

Effect of Di Tertiary Butyl Peroxide Additive on Performance and Emission Characteristics of Biodiesel Butanol Blends

Purusothaman. P^a Gurusamy. A^b
^{a,b} PG student, Dept. of IC Engg.
 University College of engineering
 Villupuram, India

Abstract—In this work, Pongamia biodiesel (50%) diesel (45%) butanol 5% (by volume) (B50D45Bu5), Pongamia biodiesel (50%) diesel (40%) butanol 5% (B50D40Bu10), Pongamia biodiesel (50%) diesel (35%)butanol 15% (B50D35Bu15) with 0.5% Di tertiary butyl peroxide additive fuels were tested to evaluate the effects of the fuel blends on the performance and exhaust emissions of a diesel engine. Engine performance parameters and exhaust gas emissions such as nitrogen oxides, carbon monoxide and hydrocarbon were measured. The results showed that butanol addition caused a slight reduction in B.S.F.C and increase in brake thermal efficiency, the emission values of the engine were improved. Therefore, DTBP can be used as a very promising additive to biodiesel butanol diesel blends.

Keywords— Biodiesel, Di tertiary butyl peroxide, Butanol, performance, Exhaust emissions

1. INTRODUCTION:

Due to stringent emission regulation and depletion of fossil fuels fostered the research towards biofuels. Biofuels made from agricultural products reduce the country's oil imports.[1] Biodiesel is the most used renewable fuel in C.I engine. It has numerous advantages such as minimal sulphur & aromatic content, high cetane number, higher lubricity. The disadvantages of biodiesel are lower oxidation stability, higher pour point and lower calorific value.[2] Based on several researches conducted prior, it is found that the biodiesel fuelled engine emit less carbon monoxide, hydrocarbon and particulate matter as compared to diesel but there is increase in NO_x emission.[3]

Due to the emission benefits derived from the oxygen in the fuel molecule, the interest in the use of bioalcohol fuel blends in compression ignition engines has been increased [4] Butanol is a feasible alternative fuel that has a number of desirable properties for use with diesel engines [5] Compared to ethanol, Butanol has superior fuel properties which make it more suitable for application in diesel engines, such as higher heating value, good intersolubility with diesel fuel, and no corrosion to existing pipelines [6]. Most studies have focused the use of ethanol as fuel in reciprocating engines. Fewer studies have reported the use of butanol as fuel, although butanol possesses some better fuel properties than ethanol [7].

Studies about utilization of butanol as fuel in diesel engines found that the soot emissions were effectively reduced.

Contrary to engine related techniques, properties of the fuel can also be altered by the addition of essential fuel additives to make biodiesel conductive for diesel engine [8]. The addition of fuel additives is gaining popularity, as this can be done with ease when compared to engine modification techniques. Fuel additives play a crucial role in changing the molecular structure of the fuel and the enhanced chemical reactivity benefits in attaining better performance [9].

However there is not much work done regarding effect of additives on butanol-biodiesel blends. Thus the intention of the current work is to begin exploring the effects of Di Tertiary Butyl Peroxide with butanol biodiesel blending on the performance and emissions characteristics of a diesel engine.

1.1. Transesterification:

Transesterification is most commonly used and important method to reduce the viscosity of vegetable oils. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called Transesterification. This esterified vegetable oil is called biodiesel. Biodiesel properties are similar to diesel fuel. After esterification of the vegetable oils its density, viscosity, cetane number & calorific values are improved more.

Single-stage laboratory transesterification setup was performed in a small rectangular container equipped electrically operated stirrer. Pongamia oil and methyl alcohol are mixed in a 6:1 molar proportion and heated in 55°C and then this combination is mixed with 2% sodium hydroxide and maintained at 60°C for 60 min. Then it is allowed to settle by gravity for 24 h. After draining of the glycerol, upper layer was washed with water & vacuum distilled to remove moisture.

1.2. Biodegradability

Biodegradability is desirable, in the event of a spill or leak of fuel to the environment. Blending biodiesel with diesel accelerates its Biodegradability and it has been

reported that blends of 50% biodiesel/50% diesel fuel degrade twice as fast as near diesel. Furthermore, experiments with blends of biodiesel showed that biodiesel can promote and speed up the Biodegradation of diesel as the more biodiesel present in a biodiesel /diesel mixture

2.EXPERIMENTAL PROCEDURE AND SPECIFICATIONS:

For the experiments, four fuel types are used. Biodiesel 50% is used for all the blends. butanol was blended with biodiesel through stirring on a magnetic stirring plate. Biodiesel butanol blends were prepared with 5%, 10%, & 15% of butanol concentrations by volume basis. Additive DTBP similarly to 2-EHN is a known accelerator for spontaneous ignition & has been used as cetane improver of diesel fuel in recent researches. [11] properties of DTBP is shown in table 1 In this study additive DTBP was added in the ratio of 0.5% in volume for increasing the cetane number of biodiesel butanol blends and Specification of the engine are shown in table 2.

