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Emission analysis from marine engine using biofuel with ZrO_2 nano additives

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ABSTRACT

World at giving is genuinely stood up to the twin emergencies of petroleum product consumption and natural degradation. The fossil fuels play a significant role in agriculture, industry, and transport other than meeting out numerous other essential human needs. As the stock of petroleum fuel is decreasing, the search for unconventional fuels received more significant attention. However, petroleum fuels are limited in quantity and are reducing day by day as the intake is increasing very promptly. Caulerpa Racemosa algae can be used to produce biodiesel, because of high oil content. The trans-esterification of oil develops biodiesel. In the present study, the zirconium oxide nano additives into the oil-based methyl ester blend and its diesel blends are analyzed the emission characteristic at different load.

Keywords: Biodiesel, Zirconium Oxide, Ultrasonicator, Emission

INTRODUCTION

The increase of the world energy consumption continues, it will be exposed with an energy disaster, as the universal fossil oil reserves will be exhausted in shorter than 25 years. Bio-derived fuels are eco-friendly in that life cycle; CO_2 emissions are lesser, which supports to slow down the effects of global warming. Many investigators have identified biofuels from several plant-based sources such as biodiesel, vegetable oils, and alcohols that are biodegradable and renewable. In the past few years, the use of plant oil in CI engine is predominant due to its abundant obtainability. Plant oils are tested in a standard CI engine and have reduced volatility and higher viscosity, affecting fuel atomization process. Hence, using plant oil directly in the engine leads to poor performance; it leads to significant problems like injector clogging and piston ring sticking. To avoid these types of difficulties, plant oils are admitted to the trans-esterification process that reduced the fuel viscosity and converted into biodiesel [8]. The general use of fossil fuel gives to increase the atmospheric CO_2. Presently, one-fifth of the CO_2 release is due to transportation. Biomass-based fuels, such as biodiesel, biogas, bio-butanol, biogas and bioethanol are considered eco-friendly alternatives. However, the increase in food harvests use for biofuel production has many ethical issues. Marine-based algae oil has been mentioned as one of the best nonedible feed stocks associated with crops [5]. Algae biodiesel is considered a more eco-friendly fuel when compared to diesel fuel because it has lower emissions. The use of nanomaterial as a fuel additive is more effective when compared to micro materials because of their higher surface area. In the present investigation, the emission characteristics of CI engine were evaluated using nano blends. Nano blends are the mixture of B20 (20% biodiesel + 80% neat diesel) with nano- additives. The blend, B20 was prepared using Caulerpa Racemosa Oil Methyl Ester, the nanoparticles such as ZrO_2 was used as nano-additives.

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MATERIALS AND METHODS

FT-IR Analysis of Biodiesel

The characterization of Caulerpa Racemosa oil biodiesel was carried out by an FTIR technique to identify the functional groups of biodiesel. The FTIR spectrum of CROME was measured by using Shimadzu Spectrum spectroscopy in the range of 4000-400 cm^{-1} with a resolution of 1.0 cm^{-1} as shown in Figure. 1. The biodiesel has two strong absorption bonds from carbonyl (C=O) in the range of 3000-2700 cm^{-1} and asymmetric axial stretching vibrations of (CO) in the range of 1500-1000 cm^{-1} [7]. It is also observed that absorption peaks are available at 1460.09 cm^{-1} and 1744.11 cm^{-1} shows the carbonyl stretching and 2921.99 cm^{-1}, 2853.60 cm^{-1} is due to the methyl group stretching. The C-O stretching for biodiesel due to asymmetric vibrations at 1167.55 cm^{-1} was also observed.

