International Journal of Ambient Energy

ISSN: 0143-0750 (Print) 2162-8246 (Online) Journal homepage: http://www.tandfonline.com/loi/taen20

Investigation of Sapindus seed biodiesel with nano additive on single cylinder diesel engine

S Padmanabhan, T Vinoth Kumar, M Chandrasekaran & S Ganesan

To cite this article: S Padmanabhan, T Vinoth Kumar, M Chandrasekaran & S Ganesan (2018): Investigation of Sapindus seed biodiesel with nano additive on single cylinder diesel engine, International Journal of Ambient Energy, DOI: 10.1080/01430750.2018.1501755

To link to this article: https://doi.org/10.1080/01430750.2018.1501755

Accepted author version posted online: 17 Jul 2018.

Publisher: Taylor & Francis & Informa UK Limited, trading as Taylor & Francis Group

Journal: *International Journal of Ambient Energy*

DOI: 10.1080/01430750.2018.1501755

Investigation of Sapindus seed biodiesel with nano additive on single cylinder diesel engine

Padmanabhan.S[1], Vinoth Kumar T[2], Chandrasekaran M[3] and Ganesan S[4]

[1]Department of Automobile Engineering, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Chennai, India
[2,3] Department of Mechanical Engineering, Vels Institute of Science, Technology and Advanced Studies, Chennai, India.
[4] Department of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai, India.

Corresponding author: padmanabhan.ks@gmail.com

Abstract

In the agriculture and transportation sector, many bio-seed based biofuels have exposed to be a better replacement for fuels derivative from fossil fuels. In the Indian context, due to the energy needs, agricultural growth, surrounding degradation and rural development these biofuels have achieved an acknowledgment as an alternative. Biofuels derived from the bio seeds such as rubber seed oil, cottonseed oil, jatropha and rapeseed oil etc. can hold the carbon emissions from vehicles in an efficient and economical method. In this research paper, an attempt has been made with blends from bio-seed based Sapindus seed oil with nano additive as an alternative for diesel. Its performance and emission characteristics were investigated on the constant speed single cylinder CI engine and results were compared.

Keywords: Sapindus seed, Biofuel, Nano additive, Engine performance.

1. Introduction

Due to the industrial revolution in the past century, most problems of uncritical utilization of the energy resources have been challenged globally. The technical growth of most of the countries is related to more energy consumption, higher industrial improvement and less considered the efficient use of the sources of energy. Now a day's people are facing the major two problems of faster enervation of fossil fuels and environmental dispossession. Henceforth, the world needs to decrease dependency on petroleum derivative products for improved environment and economy. Development of bio-origin based alternative fuels can solve both these problems.

Mathiarasi R et al (2017), deliberated a novel catalyst for producing fatty acid methyl ester form soap nut oil for the alternative source. The catalyst used for transesterification process was residue collected from the coal boiler industries. Yi-Hung Chen et al (2013), has discoursed a production of soapnut based biofuel was enlightened and the blended and raw fuel properties also tested. The several volume ratios of soapnut oil were blended with diesel

and for its fuel properties was evaluated with the suitable conditions. Misra and Murthy (2011), was investigated the emission characteristics and performance analysis on single cylinder constant speed direct injection diesel engine with blended non-edible vegetable oil and soapnut oil was studied. Yuvarajan D et al (2017) was investigated the influence of pentanol with cashew nut shell biodiesel in diesel engine on its performance and emissions characteristics. He summarized that blending of 10% and 20% of pentanol to the cashew nut shell biodiesel, a substantial decrease in HC, NOx, CO and smoke emission was observed. Also, brake thermal efficiency increased with a slight decrease in brake specific fuel consumption.

Sai Sundaram et al (2018) was investigated the engine performance and emission characteristics of zirconia coated on single cylinder diesel engine on its cylinder liner and piston head. Cerium oxide additive nanoparticle was added to diesel with different ratios. The investigations show a noticeable change results in both uncoated and coated engines. Padmanabhan et al (2017) have conducted an experimental investigation to evaluate the emission characteristics and performance analysis of aloe-vera oil biodiesel blended with cerium oxide nanoparticle and results were compared with base results. Senthil Kumar et al (2017) carried out the engine performance analysis and emission investigation with pure cinnamon oil-based biodiesel and using cerium oxide as an oxidation catalyst. Ganesan et al (2018) were deliberated on the importance of nano-additives by improves the thermal efficiency and reducing the fuel consumption during combustion. His Investigation is to study the effect of nano additive of cerium oxide with Mentha longifolia biodiesel on single cylinder CI engine.

