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Evaluation of Tail Pipe Exhaust CO Emissions with Variations in Cerium Oxide Nano Particle and Madhuca Indica Biodiesel

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Abstract

In the current research work, attempt was made to evaluate the tail pipe exhaust CO emission deviations through cerium oxide (CeO_2) nano particle involvement in Madhuca indica biodiesel (MIB). The Madhuca indica biodiesel is extracted from the seeds of the corresponding plant, and then it is processed to derive the biodiesel. The derived biodiesel is then blended with the normal diesel fuel with different propositions. The amount of CO emission percentage variation of the biodiesel blends was compared with the diesel. All the results obtained have greater emissions content. The obtained emission levels can be reduced by the influence of the cerium oxide (CeO_2) nano particle with 100 ppm power. Then, the nano fluid is mixed and blended together to evaluate the CO emissions, which are then compared with the diesel fuel emission. Finally, after the experiments, it was observed that low CO emissions were emitted with the addition of biodiesel blend with cerium oxide (CeO_2) nano particle and recommended for the usage and might reduce the effect of cancer and direct eye irritants that cause an allergic response in humans and animals.

Subject Areas

Mechanical Engineering, Transportation Engineering

Keywords

IC Engine, Madhuca Indica Oil, Biodiesel, Cerium Oxide, CO Emission

1. Introduction

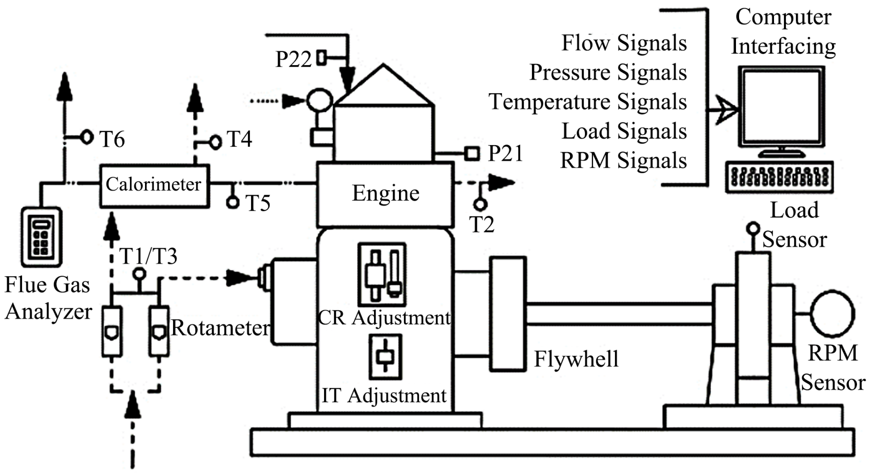
Among the world, CO emissions are mostly formed by automobile vehicles such as light or heavy-duty vehicles, CO creates considerable impact on the environment in addition to living organisms in environment. CO emission leads to the greenhouse effect and it will produce the global warming and change of climate also. It leads to augmentation of the temperature of seas, develops the activity of rainstorms, and finally produces the malfunction of the nature.

There are a number of diesels that were formed for human usage along with living things. Inhaling of CO reduces the amount of the oxygen content in the body that will affect the flow of blood to the main organs like brine, heart and etc., it will affect lugs also. It will create mental confusion, dizziness, fatigue, and headaches and may cause death also. There are so many studies going on for reduction of the CO emission towards the standards of the Europe as well as Bharat stages. Recently, further focus on the consumption of vigorous nanoparticles (NPs) as a savory or catalyst in gasoline due to their exceptional heat capability and catalytic parameter, which display uniform allocation and steady suspension over a time period. Amongst the additives, cerium dioxide (CeO_2) has individual thermodynamic property, which comprises theoretically positive high thermal conductivity properties [1], rapid ignition delay [2], improved catalytic action and enhanced reaction speed [3]. In this concern, Dale *et al.* [4] inspected the consequences of CeO_2 from diesel engine. Mirzajanzadeh *et al.* [5] have worked on the diesel, which comprises cerium oxides on different carbon nanotubes of 90, 60 and 30 ppm in 20% and 5% of left-over cooking oil—biodiesel and similar method has been implemented and used as fossil fuels in diesel engines. Bhatt *et al.* [6] have inspected on Mahua oil—methyl ester, one of the alternate fuels in regard to diesel in the diesel engines, which had more modifications done for the purpose of research and concluded that 20% Mahua biodiesel could be utilized certainly in diesel engines exclusive of any modification in brake power. Navada *et al.* [7] utilized an additional stabilizer to perform experimental test on the emission and performance characteristics of the *M. longifolia* methyl ester. Proper diesel content and diesel content mixed with *M. longifolia* biodiesel with proportions of 5%, 10%, and 15% dimethyl carbonate as additives were implemented after the tests. It was noticed that diesel has higher brake thermal efficiency (BTE) with more CO emissions when compared to *M. longifolia* biodiesel with less CO emissions. A proportion of *M. longifolia* biodiesel and brake thermal efficiency (BTE) both marginally raised with use of additives. The current research work is related to the reduction of CO emission by the implementation of biodiesel with cerium oxide nano particles.

