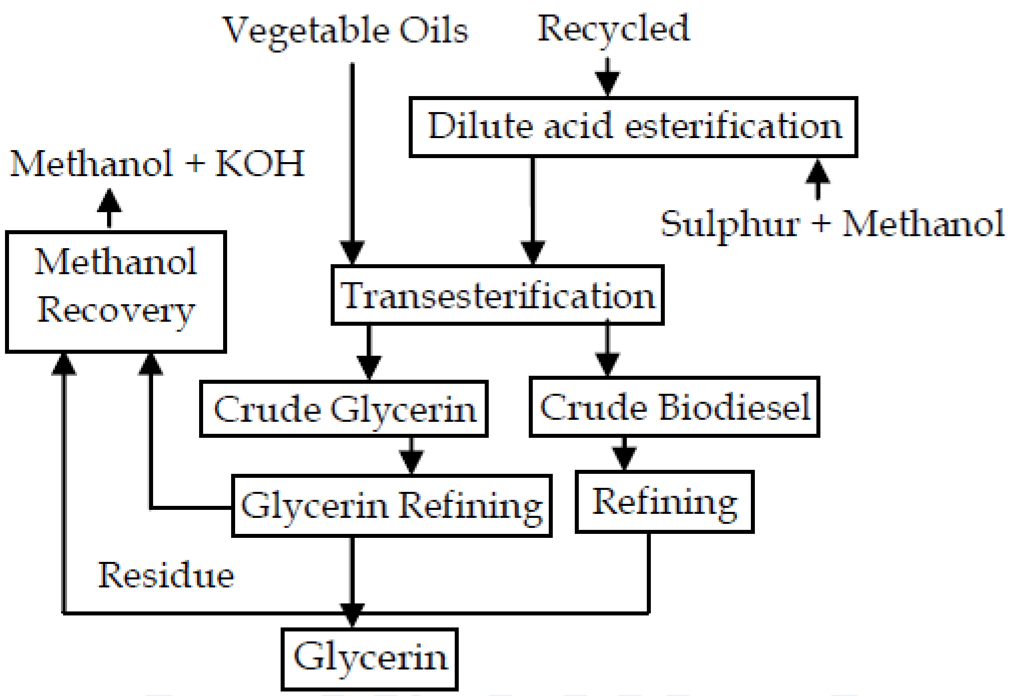

Fig. 2. Process of transesterification

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Major non-edible tree borne oil seeds

1. SOAPNUT –Soapnut is a fruit of the soapnut tree generally found in tropical and subtropical climate areas including Asia, America and Europe. Two varieties S. mukorossi and S. trifoliatus found in India, Nepal, Bangladesh, Pakistan. Soapnut tree have many application in medicinal treatment to soap and surfactants. Its fruits use as natural laundry detergents for washing fabrics ,bathing and traditional medicines.Soapnut seeds are mostly used as a biodiesel source, it is called as “waste to enrgy”scheme.so,planting of soapnut trees in community forestry and I barren lands provides sink for carbon sequestration as well as feedstock for biodiesel production.
2. MAHUA- Mahua is mostly found in tribal areas, In India it is found Orissa, chatisgada, Jharkhand, Bihar, Madhya Pradesh, Tamil nadu. From mahua seeds high amount of biodiesel are extracted. Mahvua is an important plant having vital socioeconomic value.
3. JATROPHA- Jatropha curcus is a drought resistant perennial, growing well in marginal/poor soil. It is a major source of biodiesel. Its seed contain around 37% oil, which is used for combustion as fuel without being refined. It burns with clear smoke –free flame, tested successfully as fuel for simple diesel engine. It’s by products are used as good organic fertilizer, oil contain also insecticide, it is also used for disease like cancer, piles, snakebite, paralysis, dropsy etc.
4. KARANJ (Pongomia pinnta) - Karanj is widely found in tropical Asia and it is nonedible oil of Indian origin. Pongomia’s seeds are major sources of biodiesel. The oil content extracted by various aurthors ranges between 30.0 to 33%.
5. NEEM- Neem is from Meliaceae family. Neem oil used as soaps, medicinal and insecticides. The seed kernels, which weight 0.2g, constitutes some 50-60% of the seed weight and 25% of fruit.

IV. PERFORMANCE CHARACTERISTICS OF BIODIESEL

Performance parameters like specific fuel consumption, ther-mal efficiency, power output which have been evaluated by different researchers after experimental studies are reported in this section. Gumus [18] studied with hazelnut kernel oil methyl ester and found that as the biodiesel have lower heating value and higher viscosity than that of diesel the brake specific fuel con-sumption is higher, which leads to a decrease in brake thermal efficiency.

