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Effect of Prickly Poppy Methyl Ester Blends on CI Engine Performance and Emission Characteristics

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Abstract: Problem statement: The aim of this research was to investigate the effect of using Prickly poppy methyl ester as a fuel blend on Diesel engine (CI engine) performance and exhaust emission. **Approach**: Short-term engine performance tests were conducted to evaluate and compare the use of various diesel fuel supplements at blend rations of 60/40, 70/30, 80/20, 90/10, in a standard, fully instrumented, four stroke, Direct Injection (DI), Kirlosker comet Diesel engine located at the authors' laboratory. The prickly poppy oil with high free fatty acid is not used as edible oil, it can be considered as a potential source of non edible oil for utilization as a feed stock vegetable oil for bio diesel production. The prickly poppy oil was subjected to esterification and transesterification processes and the Prickly Poppy Methyl Ester (PPME) obtained was tested as supplement. **Results:** The test showed that PPME blends with diesel could be conveniently used as a diesel substitute in a diesel engine. The test further showed increase in break thermal efficiency, brake power and reduction of specific fuel consumption for PPME and its blends with diesel generally, but the most significant conclusion from the study is that the 80 % Diesel / 20% PPME blend produced maximum values of the brake power, brake thermal efficiency and minimum values of the specific fuel consumption and also yielded minimum values of NOx, CO and HC emission. **Conclusion:** Using Prickly Poppy Methyl Ester (PPME) as a bio fuel blend with Diesel shows an improvement in performance and significant reduction in exhaust emission for the generation of cleaner environment.

Key words: Prickly Poppy Methyl Ester (PPME), Diesel, CI engine, performance, emission

INTRODUCTION

Rapid increase in energy requirements parallel to technological development in the world, necessitate increased research and development studies for new and renewable energy sources. On the other hand, diesel fuels are limited mainly by their sulphur content which causes corrosion and environmental pollution. The petroleum fuels play a very important role in the development of industrial growth, transportation, agricultural sector and to meet many other basic human needs, however, there fields are limited and depleting day by day and the consumption is increasing very rapidly. Moreover, their use is alarming the environmental problems to society (Karaosmanoplu, 1999; Murillo *et al*., 2007; Singh *et al*., 2010; Sharma and Singh, 2009).

Increasing environmental concern, diminishing petroleum reserves and agriculture based economy of our country are the driving forces to promote bio diesel as an alternate fuel. Fatty acid methyl esters derived from renewable sources such as vegetable oils has gained importance as an alternative fuel for Diesel engines (Abu-Nameh,. *et al*., 2008). The edible oil such as rape seed oil in Europe, palm oil in Malaysia and soybean in USA are being used for the production of bio diesel. But in India to produce bio diesel use of edible oils is not feasible. However, there are several non edible oil seed species such as Karanja, Jatropha, Neem, Mahua, Simarouba, Prickly Poppy etc. which could be utilized as a source for production of oil. Among these, prickly poppy is an oil seed bearing plant, which is non-edible and does not find more application. Since vegetable oils have cetane numbers close to those of diesel fuel, they can be used in

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existing compression ignition engines with little or no modifications (Al-Widyan *et al*., 2002; El Diwani et *al*., 2009; Halek *et al*., 2009).

The major problem associated with vegetable oils is their highly increased viscosity, 10-20 times greater than that of normal diesel fuel. Thus, although short term tests using neat vegetable oils showed promising results, problem appeared after the engine had been operated for longer periods. These included injector cocking with trumpet formation, more carbon deposits and piston oil ring sticking, as well as thickening and gelling of the engine lubricating oil. To overcome these constraints, the process like pyrolysis, micro-emulsification, transesterification, were especially developed. Pyrolysis of vegetable oil resulted in products with low viscosity, high cetane number accepted amount of sulphur, water and sediments, accepted copper corrosion values but were unacceptable in the term of their ash contents, carbon residues and pour point. Similarly, micro-emulsion of vegetable oil lowered the viscosity of oil but resulted in irregular injector needle sticking, heavy carbon deposit due to incomplete combustion (Halek *et al*., 2009; Demirbas, 2007). Transesterification is a chemical reaction between triglyceride alcohols in the presence of a catalyst. Out of these methods, transesterification is the most viable process adopted known so for the lowering of viscosity. It also gives glycerol as a by-product which has a commercial value.