2. Experimental Procedure

Figure 1 shows the representation of the engine setup layout. The research was performed on a diesel engine test rig located at Aravind Engineering Private Limited, Hyderabad, which is 4-cylinder-inline, turbocharged with common rail system. This engine works on Euro 4 emission standards with a ranked torque of 300 Nm @ 500 - 750 rpm, with other requirements listed in **Table 1**. The engine was attached to an internal hydraulic dynamometer which is electronically controlled and with an attachment of turbocharger, which energies the compressed air into the cylinder. The quantity of air delivered, besides other constraints such as temperature of the air inside the cylinder, subsequently compression, being above the self-ignition temperature of the fuel to provide the ignition source. Biodiesel extracted through oil of Madhuca indica is named as Madhuca indica biodiesel (MIB). The blending combinations were created based on the volume percentage.

(a)



(b)

Figure 1. (a) Experimental setup of engine test; (b) Graphical setup for engine test.

Table 1. Specification of experimental setup.

Configuration	In-line, 4-cylinder, 4-stroke, diesel engine
Aspiration	Turbocharged, charge air cooled
Displacement	4.2 L
Bore vs Stroke	102 mm × 120 mm
Fuel system	Common rail system (CRS)
Rated power	160 hp @ 2000 rpm
Rated torque	300 Nm @ 500 rpm to 750 rpm
Emission norms	Euro 4

The fuel samples were developed under different volumetric compositions as follows:

- 10% of Madhuca indica biodiesel and 90% of diesel blend named as MIB10 D90.
- 15% of Madhuca indica biodiesel and 85% of diesel blend named as MIB15 D85.
- 20% of Madhuca indica biodiesel and 80% of diesel blend named as MIB20 D80.
- 25% of Madhuca indica biodiesel and 75% of diesel blend named as MIB25 D75.
- 30% of Madhuca indica biodiesel and 70% of diesel blend named as MIB30 D70.
- 100% of diesel is named as D100.

All the blends have used in the diesel engine test setup and corresponding CO emission were measured by AVL gas analyzer. 100 ppm of CeO_2 nano particle added with all the blends and corresponding CO emissions were measured. Then, the CO emission of blend with and without nanoparticles was compared with the results of the individual diesel by the percentage valuation and finally, experiments were accompanied individually by withdrawing the complete fuel residual in the tank at the finish of each experiment. After advancing additional fuel to the tank, the engine was legitimate to operate for another 20 minutes; this was to eradicate the remaining fuel inside the source pipes and also filters.

Scanning electron microscopy (SEM) was used to determine the mole fraction of the CeO_2 prior to functionalization and images obtained showed that structure of CeO_2 was in order for the experimentation along with madhuca indica biodesiel (**Figure 2**).

Figure 2. Scanning electron microscopy (SEM) micrographs of amidated CeO_2.

3. Results

Once the engine is first set off, black smoke from the exhaust is witnessed, which occurs regularly due to the reality that inadequate air is being delivered at this period for full combustion. In this situation, nano fuels observed the lowest dilution of smoke emission as compared to D100. This reduction in the formation of smoke generally depends on characteristics such as inadequate oxygen, air fuel combination, fuel atomization and physio-chemical properties such as viscosity and volatility.

Addition of biodiesel fuels to the CeO_2 resulted in the increase of the peak heat discharge rate, which was justified by the extraordinary thermal conductivity and robust catalytic movement of CeO_2 nano particles, and therefore resulted in rapid fuel dehydration and diffusion. Comparable drop in the CO emission was seen in the case of jatropha biodiesel with diesel engine, and methyl ester.

D100 has 0.605% of CO emission at full load. Figure 3 undoubtedly declares about the CO (%) emission blends of MIB without CeO_2 nano particle. The blends MIB10 D90, MIB15 D8, MIB20 D80, MIB25 D75 and MIB30 D70 have created 1.2%, 1.4425%, 1.685%, 2.38% and 3.075% of CO emission at maximum load condition.