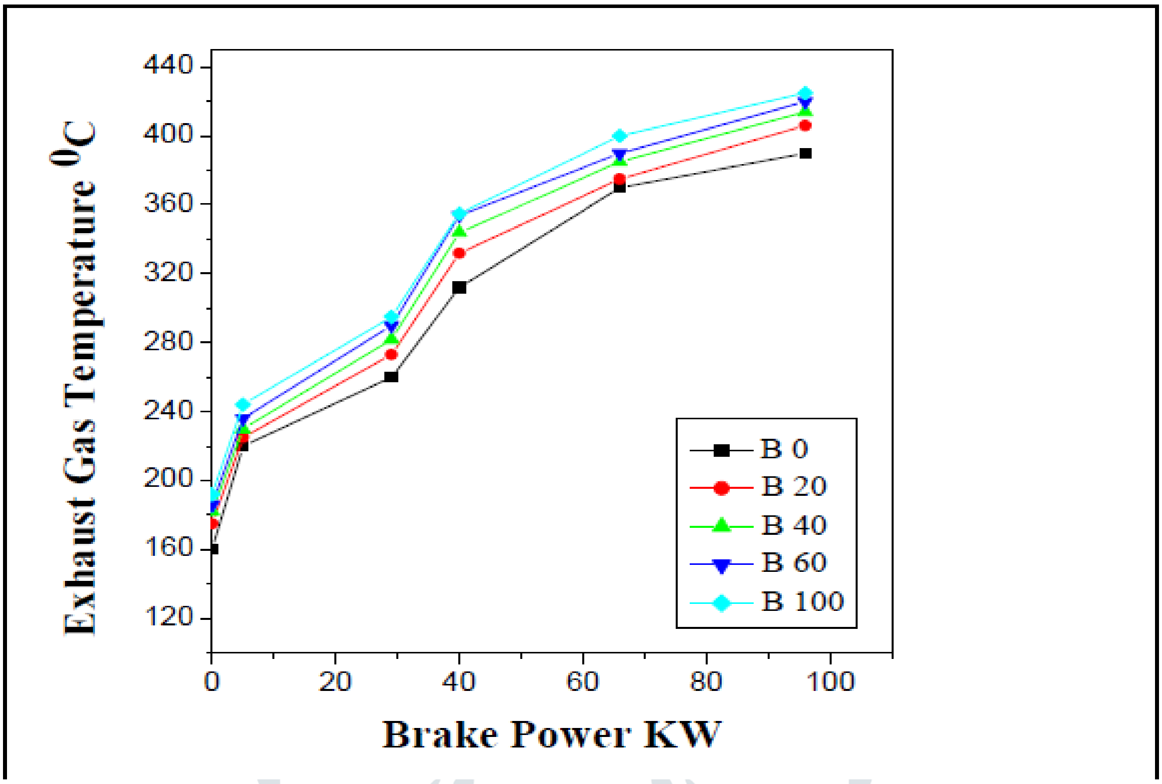

Fig. 3. Graph of Exhaust gas temperature with Brake power

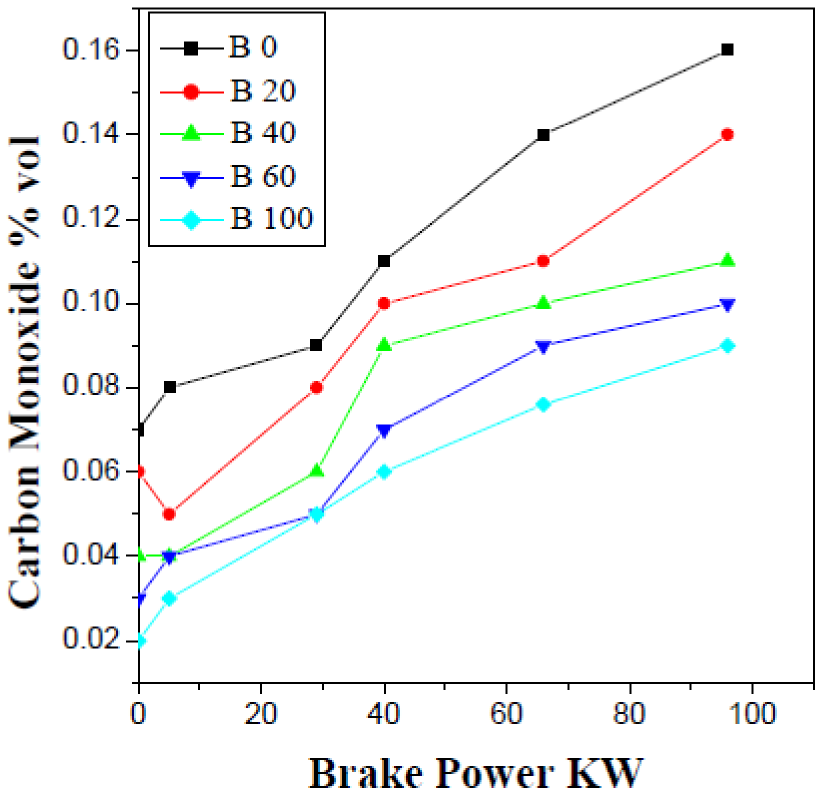

Fig. 4. Graph of carbon monoxide with Brake power

The increase of injection timing, compression ratio and injec-tion pressure decreases brake specific fuel consumption for all fuels which leads to an increase in brake thermal efficiency. Laforgia and Ardito [19] states that due to lower heating value and higher density with respect to conventional mineral di-esel, the power output is decreased using biodiesel. On the other hand an increase in specific fuel consumption also oc-curred in case of biodiesel. The efficiency with biodiesel is in-creased about 10% compared to mineral diesel. Utlua and Ko-cak [20] observed that lower torque and lower engine power is obtained for