Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Analysis of performance, combustion and emission parameters in di diesel engine by using mahua methyl ester along with nano metal additives titanium dioxide

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A R T I C L E I N F O

Article history:
Received 16 August 2020
Accepted 10 September 2020
Available online xxxx

Keywords:
Mahua oil methyl ester
Titanium dioxide
Ball Milling
Ultrasonication
Performance and Emission

A B S T R A C T

Current scenario is look at Non conventional alternative fuel source to decrease its dependence on the foreign import of various oils. Amongst all alternative fuel offered Mahua oil, in which is changed to bio - diesel by means of transesterification process. The adding up of nano-metal additive to biodiesel during a variety of form considerably improves the properties and it contributes to improved behaviour of diesel engine by reduced emission. The experimental work is done to found the behavior, combustion and emission characteristic in the diesel-engine by means of Biodiesel fuels and Nano-metal Additives Titanium Dioxide. The Bio diesel is prepared by transesterification processes, then powder metal oxide is converted in to nano form by means of ball milling, CTAB (Cetyl Trimethyl Ammonium Bromide) is taken as cationic agent, then known quantity of TiO_2 and CTAB Nano metal additives is mixed with the base fluid Mahua oil Methyl Ester (MOME) which is the biodiesel by Ultrasonication process. The blend which is obtained is tested by single cylinder four stroke diesel engines and can be noted that the adding of nano metal additive in the bio diesel improves the behavior, combustion and the emission characteristics of diesel-engine.

1. Introduction

In background of the fast reduction of fossil fuels and quick increasing of the diesel engine vehicles population, the necessity of Non conventional fuel like vegetable oil is turn into related stable with the inference of International Energy Agency, it will rised 42%. The various research works are doing for replacement of diesel fuel with proper alternative fuels like bio diesel [1]. The probably it is hypothetical that the crude oil and petroleum products spirit turn into very limited and costly to find and make [2]. Even though the fuel economy of engines is very much developed and rise in the various automobiles. An alternative fuel technology, the availability and it will turn into more ordinary in the upcoming decades. Another reason behind it to motivate the development of an alternative fuel to the I.C engine is worried more than the emission problem in the gasoline engine [3]. The collective with other air polluting system, a greater number of automobiles is main contributor to an air qualities issue in the world [4]. The other reason to alternative fuel growth is the fact that a more percentage of crude oil must import from various countries in which the control the more oil fields. Variation of the bio origin unconventional fuel can notice this issue [5]. These all were normally non petroleum and the results in the energy safety as well as surrounding benefits. It obtainable in one form to other form for many years [6–8].

2. Nano metal additives preparation

The properties of nanomaterials and Nanostructured materials were a wide classification of material, with microstructure modulated in 0 to 3D on the length scale < 100 nm. It all materials were atoms set in nano sized cluster in which turn into ingredient grains in the material. The conventional material having grain sizes varies as of microns to several mm and the contains numerous billion atoms in each [9]. The Nanometre sized grain contains around 900 atoms in each. It grains size reduces, lead to major rise in vol-

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https://doi.org/10.1016/j.matpr.2020.09.277
2214-7853/

Please cite this article as: M. Udaya Kumar, S. Sivaganesan, C. Dhanasekaran et al., Analysis of performance, combustion and emission parameters in di diesel engine by using mahua methyl ester along with nano metal additives titanium dioxide, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2020.09.277

ume fraction of the grain boundary. Its characteristics powerfully authority by physical and chemical properties of the material [10]. The Nanophase metal show noteworthy rises in elastic modulus and yield strength. It is also shown that the substantial attention in the making of the carbon nanostructure, in which were connected to famous Bucky ball. As well, use of the nano sized material as fillers to the composite material is creating interest. Particularly the polymer nano-composites [11]. These all materials were collected of the grains, in which change to include various atoms. The grains were typically unseen to the naked eye, based on the size. The conventional material has grain changeable sizes from 100′s of μm to mm [12–14]. The nanometre is an even small dimensions than the μm and it billionth (10–9) of meters. The nano crystalline materials have grains size of 1 to 100 nm. Plain mahua oil biodiesel is depicted in Fig. 1 and Titanium dioxide (TiO_2) Ultrasonicated with mahua oil biodiesel is shown in Fig. 2.

3. Process of ball milling

The powdered Titanium di oxide material is converted into Nano metal Additive using Ball Milling, then its particle size and crystal structure are analyzed via SEM test and Size distribution by Intensity.