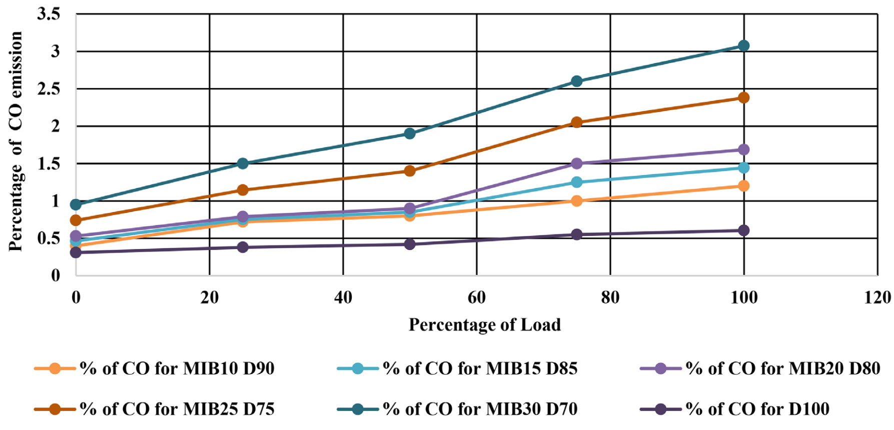


Figure 3. CO (%) emission blends of MIB without CeO_2 nano particle.

Figure 4 illustrates the increased percentage of CO emission blends of MIB without CeO_2 nano particle with respect to the CO emission of the diesel. The blends MIB10 D90, MIB15 D8, MIB20 D80, MIB25 D75 and MIB30 D70 have produced 98%, 138%, 179%, 293% and 408% of increased CO emission than diesel emission.

Similarly, from Figure 5, it can be observed the CO emissions from the blends of MIB (Madhuca indica biodiesel) with 100 ppm of CeO_2 nano particle. 0.600%, 0.577%, 0.590%, 0.833% and 1.076% of CO emission were observed by MIB10 D90, MIB15 D8, MIB20 D80, MIB25 D75 and MIB30 D70 blends with 100 ppm of CeO_2 nano particle. Figure 6 points out that there is an increase in the percentage of CO (%) emission blends of MIB with 100 ppm of CeO_2 nano particle with respect to diesel.

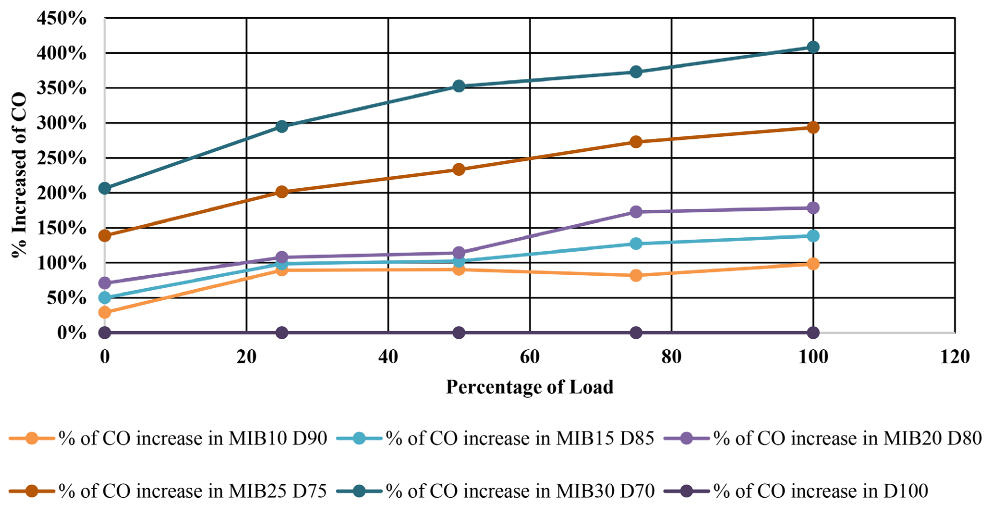


Figure 4. Increased percentage of CO (%) emission blends of MIB without CeO_2 nano particle with respect to diesel.

