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Performance of Diesel Engine Operating with Pongamia Methyl Esters as Biodiesel

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ABSTRACT
In this study the preparation and investigation of the vegetable oil (Pongamia methyl esters) is made. The methyl ester of the Pongamia oil is investigated for its performance over the conventional diesel. This study is mainly considered for overcoming the problems of increasing fuel need and an eco friendly fuel. The blend of Pongamia methyl esters is prepared by means of transesterification reaction process and the performance characteristic of the Pongamia methyl esters is determined. Investigation of the Pongamia methyl esters with the conventional diesel fuel whose engine performance, combustion and emission characteristics are determined at constant speed of 1500 rpm. Based on these, the performance parameter such as brake thermal efficiency, specific fuel consumption, exhaust gas temperature, emissions such as (CO, CO_2 and NOx) were tested and results show that the blend of Pongamia oil with diesel fuel can be used as an alternative fuel successfully in a diesel engine without any modifications. The starting and engine performance were noted to be normal and had no problems while the engine was on blends of methyl ester blends of Pongamia oil.

Key words: Alternative fuel, transesterification, Pongamia oil, methyl ester blend

INTRODUCTION
Bio-fuels offer many benefits, including sustainability, reduction of greenhouse gas emissions, regional development and improvement in agriculture (Agarwal, 2007; Srivastava and Prasad, 2000). The chemical composition of bio-fuels helps in reducing the emission of unwanted components when they are burned (Altin *et al*., 2001; Babu and Devarajane, 2003; Bhattacharyya and Reddy, 1994).

Compression-Ignition (CI) or diesel engines are widely used in the fields of commercial transportation, automotive, agricultural applications and industrial sector due to its high fuel conversion efficiency and ease of operation (Kumar *et al*., 2005). Using alternative fuels produced from non-petroleum resources in CI engines is suggested as one of the most attractive methods for improving their performance and emissions. These fuels include alcohols (such as ethanol and methanol), ethers, vegetable oils, animal fats, gaseous fuels (hydrogen, natural gas, liquefied petroleum gas) and bio-diesel (Kumar *et al*., 2005; Wang *et al*., 2000; Kumar *et al*., 2003; Jothi *et al*., 2007).

Biodiesel is an engine fuel made from vegetable oils or animal fats. The term biodiesel refers to 100% pure fuel (B100) that meets the requirements given by the American Society for Testing and

Materials (ASTM) for biodiesel fuel in their D 6751 standard. A variety of oils can be processed into fuel for compression ignition internal combustion engines including castor, mahua, canola, soybean, sunflower, palm and safflower. Rendered animal fat and waste cooking oils can also be processed into biodiesel (Ramadhas *et al*., 2005).

At present, India spends nearly Rs. 80,000 crore every year on petroleum fuels imports; it is producing only 30% of the total petroleum fuels required. It is an astonishing fact that mixing of 5% bio-diesel fuel to the present diesel fuel is made available in our country which can save about Rs. 4000 crore every year. It is estimated that 288 metric tonnes of bio-diesel by the end of 2012 which will supplement 41.14% of the total demand of diesel fuel consumption in India. The planning commission of India has launched a bio-fuel project in 200 districts from 18 states in India. Use of bio-diesel is catching up all over the world especially in developed countries (Abdul Kalam, 2006; PCGI, 2003; Bijalwan *et al*., 2006). In Malaysia, the tropical climate encourages production of bio-diesel from palm oil (Lenin *et al*., 2011a).

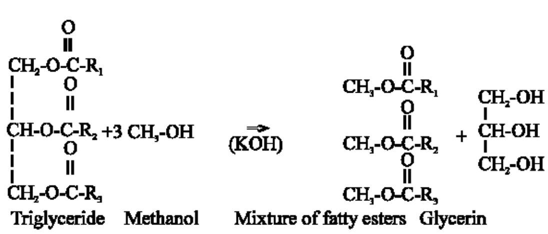
The advantages of bio-diesels as diesel fuel are the minimal sulfur and aromatic content and higher flash point, lubricity, cetane number, biodegradability and non-toxicity. On the other hand, their disadvantages include the higher viscosity and pour point and the lower calorific value and volatility. Furthermore, their oxidation stability (Chemical stability for prolonged oxidation in air) is lower, they are hygroscopic and as solvents may cause corrosion of components attacking some plastic materials used for seals, hoses, paints and coatings. For all the above reasons, it is generally accepted that blends of standard diesel fuel with 10 or up to 20% bio-diesels (and possibly vegetable oils or bio-ethanol) can be used in existing diesel engines without any modifications (Lenin *et al*., 2011b).