The following will feature the graph taken before and after the milling process through size distribution by intensity, it can be clearly seen that before milling process the size of the powdered titanium dioxide varies significantly but in the second graph which is represented as after milling it can be seen that the distribution remains constant with the average size being 100 nm. The SEM test results shows the image of the particle before and after milling process with a change in the structure of the Titanium dioxide from powder to nano size as small as 100 nm. The distribution size of TiO_2 for the before and after milling are shown in the Fig. 3 and Fig. 4. The SEM images of TiO2 before and after milling were shown in the Fig. 5 and Fig. 6.

4. Experimental setup

Experiment was conducted in a 5HP (3.5 kW) 4 Stroke direct injection research in CI engine is chosen to examine the behavior and combustion uniqueness as shown in Figs. 1 & 2. The flow rate of air into engine was noted by sensor and fuel consumption is noted by burette method. Loading was applied on the engine by eddy current dynamometer. The experiment is done at various loads. Various sensors were utilized during the experiment to gather, store up and examine the data by the help of computerized data acquisition system (IC engine soft). An exhaust gas analyzer (AIRREX HG-550, 4Gas analyzer) is employed to compute CO, HC, NOX and CO_2 emissions. The combustion, performance and emission results obtained are tabulated. The details of Research engine are shown in the table 1. (see Fig. 7Fig. 8)

Fig. 1. Plain mahua oil biodiesel.

Fig. 2. Ultrasonicated mahua oil biodiesel.

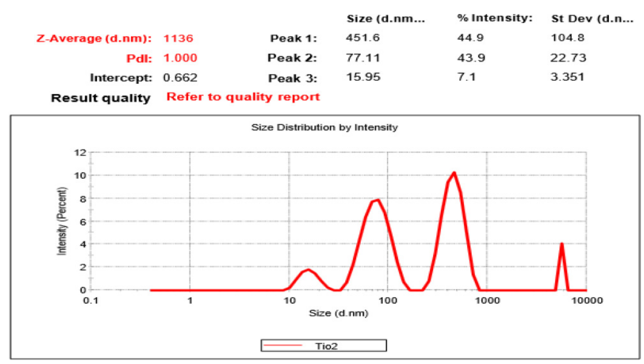

Fig. 3. Distribution size of TiO_2 (Before milling).

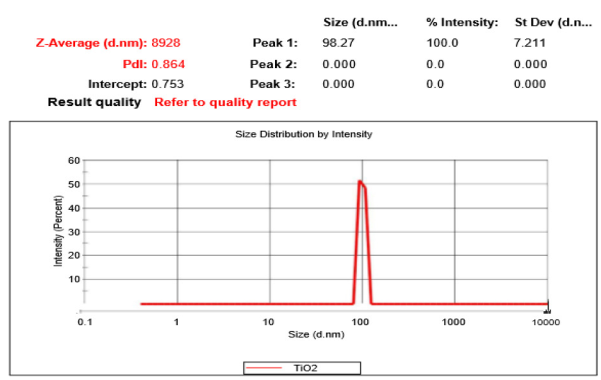

Fig. 4. Distribution size of TiO_2 (After milling).

Fumes gas analyzer was utilized toward discover CO (%vol), NOx (ppm), CO_2 (%) and UBHC (ppm) emanation in fumes. The smoke meter of AVL is utilized for gauge mistiness in fumes gas. Mistiness is eradication of light stuck between light sources as well as collector. Mistiness was estimated in the rate. The emission regulation of IC engine was the dimension requirement concerning resolution and the accuracy is receiving more namely reliability, robustness and durability tests are the major factor. The dimension challenge of the engine with the exhaust after treatment system

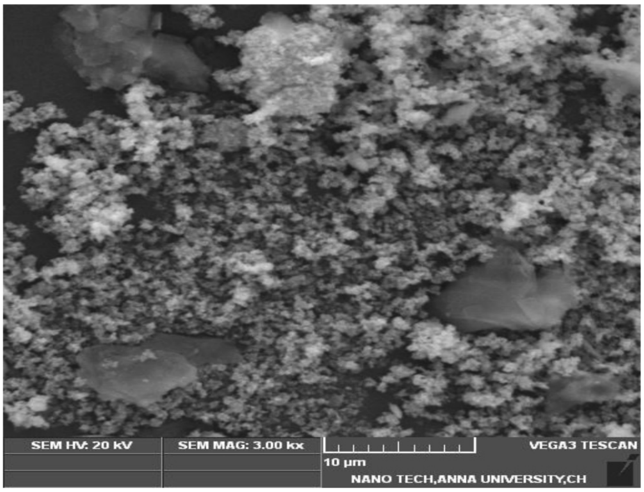

Fig. 5. TiO_2 SEM image (before milling).