WFOME (waste frying oil methyl ester) compared to diesel, due to high viscosity and lower heating value which leads to a bad combustion, i.e. combustion efficiency also de-creases. Due to these two, brake-specific fuel consumption is higher for WFOME compared to diesel.

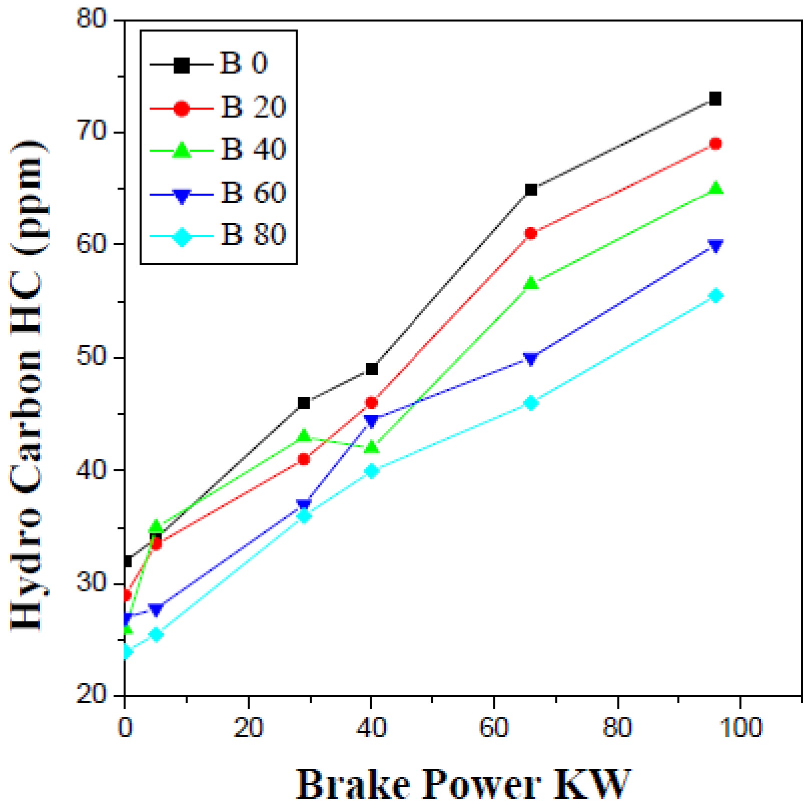

Fig. 5. Graph of carbon monoxide with Brake power

Raheman and Ghadge [21] used Ricardo E6 engine for their study. They varied compression ratio from 18:1-20:1 and igni-tion timing 35–45° before TDC. The brake specific fuel con-sumption are similar to that of diesel when compression ratio increased and ignition time advanced, that replicates that at higher compression ratio and ignition timing the brake specif-ic fuel consumptions are same for diesel and biodiesel, due to low volatility and higher viscosity.