Biodiesel blended with diesel fuel in the concentration of 20 and 40% by volume on a single cylinder caterpillar engine, using both single and multiple injection strategies. At high loads using single injection, particle and CO emission were decreased. A slight increase in NOx was observed as the biodiesel concentration is increased. But in the case of multiple injections, decrease in particulate emission was observed with little or no effect on NOx (Ramadhas *et al*., 2005). At low loads, addition of biodiesel and multiple injection schemes were found to be detrimental to particulate matter and CO emission (Meher *et al*., 2006).

In this present investigation, bio diesel is prepared from Pongamia oil. The performance, emission and combustion characteristic of bio diesel blends were evaluated on a single cylinder, four stroke, water cooled diesel engine.

MATERIALS AND METHODS

Transesterification reaction: The vegetable oil reacts with methanol and forms esterified vegetable oil in the presence of sodium hydroxide (NaOH) or potassium hydroxide (KOH) as catalyst (Ibeto *et al*., 2011; Syam *et al*., 2009). The transesterification represented as below (Murphy and McCarthy, 2005):



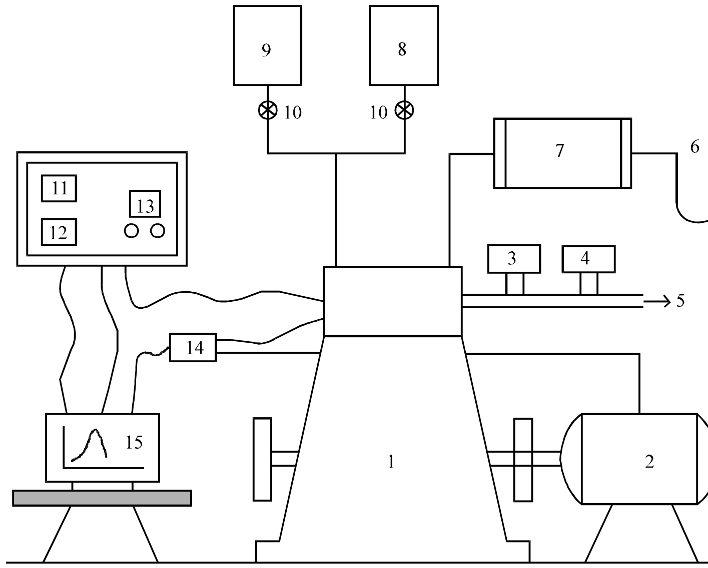


Fig. 1: The experimental setup. Source: Diesel engine is located in Thermal Engineering Laboratory, Annamalai University, Chidambaram (1) Engine, (2) Eddy current dynamo meter, (3) AVL smoke meter, (4) AVL dia-gas analyses, (5) Exhaust gas, (6) U-tube manometer, (7) Air box, (8) Diesel tank, (9) Bio diesel tank, (10) Control valve, (11) Load indicator, (12) Temperature indicator, (13) Speed indicator, (14) Charger amplifier and (15) Monitor

In Transesterification, KOH and methanol are mixed to create potassium methoxide ($K^+ CH_3O^-$). When mixed in with the oil this strong polar-bonded chemical breaks the trans fatty acid into glycerine and ester chains (biodiesel), along with some soap if you are not careful. The esters become methyl esters.

Filter the oil to remove solid particles. Warm it up a bit first to get it to run freely, 35°C should be enough. A Cartridge filter is used for the same. Heat the oil first to remove any water content. Waste oil will probably contain water which can slow down the reaction and cause saponification (soap formation). The water content in the oil should be less. Raise the temperature to 100°C, hold it there and allow any water to boil off. Run the agitator to avoid steam pockets forming below the oil and exploding, splashing hot oil. Generally the amount of methanol needed is 20% of the vegetable oil by mass. The densities of these two liquids are fairly close, so 20% of methanol by volume is enough. Different oils can have different densities depending on the type of oil used. When transesterifying, 200 mL of methanol is used for 1 L of vegetable oil. The methanol is mixed into a solution with the KOH, creating potassium methoxide in an exothermic reaction (it gets warm from bonds forming).