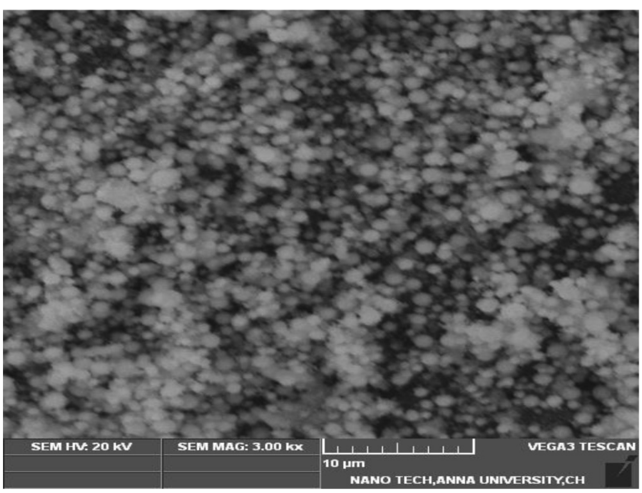

Fig. 6. TiO_2 SEM image (After milling).

was more temperature and pressures at the exhaust sample position joint with higher emission rate. In addition, the engine produces scarcely any soot behind the diesel particles filter it which need less detection limit to the particle measurements device.

5. Results & discussion

5.1. Performance parameters

The major performance namely Brake Power, Specific Fuel Consumption and the Brake thermal efficiency (BTHE) are evaluated for B100, B100 + 75PPM TiO2, B100 + 150PPM TiO2.

5.1.1. Brake thermal efficiency

BTHE is the ratio of thermal energy in the fuel to energy deliver by means of engine in crankshaft. It importantly depends on the way by energy is changed to efficiency in normalized way to calorific value of fuel. The BTHE shows the capability of combustion systems to collect an experimental fuel and offers similar by assess the efficient energy in fuel could transformed to mechanical output.

The work is for that various tests fuel BTHE improved with improves in the BP. Fig. 9 indicates that the changes of BTHE and BP of Mahua methyl ester at various combinations nano additives comparing with diesel. MOME. B100 + 150 ppm titanium dioxide (28.32%) shows BTHE similar to diesel (29.54%) at max load. The oxides metal nano particles available in biodiesel blends promote the entire combustions, while compare to individual biodiesel blends.

Table 1
Specification of engine.

Engine parameter	Specification
Make	APEX INNOVATION Pvt. ltd
Model	TV1 - Four stroke
No of cylinder	1
Bore – Stroke	88.5 mm – 115 mm
Power	5 HP @ 1550 rpm
Cc	660 cc
Cooling type	Water cooling
Compression Ratio	12 to18
Injection timing range	0–25 BTDC
Loading	Eddy current dynamometer
Data acquisition apparatus	NI USB – 6220, 16 bit, 250 kS/s.
Temperatures sensors	Thermocouple, RTD and PT100
Load sensors	Strain gauge, Load cell, range of 0 to 55 Kg

5.1.1.1. Specific fuel consumption. The deviation of SFC with brake power of MOME modified biodiesel with different dosage level of nano additives comparing with diesel. Corresponding to BP is shown in Fig. 10. SFC was reducing while increasing BP. At full loads, SFC is higher for B100 (0.31 kg/kWh) than adding nano particles but it attains 10% lower value for B100 + 150 ppm TiO2 and diesel (0.28 kg/kWh). The nano additive oxidizes the carbon settled in engine cylinders to minimized the fuel consumptions.

5.2. Combustion characteristics

The major parameters that influence the combustion inside the cylinder is heat release rate and cylinder pressures.

5.2.1. Cylinder pressure with crank angle

The cylinder pressures with the crank angle of B100 blends and customized bio-diesel blend with various dose levels of nano metal additives at various engine load condition are shown in Fig. 11. Peak pressures attain for diesel (67.2 bar) and B100 + 75 ppm TiO2 blend (59.62 bar). This may be adding of TiO2 tend to decrease the ignition delay and the enhances in combustion.

5.2.2. Net heat release rate

The change of the net heat releases rate with the crank angle of B100 blend and modified blends at various engine working conditions as shown in Fig. 12. NHR is increased the adding of the nanoparticle because of increase more carbon combustions establishment and therefore promote the complete combustions.

5.3. Emission characteristics

The major emissions of engine are unburned nitrogen oxides (NOx), HC (Hydro carbons), CO (carbon monoxide) and carbon dioxide (CO_2) particulate matter from IC engines. The special effects of nano additives in emissions of B100 blend of MOME are discussed here.

