Nat. Volatiles & Essent. Oils, 2021; 8(4): 16512-16523

Effect Of Zno Nano Particles On Performance And Emission Characteristics Of Ci Engine Fuelled With Blend Of Palm Biodiesel

Rohit Singh[1] , Dr.T.P.Singh[2]

[1]Assistant Professor Shri Ramswaroop Memorial University Lucknow.

[2]Assistant Professor BIET Jhansi.

Abstract

To improve the efficiency and emission characteristics of the CI Engine, nano particles play a very important role. In various formulations, ZnO nano additives strengthen the physical and chemical properties of palm biodiesel. Current work shows that after combining ZnO nano particles, the properties of palm biodiesel are improved. In the current investigation, the high viscosity of palm biodiesel, considered to be a possible substitute fuel for the compression ignition (C.I.) engine, was reduced by mixing with diesel. Variable proportions of palm biodiesel and diesel blends were prepared, analyzed and compared with diesel fuel. The engine efficiency was measured using a blend of palm biodiesel with ZnO nano particles in a single C.I cylinder. Important changes in engine performance were observed compared to vegetable oil alone.

Keywords: Viscosity, Biodiesel, Performance, Emissions, Properties, Nano particles, Vegetable oil, Compression Ignition.

I. Introduction

The most viable way to satisfy the increasing demand for energy in transport without greenhouse gas emissions is through the use of alternative fuels. One of these alternative fuels is palm oil (PO). Its physical and chemical characteristics are very similar to diesel. Because of its elevated viscosity, however, its immediate use as fuel in diesel engines should result in bad atomisation, carbon deposits or obstruction of fuel lines.

De Almeida et al. researched the efficiency of a diesel generator fuelled by preheated PO and found that PO had reduced viscosity, better combustion and fewer deposits when heated at 100℃.

In addition, one way to reduce waste cooking oil disposal is to use it in diesel engines as fuel. Mazumdar et al. used waste cooking oil through transesterification processes to produce biodiesel. The generated biodiesel was then mixed with diesel fuel to be used in a diesel engine.

Since the use of palm oil as a fuel has a adverse effect on human edible oil requirements (increase in cost), the use of WCO is one of the ways to decrease this effect by restricting the biodiesel portion of edible oil. In this job, the primary raw material for the preparation of the methyl ester is refined palm oil. Refined palm oil is used as the primary raw material in this job to prepare the methyl ester. Waste cooking oil is used as an intersterification agent to decrease the blend's general viscosity and cloud point as well as ester.

The aim of this job is to explore the impacts of biofuels based on palm oil on the performance and emission features of a diesel engine fuelled by ZnO nanoparticles as fuel additives. Performance and emission tests were carried out for each formulation at different loads and a fixed engine speed condition.

A. Additives

Additives are playing very important role in biodiesel. With the help of additives properties of fuel can be enhanced and biodiesel in blend can be used with diesel in the vehicle which increase the performance and reduction in exhausts emissions from the engine.
Biodiesel has certain disadvantages with lower temperature, higher emissions and lower effectiveness, such as oil thickening. The use of fuel additives obtained from organic and inorganic metals of chemical substances eliminates biodiesel-related problems. Aalam et al. (2015) discussed that the nano metal oxide additive fuel used in diesel engine increases the performance and decreases the emissions significantly.

II. Preparation Of Fuel

The fuel (diesel) was collected from Central Delhi petrol pump and mixed in different proportions with produced biodiesel and nano particles (zinc oxide). Tech4Nano purchased zinc oxide nano particles with a particle size of less than 100 nm. Nano particle specifications are: 99.9% purity, 30 nm average particle size, 5.606gm / cc density, single crystal colour white and crystal phase. By using ultrasonicator continually until clear mixture is created, the particles were mixed with distinct concentrations of diesel and biodiesel.