Experimental setup: The tests were conducted on a four stroke, water cooled, single cylinder, direct injection diesel engine developing a power output of 5.2 kW at a constant speed of 1500 rpm. The engine was connected with eddy current dynamometer, the injection pressure of 220 bar. The specifications of the engine are given in Table 1.

The experimental setup is shown in Fig. 1. The fuel tank is filled with base oil (diesel) in which the experiment is to be carried out. Then the shaft of the engine is rotated to start the engine at no

Table 1: The specifications of engine

Make and model	Kirloskar, TV- I
Type	Single cylinder, vertical, direct injection constant speed, water cooled, four stroke diesel engine
Bore	87.5 mm
Stroke	110 mm
Cylinder diameter	0.0875 m
Stroke length	0.11 m

load condition. The following set of readings are noted after an equilibrium is reached, speed, fuel consumption, manometer head, load applied using dynamometer. Similarly using the same procedure, the readings are noted. Then the blend of biodiesel and diesel were mixed in different proportions such as B25 (25% biodiesel) and B50 (50% biodiesel). The same procedure is repeated for blended biodiesel. The emission values are also recorded.

RESULTS AND DISCUSSION

Figure 2 shows the variation between exhaust gas temperatures with brake power. The exhaust gas temperature increased with increase in load and amount of blended biodiesel in the fuel (Rao *et al*., 2009). It is observed that the exhaust gas temperature of the B50 blend is higher than that of all other blends; this is mainly due to the lower cetane number and higher ignition delay of the blend. The cetane number of the fuel was reduced with an increase of the Pongamia oil content in the fuel because of the low cetane number of Pongamia oil.

The variation of brake thermal efficiency with respect to brake power for different fuels considered for the present analysis is presented in Fig. 3. The brake thermal efficiency of B10 and B20 are very close to brake thermal efficiency of Diesel. B20 can be suggested as best blend for biodiesel preparation with Pongamia oil (Rao *et al*., 2008). In all cases, brake thermal efficiency has the tendency to increase with increase in applied load. This is due to the reduction in heat loss and increase in power developed with increase in load. Initially the thermal efficiency of the engine is improved with increasing concentration of the biodiesel in the blend.

Both B20 and B40 blends show better SFC than the B100 (Prakash *et al*., 2006). The brake specific energy consumption of the B50 blend was lower than that of all other blends and neat diesel. This may be due to better combustion and an increase in the energy content of the blend as shown in Fig. 4.

Figure 5 shows the comparison of carbon monoxide with brake power. CO emission of all blends is higher than that of diesel. Among the blends, 50% blend has a lower CO emission followed by 25% blend (Hebbal *et al*., 2006). At low and medium loads, CO emissions of the blends were not much different from those of diesel. However, at full load, CO emissions of the blend (B25) decreased significantly when compared with those of standard diesel.

The variation of Carbon dioxide with Brake power is shown in Fig. 6. The Jatropha biodiesel followed the same trend of CO_2 emission which was higher than in case of diesel (Rao *et al*., 2009). As expected, it was noted that the Carbon dioxide emission increases with increase in load. The Carbon dioxide emission is found to increase with increase in the concentration of biodiesel blends as the fuel.

Figure 7 shows the variation of cylinder pressure with Crank angle. Neat poon oil and Neat 20 blend at full load. It is observed that peak pressures of 67.5, 60 and 63 bar were recorded for standard diesel, Neat poon oil and Neat 20 blend, respectively (Devan and Mahalakshmi, 2009).