5.3.1. Hydro carbon (HC) emission

The variation of Hydro carbon by Brake Power for all modified blends is shown in Fig. 13. The HC increases with BP for the entire blend. Though HC emission is significantly minimized with adding high ppm nano particles. Fundamentally, oxygen fuel content is main reason for hydro carbon emissions reduction. May be addition of TiO_2 improves the combustion by excess oxygen.

Fig. 7. Experimental arrangement of engine.

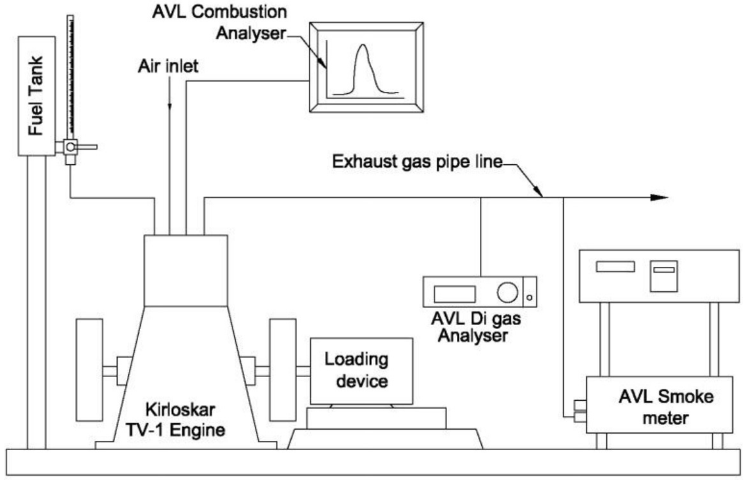

Fig. 8. Experimental setup schematic diagram.

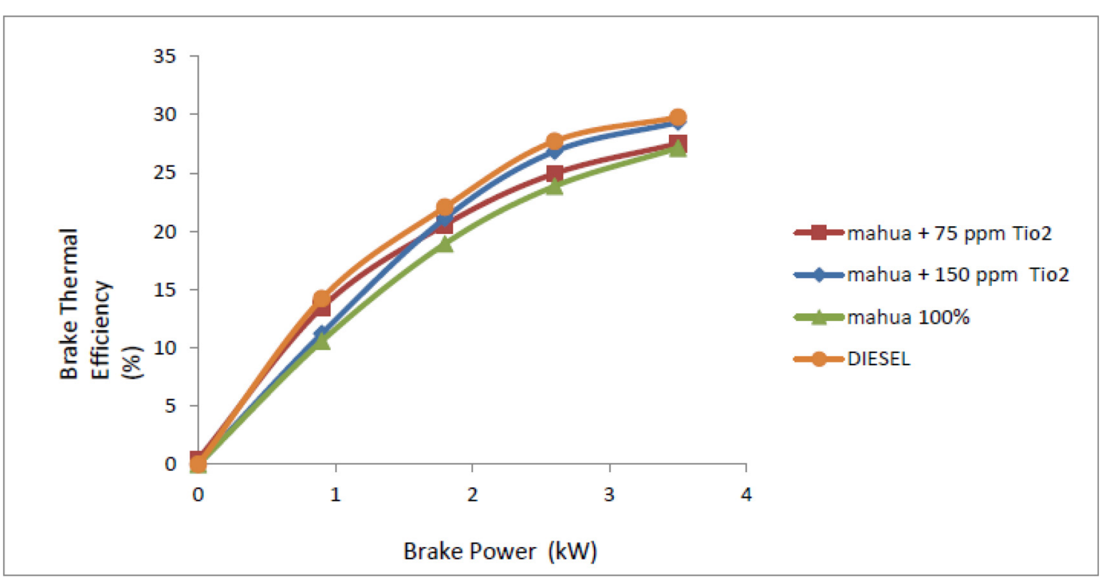

Fig. 9. Brake thermal efficiency vs Brake power.

