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Comparative Analysis of the Effects of Different Nanoadditives on the Performance Characteristics of a Diesel Engine Fueled with Ternary Biodiesel-Ethanol-Diesel Blends

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Abstract

The demand for sustainable fuels and the reduction of exhaust emissions in diesel engines have led to the exploration of alternative fuel blends. The present investigation is carried out on the effects of incorporating Al_2O_3 and ZnO nanoparticles into ternary blends of Alexandrian laurel biodiesel, ethanol, and diesel. Engine performance parameters, including BTE and BSFC, as well as emission characteristics such as NOx, CO, UBHC, and smoke opacity, were analysed under varying engine loads. The results showed that adding nanoparticles improved fuel combustion and thermal efficiency while significantly reducing emissions. Al_2O_3 nanoparticles enhanced BTE by up to 12.46% at full load compared to blends without nanoparticles, while ZnO nanoparticles achieved a higher improvement of 10.99%. In terms of emissions, CO and NOx levels were reduced by 9.53% and 8.76%, respectively, with Al_2O_3, whereas ZnO achieved reductions of 10.17% and 12.16%. Smoke opacity also decreased significantly, with ZnO outperforming Al_2O_3 across all load conditions. The study demonstrates that ZnO nanoparticles exhibit superior catalytic properties, making them more effective in optimising engine performance and emissions. The outcomes of the study show that ternary blends with nanoparticles achieve optimum engine performance with lower emissions, and that the DB20E10A100 blend has shown optimum results compared with other fuel blends.

Major Findings: *Ternary blends containing nanoparticles significantly improve performance and reduce emissions. Al_2O_3 nanoparticles delivered better emission control and performance analysis than ZnO. The DB20E10A100 blend showed the most optimal engine performance with the lowest emissions.*

Keywords: *Al_2O_3, ZnO, Alexandrian Laurel Biodiesel, Diesel Engine, Ethanol*

1.0 Introduction

Alternative fuels for diesel engines are the subject of extensive research due to the growing need for environmentally acceptable and sustainable energy sources. Due to its low toxicity, biodegradability, and ability to reduce greenhouse gas emissions, biodiesel made from renewable resources has emerged as a viable alternative. Rapeseed, sunflower, palm, and soybean oils are among the edible oil sources used to make first-generation biodiesel. While these feedstocks are easy to process and commercially available, they face criticism for competing with food supplies, which raises concerns about food security. Studies have reported that Second-

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generation biodiesel is derived from non-edible oils[1] (e.g., jatropha, karanja, and Alexandrian laurel), waste cooking oils[2], and animal fats[3]. These feedstocks do not compete with food resources and utilise marginal lands and waste materials, making them more sustainable. Farid *et al*[4]., investigated the effects of the second-generation biodiesels on the performance and emissions of a diesel engine. The B20 blends showed the best balance of torque, power, and BSFC, with Iris meda biodiesel achieving the highest torque. Viola odorata biodiesel exhibited higher NOx emissions and smoke opacity reduction in B100 blends, highlighting its potential for cleaner combustion despite trade-offs in emissions. Nabi *et al*[5]., studied diesel engine performance with biodiesel blends such as waste cooking biodiesel and macadamia biodiesel and compared them to diesel. The study revealed that the addition of biodiesel causes an increase in viscosity as well as a reduction in heat energy. The fuel blends showed a reduction in emissions of THC, CO, and PM but a slight increase in NOx with little performance loss, demonstrating their potential for cleaner combustion. Using a hybrid fuel system, Zhanbin *et al*[6]., examined the second-generation biodiesel-diesel blends on engine operating parameters. The study found that a 90% diesel and 10% biodiesel blend was optimal, resulting in a 5.6% decrease in fuel consumption and a 4.7% and 4.9% drop in NOx and soot emissions, respectively.