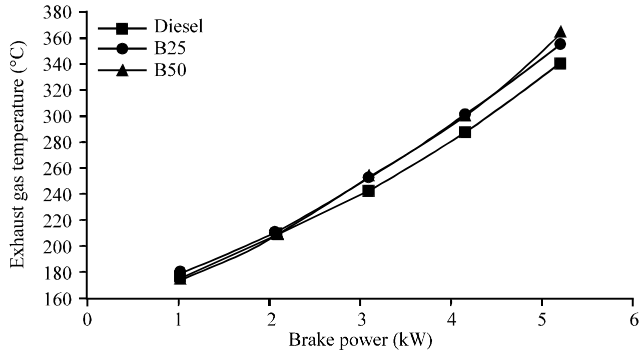


Fig. 2: Comparison of exhaust temperature with brake power

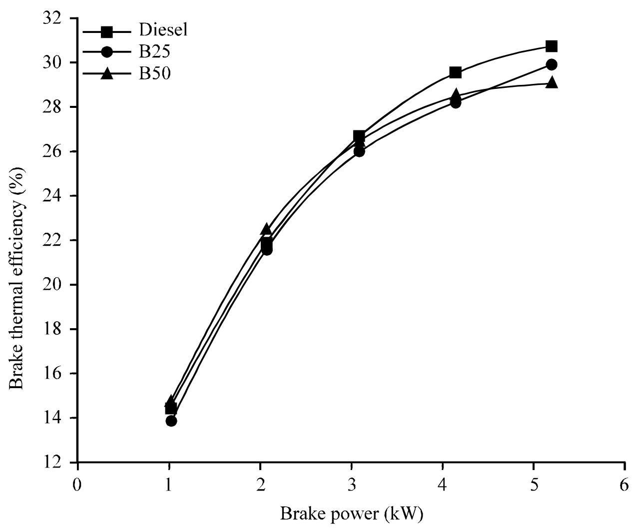


Fig. 3: Comparison of brake thermal efficiency with brake power

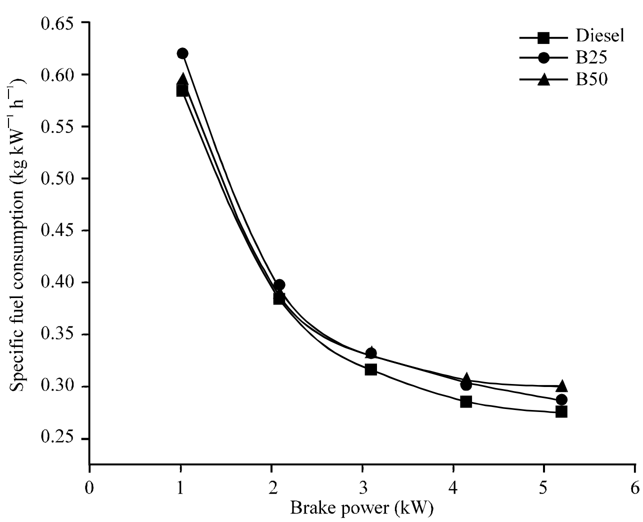


Fig. 4: Comparison of specific fuel consumption with brake power

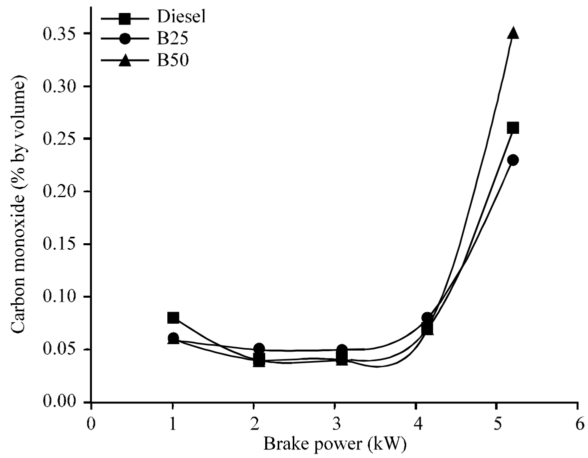


Fig. 5: Comparison of carbon monoxide with brake power

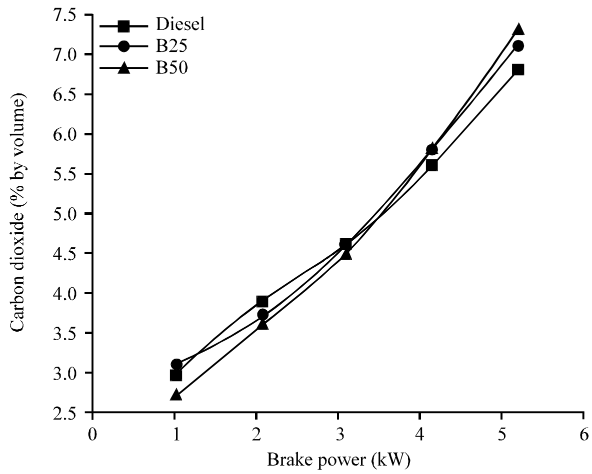


Fig. 6: Comparison of carbon dioxide with brake power

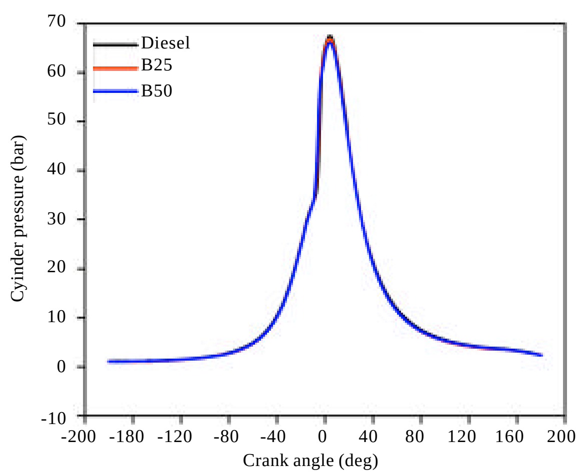


Fig. 7: Comparison of cylinder pressure with crank angle

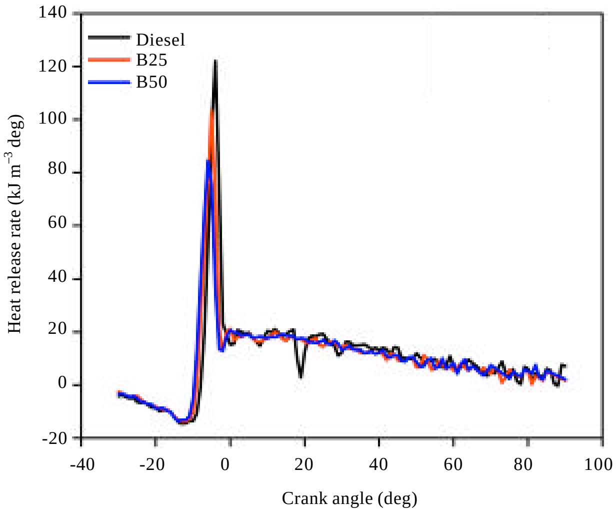


Fig. 8: Comparison of heat release rate with crank angle

The maximum pressure is for diesel and followed by B25 and B50. From this above figure we can see all the fuels are having very closer values.

The variation of Heat release rate with Crank angle is shown in Fig. 8. High heat release rate of diesel is a consequence of premixed or uncontrolled combustion phase. It is clear that premixed combustion phase of rubber seed oil is significantly lower in comparison with diesel (Geo *et al.*, 2010). It can be observed that heat release rate is high for diesel. This is due to premixed and uncontrolled combustion phase.

CONCLUSIONS

In this study, the effects of Pongamia biodiesel blend mixture with diesel as an alternative fuel on engine performance were investigated experimentally. Based on the experimental results of this study, the following conclusions can be drawn:

- The engine test of biodiesel from vegetable oil performed smoothly and exhibited no starting problems