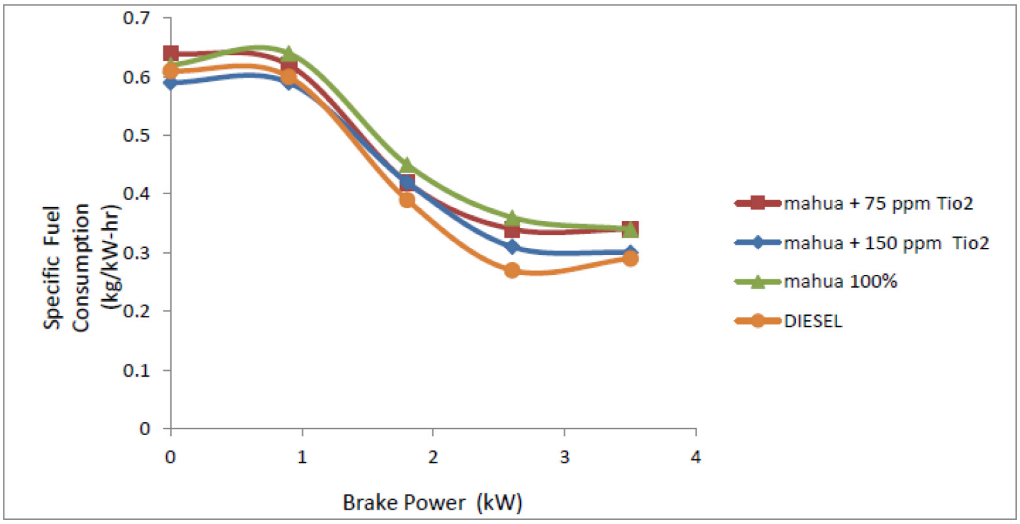

Fig. 10. SFC vs brake power.

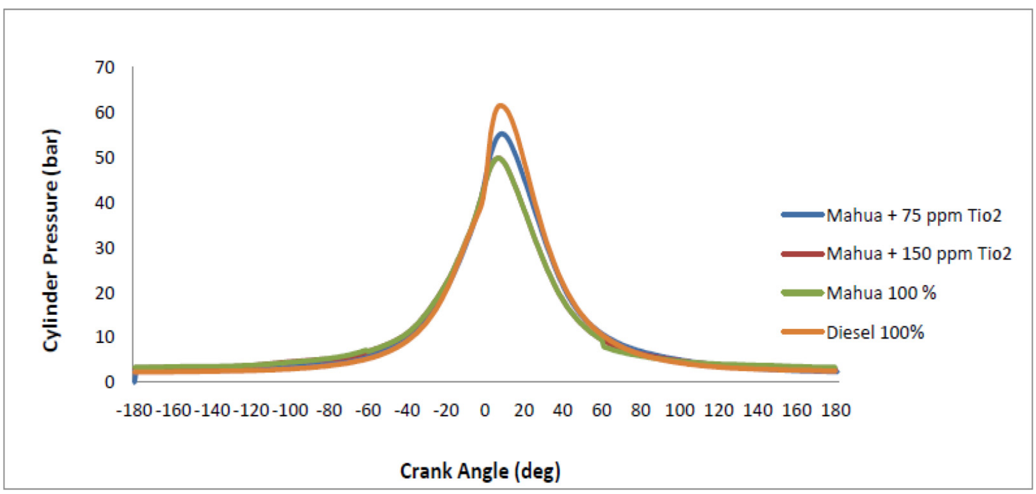

Fig. 11. Cylinder pressures with crank angle.

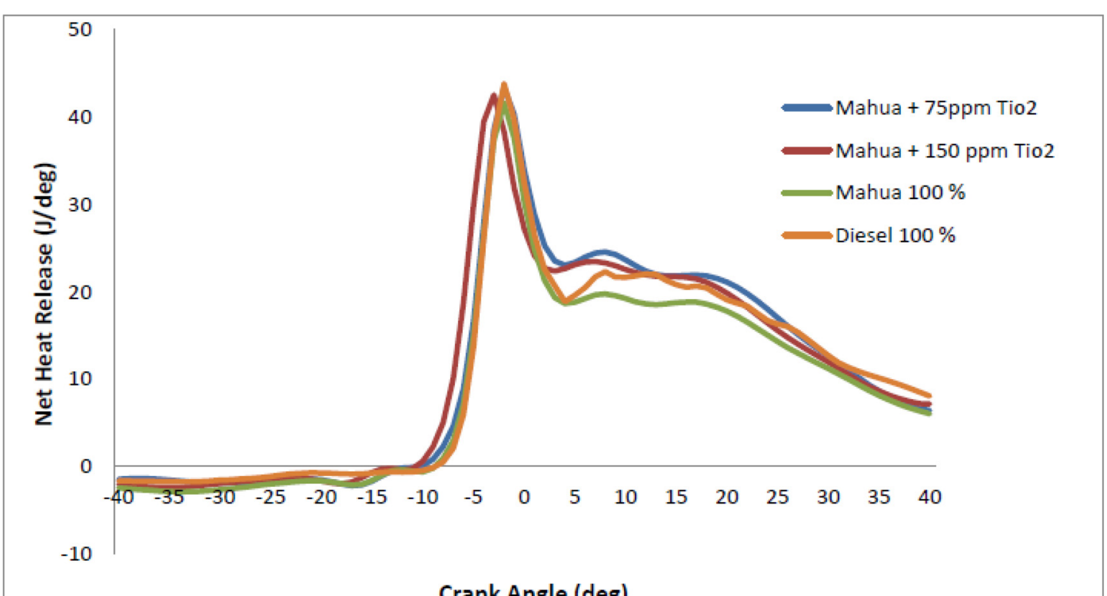

Fig. 12. Net heat release rate with crank angle.