However, biodiesel's higher viscosity and cold flow properties pose challenges in achieving optimal engine performance. To address these issues, blending biodiesel with ethanol is showing an optimal solution. Ethanol, with its oxygenated structure, improves combustion efficiency and reduces emissions. Hussain *et al*[7]., found that the blending of ethanol with the diesel fuel reduces the viscosity of the fuel blend. It is noted that ethanol addition lowers the performance of the engine. The study also found that the emissions of NOx and CO are reduced. Despite these advantages, the performance of ternary biodiesel-ethanol-diesel blends is limited by factors such as incomplete combustion and higher specific fuel consumption. In recent years, there has been increased interest in using nanoparticles as fuel additives to address these restrictions[8]. Metal oxide nanoparticles, such as TiO_2, CNT, Al_2O_3 and ZnO, have demonstrated significant potential in enhancing combustion, lowering emissions, and improving thermal efficiency[9]. Their high thermal conductivity, catalytic activity, and ability to improve fuel atomization contribute to a more complete combustion. Tamilvanan *et al*[10]., evaluated the impact of copper nanoparticle additives on the performance, combustion, and emissions of a diesel engine fueled with biodiesel from tamanu oil. Results showed improved BTE, lower SFC, and enhanced combustion with nano-additives. Emissions of HC, NOx decreased significantly, while emissions of CO_2 increased due to better oxidation and combustion efficiency. Gad *et al*[11]., examined nano-additives' effects on a 20% Jatropha biodiesel blend. Al_2O_3 improved thermal efficiency by 6.5%, CNTs reduced CO and NOx by 35% and 52%, and TiO_2 cut HC and smoke emissions by 22% and 50%, enhancing performance and reducing emissions. Gavhane *et al*[12]., observed the impact of SiO_2 nano-additives on a diesel engine using soybean biodiesel. The addition of SiO_2 results in an improvement in BTE by 6.39% and a reduction in BSFC by 9.88%. It was also noted that CO, HC, and smoke emissions are reduced by 17.5%, 27.5%, and 23.54%, compared to SBME25 fuel blends. Vali *et al*[13]., optimised diesel engine performance using Al_2O_3 nanoparticles via RSM. Input parameters included compression ratio (16.5-18.5), load (25-100 %), and nanoparticle concentration (1–100 ppm). The model accurately predicted BTE, BSFC, CO, HC, NOx, and CO_2 with R^2 values above 95%. Experimental results validated the model's reliability within a 5% error margin. Ambar *et al*[14]., reviewed the role of additives like nanoparticles and antioxidants in enhancing biodiesel's performance and emission characteristics. Additives cause an improvement in BTE, a reduction in BSFC, and decreased pollutant emissions like CO, HC, and NOx. These enhancements make biodiesel blends more efficient and eco-friendly for CI engines. Manimaran *et al*[15]., investigated the use of green-synthesised CeO_2 nano-additives in biodiesel emulsions to reduce emissions and enhance engine performance. The TCB20 incorporated a 30 ppm CeO_2 blend achieved significant reductions in NO (6.06%), CO (38.30%), HC (16.78%), and smoke emissions (20.73%) compared to diesel, alongside improved combustion characteristics and energy efficiency. The study highlights this blend as a promising alternative to diesel with no engine modifications needed. Modi *et al*.[16] highlighted biodiesel's potential as an environmentally friendly substitute to fossil fuels that reduces greenhouse gas emissions and reliance on

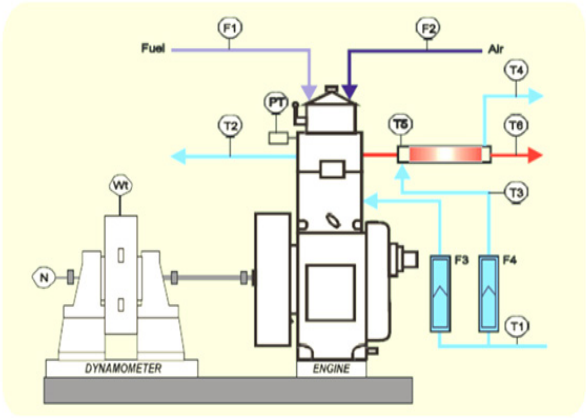
foreign fuels. However, challenges like increased NOx emissions, cold weather incompatibility, and clogging of engine parts persist. The study reviewed the role of nanoparticles as fuel additives, noting improvements in thermophysical properties, heat transfer, and engine working characteristics with biodiesel-diesel blends. Lamore *et al*[17]., experimentally found the effects of CeO_2 and Al_2O_3 nanoparticles on castor biodiesel-diesel blends. The study found that hybrid nanoparticle blends (CB20A50C50) improve BTE by 20.38%, reduce NOx emissions by 10.24%, and decrease HC and CO emissions in other blends. Mofijur *et al*[18]., reviewed the impact of nanoparticle (NP) additives on biodiesel combustion in diesel engines. It was observed that incorporating NP blends (CeO_2 + Al_2O_3) improves the engine performance, combustion efficiency, and lowers the exhaust emissions. The study highlights the potential of nanoparticle-enhanced biodiesel for sustainable energy solutions. Sujin *et al*[19]., studied a biodiesel blend from nonedible oils with CaO-TiO_2 nano-additives. Using optimisation techniques, they improved engine performance, reducing brake-specific fuel consumption by 41%, CO emissions by 32%, NOx emissions by 25%, and increasing BTE by 16.9% compared to diesel. Zhou *et al*[20]., conducted numerical simulations on the addition of ozone to biodiesel in an HCCI engine, demonstrating its strong influence on auto-ignition behaviour. Chacko *et al*[21]., studied the effects of graphene oxide and nanoplatelets in diesel and biodiesel blends, finding that graphene oxide effectively reduced smoke emissions, while nanoplatelets helped lower other emissions. Liu *et al.*[22] investigated palm oil biodiesel blends in a common rail system and reported reductions in HC, CO, and soot emissions, although NOx emissions increased.