The Biodiesel was made from pongamia oil following the standard transesterification process based on ASTM D6751. basic fuel properties for diesel, biodiesel and butanol are shown in table 3

Table 2 Engine specification

Type	Vertical, Water cooled, Four stroke
Number of cylinder	1
Bore	87.5 mm
Stroke	110 mm
Compression ratio	17.5:1
Maximum power	5.2 Kw
Speed	1500 rev/min
Dynamometer	Eddy current
Injection timing and pressure	23° before TDC &
Injection pressure	220kgf/cm ²

Table 1 Properties of DTBP(di tertiary butyl peroxide)

Property	value
Composition	C ₈ H ₁₈ O ₂
Flash point(°C)	6
Density(@20°C)	0.79
Autoignition temperature(°C)	165

Table 3 Properties of biodiesel, butanol and diesel.

Properties	Biodiesel	Butanol	Diesel
Heating value (MJ/kg)	40.5	33.1	43
Density @20°C(kg/m ³)	865	808	815
Viscosity@40°C (mpa-s)	4.57	2.95	2.63
Flashpoint (°C)	126	35	70
Cetane number	52	25	48

2.1. Experimental procedure

The load test was conducted by maintaining a constant speed at 1500rpm

1. The water flow is started and maintained constant throughout the experiment
2. The engine is allowed to run at the rated speed of 1500 rev/min for a period of 20 minutes to reach the steady state.
3. The fuel consumption is measured by a stop watch.
4. Then the load is applied gradually, which is connected to the Eddy Current Dynamometer. The load to the engine is varied as 20, 40, 60, 80 & 100% of the full load of the engine.
5. Experiments were conducted using sole fuel diesel. i.e. diesel and the corresponding fuel consumption, smoke density, exhaust gas

temperature and exhaust emissions are measured and noted .

6. Then the engine is allowed to cool down before changing the fuel and then the experimental procedure was repeated for biodiesel butanol blends and the corresponding fuel consumption, exhaust gas temperature, & exhaust emission were measured.

Once the test fuels were prepared, test were performed at 20%,40%,60%,80%,100% for each fuel type. The fuel consumption, exhaust temperature and engine emissions were recorded. Exhaust gas temperature was measured with a type-k thermocouple, while gaseous emissions such as CO, HC, and NO_x were measured using an AVL gas analyzer and Specification of the AVL gas analyzer are shown in table 4 .fig 1 shows the details of the experimental set-up.

Table 4 Specification of an AVL gas analyzer

DETAILS	SPECIFICATION
Make	AVL
Type	AVL Diagas 444
Power supply	11-22 voltage 25W
Warm up time	7 min
Connector gas in	180 l/h, max. over pressure 450 hpa
Response time	T 95<15s
Operating temperature	5-45 °C
Storage temperature	28 °C
Relative humidity	<95%, non-condensing
Inclination	0-90°
Dimension	270x320x85mm
Weight	4.5 kg net weight without accessories
Interfaces	RS 232 c, pick up, oil temperature