It was observed that many researchers have used a variety of biodiesel along with nano additive of cerium oxide in the investigation of emission characteristics and performance analysis of a wide range of diesel engines with little or without modification. In this research work, biofuel blends from Sapindus seed oil with nano additive is explored in its emission characteristics, performance analysis on a constant speed single cylinder diesel engine. Results were observed to find a substitute fuel by comparing with base pure diesel.

2. Sapindus seed oil and Nano additive

Sapindus seed has many applications from nourishing treatments as a soap and a chemical agent. It has an enormous amount of surfactant, hence Sapindus seed shells are in use as natural and home laundry detergents. It also used in bathing and ancient medicines. The oil from Sapindus seed has been extracted as a non-edible oil having a large prospective for biodiesel production from the seeds shells. The biodiesel has high density and viscosity compared to the fossil fuels. The transesterification process was introduced to decrease the density and viscosity and raise the combustion efficiency of the biofuel. The biodiesel produces considerably fewer emissions than conventional fuels when used in an internal combustion engine. But, it produces slightly higher levels of nitrogen oxides. The property of Sapindus seed oil is tabulated in table 1.

Table 1. Properties of Sapindus seed oil

Sl.No	Property	Values
1	Density	0.932g/cc
2	a s s s y	9.989cSt

3	Flashpoint by PMCC method	C
4	Firepoint by PMCC method	
5	Calorific value	38325 kJ/kg

A nano additive of cerium oxide (CeO2) was used as an oxygen improver in this research work. It offers the oxygen for the oxidation of carbon monoxide and absorbs oxygen for the reduction of nitrogen oxides. CeO2 additives in the biofuel grades into a green combustion and effectually diminish the spiteful exhaust gas emissions. Accumulation of cerium oxide in the nanosized form to diesel fuel causes an extensive reduction in number-weighted size distributions, and the oxidation level and light-off temperature are also increased in notable level. The properties of cerium oxide were listed in table 2.

Table 2. Properties of Cerium Oxide

Molecular formula	CeO_2
Molar mass	172.125 g/mol
Appearance	White or pale yellow solid, Slightly Hygroscopy
Density	7.215 g/cm^3
Melting point	2,400 °C (4,350 °F; 2,670 K)
Boiling point	3,500 °C (6,330 °F; 3,770 K)
Solubility in water	Insoluble
Crystal structure	Cubic (fluorite)

Biofuel of Sapindus seed oil is prepared in the different proportions of diesel and Sapindus seed oil with nano additive of cerium oxide in weight-based ratio. That is, B10 (D89%+Soapnut10%), B20 (D79%+Soapnut20%) and B30 (D69%+Soapnut30%) and cerium oxide were blended in all the biofuel blends with 1% on weight-based ratio.

3. Experimental Setup

A Constant speed Single cylinder, Direct Injection engine (Table 3) was used to examine the engine emission characteristics and performance analysis of the blended Sapindus seed oil with cerium oxide. The Single cylinder diesel engine evaluated under different engine load conditions with the predefined biofuel blends of Sapindus seed oil with cerium oxide. The investigational Single cylinder diesel engine was directly coupled with an eddy current dynamometer for varying the loads from zero loads (0%) to full load (100%). The engine loads are varied from zero load condition of 0%, 25%, 50%, 75% and full load condition of 100% manually with help of an eddy current dynamometer.

Table 3. Specifications of the Test Engine

Engine Type	4 Stroke, Single-Cylinder, Water Cooled Engine Stoke 110mm, Bore 87.5mm, 661 cc
Power	5.20 kW @ 1500 rpm
Compression ratio	17.5
Injection variation	0-25 deg bTDC
Dynamometer	Eddy current, Water cooled with Loading unit
Fuel tank	15 lit, Duel compartment with fuel metering

AVL five gas analyzer was used to assess the emission characteristics such as hydrocarbon, carbon monoxide, carbon dioxide and oxides of nitrogen standards from the exhaust gas emissions. The AVL smoke meter was involved in measuring the exhaust gas temperature and smoke density. The investigation was carried out for different blend proportions of Sapindus seed oil with cerium oxide. The performance investigation of the Constant speed DI Single cylinder diesel engine at different rated loads was assessed in terms of SFC, BTE and emissions parameters such as UBHC, CO, CO_2, and NOx.

