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CERTAIN INVESTIGATION ON EFFECT OF NANOADDITIVES WITH JULIFLORA BIODIESEL ON DI DIESEL ENGINE

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Abstract - The investigation focused on examining the influence of nano additives to the performance, combustion and emission characteristics of a direct injection diesel engine fueled by juliflora biodiesel. This analysis considers main engine parameters as brake thermal efficiency, BTE and brake-specific fuel consumption BSFC besides checking the quantities of emitted materials such as nitrogen oxides NOx, carbon monoxide, CO, hydrocarbons HC and smoke opacity. Results show that the incorporation of nano additives improves engine performance by 6% BTE, reduces BSFC by 4%, and decreases NOx by 9%. The findings thus suggest the potential of nano additives to enhance biodiesel as a sustainable and efficient fuel source.

Key Words: Juliflora biodiesel, nano additives, direct injection diesel engine, engine performance, combustion characteristics, emission reduction, sustainable fuel, brake thermal efficiency (BTE), brake-specific fuel consumption (BSFC), nitrogen oxide (NOx) emissions.

1. INTRODUCTION

In pursuing clean and sustainable energy, it is of interest to pursue alternative fuels that are made up of biodiesel rather than petroleum-based fuels. Renewable in its feedstocks, biodiesel holds other benefits in terms of reduced emissions and a rate of biodegradability. The non-edible, an invasive species, Prosopis juliflora, is becoming very relevant today in terms of being very versatile for arid regions as well as potentially producing large quantities of biodiesel. Biodiesel, however, has disadvantages of its own. There is End Higher viscosity as compared to diesel, resulting in inefficient atomization and combustion. That is, lower calorific value, which lowers engine power output.Higher NOx emissions because of the oxygen content in biodiesel. Nano additives have emerged as a promising solution to overcome these challenges. Nanoparticles exhibit unique properties, including high surface area-to-volume ratio, excellent thermal conductivity, and catalytic activity, which enhance combustion and reduce emissions. This study focuses on the effect of nano additives on the performance of juliflora biodiesel in a DI diesel engine, providing comprehensive insights into their potential to improve biodiesel fuel properties.

1.1 Background of the Work

An overall increased demand for energy plus environmental concerns related to nonrenewable fossil-based resources have led to investigations in renewable and sustainable replacements such as biodiesel. The benefits of biodiesel derived from biological sources will offer significant advantages over petrodiesel, including lowering the greenhouse gas emissions involved with the production of its nonrenewable alternatives. Prosopis juliflora is an inedible, invasive species that has received interest because of its high oil yield, tolerance to arid climates, and low interference with food supply chains. However, the major drawbacks of juliflora biodiesel are the same as those for most biodiesels, such as high viscosity, lower calorific value, and NOx emissions.

Nano-additives have emerged as one promising approach to overcome these shortcomings. Nanoparticles with high surface area-to-volume ratios, enhanced thermal conductivity, and catalytic properties are thus found to improve fuel properties, enhance combustion efficiency, and reduce harmful emissions.

1.2 Motivation and Scope of the Proposed Work

The urgency to minimize greenhouse gas emissions and dependence on depleting fossil fuel sources has emphasized the adoption of renewable energy. Biodiesel, a clean and renewable diesel alternative, has tremendous scope in combating environmental challenges as well as meeting energy demands. Prosopis juliflora biodiesel among other feedstocks is noted for its availability, affordability, and non-competitiveness with food crops. However, its widespread use is restricted by some inherent limitations, such as higher viscosity, lower calorific value, and increased NOx emissions. All these factors adversely affect engine performance and environmental compliance, thus requiring the development of effective solutions to optimize biodiesel performance.

Nano additives mark a significant step in biodiesel technology. Nanoparticles with excellent thermal and catalytic properties have shown their potential in increasing combustion efficiency, lowering harmful emissions, and also enhancing engine performance. Promising results have been reported in earlier studies; however, there is a need to evaluate more critically the role of certain nano additives with biodiesel

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blends in real-world engine conditions. This work is aimed at filling the gap by studying the impact of nano additives on the performance, combustion, and emission characteristics of a DI diesel engine fuelled with juliflora biodiesel.