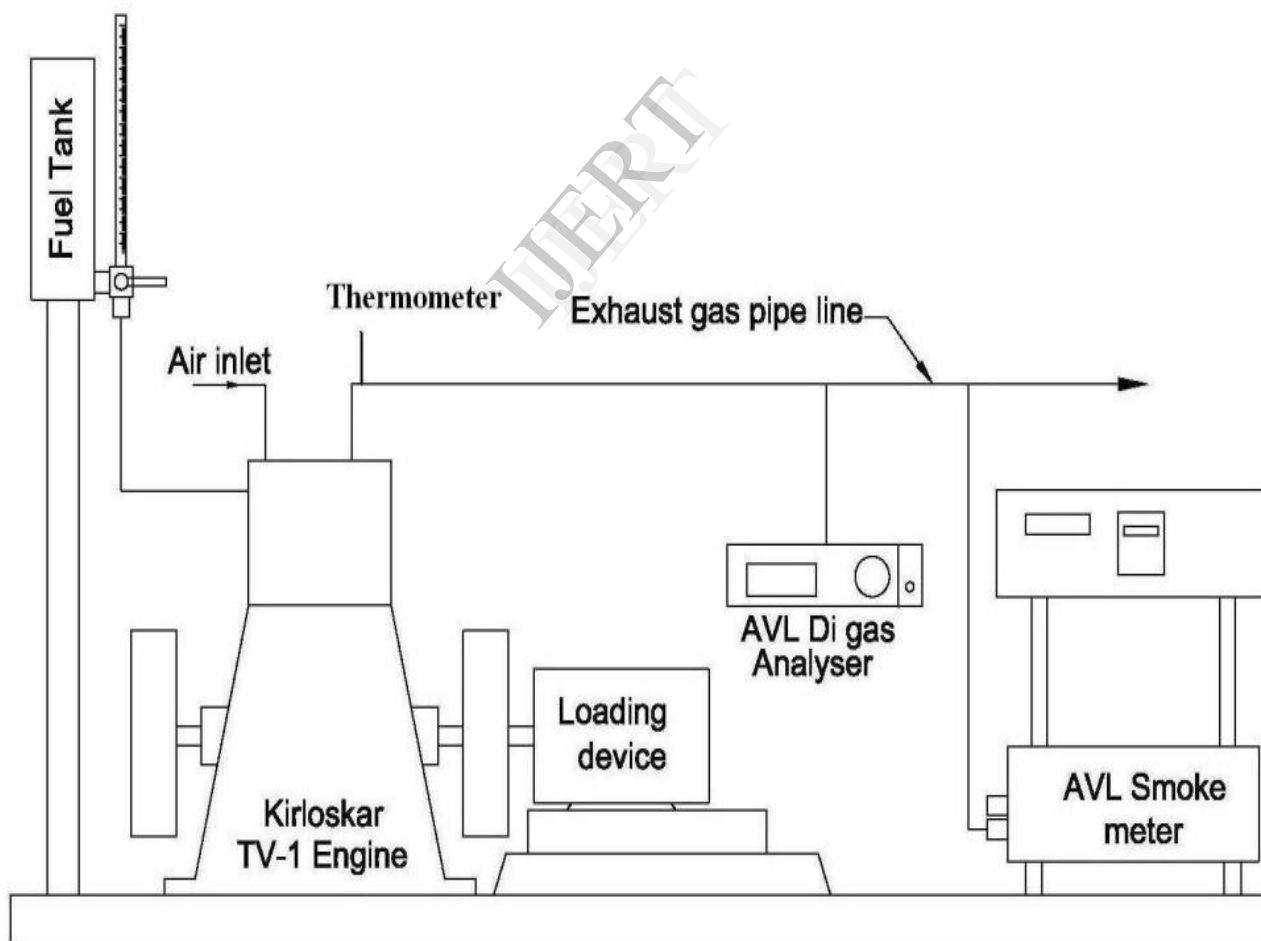


Fig.1 experimental setup

3. RESULTS AND DISCUSSION

3.1. PERFORMANCE AND EMISSION CHARACTERISTICS

3.1.1. Brake specific Fuel consumption:

Fig. 2 shows B.S.F.C value of various blends with respect to engine load. It is clearly observed from fig that B.S.F.C decreases as the load increases because more fuel is required to carry a light load. In all cases diesel fuel shows lowest B.S.F.C as compared to biodiesel butanol blends because biodiesel & butanol has lower heating value. Overall, in higher load butanol addition does not create significant change in B.S.F.C.

3.1.2. Brake Thermal efficiency :

Brake Thermal Efficiency simply the inverse of product of B.S.F.C and lower calorific value. As seen in fig.3 BTE for all butanol blends is slightly higher than that for neat diesel with the increase being higher the higher the percentage of butanol in the blend. This may be attributed to enhanced oxygen content higher laminar flame speed of butanol biodiesel blends.

3.1.3. HC emission:

Fig.4 shows, at low loads, hydrocarbon emission of biodiesel butanol blends are lesser than diesel. But at higher loads, HC emissions does not show any significant change compared to diesel because DTBP opposing the effects (lesser cetane number) caused by butanol.

3.1.4. CO emission:

As seen in fig.5 CO emission decrease as the load increase. At high loads there is no significant difference between in terms of CO emission. However, at lower load CO emission decrease mainly due to oxygen content of biodiesel and butanol blends. And also DTBP improves the combustion.