From the previous studies, it was noted that very few studies have been conducted on ternary fuel blends. To the best of the author's knowledge, very little work has been conducted on the effect of different nanoaditives on ternary fuel blends (biodiesel-alcohol blends). Given this, the present study investigates the effects of adding Al_2O_3 and ZnO nanoparticles to ternary Alexandrian laurel biodiesel-ethanol-diesel blends. The analysis focuses on key engine performance parameters, including BTE and BSFC, as well as emission characteristics such as CO, NOx, smoke opacity, and UBHC. The comparative evaluation aims to determine the extent to which Al_2O_3 and ZnO nanoparticles improve engine performance and mitigate emissions, helping produce a cleaner and more efficient alternative fuel blend.

2.0 Materials and Methods

2.1 Experimental Test Setup and Methodology

Figure 1 illustrates the experimental configuration, which consists of a four-stroke, single-cylinder diesel engine which is coupled with a dynamometer to facilitate loading during the experiments. The system is equipped with a range of instruments to accurately measure key parameters such as temperatures, fuel flow, airflow, and load, ensuring a comprehensive evaluation of engine performance under varying load conditions. The specifications of the engine are provided in Table 1. The setup consists of a panel box that houses several essential components for monitoring and controlling the parameters. These components consist of an air box for airflow regulation, a fuel tank for storage, and a manometer to measure pressure variations. Additionally, it features a fuel measuring unit, which ensures precise quantification of fuel consumption, along with transmitters dedicated to air and fuel flow measurement. The system also incorporates a process indicator and an engine indicator, which can offer data on



PT Pressure Transducer
N Rotary encoder
Wt Weight
F1 Fuel flow
F2 Air flow
F3 Jacket water flow
F4 Calorimeter water flow
T1 Jacket water inlet temperature
T2 Jacket water outlet temperature
T3 Calorimeter water inlet temperature = T1
T4 Calorimeter water outlet temperature
T5 Exhaust gas to calorimeter tempera
T6 Exhaust gas from calorimeter temperature

Figure 1. Experimental setup layout.

different engine characteristics in real time. Temperature measurements are critical for performance evaluation, and for this purpose, K-type thermocouples are employed. These thermocouples are strategically positioned to measure the temperatures of the engine cylinder and the calorimeter, providing accurate thermal data during the tests. To facilitate online performance analysis, the setup is integrated with the LabVIEW-based software package called "Enginesoft." This software enables real-time monitoring, data acquisition, and analysis of engine performance metrics. Before initiating the experiments, the engine was prepared by conducting a preliminary run using diesel fuel. This initial 30-minute operation served to flush out any residues or remnants of previously used fuels in the feed line and pump, ensuring that the system was clean and ready for accurate testing. The performance of each fuel blend was evaluated at four distinct loading conditions—100%, 75%, 50%, and 25% of the engine's full load—while maintaining a constant speed of 1500 revolutions per minute (rpm). This speed was selected to replicate standard operating conditions and provide consistent test results. At each load level, the engine was operated for 20 minutes to allow the system to stabilise and ensure reliable readings. In order to confirm the precision and consistency of the findings, each test was performed three times for every fuel blend.

Table 1. Specifications of diesel engine

Parameters	Specifications
Model	Kirloskar single-cylinder, four-stroke VCR diesel engine
Compression ratio	17.5:1
Bore x Stroke	87.5 x 110 mm
Rated speed	1500 RPM
Rated power	5.2 kW

2.2 Fuel Preparation

The initial stage of this research focuses on identifying and preparing ternary fuel blends by mixing diesel, biodiesel, and ethanol in different ratios. Through a thorough review of existing literature, Alexandrian laurel seed oil emerged as a viable feedstock for biodiesel production due to its favourable properties. The Alexandrian laurel seed oil was sourced from Grenara Pvt. Ltd., India, and processed into biodiesel using the transesterification method, which is widely recognised for its efficiency in converting oils into biodiesel with high yield and quality. Once the biodiesel was synthesised, it was utilised to create a ternary fuel blend. The blend was formulated by mixing diesel, biodiesel, and ethanol in fixed proportions to achieve an optimal composition of 10% ethanol, 20% biodiesel, 68% and diesel. To increase the stability and homogeneity of the blend, 2% surfactants, specifically Tween 80 and Span 80, were added. These surfactants are known for their emulsifying properties, which help maintain the mixture's uniformity and prevent phase separation. To further improve the fuel properties and performance characteristics of the blend, Al_2O_3 and ZnO nanoparticles have been incorporated by using an