Zinc Oxide Nano particle, eight fuels blends were achieved in 25ppm, 50ppm, 100ppm and 200ppm with diesel and biodiesel, i.e. ZnO (dispersion of ZnO NP in 81.39g / mol mass fraction).

TABLE I DIESEL AND BIODIESEL BLENDS

	Formulations			
	B5	**B10**	**B15**	**B20**
Diesel %	95	90	80	75
Biodiesel %	5	10	20	25

TABLE III B25 AND ZINC OXIDE NANOPARTICLES BLEND

	Formulations			
	25ZnO	**50ZnO**	**100ZnO**	**200ZnO**
B25+D75% +ZnO ppm	25	50	100	200

TABLE IIIII PROPERTIES OF ZINC OXIDE NANO ADDITIVES

S.No	Parameter	Zno Particles
1	Average Particle Size	67nm
2	Formula	ZnO
3	Formula Weight	81.39g/mol
4	Specific Surface Area	$16m^2/g$
5	Appearance	White

6	Form	Powder
7	Mass Fraction	81.39g/mol
8	Melting Point	2350℃
9	Boiling Point	3450℃
10	Solubility in water	Insoluble

III. Experimental Setup

For the current studies, which are connected to the dynamometer type eddy current, a four-stroke single cylinder water-cooled diesel motor was used. The detailed specifications for the engine are displayed in the table. The efficiency characteristics of the variable compression ignition engine were conducted. The configuration involves the instruments needed to measure the pressure of combustion and the angle of the crank. The setup enables to study braking power, stipulated power, frictional power, BMEP, IMEP, thermal brake efficiency, defined heat efficiency, mechanical efficiency, volumetric efficiency, specific energy usage, A / F ratio and temperature equilibrium.

TABLE IVV Specifications Of The Engine

Make and model	Kirloskar, TV1
Type of engine	4 stroke Variable compression diesel engine
No. Of cylinders	Single cylinder
Cooling media	Water cooled
Rated capacity	3.5 kW at 1500 rpm
Cylinder diameter	87.5mm
Stroke length	110mm
Connecting rod length	234mm
Compression ratio	12:1 to 18:1
Dynamometer	Eddy current dynamometer

A. Adjuster

This consists of a built-in valve mechanism for changing the engine's compression ratio by adjusting it to the desired mark using a spanner.

B. Exhaust Gas Emission Analysis

The various pollutants that appear in the exhaust of a diesel engine are oxides of nitrogen. UBHC, CO and CO_2 were measured using AVL 4000 Light Di-Gas Analyser. This is an instrument used to assess the exhausts of an engine. Analysis of exhaust gas from combustion of engines will help to assess engine efficiency and identify the associated problem. To evaluate the features, the inlet manifold of the analyser is connected to the exhaust valve of the engine. Oxygen (O_2), carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbons (HC) will be evaluated by this analyser.

IV. Results And Discussion

The engine is run continuously with diesel, palm oil (PO), PO / diesel oil blends and ZnO nano particles at distinct concentrations (25, 50, 100, 200 ppm). The experiments were performed on a single-cylinder CI diesel engine, unchanged at 1500rpm, compression ratio of 17.5:1 and, loads of 1 kg, 2 kg, and 3 kg.

A. Properties of Different Formulations

a). Density

Density is defined as the ratio of weight and volume or weight per unit volume. It is a measure of how much an object changes in a unit volume. Mass is a measure of how much space an object occupies in a three-dimensional space.