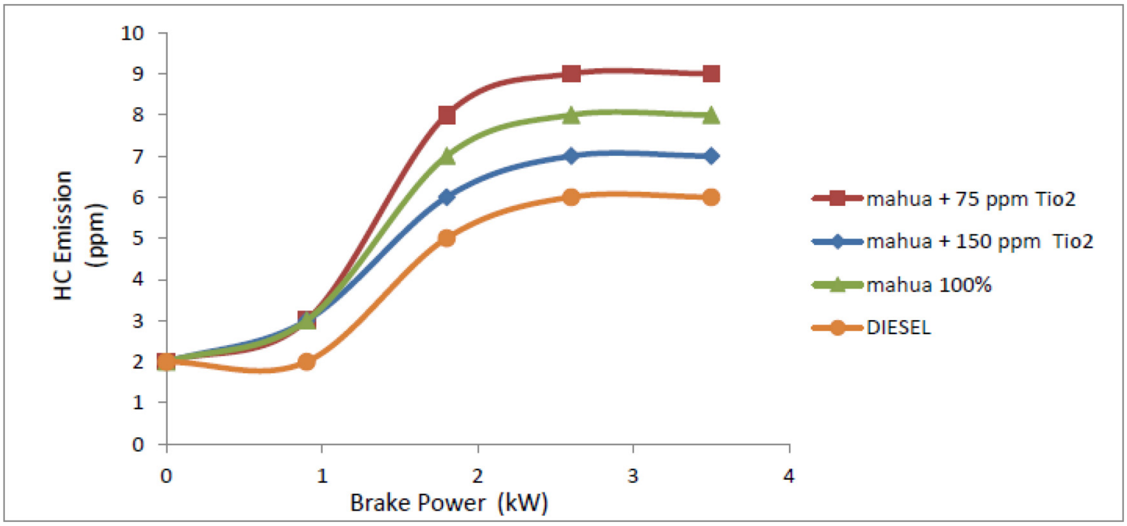

Fig. 13. HC emission vs brake power.

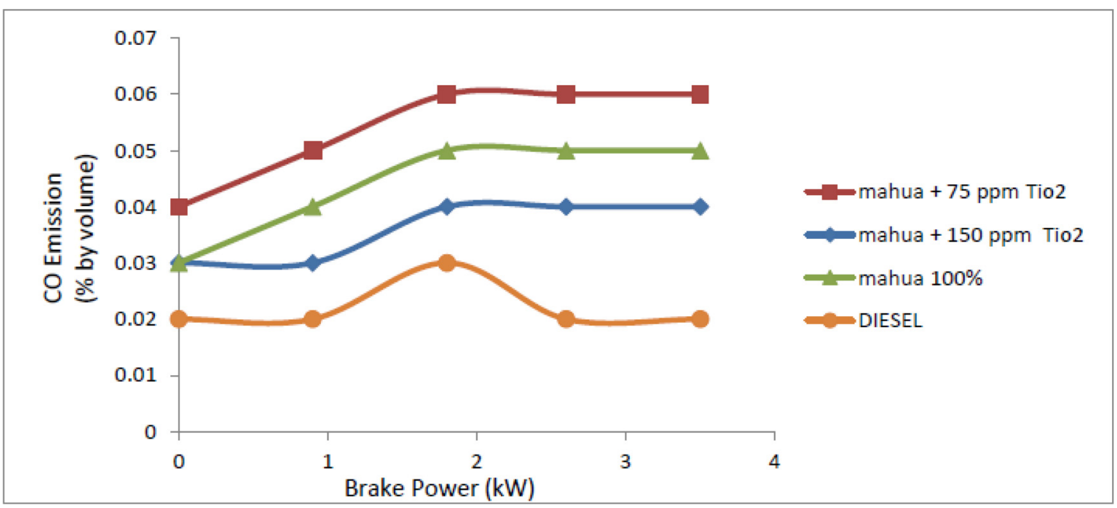

Fig. 14. CO emission vs brake power.