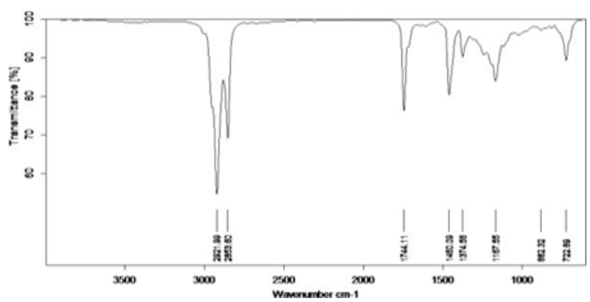

Figure 1. FT-IR Analysis of biodiesel

Characterization of ZrO2 Nano-Particles

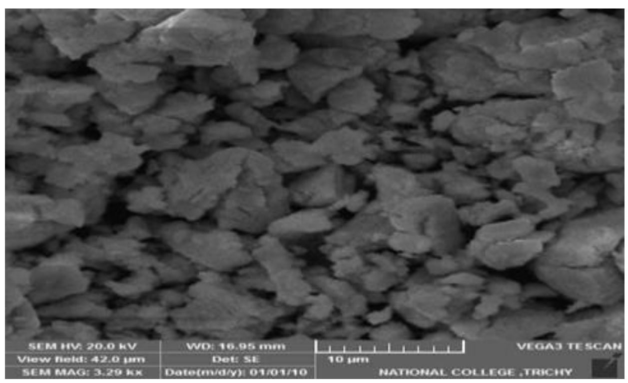

Figure 2. SEM Image of ZrO_2 nanoparticles

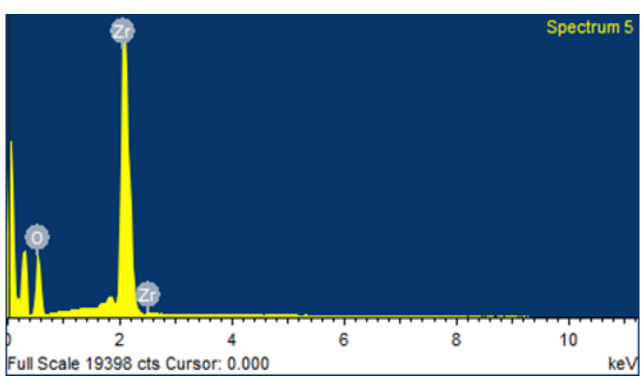

Figure 3. EDS of ZrO_2 nanoparticles

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The characterization of ZrO_2 nanoparticles was analyzed using SEM and EDS techniques. The mean size of the ZrO_2 nanoparticles was determined by using the Scherer's equation D=K λ/β cos θ. Where K, is usually taken as 0.89, D is the crystal size, λ is the wavelength of the X-ray radiation, β is the line width at maximum height, and θ is the diffraction angle. The mean size of the alumina nanoparticle was approximately 46 nm by using the above equation. SEM was used to measure the morphology and average particle size of nanoparticles. SEM image of ZrO_2 nanoparticles at a magnification of 50,000x as shown in Figure. 2. The mean size of the ZrO_2 nanoparticles from SEM image varies from 39.24 to 44.45nm. The Energy EDS of ZrO_2 nanoparticles were shown in Figure. 3. The EDS analysis confirms the presence of Zr and O_2 in the composition of ZrO_2 nanoparticles

Preparation of Nano Blends

In the present study commercially available ZrO_2 nanoparticles with an average particle size of 50-100 nm were procured from the Sigma Aldrich. The nanoparticles with a concentration of 50 ppm are weighed and dispersed into the Caulerpa Racemosa algae biodiesel blend (B20) with the aid of an ultrasonicator. The Ultra sonication process was carried out at a frequency of 50 kHz, 120 W for 45 min duration. The prepared fuel sample was named B20+50ppm [3]. The same procedure is applied for the mass fraction of 75 &100 ppm to prepare the ZrO_2 nanoparticles blended biodiesel fuel (B20+100ppm). The fuel properties of B20, B20+50ppm, B20+75ppm and B20+100ppm are determined according to the ASTM standards as shown in Table 1.The detail of ZrO_2 nano additives shown in Table 2.