TABLE V DENSITY OF DIFFERENT BLENDS

S.No	Sample Name	Result (Kg/m^3)
1	Diesel	830
2	5B	835
3	10B	838
4	20B	844
5	25B	850
6	25B25ZnO	851
7	25B50ZnO	853
8	25B100ZnO	855
9	25B200ZnO	861

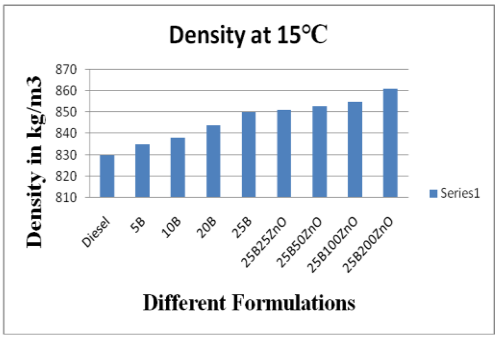

Figure 1: Density of Different Formulations

Density of various concentration are shown in above graph.

b). Calorific Value of Different Formulations

Calorific value is the quantity of energy that the substance accumulates, produces and releases through a kilogram of particular burning. It's a Joules / Kilogram unit.

TABLE VV CALORIFIC VALUE OF DIFFERENT BLENDS

S.No	Sample Name	Calorific Value ((kJ/kg))

1	Diesel	41794
2	5B	39287
3	10B	40148
4	20B	40254
5	25B	40675
6	25B25ZnO	41284
7	25B50ZnO	41997
8	25B100ZnO	42201
9	25B200ZnO	43112

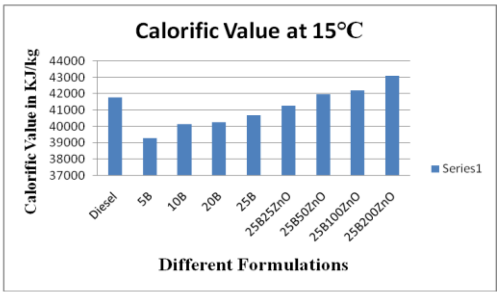

Figure 2: Calorific Value of Different Formulations

B. Performance Analysis

a). Brake Thermal Efficiency [BTE in %]

It is defined as the ratio of power output to that of chemical energy in the form of fuel supply. It is the true indication that the thermodynamic input is converted into mechanical work. It may be based on brake strength or indicated power.

BTE = brake power/ (mass of fluid* calorific value)

BP= Brake Work Done/S = $F_b \times 2\pi r_b \times N/60$

F_b- Load on engine

r_b- Brake radius

N- Speed of engine in rpm

It is defined as the ratio of power output to the ratio of chemical energy in the form of fuel supply. It is the true indication that the thermodynamic input is being converted into mechanical work. It can be based on the brake intensity or the strength indicated.

TABLE VII BTE OF DIFFERENT FORMULATIONS

S.No	Sample Name	Load (Kg)		
		1	2	3
1	Diesel	17.54	27.54	30.01
2	25B	11.46	20.64	22.62
3	25B25ZnO	15.42	22.38	25.32
4	25B50ZnO	16.02	23.82	26.84
5	25B100ZnO	17.24	24.84	27.32

6	25B200ZnO	18.24	26.42	31.62

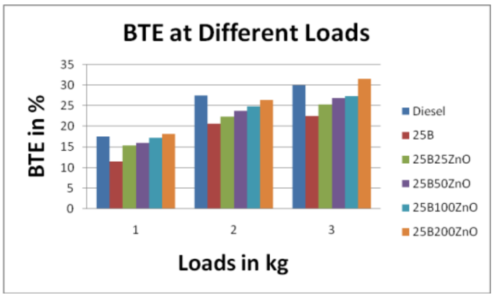

Figure 3: BTE Vs Loads of Different Formulations

Thermal efficiency is rising with increased load. The peak thermal brake efficiency is found at a load of 3 kg for 25B200ZnO. This rise in heat brake efficiency can be attributed to improved combustion and air and fuel mixing. BTE increases continuously when ZnO nanoparticles are used in B25 palm biodiesel at peak load as a fuel additive.

b). Brake Specific Fuel Consumption [BSFC in kg/KW-h]

Break specific fuel consumption is the amount of fuel consumed by an engine for each unit of energy output. The quantity of fuel consumed to produce a drive unit is engine-specific fuel consumption**.**