- Pongamia oil based methyl esters (biodiesel) can be directly used in diesel engines without any engine modifications
- Exhaust gas temperature, specific fuel consumption of B25 blends of Pongamia oil based methyl ester are compared with diesel and found to be effective as characteristics of diesel
- CO emissions of the blend (B25) decreased significantly when compared with those of standard diesel
- The carbon dioxide emission is found to increase with increase in the concentration of biodiesel blends as the fuel
- The engine performance with the bio-diesel and the vegetable oil blends of various origins was similar to that of the neat diesel fuel with nearly the same brake power. The present experimental result shows that methyl esters of Pongamia oil can be used as an alternative fuel in diesel engine without any modifications in the existing engine

REFERENCES

Abdul Kalam, A.P.J., 2006. Dynamics of rural development. 93rd Indian Science Congress Annual Report, 2005-2006, pp: 34-40. http://www.scribd.com/doc/6890288/AnnualReport1A06

Agarwal, A.K., 2007. Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines. Prog. Energy Combust. Sci., 33: 233-271.

Altin, R., S. Cetinkaya and Y.H. Serdar, 2001. The potential of using vegetable oil fuels as fuel for diesel engines. Ener. Con. Manage., 42: 529-538.

Babu, A.K. and G. Devarajane, 2003. Vegetable oils and their derivatives as fuels for Cl engines: An overview. SAE Trans., 112: 406-419.

Bhattacharyya, S. and C.S. Reddy, 1994. Vegetable oils as fuels for internal combustion engines: A review. J. Agric. Eng. Res., 57: 157-166.