Table 1. The specifications measured based on ASTM standard for B20 and its blend fuels

Properties	ASTM	B100	B20P50ppm	B20P75ppm	B20P100ppm
Density (g/cm3)	D-4052	0.8300	0.8317	0.8317	0.8318
Kinematic viscosity at 40 ˚C (mm^2/s)	D-445	4.73	5.6449	5.6894	5.6694
Flashpoint (min ˚C)	D-92	176	177	178	180
Cloud point (˚C)	D-2500	-1	-4	-4	-4
Pour point (˚C)	D-97	-4	-4	-4	-4
Calorific value (kJ/kg)	D-240	43542	45480	45518	45582
Cetane index	D-613	58	51.5	52	52
Water and sediment (% vol.)	D-2709	0.05	0.05	0.05	0.05

Table.2 Specification of nano particle

Formula:	ZrO_2
Particle size	90 -210nm
Product Number:	637213
CAS Number:	1340-67-4
MDL:	MFCD00004326
Formula Weight:	456.6 g/mol

EXPERIMENTAL SETUP

Single cylinder four stroke diesel engines coupled with an eddy current dynamometer is one of the commonly used engines for small, medium and high scale commercial purposes. It can withstand the peak pressure because of its enormous compression ratio. An experimental setup was advanced to conduct experimentations on the selected compression ignition engine with different fuel types to estimate emission parameters at different operational conditions. The various components of the experimental setup are described below. The test engine used was a four-stroke, single cylinder, direct injection, water cooled and naturally aspirated CI engine. It had a bore of 87.5 mm and stroke of 110 mm. The maximum power delivered by the engine was about 5.2 KW at a constant speed of 1500 rpm and the compression ratio of 16.5:1. The suggested injection pressure and injection timings were 210 bar and 23ºCA bTDC, respectively [2].

RESULTS AND DISCUSSION

Carbon monoxide (CO)

The variation of CO emissions with the load for all the fuel samples was shown in Figure. 4. It is observed that CO emissions from B20 fuel are higher than the diesel fuel due to the low oxygen content in biodiesel. It is observed that CO emissions, reduced with the addition of ZrO_2 nanoparticles to the B20 biodiesel blend compared to the B20 fuel. This is due to the reduced ignition delay and improved combustion with the addition of nanoparticles to the biodiesel [3].

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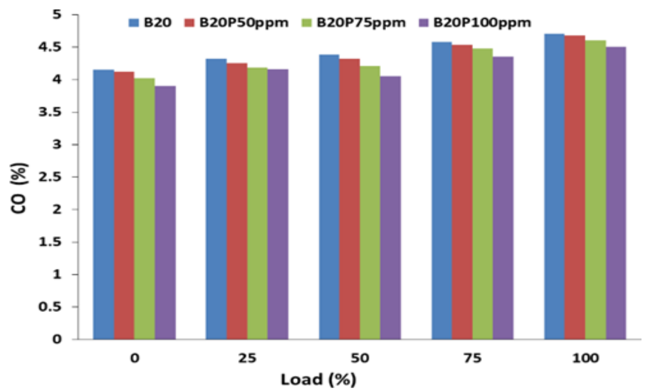

Figure 4. Variation of carbon monoxide with load

Hydrocarbons (HC)

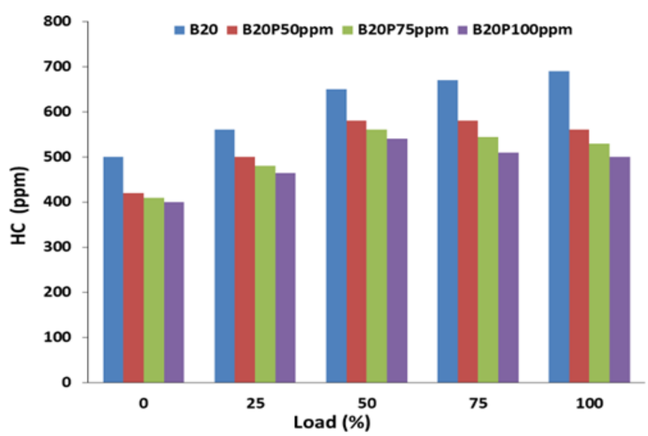

Figure 5. Variation of Hydrocarbon with load

The variation of HC emissions with the load for all the fuel samples is shown in Figure.5. It is observed that HC emissions are lower for ZrO_2 nanoparticles blends compared to the B20 blend due to the better combustion and higher certain number. This is also due to the addition of nanoparticles to the biodiesel blend lowers the carbon activation temperature and promotes the enhanced combustion. It is also observed that HC emissions of B20 blend is increased due to the lower oxygen available in the blend results poor combustion and leads to the formation of HC emissions [6].