BSFC= BP/(FC*CV)
BP- Brake Power in KW
FC- Total Fuel Consumption in Liters/given time
CV= Calorific Value of Fuel

TABLE VIII BSFC OF DIFFERENT FORMULATIONS

S.No	Sample Name	Load (Kg)		
		1	2	3
1	Diesel	0.7	0.9	0.8
2	25B	0.43	0.54	0.58
3	25B25ZnO	0.40	0.41	0.52
4	25B50ZnO	0.28	0.30	0.35
5	25B100ZnO	0.19	0.21	0.23
6	25B200ZnO	0.3	0.19	0.5

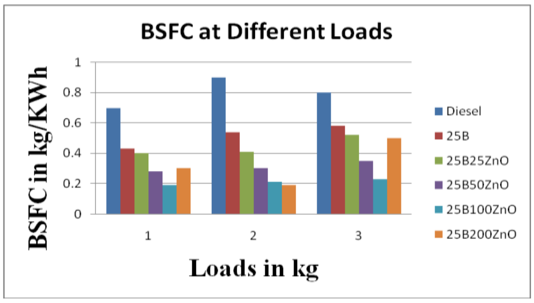

Figure 4: BSFC Vs Loads of Different Formulations

Brake Specific Fuel Consumption (BSFC) variations in diesel load and B25 palm biodiesel mixed with ZnO nanoparticles are shown in the diagram above. BSFC is noted to decrease with load increases**.** BSFC is lower when used with ZnO nanoparticles as a fuel additive. The BSFC value at peak load is continuously decreased when ZnO nanoparticles are used as a fuel additive. This can be due to enhanced air and fuel mixture resulting in better combustion.

B. Exhaust Gas Emission Analysis

a). Unburnt Hydrocarbon Emission[UHC in mg/Nm^3]

Hydrocarbons, their primary energy source, are involved in the fuel for motor vehicles. Any hydrocarbons emitted by car show unused gas resulting from incomplete combustion of petrol. The combination of sunlight and ozone-forming nitrogen is the risk in hydrocarbon emissions.

TABLE IX UHC Emission Of Different Formulations

S.No	Sample Name	Load (Kg)		
		1	2	3
1	Diesel	27.85	26.47	24.74
2	25B	26.22	25.02	23.01
3	25B25ZnO	18.34	17.16	16.64
4	25B50ZnO	17.26	16.01	14.21
5	25B100ZnO	14.84	15.0 5	13.02
6	25B200ZnO	12.86	12.04	10.92

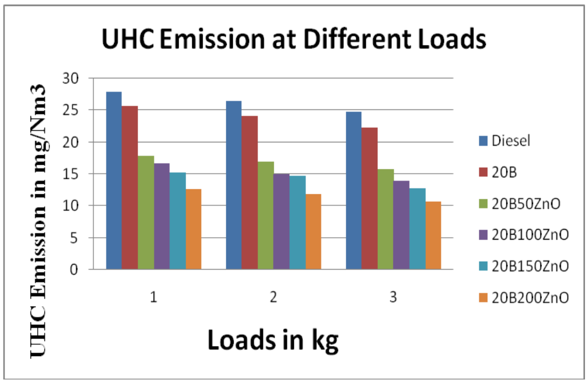

Figure 5: UHC Emission Vs Loads of Different Formulations

As the load rises, UBHC reduces. HC emissions are constantly decreased at peak load when ZnO nano particles are used in B25 palm biodiesel. The reason for UBHC's decrease may be that ZnO nano particles act as oxygen buffers resulting in increased combustion.

b). Carbon Mono Oxide Emission in mg/Nm^3[CO]

While carbon monoxide is only a small greenhouse gas, its climate effect expands beyond its own direct effects. Other greenhouse gas levels such as methane, tropospheric ozone and carbon dioxide are affected. Like many pollutants, both anthropogenic and natural sources of carbon monoxide.