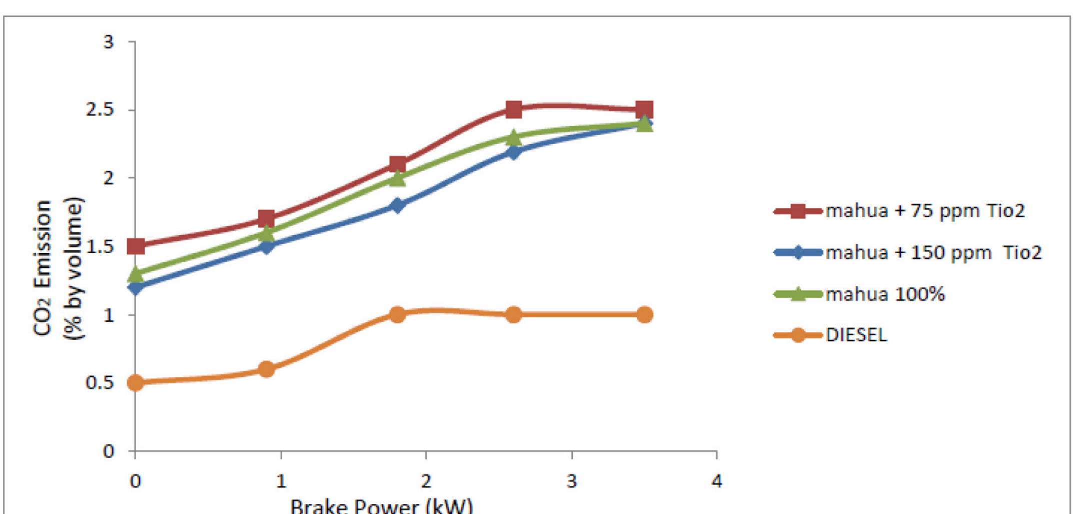

Fig. 15. Carbon dioxide emission vs brake power.

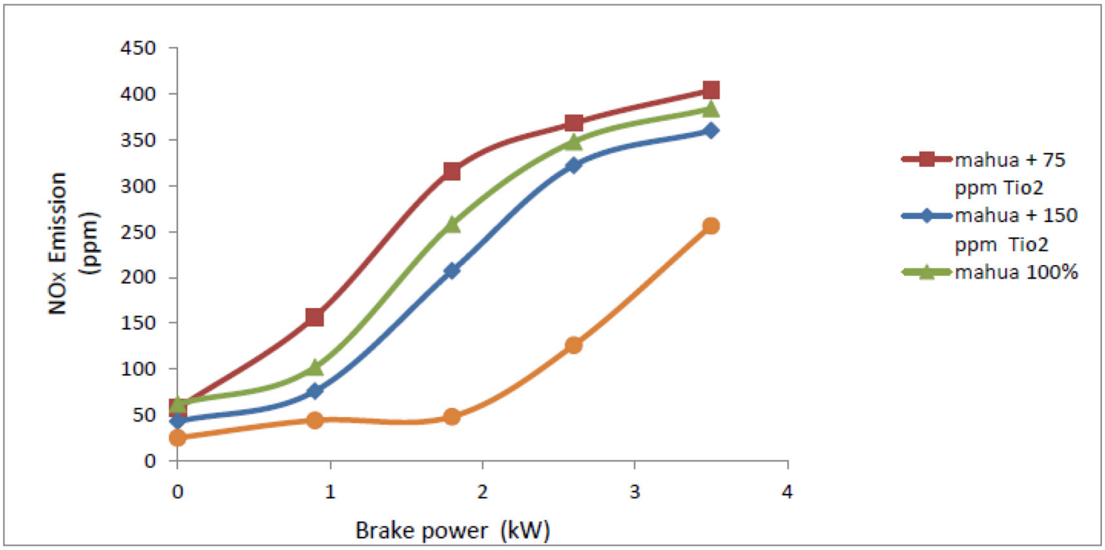

Fig. 16. NOx emission vs brake power.

5.3.2. Carbon monoxide emission

The influence of the additives to biodiesel on CO emissions is shown in Fig. 14. CO emissions are increasing while increasing the BP for all the blends. Hence CO emissions shows lower values for B100 blend adding TiO2 additives. This may be combustion improvement due to adding TiO_2. Because of incomplete combustion causes CO emissions.

5.3.3. Carbon di-oxide emission

The different of CO_2 by BP for various combinations of B100 blend is shown in Fig. 15. It is clearly explaining that conventional diesel having lesser CO_2 emissions than biodiesel blends. Hence the addition of nano particles increases CO_2 emissions.