4. Results and Discussions

A Single cylinder Direct Injection engine was used to examine the engine performance and emission characteristics of the different blends Sapindus seed oil with cerium oxide.

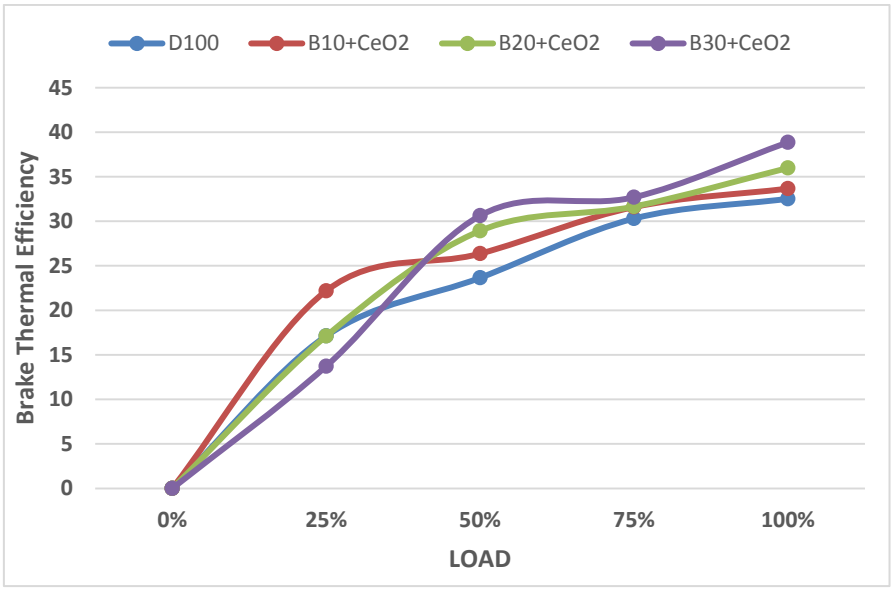

Fig. 1: Performance of Brake Thermal Efficiency by Sapindus seed oil with CeO_2

The performance of the brake thermal efficiency for different loads with diesel blended biofuel of Sapindus seed oil with cerium oxide was shown in Fig 1. The biofuel B30 shows higher brake thermal efficiency to that of the diesel performance with 19.5% increase in BTE at full load condition. In half load condition all the biofuel performed ahead of diesel, it is due to increase in the oxidation rate by cerium oxide.

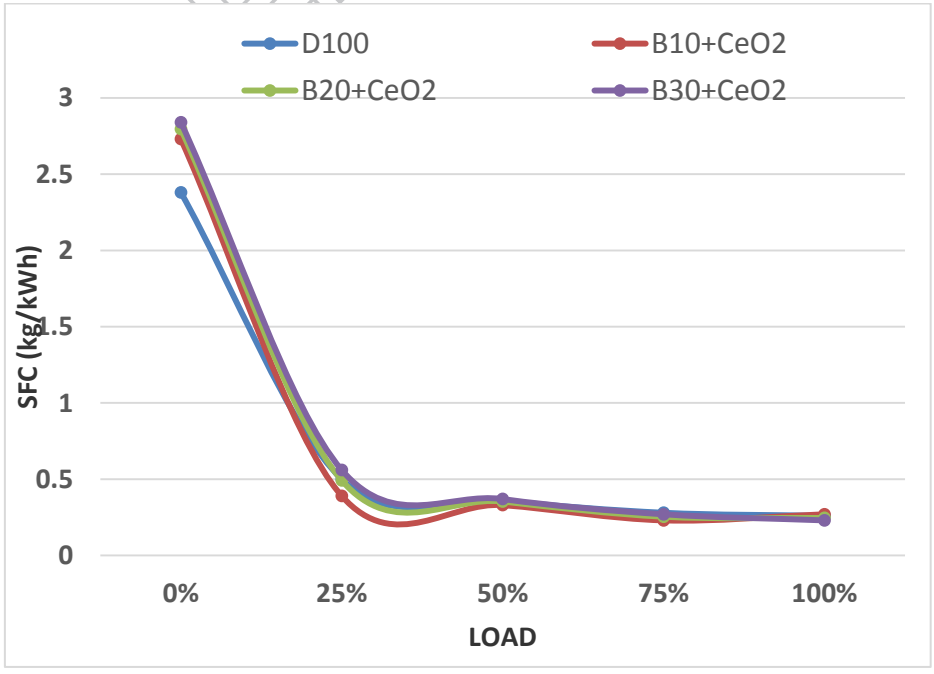

Fig 2: Performance of Specific Fuel Consumption by Sapindus seed oil with CeO_2

The Specific fuel oil consumption of blended oil is marginally greater than diesel. Fig 2 shows that the diesel has a lower Specific fuel oil consumption because of high calorific value. B20's the equivalent SFC was very close and B30 higher than base diesel fuel. It was perceived due to the lower calorific value and higher viscosity of the Sapindus seed biofuel.