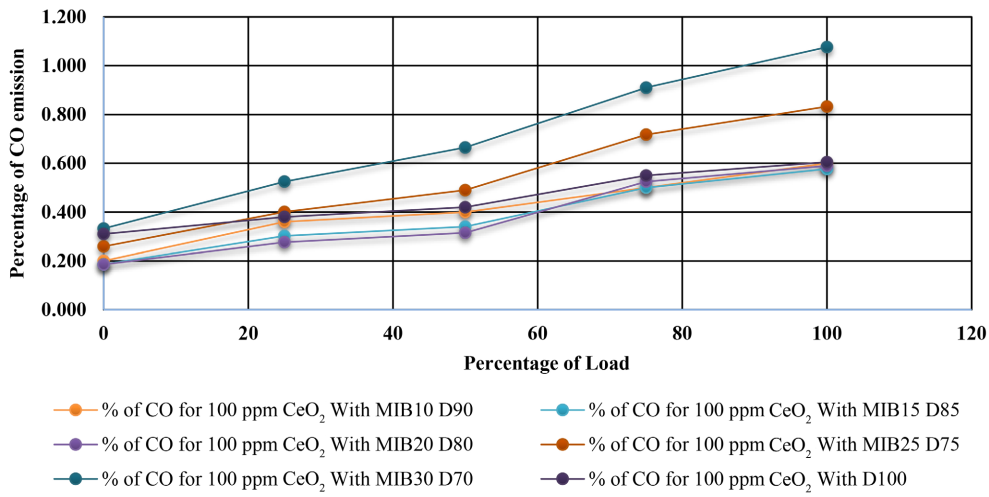


Figure 5. CO (%) emission blends of MIB with 100 ppm of CeO_2 nano particle.

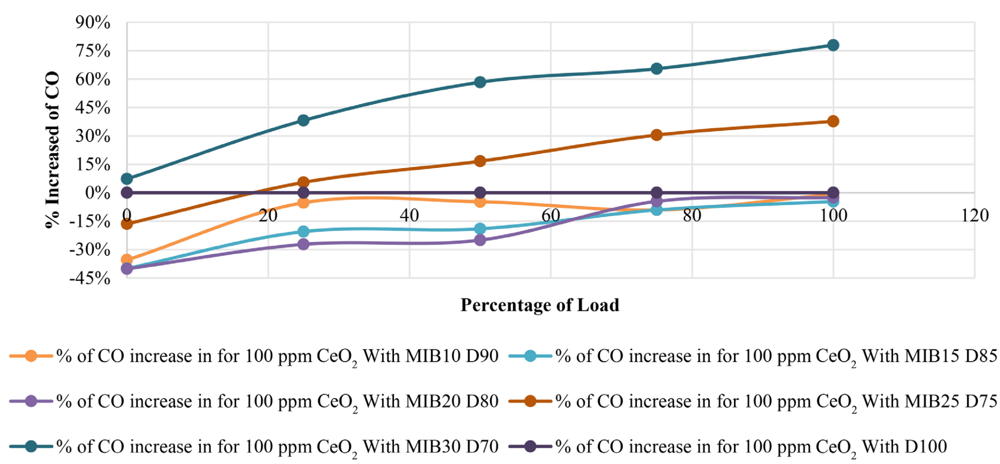


Figure 6. Increased percentage of CO (%) emission blends of MIB with 100 ppm of CeO_2 nano particle with respect to diesel.

1%, 5% and 3% of lesser CO emission produced by CeO_2 nano particle mixed MIB10 D90, MIB15 D8 and MIB20 D80 biodiesel blends. But MIB25 D75 and MIB30 D70 blends with 100 ppm of CeO_2 produced 38% and 78% of increased CO emission. The increase and decrease were considered based on the diesel fuel emission at engine full load conditions.

4. Conclusions

The following results were obtained by this evaluation on tail pipe exhaust CO emission variations through cerium oxide nano particle involvement in biodiesel of Madhuca indica:

1) The Madhuca indica biodiesel blend produced higher CO emission than diesel fuel in IC engine at full load condition.

2) Nano particles of CeO_2 help to increase the oxidation during combustion and considerably reduce the CO emission after blending with different proportions.

3) The biodiesel of Madhuca indica can be used in the CI engine with less CO emissions from the tail exhaust by blending proportion with 15% of Madhuca indica biodiesel and 85% of diesel at 100 ppm of CeO_2 nanoparticles.

4) The current research work also concluded after observations that biodiesel with CeO_2 nano particle and blend fuels has enhanced oxidation characteristics and occurrence of high in-cylinder temperatures, which resulted in comprehensive fuel burn, which in turn reduced the CO emission levels.

5) Finally, the experimental results exhibited a slight increase in aliphatic compounds and reduction in aromatic compounds. It was explained by the catalytic effect of metals on soot oxidation, resulting in low amount of total PM mass presence.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Nomenclature

MIB	Madhuca Indica Biodiesel
CO	Carbon monoxide
CeO_2	Cerium oxide
NO_x	Oxides of nitrogen
BTE	Brake thermal efficiency
SEM	Scanning electron microscopy
EGT	Exhaust gas temperature
EGR	Exhaust gas recirculation
Kw	Kilowats
Rpm	Revolutions per min
Cc	Cubic centimeter