TABLE X CO EMISSION OF DIFFERENT FORMULATIONS

S.No	Sample Name	Load (Kg)		
		1	2	3
1	Diesel	12.32	10.86	10.58
2	25B	9.91	9.16	8.85
3	25B25ZnO	7.92	7.34	6.78
4	25B50ZnO	7.78	7.04	6.49
5	25B100ZnO	7.68	7.01	6.33
6	25B200ZnO	6.41	5.88	5.69

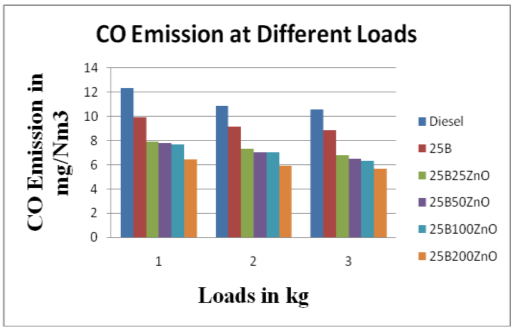

Figure 6: CO Emission Vs Loads of Different Formulations

As load rises, CO is noted to decrease. This is because the cylinder load increases the temperature and the combustion is improved. It is also observed that in B25 palm biodiesel ZnO nano particles are added, CO emissions are lower at all loads than diesel emissions.

At peak load, CO emissions are constantly reduced. This can be due to ZnO nanoparticles that act as oxygen buffers to enhance combustion.

V. Conclusion

Different formulations are ready and compared to smooth diesel for all blends. Palm biodiesel mixed ZnO nanoparticles are tested on a single cylinder 4-stroke CI engine. Palm biodiesel blends and B25 diesel composition have been prepared, adding distinct ZnO nanoparticles levels. The results will be drawn based on the experiment.

1. The BTE of blends is found to be higher than neat diesel. The maximum BTE is observed for B25 with ZnO, 200 ppm as 31.62% for 3 kg load where as for neat diesel it is 30.01%.
2. The BSFC is lower than neat diesel for 25B200 ZnO. The blend B25with ZnO, 200 ppm, has lowest bsfc obtained as 0.5% where as for diesel it is 0.8% at 3 kg load.
3. Unburnt HC Emissions are lowered for blends could be due to high surface to volume ratio of nano particles and blend B25 with nano additive ZnO, 200ppm has lowest emission as 10.92% compare to neat diesel at 3 kg load.
4. The CO emissions are lower for blend B25 with nano additive as compare to neat diesel. The blend B25 with ZnO, 200ppm has lower CO emission as 5.69% compare to neat diesel at 3kg load.

Acknowledgments

The authors are grateful for the experimental support from BIET Jhansi and Shri Ram Testing laboratory Delhi.

References

[1] M. Canaki and J. H. Van Garpen, Comparison of engine performance and emissions for petroleum diesel fuel, yellow-grease biodiesel and soybean-oil biodiesel, Transactions of the ASAE, 46 (4) (2003) 937-944.

[2] B. Freedman and E. H. Pryde, Fatty esters from vegetable oils for use as a diesel fuel, Transactions of the ASAE (1982) 117-122.

[3] E.T.Akintayo, Characteristics and composition of Parkia biglobbossa and Jatropha curcas oils and cakes, Bioresource Technology, 92 (2004) 307-310.

[4] S. M. Geyer, M. J. Jacobus and S. S. Lestz, Comparison of diesel engine performance and emissions from neat and transesterified vegetable oils, Transactions of the ASAE, 27 (2) (1984) 375-381.

[5] A.W.Schwab, M.O.Bagby and B.Freedman, Preparation and properties of diesel fuels from vegetable oils, Fuel, 66 (1987) 1372-1378.

[6] A.Srivastava and R. Prasad, Triglycerides-based diesel fuels, Renewable & Sustainable Energy Reviews, 4 (2000) 111-133.

[7] M. S. Graboski and R. L. McCornic, Combustion of fat and vegetable-oil revived fuels in diesel engines, Progress in Energy and Combustion Science, 24 (1998) 125-164.