In unburned hydrocarbon emission, B30 blend Sapindus seed oil was higher than all biofuel and diesel as shown in Fig 3. This is because of the lower calorific value of biofuel. In a base diesel, the oxygen-enriched the environment with complete combustion, lower unburned hydrocarbon emission was observed.

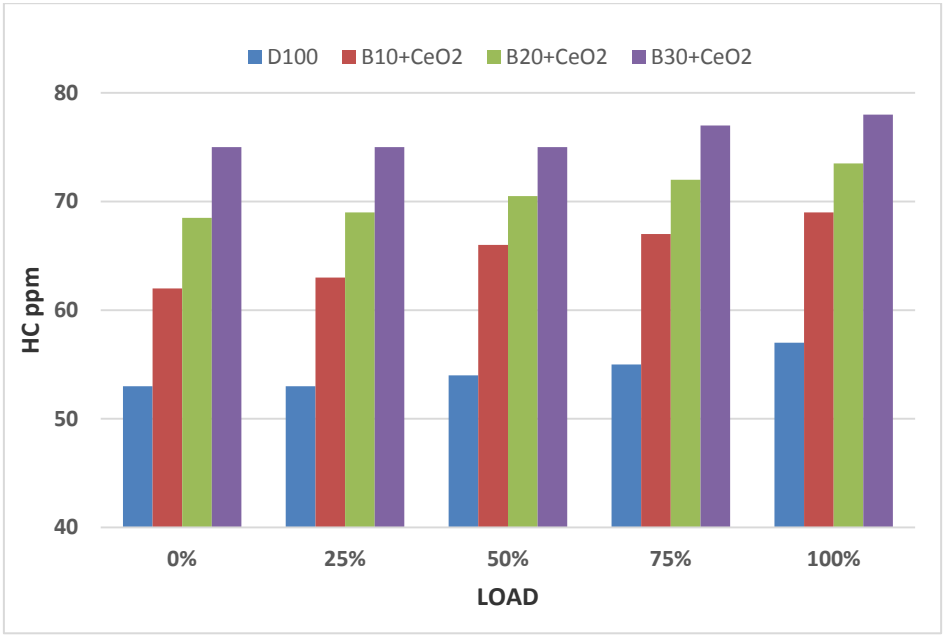

Fig 3: Emission Characteristics of HC by Sapindus seed oil blends with CeO_2

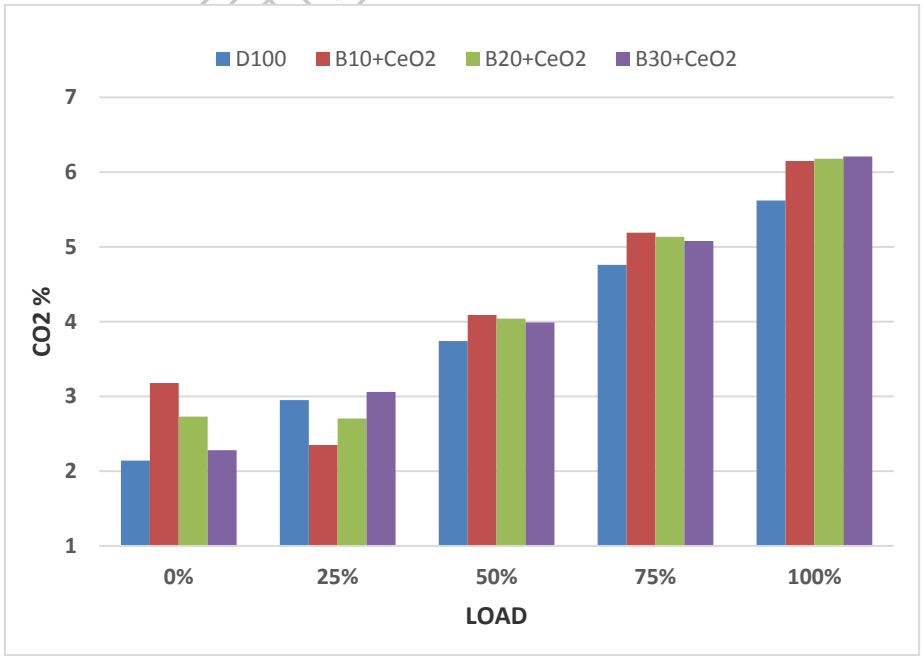

Fig. 4: Emission Characteristics ofCO_2 by Sapindus seed oil with CeO_2