3.1.5. NO_x emission:

Fig.6 shows the comparison and variation of NO_x emissions as a function of engine load. Butanol and DTBP addition to biodiesel decrease NO_x and reduction increase as the butanol concentration rises. This may be attributed to engine running over all leaner & temperature lowering effect of butanol due to higher heat of evaporation. And also DTBP reduces the ignition delay leads to more diffusive combustion. It also contributes to lesser NO_x emissions. This effect is very pronounced on emission product by B50 D35 Bu15 compared to other blends.

3.1.6. Exhaust gas temperature:

Exhaust gas temperature as a function of load for all the fuel types is shown in fig.7 Butanol blended fuels produce lower exhaust gas temperature because butanol has a lower energy density and lower cetane number than diesel or biodiesel. Additionally, the introduction of butanol to fuel blends increase the oxygen content while decreasing the overall energy content, both of which cause lower combustion and exhaust temperature.

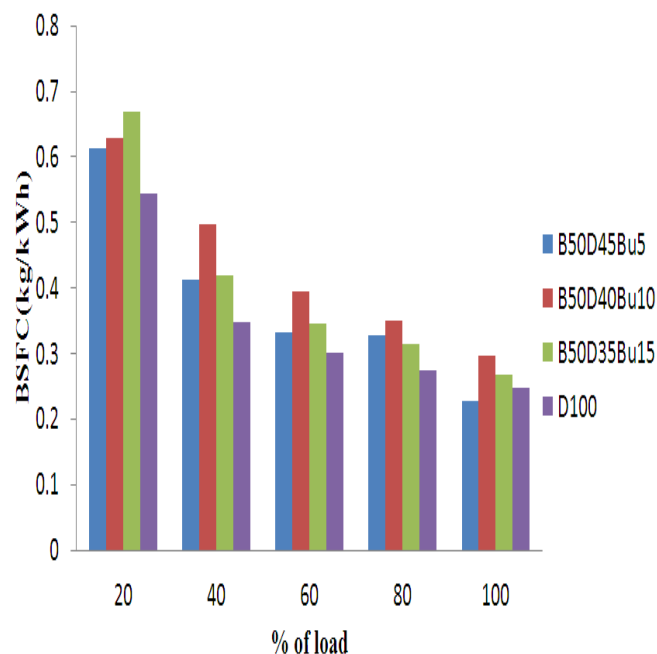


Fig.2. % of load vs. Brake specific Fuel consumption (Kg/kWh)

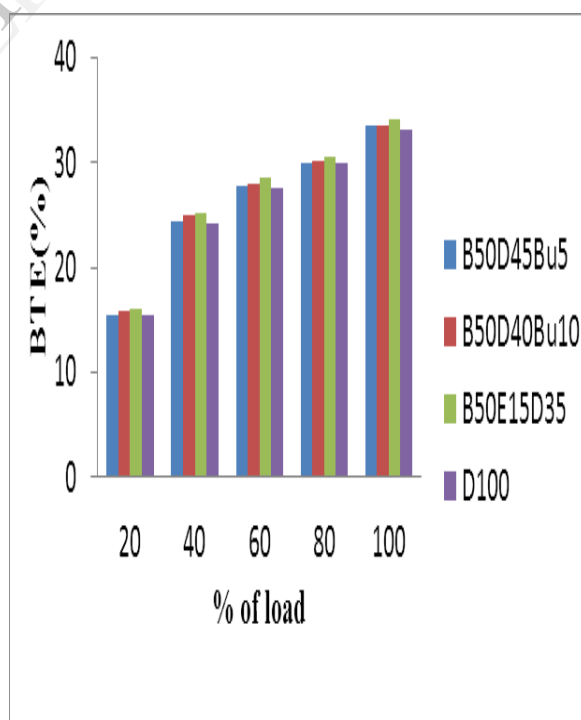


Fig. 3 % of load vs. Brake Thermal efficiency (%)