Bio diesel is considered as a promising alternative fuel for the Diesel engines. On its fuel characteristics are approximately the same as those of fusil Diesel fuel and thus may be directly used as a fuel for Diesel engines without any prior modification of the design. Many varieties of vegetable oils have been found suitable for transesterification into bio-diesel (Qi *et al*., 2010; Nagarhalli *et al*., 2010; Bozbas, 2008).

The objective of this study is to examine the effects of using PPME, as an alternative fuel in diesel engine with different blend ratios, to determine any significant effects on performance and exhaust emissions. Four blends were obtained by mixing diesel and PPME in the following proportion by volume: 60% Diesel/40% PPME; 70% diesel/30% PPME; 80% Diesel/20% PPME and 90% diesel/10% PPME. Comparison purposes test runs were carried out for the diesel fuel. Performance and emission parameters for Diesel and PPME blends were measured under the range of varying loads (torque) applied to the engine.

MATERIALS AND METHODS

Prickly Poppy seeds collected are dried in sunlight for a week and the dried seeds are peeled to obtain the kernel for extraction of Prickly Poppy oil by using a Mechanical expeller. Small traces of organic matter, water and other impurities were present in the prickly poppy oil. These can be removed by adding 5% by volume of hexane to the raw oil and stirring it for 15-20 min at 80-90°C and allowing it to settle for 30 min. Since hexane is having low boiling point (68.7°C), it gets evaporated on heating beyond the boiling point of hexane. The impurities and gum particles that settle down at the bottom can be removed. The remaining oil is the purified oil. The purified oil can be used for transesterification process.

The free fatty acid content of unrefined filtered prickly poppy oil was found to be 21.5%, i.e., acid value of 42 mg KOH g^{-1}. The fatty acid content was determined by a standard titrimetry method (Meher *et al*., 2006). The yield of esterification process and quality of bio diesel decreases considerably if acid value is greater than 4 mg KOH g^{-1}, i.e., free fatty acid content is 2%. Therefore development of any method to produce bio diesel from high acid value oils is significant. Hence, the efforts are made to esterify a typical high free fatty acid type of oil, i.e., prickly poppy seed oil in this study (Boehman, 2005; Ma and Hanna, 1999; Refaat *et al*., 2008).

Therefore, FFAs were first converted to esters in a two step pre treatment process using an acid catalyst ($H_2SO_4$1% v/v) to reduce the acid value of prickly poppy oil below 2 mg KOH g^{-1}. Experiments were conducted in a laboratory scale setup which consisted of 500cc glass flasks with an tight cap that retained any vaporized methanol to the reacting mixture. The flasks were kept in a water bath maintained at 60°C, just below the boiling point of methanol. The mixture was stirred at the same rate for all sums by manually shaking the flasks at every 5 min interval. The progress of the reaction was monitored by measuring the acid value (Rahman *et al*., 2010; Fukuda, *et al*., 2001).

The acid pretreated oil was poured into the reaction flask and heated. The solution of KOH in methanol (1% based on the prickly poppy seed weight) was heated at 60°C and then added with the pretreated crude prickly poppy seed oil. The contents were stirred till ester formation began. The mixture was heated to 65°C and held that temperature without stirring for an hour and then it was allowed to cool for 24 hour without stirring. Two layers were formed. The bottom layer consisted of glycerol and the top layer was the ester. The bottom layer was removed and ester was collected and washed with hot distilled water three times. The lower layers were discarded, while the upper layer after the third washing was the bio diesel product.

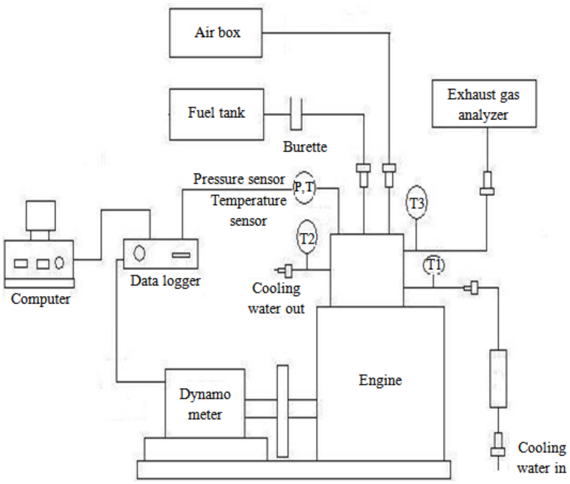

Fig. 1: Experimental setup

Table 1: Specification of test engine

Manufacturer	Kirloskar
Engine Type	4 stroke, single cylinder, Water cooled, CI engine
Stroke	110 mm
Bore	95 mm
Power	5.9 kW
Rated speed	1500 rpm
Loading type	Electrical dynamometer

Experimental setup and procedure: The present study was carried out to investigate the performance and emission characteristics of prickly poppy methyl ester blends in a stationary single cylinder four stroke direct injection Diesel engine and to compare it with Diesel fuel. Technical specifications of the engine are given in Table 1. The schematic diagram of the experimental setup was shown in Fig. 1. The engine was coupled to an electrical dynamometer to provide the brake load. The fuel consumption was measured with the aid of a glass burette and stop watch on volume basis. Exhaust gas analyzer was used to determine the emissions of CO, HC and NOx.