The Carbon Dioxide percentage for varying blends were shown in Fig 4. From the evaluation, it was observed that emission of Caron dioxide is marginally higher than pure diesel. Blends of B10, B20, and B30 was observed with the same percentage of CO_2 for different loads.

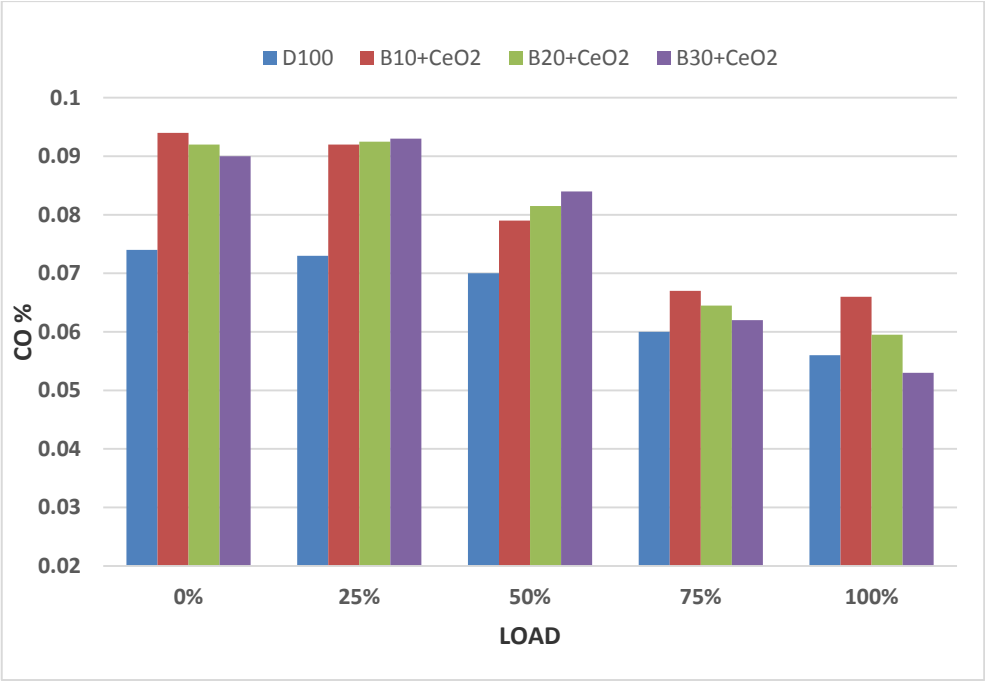

Fig. 5: Emission Characteristics of CO by Sapindus seed oil with CeO_2

The Carbon Monoxide emissions for varying loads were shown in Fig 5. In full load condition, B30 with cerium oxide shows a lower percentage of CO compared with all blends and base diesel. This is because of conversion of Carbon monoxide to dioxide in presence of cerium oxide.