Table 2. Properties of test fuel blends

Properties	Diesel(D)	DB20	DB20E10	DB20E10Z50	DB20E10Z100	DB20E10A50	DB20E10A100
Density (kg/m^3) at 20 ∘ C	840	868	853	853	855	853	856
Flash point (∘ C)	62	118	54	56	59	57	60
Calorific value (kJ/kg)	42600	40800	39800	40100	40700	40400	41000
Kinematic viscosity (mm^2/s) at 40 ∘ C	2.68	3.92	3.15	3.19	3.25	3.20	3.27

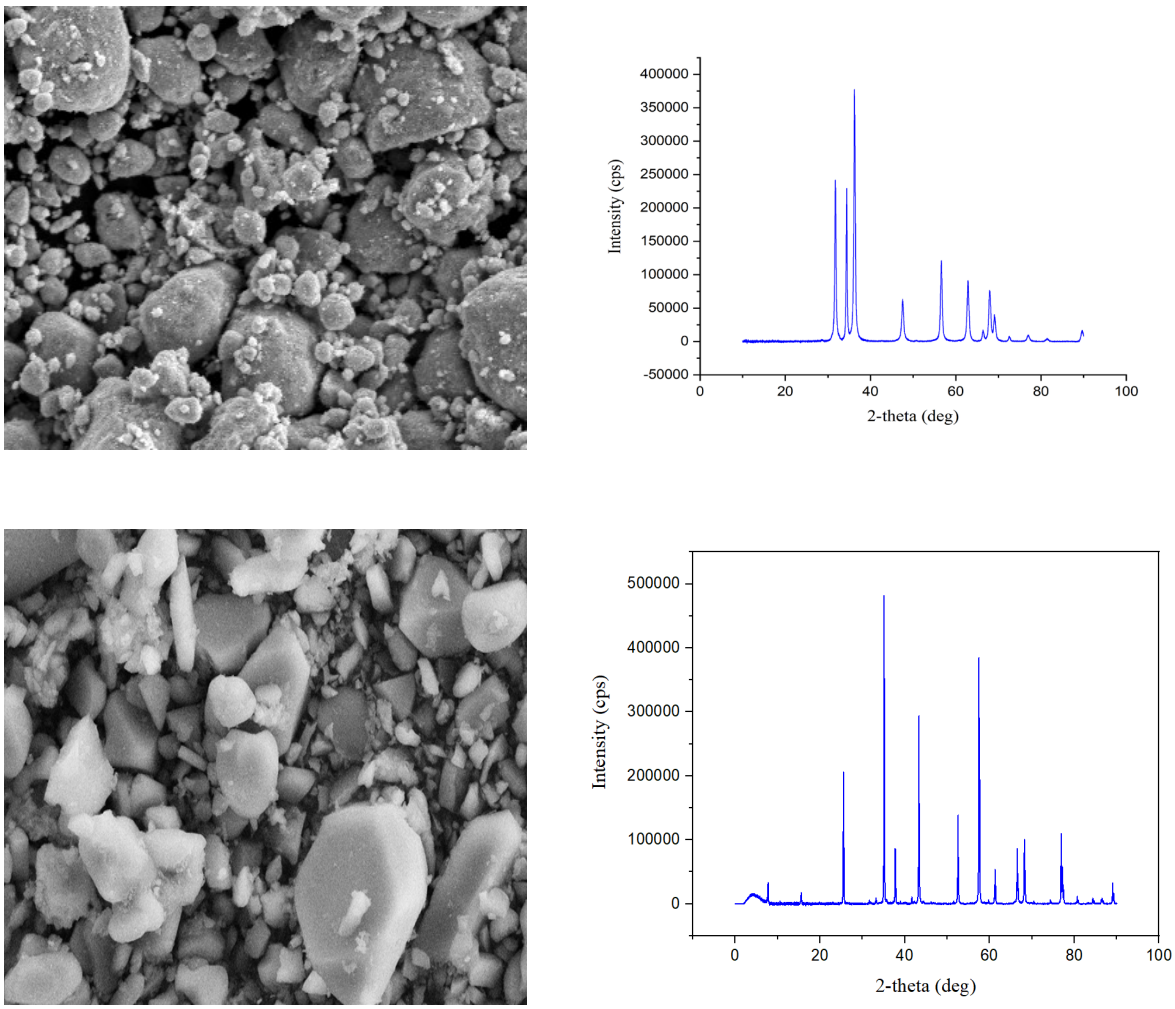


Figure 2. FeSEM and XRD of ZnO and Al_2O_3 nanoparticles.