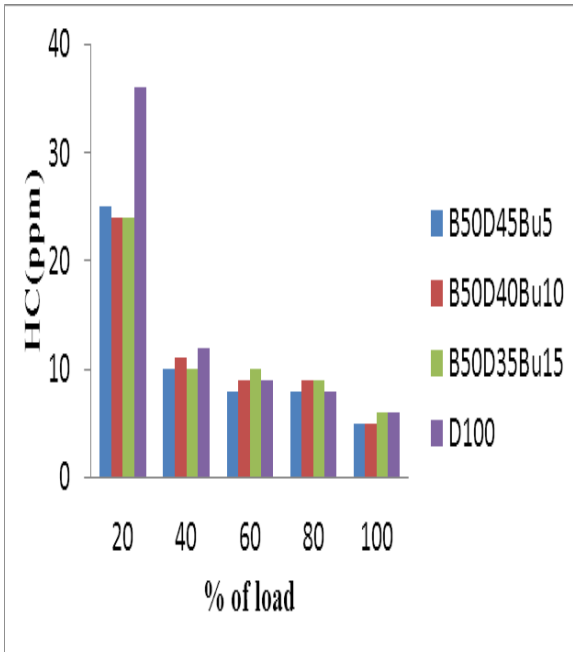


Fig. 4 % of load vs. HC (ppm)

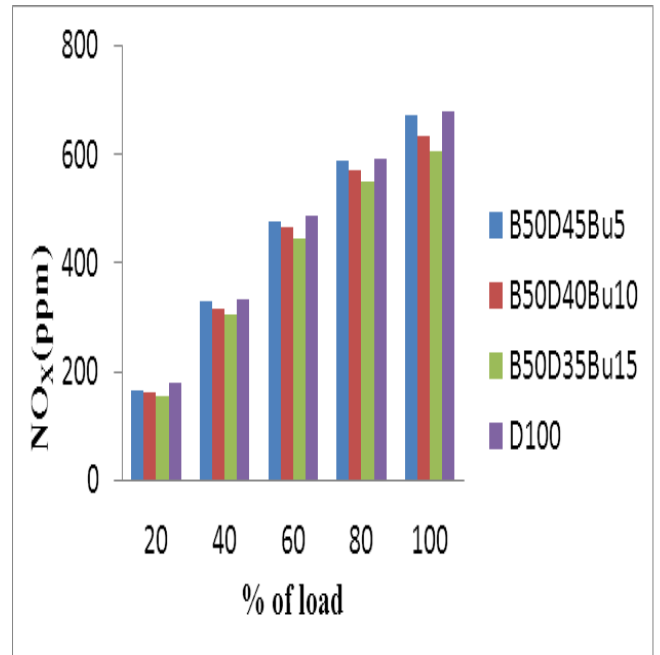


Fig. 6 % of load vs. NO_x(ppm)

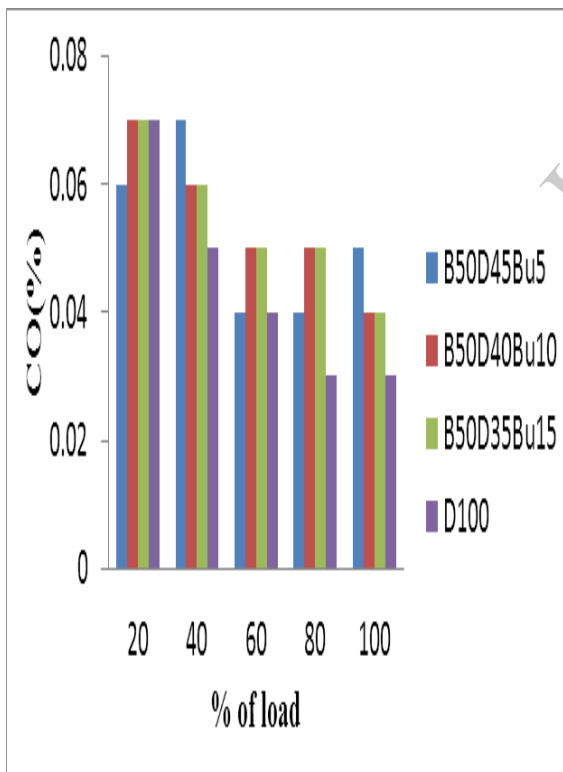


Fig. 5 % of load vs.CO(%)