Bijalwan, A., C.M. Sharma, and V.K. Kediyal, 2006. Bio-diesel revolution. Sci. Rep., 43: 14-17.

Devan, P.K. and N.V. Mahalakshmi, 2009. Performance, emission and combustion characteristics of poon oil and its diesel blends in a DI diesel engine. Fuel., 88: 861-867.

Geo, E.V., G. Nagarajan and B. Nagalingam, 2010. Studies on improving the performance of rubber seed oil fuel for diesel engine with DEE port injection. Fuel, 89: 3559-3567.

Hebbal, O.D., K.V. Reddy and K. Rajagopal, 2006. Performance characteristics of a diesel engine with deccan hemp oil. Fuel, 85: 2187-2194.

Ibeto, C.N., A.U. Ofoefule and H.C. Ezugwu, 2011. Anlytical methods for quality assessment of biodiesel from animal and vegetable oils. Tren. Applied Sci. Res., 6: 537-553.

Jothi, N.K.M, G. Nagarajan and S. Renganarayanan, 2007. Experimental studies on homogeneous charge CI engine fueled with LPG using DEE as an ignition enhancer. Renew. Energy, 32: 1581-1593.

Kumar, M.S., A. Kerihuel, J. Bellettre and M. Tazerout, 2005. Experimental investigations on the use of preheated animal fat as fuel in a compression ignition engine. Renew. Energy, 30: 1443-1456.

Kumar, M.S., A. Ramesh and B. Nagalingam, 2003. An experimental comparison of methods to use methanol and Jatropha oil in a compression ignition engine. Biomass Bioenergy, 25: 309-318.

Lenin, A.H., A.R. Navrro, M.G. Syed Mohamed and K. Thyagarajan, 2011a. Experimental investigation of sunflower oil and mahua oil as biodiesel on ci engine. Proceedings of the 4th international conference on Advanced Design and Manufacture, September 21-23, 2011, Einstein College of Engg, 40-48.

Lenin, A.H., A.R. Navrro, R. Ravi and K. Thyagarajan, 2011b. Experimental investigation of sesame oil as biodiesel on CI engine. Proceedings of the National Conference on Advances and Challenges in Mechanical and Mechatronics Engineering, March 18, 2011, Rajaas Eng. College, pp: 295-298.

Meher, L.C., V.S. Dharmagadda and S.N. Naik, 2006. Optimization of alkali-catalyzed transesterification of *Pongamia pinnata* oil for production of biodiesel. Bioresour Technol., 97: 1392-1397.

Murphy, J.D. and K. McCarthy 2005. The optimal production of biogas for use as a transport fuel in Ireland. Renew Energy, 30: 2111-2127.

PCGI, 2003. Report of the committee on development of bio fuel. Planning Commission, Government of India, New Delhi-110001. http://planningcommission.nic.in/reports/genrep/cmtt_bio.pdf

Prakash, N., A.A. Jose, M.G. Devanesan and T. Viruthagiri, 2006. Optimization of Karanja oil transesterification. Indian J. Chem. Tech., 13: 505-509.

Ramadhas, A.S., C. Muraleedharan and S. Jayaraj, 2005. Performance and emission evaluation of a diesel engine fueled with methyl esters of rubber seed oil. Renewable Energy, 30: 1789-1800.

Rao, H.Y.V., R.S. Voleti, A.V.S. Raju and P.N. Reddy, 2009. Experimental investigations on jatropha biodiesel and additive in diesel engine. Indian J. Sci. Technol., 2: 25-31.

Rao, V.T., G.P. Rao and K.H.C. Reddy, 2008. Experimental investigation of Pongamia, Jatropha and neem methyl esters as biodiesel on C.I. engine. Jordan J. Mech Ind. Eng., 2: 117-122.

Srivastava A. and R. Prasad, 2000. Triglycerides-based diesel fuels. Renew. Sustainable Energy Rev., 4: 111-133.

Syam, A.M., R. Yunus, T.I.M. Ghazi and T.C.S. Yaw, 2009. Methanolysis of jatropha oil in the presence of potassium hydroxide catalyst. J. Applied Sci., 9: 3161-3165.

Wang, H.W., Z.H. Huang, L.B. Zhou, D.M. Jiang and Z.L. Yang, 2000. Investigation on emission characteristics of a compression ignition engine with oxygenated fuels and exhaust gas circulation. Proc. Inst. Mech. Eng., 214: 503-508.