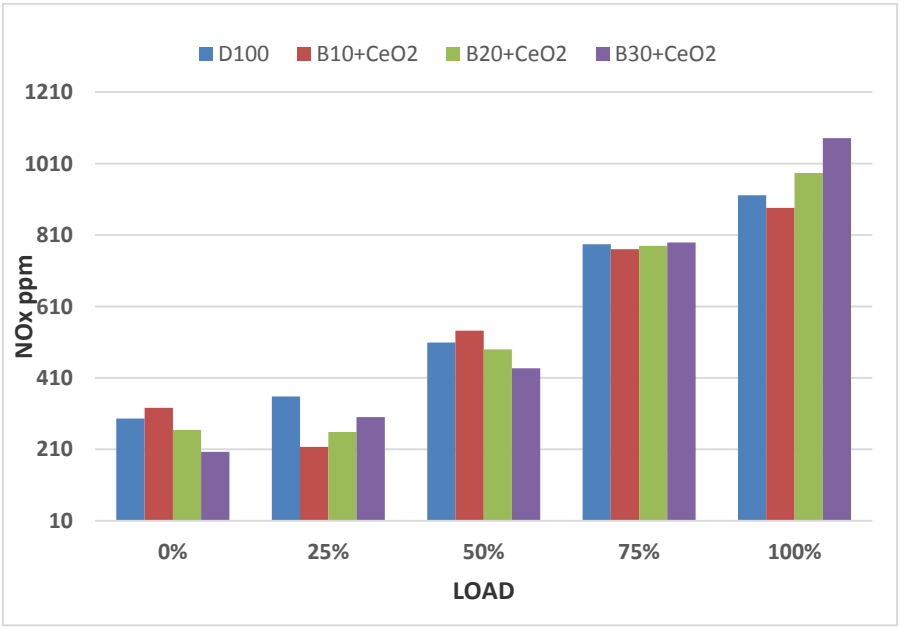

Fig. 6: Emission Characteristics of NO_X by Sapindus seed oil with CeO_2

Due to the increase in the combustion temperature, nitrogen oxide emission of Sapindus seed oil blends are slightly higher than the base diesel at maximum loads and it was shown in Fig 6. In half load and 75% load condition, blends of Sapindus seed oil with cerium oxide, the level of nitrogen oxide was very nearer to diesel.

5. Conclusion

An extensive research on Sapindus seed oil with cerium oxide additive was carried out in this paper. A nano additive of Cerium oxide used to oxygen catalyst on these biofuel blends and to improve the cetane number for enhanced combustion. All the performance and emission experimentations were supported without any modification on the engine. Based on the experimental investigations of the Sapindus seed oil biofuel blends with cerium oxide additive, it indicates a decent substitute fuel which gives good performance and better emission characteristics. Alternative fuels should be obtainable and affable at easily, should be environment-friendly and delivers the r gy ds w h u pr s g d s l g 's functional performance. This study also resulted in, the Sapindus seed oil is another new alternative in biofuel category which is atmosphere friendly.

References

[1]. Mathiarasi R, C. Mugesh kanna, N. Par ha (17), "Tra s s r f a f s ap u l us g l a alys ", J ur a l f Saud h al S y, V l 1, Is su 1 , pp 11–17.

[2]. Misra R.D., M.S. Mur hy (11) , "P r f r a , ss a d bus al ua of soapnut oil–diesel blends in a compression ignition engine", Fuel, Vol 90, pp 2514–2518.

[3]. Yi-Hung Chen, Tsung-Han Chiang, Jhih-H g h (1), "Pr p r s f s ap u (Sapindus mukorossi) oil biodiesel and its blends with diesel", Biomass and Bioenergy, Vol 52, pp 15–21.

[4]. S. Padmanabhan, S. Ganesan, Anipeddi Masen Venkata Anvesh & Bonthu Pradeep (2017) Influence of cerium oxide additive and aloe vera biodiesel on a CI engine, International Journal of Ambient Energy, 39:5,516-520, DOI: 10.1080/01430750.2017.1319418

[5]. V. S. Shaisundaram, M. Chandrasekaran, S. Mohan Raj & R. Muraliraja (2018) Investigation on the effect of thermal barrier coating at different dosing levels of cerium oxide nanoparticle fuel on diesel in a CI engine, International Journal of Ambient Energy, DOI: 10.1080/01430750.2018.1451385

[6]. S. Ganesan, S. Mahalingam, R. Arul Shyam Daniel Raj & S. Rajesh (2018) Effects of Nano additives on performance and emission characteristics of Mentha longifolia biodiesel, International Journal of Ambient Energy, DOI: 10.1080/01430750.2018.1456972

[7]. J. Senthil Kumar, S. Ganesan & K. S. Sridhar Raja (2017) Experimental analysis of the effects of cerium oxide nanoparticles on a single-cylinder diesel engine using biofuel blended with diesel as fuel, International Journal of Ambient Energy, DOI: 10.1080/01430750.2017.1410230

[8]. Yuvarajan Devarajan, Beem Kumar Nagappan, Dinesh Babu Munuswamy, (2017)"P r f r a e and emissions analysis on diesel engine fuelled with cashew nut shell b d s l a d p a l bl ds", r a J. h . E g., Spr g r, 34, Issue. 4, pp. 1021-1026.