The engine was operated on diesel first and then on Methyl Ester of Prickly Poppy (PPME). The PPME Diesel blends and mineral diesel were subjected to performance and emission tests on the same engine without any modification.

RESULTS AND DISCUSSION

In this research, an attempt has been performed to compare the performance and emission characteristics of prickly poppy methyl ester blends in a stationary single cylinder four stroke direct injection Diesel engine and to compare it with Diesel fuel.

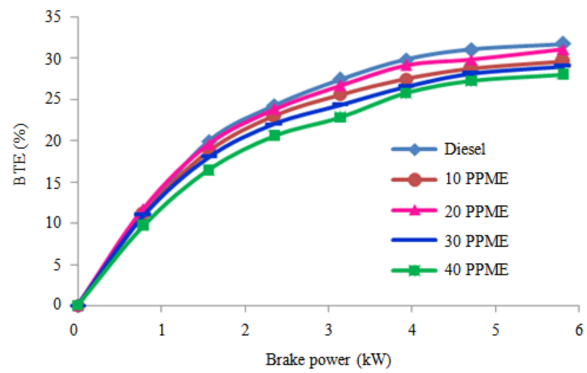

Fig. 2: Brake thermal efficiency Vs. Brake power

Table 2: Properties of fuels

Properties	Biodiesel (PPME)	Diesel
Density (15°C) (kg/ m ^{3})	890	820
Viscosity (40°C) (CST)	4	2.5
Cloud point (°C)	2	-4.0
Pour point (°C)	5	-10.0
Lower heating value (MJ/ kg^1)	37	42.5
Cetane number	48	42.0

Fuel properties: The properties of the diesel and PPME were determined and the results are shown in Table 2. Density of PPME is slightly higher than diesel. At 40°C, the kinematic viscosity of PPME is two times higher than that of Diesel. The cloud point, pour point, cetane number and lower heating values are shown in Table 2 for PPME and Diesel.

Break thermal efficiency: The variation of brake thermal efficiency with engine brake power is shown in the Fig. 2. The brake thermal efficiency increases with the engine load as the amount of the PPME in the blends increases. It can be seen from the Fig. 2 that the 80% diesel/20% PPME blend incidentally gives higher efficiencies at all loads. The diesel fuel produced the higher thermal efficiency at all loads.

Specific fuel consumption: The results for the variation in the brake specific fuel consumption with increasing load on the engine for the various fuel blends are presented in the Fig. 3. It is observed that with increasing load, the specific fuel consumption for all PPME blends decreases and becomes minimum and then increases again. It can be seen from the figure that in case of biodiesel mixtures, the BSFC values were determined to be higher than those of neat diesel fuel, and thus more biodiesel mixtures were required for the maintenance of a constant power output.

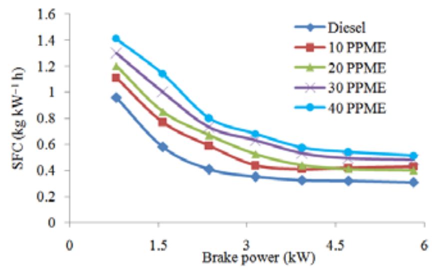

Fig. 3: Specific fuel consumption Vs. Brake power

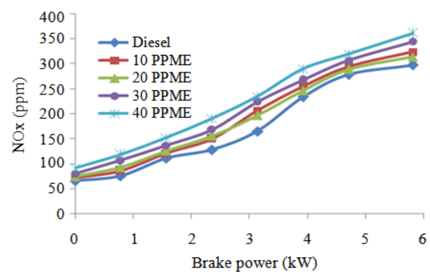

Fig. 4: NOx emission Vs. Brake power

NOx emission: Figure 4 shows the NOx emission of the PPME blends at different load with that of Diesel. The important factor that causes NOx formation is due to high combustion temperature and availability of oxygen. The emissions of the NOx in exhaust with PPME blends are found to be increase with increase in load. As an oxygenated fuel, PPME supplies additional oxygen into the combustion chamber during the fuel intake stoke, which reduces the richness of the mixture and improves the combustion process to lead to a higher combustion temperature. This enhances the reaction between free oxygen and nitrogen to form NOx for all the fuels used. It was absorbed that for maximum load 80% diesel/20% PPME blend had minimum level of NOx emission. So 80% diesel/20% PPME blend can be suggested as best blend. This is the most important characteristics of PPME and its blends, as the NOx emission is the most harmful gaseous emission from engines, the reduction of it is always the target for engine researchers and engine manufacturers.