ultrasonicator bath with a frequency of 40 ± 3 KHz. The amount of nano-additives added was precisely measured at 50 ppm and 100 ppm for Al_2O_3 and ZnO (zinc oxide) nanoparticles, respectively. The nanoparticles were subjected to rigorous characterisation using FESEM and XRD analyses. The FESEM analysis provided detailed insights into the surface morphology of the nanoparticles, revealing their structural features and particle size distribution. Meanwhile, the XRD analysis identified the chemical composition and crystalline structure of the nanoparticles, confirming their purity and suitability for fuel enhancement applications. These results are illustrated in Figure 2, where the morphological details and chemical constituents of the nanoparticles are comprehensively presented. The properties of test fuel blends are shown in Table 2.

3.0 Results and Discussions

3.1 Carbon Monoxide (CO) Emissions

The CO emissions were analyzed for diesel (D) and various ternary biodiesel-ethanol-diesel blends under different engine loads are shown in Figure 3. In contrast to diesel, DB20 exhibited a slight reduction in CO emissions, with a 4.68% decrease at 75% load and an 8.84% reduction at 100% load, due to the oxygen-rich nature of biodiesel. Adding ethanol (DB20E10) further reduced CO emissions, achieving a 1.4% reduction at 100% load compared to DB20, as ethanol enhanced combustion efficiency. The inclusion of ZnO nanoparticles (DB20E10Z50 and DB20E10Z100) reduced CO emissions by 13.6% and 14.8%, respectively, at full load over DB20E10, attributed

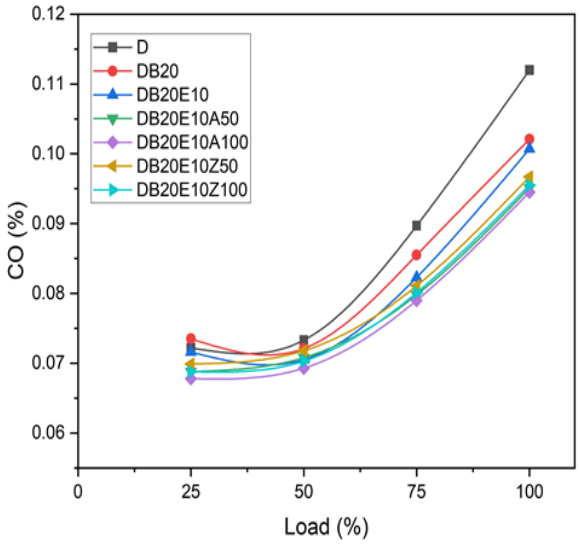


Figure 3. CO emissions vs. engine load for different fuel blends.

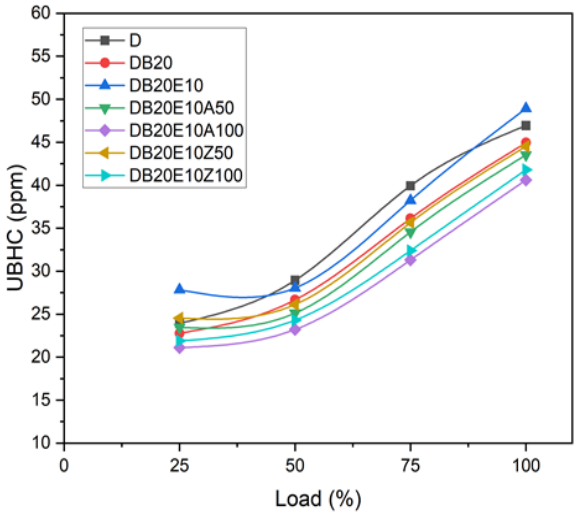


Figure 4. UBHC emissions vs. engine load for different fuel blends.

to improved catalytic oxidation. Al_2O_3 nanoparticles (DB20E10A50 and DB20E10A100) provided slightly better reductions of 15.1% and 16.2%, respectively, at full load compared to DB20E10. Al_2O_3's superior catalytic activity and thermal conductivity made it more effective than ZnO in further reducing CO emissions, promoting complete fuel combustion and minimising incomplete oxidation.