5.3.4. NO_X emission

The changes of nitrogen oxides along with brake power to different blends of the bio - diesel is illustrated in the Fig. 16. Nitrogen oxides are mainly formed due to high temperatures. NO_X is increasing with brake power however diesel values are lower than B100 blend having nano particles. B100 + 75 ppm TiO_2 shows higher values.

6. Conclusion

The experimental study is done to examine the special effects of Titanium dioxide (TiO_2) Nano particles as additives for Mahua Oil Methyl Ester on the performance, combustion and emission characteristics of the CI engine, based on experiments the BTHE is approximately same to diesel and Mahua oil methyl ester blended along with titanium dioxide (150 ppm). By using Mahua Oil Methyl Ester blended with titanium dioxide (150 ppm) carbon monoxide emission is minimized when compared to the other blend. Mahua oil methyl ester blended with titanium dioxide (75 ppm) has higher NOx emissions. NOx emissions of Mahua oil methyl ester blended with titanium dioxide (150 ppm) has lesser NOx emission when compared with other blends. On the whole it is concluded that 150 ppm of Titanium dioxide can be utilized as an additive which show the reduced emission and well-matched performance and combustion uniqueness with Mahua Oil Methyl Ester.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] R.D. Misra, M.S. Murthy, Performance, emission and combustion evaluation of soapnut oil–diesel blends in a compression ignition engine, Fuel 90 (7) (2011) 2514–2518.
[2] M.M. Rahman, M.H. Hassan, M.A. Kalam, A.E. Atabani, L.A. Memon, S.M.A. Rahman, Performance and emission analysis of Jatropha curcas and Moringa oleifera methyl ester fuel blends in a multi-cylinder diesel engine, J. Cleaner Prod. 65 (2014) 304–310.
[3] S. Senthil Kumar, K. Purushothaman. (2012), "High FFA rubber seed oil as an alternative fuel for diesel engine – An overview" Int. J. Eng. Sci. ISBN: 2319-6483, ISSN: 2278-4721, Vol. 1, Issue 10, pp.16-24.
[4] S. Sivaganesan, M. Chandrasekaran, The influence of thermal barrier coating on the combustion and exhaust emission in turpentine oil powered DI diesel engine, ARPN J. Eng. Appl. Sci. 10 (22) (2015) 10548–10554.
[5] Y.-H. Chen, T.-H. Chiang, J.-H. Chen, Properties of soapnut (Sapindus mukorossi) oil biodiesel and its blends with diesel, Biomass Bioenergy 52 (2013) 15–21.
[6] S. Sivaganesan, C. Dhanasekaran, A. Parthiban, R. Pugazhenthi, Comparison of performance and emission characteristics of mahua and jatropha methyl ester with bioadditive in VCR engine, Int. J. Mech. Eng. Technol. 10 (01) (2019) 725–734.
[7] S. Sivaganesan, M. Chandrasekaran, M. Ruban, The influence of bio additive on the various compression ratio with diesel and mahua methyl ester biodiesel in DI diesel engine, J. Adv. Res. Dynam. Control Syst. 04 (2017) 210–217.
[8] S. Sivaganesan, M. Chandrasekaran, The influence of bio additive on the compression ignition engine with diesel and mahua methyl ester biodiesel, Int. J. Chem. Sci. 14 (4) (2016) 3097–3106.
[9] Jyothi Phaneendra (2016), "Experimental investigation of CI engine performance and emissions of soap nut seed oil as biodiesel" I J C T A, 9(25), 2016, pp. 407-415.
[10] S. Abdalla, Reem AL-wafi, A. Pizzi "Stability and combustion of metal nano-particles and their additive impact with diesel and biodiesel"- J. Renew. Sustain. Energy 022701 (2017).
[11] R. Bharathiraja, N. Praveen kumar "Study on characteristics of CI engine using nano additives blended diesel fuel"- Int. J. Appl. Eng. Res., ISSN 0973-4562 VOL.10 (2015).
[12] Sudheer nandi "Performance of C.I Engine by using Bio diesel-Mahua oil" – Am. J. Eng. Res., ISSN 2320-0936 (2013).
[13] Shaafi Tajudeen, R. Velraj "Nanoadditives: Enhancement of combustion and performance characteristics of a C.I Diesel Engine" – Int. J. Appl. Environ. Sci., ISSN 0973-6077 VOL.9 (2014).

Further reading

[14] C. Syed Aalam, C.G. Saravanan, Effects of nano metal oxide blended Mahua biodiesel on CRDI diesel engine, Ain Shams Eng. J. (2015).