2. METHODOLOGY

2.1 Biodiesel Production

Juliflora biodiesel was synthesized using a transesterification process. The feedstock was processed with methanol and potassium hydroxide (KOH) as a catalyst under the following conditions:

- Reaction temperature: 60°C
- Reaction time: 2 hours
- Molar ratio (oil to methanol): 1:6

The resulting methyl esters were washed and purified to meet ASTM D6751 biodiesel standards. Key properties of juliflora biodiesel are shown in Table 1.

Table 1: Properties of Juliflora Biodiesel

Property	Value	Standard(ASTM D6751)
Density (g/cm³)	0.880	0.860–0.900
Viscosity (mm²/s)	4.8	1.9–6.0
Calorific Value (MJ/kg)	38.1	Min. 35
Flash Point (°C)	172	Min. 130

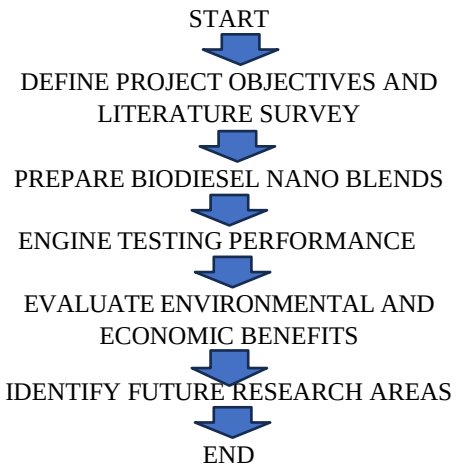

Fig-1: Flowchart

2.2 Preparation of Nano Additive Blends

Nano additives were incorporated into juliflora biodiesel at a concentration of 0.05 wt.% using an ultrasonication process to ensure uniform dispersion. The steps included:

1. Weighing the appropriate amount of nano additive.
2. Mixing it with juliflora biodiesel using a magnetic stirrer for 30 minutes.
3. Subjecting the mixture to ultrasonication at 40 kHz for 45 minutes.

The resulting blend, referred to as JBN (Juliflora Biodiesel + Nano Additive), was tested for stability and homogeneity before engine testing.

2.3 Engine Testing

Experiments were conducted on a single-cylinder, four-stroke, water-cooled DI diesel engine with the following specifications:

- **Bore × Stroke**: 87.5 mm × 110 mm
- **Compression Ratio**: 17.5:1
- **Rated Power**: 5.2 kW at 1500 rpm

The engine was coupled with an eddy current dynamometer to measure performance parameters. Emission characteristics (NOx, CO, HC, and smoke opacity) were analyzed using a gas analyzer

3. CONCLUSION

The performance characteristics of **Prosopis juliflora** biodiesel blended with nano additives were evaluated through several engine parameters, including brake thermal efficiency (BTE), brake-specific fuel consumption (BSFC), and combustion behavior. The addition of nano additives resulted in a noticeable improvement in engine performance. The brake thermal efficiency (BTE) was enhanced due to the improved combustion efficiency, which can be attributed to better fuel atomization and more complete combustion facilitated by the nano additives. As a result, the engine was able to extract more useful work from the same amount of fuel, leading to an increase in overall efficiency. On the other hand, brake-specific fuel consumption (BSFC) showed a reduction with the addition of nano additives, indicating that less fuel was required to produce the same power output, further highlighting the efficiency gains. The combustion characteristics, including cylinder pressure and heat release rates, were also optimized with nano additives, resulting in smoother and more stable engine operation. These performance improvements demonstrate the potential of nano additives in enhancing the practical applicability of biodiesel in real-world engine operations, making it a viable and efficient alternative to conventional diesel.

Suggestions for Future Work

1. **Optimization of Nano Additive Concentration**: Further research could focus on optimizing the concentration of nano additives in biodiesel blends. The current study observed improvements in engine performance and emissions with specific concentrations; however, the impact of varying the additive concentration should be systematically explored to identify the ideal balance between enhanced performance and minimal engine wear or fuel stability issues.
2. **Long-Term Engine Durability Testing**: While this study assessed the immediate effects of nano additives on performance and emissions, it is important to conduct long-term durability tests to evaluate the impact of these additives on engine wear, fuel system components, and maintenance requirements. This will ensure the long-term viability of nano-enhanced biodiesel in real-world applications.
3. **Assessment of Different Types of Nano Additives**: Future work could investigate a broader range of nano additives beyond the ones studied here, such as carbon-based nanoparticles (graphene, carbon nanotubes), metal oxide nanoparticles, and hybrid nanoparticles. A comparative study of these additives will help identify the most effective and sustainable options for improving biodiesel performance.

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