3.2 Unburnt Hydrocarbon (UBHC) Emissions

The Unburnt Hydrocarbon (UBHC) emissions for different fuel blends were analysed across varying engine loads and are shown in Figure 4. In contrast to diesel, the addition of biodiesel lowers the formation of UBHC emissions, and the percentage of reduction at full load is 4.3%, due to improved oxygenation from biodiesel. When Al_2O_3 nanoparticles were added (DB20E10A50 and DB20E10A100) to a diesel-biodiesel-ethanol blend, emissions showed further reductions of 11.05% and 17.02% at 100% load, respectively, over DB20E10. Similarly, ZnO nanoparticles (DB20E10Z50 and DB20E10Z100) resulted in reductions of 9.03% and 14.6%, respectively, at 100% load, due to their catalytic properties enhancing combustion efficiency. The maximum UBHC reduction was achieved with DB20E10A100, showing a 17.02% improvement over DB20E10 at full load. Overall, the inclusion of Al_2O_3 and ZnO nanoparticles significantly improved combustion by reducing UBHC emissions, highlighting their potential in optimising ternary biodiesel-ethanol-diesel blends. In comparison to ZnO nanoparticle addition, Al_2O_3 nanoparticle showed improved performance,

3.3 Nitrogen Oxide (NOx) Emissions

The NOx emissions were evaluated for Diesel (D) and various ternary biodiesel-ethanol-diesel blends as shown in Figure 5. In contrast to diesel, the DB20 blend increased NOx emissions by 7.56% at 25% load and by 1.16% at 100% load, due to higher oxygen content in biodiesel enhancing combustion temperatures. The addition of ethanol (DB20E10) reduced NOx emissions by 2.01% at 100% load compared to DB20, attributed to ethanol's lower combustion temperature. Incorporating ZnO nanoparticles (DB20E10Z50 and DB20E10Z100) further decreased NOx emissions by 3.94% and 7.59%, respectively, at full load over DB20E10. Al_2O_3 nanoparticles (DB20E10A50 and DB20E10A100) showed superior performance, reducing NOx emissions by 4.82% and 8.76%, respectively, at full load, because of their superior catalytic characteristics and heat conductivity. Al_2O_3 nanoparticles consistently outperformed ZnO in

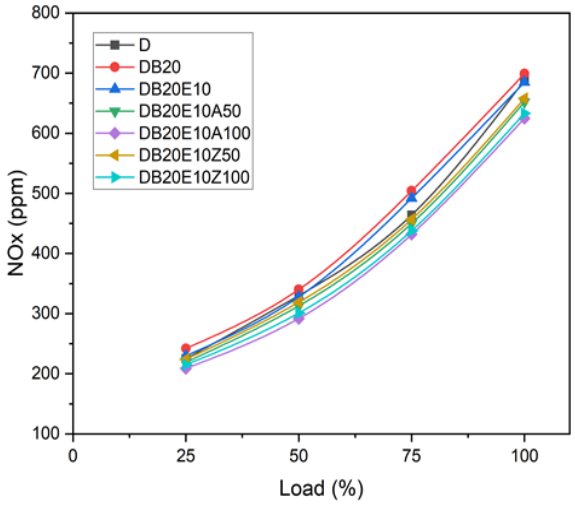


Figure 5. NOx emissions vs. engine load for different fuel blends.

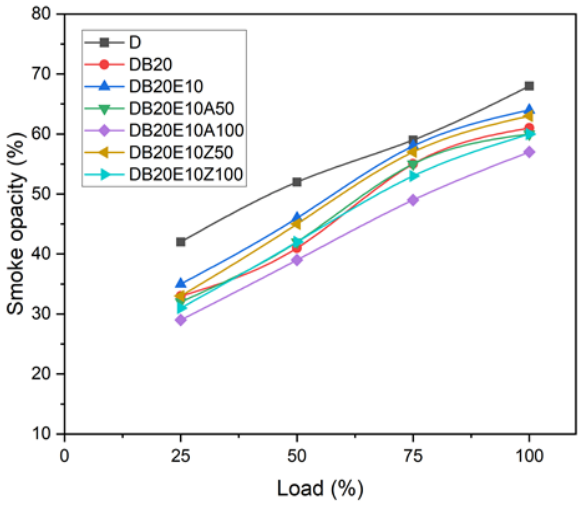


Figure 6. Smoke opacity vs. engine load for different fuel blends.

reducing emissions of NOx across all load conditions, demonstrating their greater potential in mitigating NOx emissions in ternary biodiesel-ethanol-diesel blends.