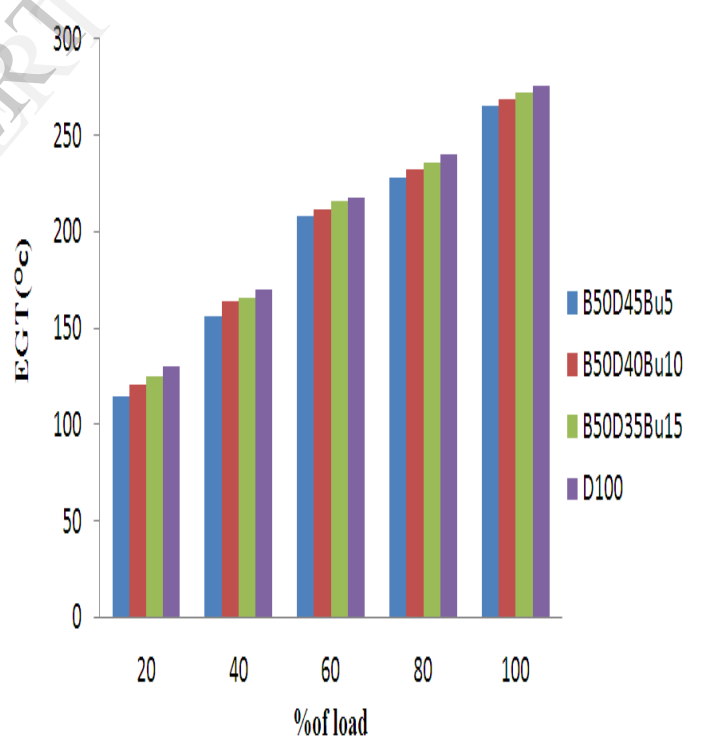


Fig. 7 % of load vs. EGT (°C)

CONCLUSION:

Emission and engine performance experiments were conducted on a single cylinder diesel engine. The effects of DTBP addition in biodiesel Butanol diesel blends on engine performance, oxides of nitrogen, carbon monoxide and hydrocarbon values were investigated. The following major conclusions were drawn from this study:

- i. Brake specific fuel consumption of B50D45Bu5 was comparable with diesel.
- ii. Brake thermal efficiency of all the butanol biodiesel blends are slightly higher than diesel.
- iii. The exhaust emission tests revealed that CO and NO_x emission improved with butanol addition. Finally, it can be concluded that, DTBP can be used as a very promising additive to butanol biodiesel blends in conventional diesel engines, by this way exhaust emission values can be improved.

ACKNOWLEDGEMENT

The author wish to express their gratitude to staff members of Department of Internal Combustion Engineering, University college of engineering, Villupuram, for their support in carrying these tests.

REFERENCES:

1. Demirbas A. Use of Algae as biofuel sources. *Energy Conversion management* 2010 47:2738-49.
2. Rakopoulos D.C. Combustion & Emission characteristics of cottonseed oil & its biodiesel in blends with either n-butanol or DEE in HSDI diesel engine. *Fuel* 2013;105:603-13.
3. Joshi R.M. and Pegg J., Flow properties of biodiesel fuel blends at low temperature. *Fuel* 86;143-151
4. Moneym A. and van gerpen J.H. The effect of biodiesel oxidation on engine performance and emissions, *Biomass bioenergy* 2001;317-325
5. Yilmaz N, Vigil FM, Donaldson AB, Darabseh T. Investigation of CI engine emissions in biodiesel-ethanol-diesel blends as a function of ethanol concentration. *Fuel* 2014;115:790-3.
6. Chang Y-C, Lee W-J, Lin S-L, Wang L-C. Green energy: water-containing acetone-butanol-ethanol diesel blends fueled in diesel engines. *Appl Energy* 2013;109:182-91.
7. Liu H, Li S, Zheng Z, Xu J, Yao M. Effects of n-butanol, 2-butanol, and methyl octynoate addition to diesel fuel on combustion and emissions over a widerange of exhaust gas recirculation (EGR) rates. *Appl Energy* 2013;112:246-56.
8. Siwale L, Lukacs K, Torok A, Akos B, Makame M, Antal P, et al. Combustion and emission characteristics of n-butanol/diesel fuel blend in a turbo-charged compression ignition engine. *Fuel* 2013;107:409-18.
9. Vallinayagam R, Vedharaj S, Yang W, Saravanan C, Lee P, Chua K. Impact of ignition promoting additives on the characteristics of a diesel engine powered by pine oil-diesel blend. *Fuel* 2013;117:27885.
10. Sundar RC, Arul S, Sendilvelan S, Saravanan G. Performance analysis of 1,4-dioxane-ethanol-diesel blends on diesel engines with and without thermal barrier coating. *ThermSci* 2010;14:979-88.
11. Lee S.W, CHO Y.S, BAIK D.S 2010 Effect of cetane enhancer on spray & combustion characteristics of compressed ignition type LPG fuel. *International Journal of Automotive technology*, vol 11.No.3, pp.381-386.