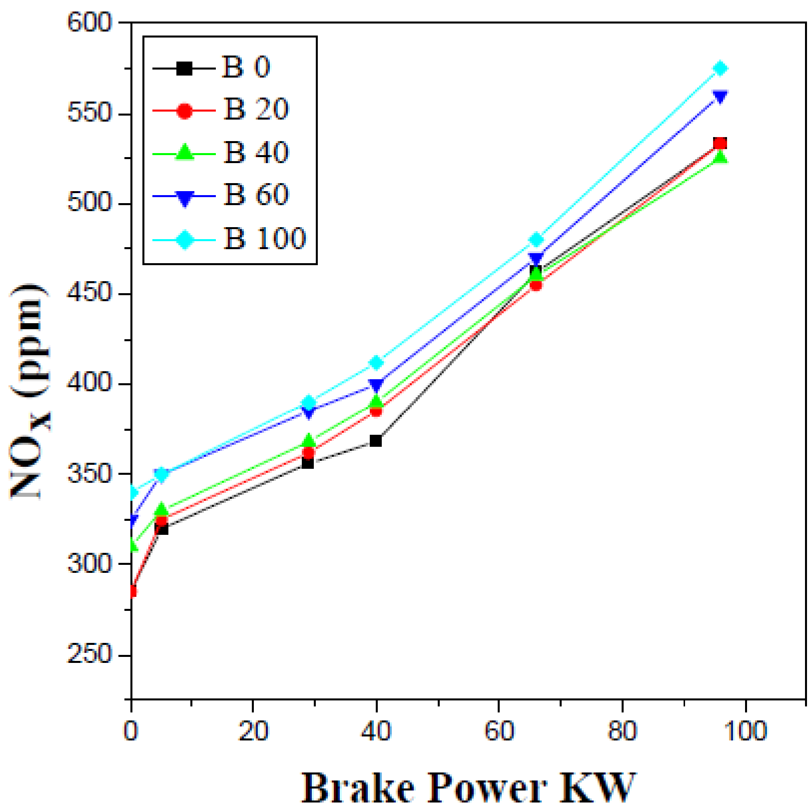

Fig. 6. Graph of carbon monoxide with Brake power

In case of brake thermal efficiency the change in compression ratio increases efficiency because of improvement of combustion characteristics, with the ignition advance the efficiency also increases with the higher percentage of biodiesel due to more time for injection. However, with increase of compres-sion ratio and injection timing enhance the performance of biodiesel compared to diesel. Raheman and Ghadge [22] also studied that at a compression ratio of 18:1 and injection timing of 40° before TDC. The brake specific fuel consumption is higher in case of biodiesel because of lower heat content and higher viscosity. The brake thermal efficiency is comparable with respect to diesel as the load increases in case of biodiesel. The exhaust gas temperature also follows the same trend as brake thermal efficiency. Kaplan et al [23] used sunflower oil methyl esters as biodiesel. They found that the maximum en-gine torque is maintained in case of biodiesel for a large range of engine speed as the calorific value of biodiesel is lower than that of diesel, which leads to a better combustion. Due to the lower calorific value the engine power is relatively low in case of biodiesel and the fuel consumption is higher for it com-pared to diesel. Has-imoglua et al. [24] reported that the high-er viscosity of biodiesel caused a lower engine torque and power. The lower heating value increases the specific fuel con-sumption of biodiesel, but on the other hand it reduced ex-haust gas temperature and also reduces in cylinder tempera-ture which leads to an increase in volumetric efficiency. Qi et al. [25] studied the combustion and performance characteris-tics fuelling with soybean biodiesel in a diesel engine. They concluded that as the engine delivers fuel on volumetric basis and the density of biodiesel is higher than that of diesel, the power output of biodiesel engine is almost the same as diesel engine.

CONCLUSIONS

Biodiesel are viable alternative to mineral diesel as fuel in Compression ignition engine. Biodiesel can be prepared from different renewable feedstocks like vegetable oil, waste cook-ing oil, animal tallow and algae. In India, the potential non-edible feedstocks are karanja, jatropa, polanga. The engine performances of biodiesel are comparable to that of mineral diesel. Emission characteristics of biodiesel are better than diesel fuel except NOX emission. The carbon monoxide, un-burned hydrocarbon and particulate matter are found to be less in the tail pipe emissions. But and oxides of nitrogen are found to be slightly greater in exhaust in case of biodiesel compared to mineral diesel. The higher viscosity also en-hances the lubricating property and excess oxygen content results better combustion for biodiesel.

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