3.4 Smoke Opacity

The smoke opacity of the engine exhaust was analysed for diesel (D) and various ternary biodiesel-ethanol-diesel blends with nano additives are shown in Figure 6. DB20 reduced smoke opacity by 21.43% at 25% load and 10.29% at full load compared to diesel, due to the better combustion of biodiesel. Adding ethanol (DB20E10) slightly increased smoke opacity at partial loads over the DB20 blend, but at full load, it showed a 5.88% reduction over diesel because of the oxygen enrichment from ethanol. The inclusion of Al_2O_3 nanoparticles (DB20E10A50 and DB20E10A100) decreased smoke opacity by 6.25% and 10.94%, respectively, at full load compared to DB20E10, owing to their role in promoting more complete combustion. ZnO nanoparticles (DB20E10Z50 and DB20E10Z100) further enhanced performance, with reductions of 1.56% and 6.3%, respectively, at full load over DB20E10. Al_2O_3 exhibited superior smoke opacity reduction compared to ZnO nanoparticles, highlighting its enhanced catalytic effects and thermal properties, making it more effective in improving combustion quality and reducing particulate formation.

3.5 Brake Specific Fuel Consumption (BSFC)

Figure 7 displays the results of the BSFC analysis for diesel and several ternary biodiesel-ethanol-diesel mixes with nano additives under varied loads. DB20 increased BSFC by 4.35% at 25% load and 5.22% at 100% load in contrast to diesel, attributed to biodiesel's lower energy content, which lowers the total energy availability of the fuel blend. Adding ethanol (DB20E10) further

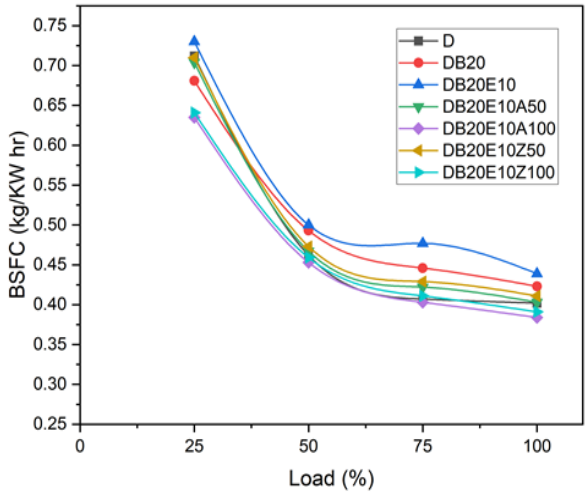


Figure 7. BSFC vs. engine load for different fuel blends.

increased BSFC by 7.19% at 25% load, but at 100% load, it exhibited only a 3.78% increase compared to DB20, as ethanol's oxygenation improved combustion efficiency. The incorporation of ZnO nanoparticles (DB20E10Z50 and DB20E10Z100) reduced BSFC by 2.84% and 7.57%, respectively, at full load compared to DB20E10, owing to their catalytic role in enhancing fuel utilisation. Al_2O_3 nanoparticles (DB20E10A50 and DB20E10A100) demonstrated even better performance, with BSFC reductions of 4.73% and 9.22%, respectively, at 100% load compared to DB20E10. The superior thermal conductivity and catalytic activity of Al_2O_3 nanoparticles make them more effective than ZnO in reducing BSFC, improving combustion efficiency, and optimizing engine performance.

3.6 Brake Thermal Efficiency (BTE)

The BTE was evaluated for diesel (D) and ternary biodiesel-ethanol-diesel blends at varying engine loads, as shown in Figure 8. Compared to diesel, DB20 showed a reduction in BTE of 2.09% at 25% load and 8.36% at 100% load due to biodiesel's lower calorific value. The addition of ethanol (DB20E10) causes a further reduction in BTE of 10.51% at 25% load but shows a smaller reduction of 4.46% at full load compared to DB20, as ethanol improves combustion efficiency at higher loads. The inclusion of Al_2O_3 nanoparticles (DB20E10A50 and DB20E10A100) improved BTE by 9.42% and 17.46%, respectively, at full load over DB20E10, owing to enhanced fuel atomization and better combustion. ZnO nanoparticles (DB20E10Z50 and DB20E10Z100) also showed an improvement in BTE by 7.14% and 14.99%, respectively, at full load compared to DB20E10. Al_2O_3's superior thermal and catalytic properties resulted in more efficient energy conversion, making it more effective than ZnO in enhancing engine performance.