[8] C. A. Sharp, S. A. Howell and J. Jobe, The effect of bio-diesel fuels on transient emissions from modern diesel engines, part-I regulated emissions and performance, SAE 2000-01-1967 (2000).

[9] R. McCornic, M. S. Graboski, A. M. Herring and T. L. Al-leman, Impact of biodiesel source material and chemical structure of emissions of criteria pollutants from a heavy duty engine, Environmental Science & Technology 35, (2001) 1742-1747.

[10] EPA Report, A comprehensive analysis of biodiesel impacts on exhaust emissions, Draft technical report, USEP agency (2002).

[11] D.Agarwal, S. Sinha and A. K. Agarwal, Experimental investigation of control of NOx emissions in biodiesel fueled compression ignition engine, Renewable Energy, 31 (2006) 2356-2369.

[12] C. Carraretto, A. Macor, A. Mirandola, A. Stoppato and S. Tonon, Biodiesel as alternative fuel: Experimental analysis and energetic evaluations, Energy, 29 (2004) 2195-2211.

[13]A. A. Aziz, Md. F. Said and Md. A. Awang, Performance of palm oil-based biodiesel fuels in a single cylinder direct injection engine, Palm Oil Developments, 42 (2005) 15-27.

[14]Y. V. H. Rao, R. S. Voleti, V. S. Hariharan and A. V. S. Raju, Jatropha oil methyl ester and its blends used as an alternative fuel in diesel engine, International Journal of Agricultural and Biological Engineering, 1 (2) (2008) 32-38.

[15]B. Baiju, M. K. Naik and L. M. Das, A comparative evaluation of compression ignition engine characteristics using methyl & ethyl esters of karanja oil, Renewable Energy, 34 (2009) 1616-1621.

[16]A. K. Agarwal, Biofuels (alcohols & biodiesel) applications as fuel for internal combustion engine, Progress in Energy and Combustion Science, 33 (2007) 233-271.

[17]H. Raheman and S. V. Ghadge, Performance of compression ignition engine with mahua (Madhuca indica) biodiesel, Fuel,86 (2007) 2568-2573.

[18] H. Raheman and S. V. Ghadge, Performance of diesel engine with biodiesel at varying compression ratio and ignition timing, Fuel,87 (2008) 2659-2666.

[19] M. J. Ramos, C. M. Fernandez, A. Casas, L. Rodrigez and A. Perez, Influence of fatty acid composition of raw materials on biodiesel properties, Bioresource Technology, 100 (2009) 261-268.

[20]V. Pradeep and R. P. Sharma, Use of HOT EGR for NOx control in a compression ignition engine fuelled with bio-diesel from Jatropha oil, Renewable Energy, 32 (2007) 1136-1154.

[21]B. S. Chauhan, N. Kumar and H. M. Cho, Performance and emission studies on an agriculture engine on neat Jatropha oil, Journal of Mechanical Science and Technology, 24 (2) (2010) 529-535.

[22]X. Shi, Y. Yu, H. He, S. Shuai, J. Wang and R. Li, Emission characteristics using methyl soya ethanol diesel fuel blends on a diesel engine, Fuel, 84 (2005) 1543-1549.

[23]A. C. Pinto, L. L. N. Guarieiro, J. C. Rezende, N. M. Ribeiro, E. A. Torres and E. A. Lopes, Biodiesel: an over-view, Journal of the Brazilian Chemical Society, 16 (2005) 1313-1330.

[24]C. D. Rakopoulos, D. T. Hountalas, T. C. Zannis and Y. A. Levendis, Operational and environmental evaluation of diesel engines burning oxygen-enriched fuels: a review, SAE 2004-01-2924 (2004).