Oxides of nitrogen (NOx)

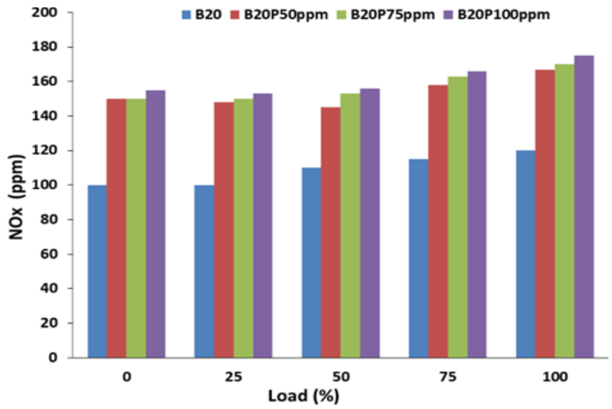

Figure 6. Variation of Oxides of Nitrogen with load

The variation of NOx emissions with the load for all the fuel samples is shown in Figure. 6. The NOx emissions increase with an increase in load for all the fuel samples due to improved combustion temperature at high load conditions. It is observed that NOx emissions for the ZrO_2 blends are higher than the B20 blend. This is due to the increased adiabatic flame temperature, and more oxygen content in biodiesel blend leads to increase the formation of NOx emissions. It can also be observed that NOx emissions drastically reduced for the B20 blend. This is due to the reduced exhaust gas temperature lowers the formation of NOx emission for B20 blend [9].

Smoke opacity

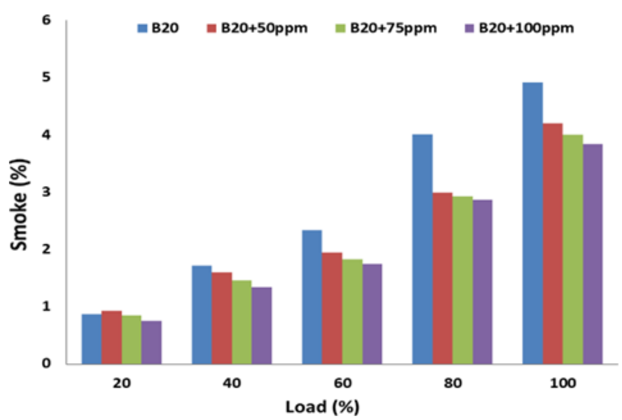

Figure 7. Variation of smoke with load

The variation of smoke opacity with the load for all the fuel samples is shown in Figure. 7. It is observed that Smoke opacity for ZrO_2 fuel was lower than the B20 fuel. This is due to the higher certain index, and inherent oxygen content of ZrO_2 blends results in better combustion of blend decreases the smoke opacity [1]. This is due to the shorter ignition delay, and better air-fuel mixing with the nanoparticles leads to improve the combustion and reduces the smoke opacity.

CONCLUSION

In this study, the emission of the modified fuels by mixing of ZrO_2 nano additives biodiesel- diesel in CI engine and their impact on various exhaust emissions was studied. The ZrO_2 nanoparticles mixed with B20 fuel blends were used to evaluate the exhaust emissions characteristics of a single-cylinder engine. The ZrO_2 with dosages of 50ppm, 75ppm and 100 ppm was applied to the fuel blends. Emissions of CO, HC and smoke decrease respectively, however, the NO emissions enhance. Other researches demonstrated that emissions in bio- diesel fuel blends with nanoparticles are reduced, which is due to the sufficient oxygen to improve combustion of fuel.

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