CO emission: CO production depends upon mixture strength i,e., oxygen quantity and fuel viscosity, in turn atomization. At low load range air fuel ratio is high, availability of oxygen is more and hence production of CO is also low. From Fig. 5, it is clear that the concentration of CO for PPME blends marginally decreases for all loads of the engine. It can be absorbed that the CO emitted by all bio-diesel blends is lower than that by the corresponding neat diesel fuel case, with the reduction being higher the percentage of the bio-diesel in the blend. CO emission has shown 7% of reduction for 20% PPME and suggested as best blend.

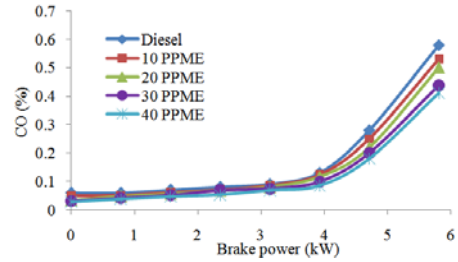

Fig. 5: CO emission Vs. Brake power

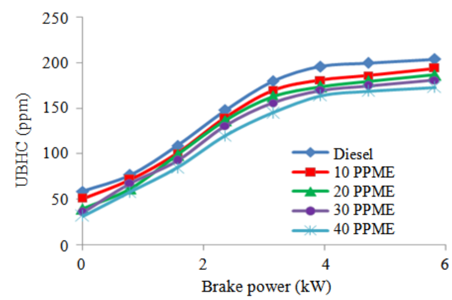

Fig. 6: HC emission Vs. Brake power

HC emission: Figure 6 shows the unburned hydrocarbon of the PPME at various loads compared with that of diesel. It was found that the UBHC emission increase with an increase in load. This may be due to the increased amount of fuel injection at higher loads. The UBHC emission decrease significantly when the engine is operated with PPME. PPME gives fewer hydrocarbons when compared to diesel. When percentage of blend of PPME increases hydrocarbon decreases. This is because of better combustion of bio-diesel inside the combustion chamber due to the availability of oxygen atom in bio-diesel.

CONCLUSION

Based on the experimental results of this work, it can be concluded that Prickly Poppy Methyl Ester can be adopted as an alternative fuel for the existing conventional Diesel engine without any major modification.

The engine performance with biodiesel (PPME) blends was similar to that of the neat Diesel fuel with nearly the same brake thermal efficiency, showing higher specific fuel consumption for the maximum load.

NOx was increased for all PPME blends with increase in load. The increase in NOx may be due to the higher intensity of heat release in the premixed combustion phase for PPME.

The CO, HC emissions were slightly reduced with the use of PPME blends with respect to that of the Diesel fuel, with this reduction being higher the higher the percentage of PPME. As a CI engine fuel PPME has exclusive emission characteristics and shows a substantial reduction in CO and HC. Consequently, efforts can be made to utilize this special feature to reduce pollutants and in the process, to ensure a pollution free and sustainable environment.

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REFERENCES

Abu-Nameh, E.S.M. and J.A.A. Yamin, 2008. Environmental pollution assessment of different diesel injector location of direct-injection diesel engines: Theoretical study. Am. J. Environ. Sci., 4: 157-163. DOI: 10.3844/AJESSP.2008.157.163

Al-Widyan, M.I., G. Tashtoush and M. Abu-Qudais, 2002. Utilization of ethyl ester of waste vegetable oils as fuel in diesel engines. Fuel Process. Technol., 76: 91-103. DOI: 10.1016/S0378-3820(02)00009-7

Boehman, A.L., 2005. Biodiesel production and processing. Fuel Process. Technol., 86: 1057-1058. DOI: 10.1016/J.FUPROC.2004.11.001

Bozbas, K., 2008. Biodiesel as an alternative motor fuel: Production and policies in the European Union. Renewable Sustainable Energy Rev., 12: 542-552. DOI: 10.1016/J.RSER.2005.06.001

El Diwani, G., N.K. Attia and S.I. Hawash, 2009. Development and evaluation of biodiesel fuel and by-products from Jatropha oil. Int. J. Environ. Sci. Technol., 6: 219-224.