[25] A. Monyem, J. H. Van Gerpen and M. Canakci, The effect of timing and oxidation on emissions from biodiesel-fueled engines, Transactions of the ASAE, 44 (2001) 35-42

[26]Shrivastava R. K., Saxena Neeta and Gautam Geeta, "Air pollution due to road transportation in India: A review on assessment and reduction strategies", Review Paper (NS2), Journal of Environmental Research and Development, Vol. 8 No. 1, July-September 2013.

[27]R. Sarathi, T.K. Sindhu, S.R. Chakravarthy, "Generation of nano aluminium powder through wire explosion process and its characterization", Mater. Charact. 58 (2007) 148–155.

[28]Arno Hahma, Alon Gany, Karri Palovuori, "Combustion of activated aluminium", Combustion and Flame, 145 (2006) 464–480.

[29]M.J. Kao, B.F. Lin, T. Tsung, "The study of high temperature reaction responding to diesel engine performance and exhaust emission by mixing aluminium nanofluid in diesel fuel", in: 18th Internal Combustion Engine Symposium Jeju, Korea, 2005.

[30]Yetter. RA., et al., "Metal particle combustion and nanotechnology", Proceedings of the Combustion Institute, 32 (2009), pp. 1819–1838.

[31]Tock.R.W., Hernandez., A, Sanders, J.K. & Yang.D.J., "Nano sized zinc oxide particles for fuel", US Pat8, 182,555 B2, united states patent 2012.

[32]Danilov, A.M., Fuel additives evolution and use in 1996- 2000, Chemistry and Technology of Fuel Oils, 2001, 37:445-55.

[33]Choi, Y., Lee, C., Hwang, Y., Park, M., Lee, J., Choi, C. and Jung, M., "Tribological behaviour of copper nanoparticles as additives in oil", Current Applied Physics, 2009, 9:e124-e27.

[34]S.Karthikeyan, A Elango,A Prathima, "An environmental effect of GSO Methyl Ester with ZNO additive fuelled marine engine", Indian Journal of Geo Marine Sciences, April 14.

[35][Prabhu L, S.Satish Kumar, A.Andrerson,K.Rajan, "Investigation on performance and emission analysis of TIO2 nanoparticle as an additive for bio-diesel blends", Journal of Chemical and pharmaceutical Sciences, Special Issue 7, pp 408-412, ISSN: 0974-2115, 2015.

[36]V. Arul Mozhi Selvan, R. B. Anand and M. Udayakumar, "Effects of cerium oxide nanoparticle addition in diesel and diesel-biodiesel-ethanol blends on the performance and emission characteristics of a CI engine", ARPN Journal of Engineering and Applied Sciences, ISSN 1819-6608, 2009.

[37]C.Syed Aalam, ,C.G. Saravanan,M. Kannan, "Experimental investigations on a CRDI system assisted diesel engine fuelled with aluminium oxide nanoparticles blended biodiesel", Alexandria Engineering Journal Volume 54, Issue 3, September2015.

[38]M.Santhanamuthu, S.Chittibabu, T.Tamizharasan and T.P.Mani, “Evaluation of CI engine performance fuelled by Diesel-Polanga oil blends doped with iron oxide nanoparticles”, International Journal of Chem Tech Research CODEN(USA): IJCRGG ISSN : 0974- 4290 Vol.6, No.2, pp 1299-1308, April-June 2014.

[39]T. Narasimhalu, Anand Hunshyal, Radhakrishnan Sankaran, “Effect of silver nano-particle blended biodiesel and swirl on the performance of diesel engine combustion”, International Journal of Sustainable and Green Energy, December 08, 2014.

[40]K. Balamurugan, A. Tamilvanan, M., “Nano-Copper additive for Reducing NOx Emission in Soya Bean Biodiesel-Fuelled CI Engine”, Journal of Biofuels, June 2013.

[41]Vishwajit A. Bhagwat, Chetan Pawar , N. R. Banapurmath, “Graphene Nanoparticle – Biodiesel Blended Diesel Engine”, International Journal of Engineering Research & Technology (IJERT), February-2015.