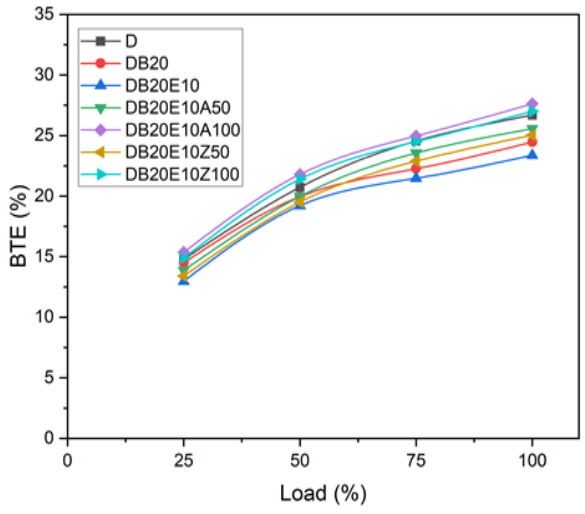


Figure 8. BSFC vs. engine load for different fuel blends.

7.0 Conclusion

The performance and emission characteristics of a diesel engine running on ternary mixes of diesel, ethanol, and Alexandrian laurel biodiesel were investigated in this work concerning AlO_3 and ZnO nanoparticles. The addition of nanoadditives significantly enhanced combustion efficiency and reduced harmful emissions. Al_2O_3 and ZnO nanoparticles both show improved BTE and reduced CO and nitrogen oxide emissions, highlighting their catalytic properties. However, Al_2O_3 nanoparticles demonstrated superior performance, further enhancing thermal efficiency, lowering BSFC, and achieving greater reductions in emissions, particularly CO and NOx.

- Al_2O_3 nanoparticles enhanced BTE by up to 17.46%, outperforming ZnO, which achieved an improvement of 14.99% at full load compared to the DB20E10 blend.
- ZnO and Al_2O_3 nanoparticles reduced BSFC significantly, with Al_2O_3 achieving superior reductions due to better combustion efficiency and thermal conductivity.
- ZnO reduced CO emissions by 14.8 % at full load, while Al_2O_3 achieved a higher reduction of 16.2%.
- NOx emissions decreased with nanoparticle addition. Al_2O_3 showed the highest reduction, which is 8.76%, whereas ZnO is 7.59% in comparison with the DB20E10 blend.
- ZnO and Al_2O_3 both reduced smoke opacity, with Al_2O_3 outperforming ZnO across all load conditions, demonstrating better catalytic effects on particulate matter reduction.
- Al_2O_3 nanoparticles showed significant improvements in reducing UBHC emissions compared with ZnO nanoparticles, attributed to more complete combustion.

The study highlights the effectiveness of Al_2O_3 and ZnO nanoparticles in improving the characteristics of diesel engines fueled with ternary Alexandrian laurel biodiesel-ethanol-diesel blends. Both nanoparticles enhanced combustion efficiency and reduced emissions, but Al_2O_3 demonstrated superior catalytic activity, achieving greater improvements in BTE, BSFC, and reductions in CO, NOx, smoke opacity, and UBHC emissions. These findings establish Al_2O_3 as a more effective additive than ZnO for optimising fuel blends, contributing to cleaner and more efficient engine operations. This work supports the development of nanoparticle-enhanced biofuel technologies for sustainable energy solutions. These findings support the use of nanoparticle-enhanced ternary fuel blends as a viable approach to reducing reliance on fossil fuels while mitigating environmental impacts. Future work could focus on long-term engine durability tests and exploring other nanoparticle additives to further refine this technology.

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Nomenclature

Al_2O_3	: Aluminum Oxide
CeO_2	: Cerium Oxide
MgO	: Magnesium Oxide
TiO_2	: Titanium Dioxide
ZnO	: Zinc Oxide
BTH	: Brake Thermal Efficiency
BSFC	: Brake Specific Fuel Consumption
CO	: Carbon Monoxide
CO_2	: Carbon Dioxide
NO_x	: Nitrogen Oxides
UBHC	: Unburnt Hydro Carbon
WPPO	: Waste Plastic Pyrolysis Oil
DEE	: Diethyl Ether
DB20	: 80% Diesel, 20% Biodiesel
DB20E10	: 80% Diesel, 20% Biodiesel and 10% Ethanol
DB20E10Z50	: 80% Diesel, 20% Biodiesel and 10% Ethanol and 50 ppm ZnO nanoparticles
DB20E10Z100	: 80% Diesel, 20% Biodiesel and 10% Ethanol and 100 ppm ZnO nanoparticles
DB20E10A50	: 80% Diesel, 20% Biodiesel and 10% Ethanol and 50 ppm Al_2O_3 nanoparticles
DB20E10A100	: 80% Diesel, 20% Biodiesel and 10% Ethanol and 100 ppm Al_2O_3 nanoparticles