Demirbas, A., 2007. Progress and recent trends in biofuels. Progress Energy Combustion Sci., 33: 1-18. DOI: 10.1016/J.PECS.2006.06.001

Fukuda, H., A. Kondo and H. Noda, 2001. Biodiesel fuel production by transesterification of oils. J. Biosci. Bioengineer., 92: 405-416. DOI: 10.1263/JBB.92.405

Halek, F., A. Kavousi and M. Banifatemi, 2009. Biodiesel as an alternative for diesel engines. World Academy Sci. Eng. Technol., 57: 460-463.

Kaplan, C., R. Arslan and A. Surmen, 2006. Performance characteristics of sunflower methyl esters as biodiesel. Energy Sources, Part A: recovery. Utilization Environ. Effects, 28: 751-755.

Karaosmanoplu, F., 1999. Vegetable oil fuels: A review. Energy sources, part A: Recovery. Utilization Environ. Effects, 21: 221-231. DOI: 10.1080/00908319950014858

Kegl, B., 2008. Effects of biodiesel on emissions of a bus diesel engine. Bioresource Technol., 99: 863-873. DOI: 10.1016/J.BIORTECH.2007.01.021

Ma, F. and M.A. Hanna, 1999. Biodiesel production: a review. Bioresource Technol., 70: 1-15. DOI: 10.1016/S0960-8524(99)00025-5

Meher, L.C., D. Vidya Sagar and S.N. Naik, 2006. Technical aspects of biodiesel production by transesterificationa review. Renewable Sustainable Energy Rev., 10: 248-268. DOI: 10.1016/J.RSER.2004.09.002

Murillo, S., J.L. Míguez, J. Porteiro, E. Granada and J.C. Morán, 2007. Performance and exhaust emissions in the use of biodiesel in outboard diesel engines. Fuel, 86: 1765-1771. DOI: 10.1016/J.FUEL.2006.11.031

Nagarhalli, M.V., V.M. Nandedkar and K.C. Mohite, 2010. Emission and performance characteristics of karanja biodiesel and its blends in a C.I. engine and its economics. ARPN J. Eng. Applied Sci., 5: 52-56.

Qi, D.H., H. Chen, L.M. Geng and Y.Z.H. Bian, 2010. Experimental studies on the combustion characteristics and performance of a DI engine fueled with biodiesel/diesel blends. Energy Conversion Manage., 51: 2985-2992. DOI: 10.1016/J.ENCONMAN.2010.06.042

Rahman, M.M., K.I. Hamada, M.M. Noor, R.A. Bakar and K. Kadirgama *et al*., 2010. In-cylinder heat transfer characteristics of hydrogen fueled engine: steady state approach. Am. J. Environ. Sci., 6: 124-129. DOI: 10.3844/AJESSP.2010.124.129

Singh, P., J. Khurma and A. Singh, 2010. Coconut oil based hybrid fuels as alternative fuel for diesel engines. Am. J. Environ. Sci., 6: 71-77. DOI: 10.3844/AJESSP.2010.71.77

Yadav, S.R., K.V. Murthy, D. Mishra and B. Baral, 2005. Estimation of petrol and diesel adulteration with kerosene and assessment of usefulness of selected automobile fuel quality test parameters. Int. J. Environ. Sci. Technol., 1: 253-255.

Refaat, A.A., N.K. Attia, H.A. Sibak, S.T. El Sheltawy and G.I. El Diwani, 2008a. Production optimization and quality assessment of biodiesel from waste vegetable oil. Int. J. Environ. Sci. Technol., 5: 75-82.

Refaat, A.A., S.T. El Sheltawy and K.U. Sadek, 2008b. Optimum reaction time, performance and exhaust emissions of biodiesel produced by microwave irradiation. Int. J. Environ. Sci. Technol., 5: 315-322.

Semin, R.A. and B.A.R. Ismail, 2009. Green engines development using compressed natural gas as an alternative fuel: a review. Am. J. Environ. Sci., 5: 371-381. DOI: 10.3844/AJESSP.2009.371.381

Sharma, Y.C. and B. Singh, 2009. Development of biodiesel: Current scenario. Renewable Ustainable Energy Rev., 13: 1646-1651. DOI: 10.1016/J.RSER.2008.08.009