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STUDY ON DI-CI ENGINE CHARACTERISTICS FUELED WITH CITRUS MEDICA BIODIESEL DOPED WITH GREEN SILVER NANOPARTICLE

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Abstract

Research in the subject of engines, as well as adjacent fields, has focused heavily on how to increase combustion efficiency while decreasing hazardous emissions. Nano-additives to diesel-biodiesel fuel blends have shown promising outcomes, according to the research. Evidence from several studies on nanoparticles, both new and old, has revealed that nano-additives are crucial for enhancing the effectiveness of internal combustion engines and decreasing emissions of dangerous compounds. This research review compiles the most recent results on the possible advantages of nanomaterials as enhancers for diesel-biodiesel fuel mixes. The study's goal is to learn whether Citrus Medica biodiesel blends including silver nanoparticles made using environmentally friendly processes impact the efficiency of a DI-CI spontaneously aspirated motor. Green produced silver nanoparticles are employed as a Nano addition, with Citrus Medica biodiesel serving as the base fuel. The outstanding qualities of nanoparticles are first explained at length, and the techniques for manufacturing them are then summarized and debated. Second, we look at how different nanoparticles employed in diesel-biodiesel blends affect combustion effectiveness and dangerous substance emissions by analyzing their impacts on thermal efficiency, specific fuel consumption, carbon monoxide, nitrous oxide, and other gases. After everything is said and done, we talk about how nano-additives affect ICEs, the environment, and people's health. This paper's study has the potential to significantly advance the field of fuel applications including nanomaterials. As a result of our findings, scientists have a better foundation on which to make informed decisions on which nano-additives will best help internal combustion engines achieve clean combustion and minimal pollution.

Index Terms— Nanoparticles, Biodiesel, and the Healing Power of Citrus, biodiesel, characterization, fuel characteristics.

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I. INTRODUCTION

Fossil fuels are a non - renewable resource that are being depleted at an alarming rate due to human consumption. Emissions from burning fossil fuels harm plant and animal health and the ecosystem, hence low-carbon lifestyles have gained popularity in recent years [1]. The average temperature today is more than four degrees higher compared to the time before the industrialization, as well as the greenhouse changes wrought by the big usage of fossil fuels will have a lasting impact on human health. As this is the case, finding renewable, environmentally friendly alternatives to fossil fuels that can serve the same purpose is a major focus of research and development today.

Scientists are encouraged to identify alternative fuels to replace depleted fossil fuel reserves since the price of petroleum-based fuels continues to rise, environmental pollution continues to grow as a result of exhaust emissions from automobiles, and fossil fuel reserves continue to dwindle. Bio-diesel is being discussed as a possible energy source in light of growing concerns about the need for environmentally acceptable alternative energy sources [2]. Biodiesel is made from a variety of different sources, including vegetable oils, animal fats, waste greases, and recycled oils, and is referred to as FAAEs (fatty acid alkyl esters).

Vegetable oil, which is readily available, might serve as a feed-stock for biodiesel manufacturing. Edible oils are less desirable for making biodiesel due to the debate regarding their dual use as food and fuel. Yet, the high free fatty acid (FFA) and low sulphur content of non-edible oils make them particularly attractive for biodiesel generation. It aids in the prevention of acid rain by lowering the levels of sulphur dioxide (SO2). Now and in the future, it is important to lessen the amount of pollution released by cars and trucks powered by internal combustion engines. Vehicle emissions account for around 23.5 percent of all air pollution, and several nations have enacted environmental laws and regulations to combat this problem. Contrasted to diesel, biodiesel has a bigger cetane no, is devoid of aromatics and sulphur, and includes 10-11% oxygen by mass ratio, all of which make it an excellent fuel choice.

Engines with internal combustion will continue to be widely used as the standard for transporting power. Renewable sources of energy should also replace old fuels [3, 4]. Scientists have looked into a wide variety of diesel engine alternatives and have settled on biodiesel as their preferred fuel. Biodiesel is a renewable fuel that may be manufactured in huge amounts using a number of different processes. Most of it comes from the esterification of various fats and oils are used in the presence of a catalyst [5]. The biggest benefit of using it as an engine fuel is that very little alterations to engines are necessary. Engine effectiveness in terms of brake thermal efficiency (BTE), brake specific fuel consumption (BSFC), and braking power are essentially unaffected. Extensive study of biodiesel fuels led to the discovery that various blends of diesel and biodiesel—can improve emission and combustion effectiveness.

In order to boost engine performance, decrease emissions, and enhance combustion, nanoparticles may be the best addition for biodiesel mix fuels. In this study, the possibility of utilizing Citrus Medica seed oil as a biodiesel via the transesterification process is explored. Earlier studies indicated that, with the exception of NOx, exhaust emissions from diesel engines run on biodiesel were lower than those of conventional diesel engines. By incorporating a nano-additive into the gasoline, NOx emissions may be lowered while engine performance is also improved.

This research aims to investigate the fuel qualities of Citrus Medica biodiesel (CMBD), an alternative fuel made from Citrus Medica seed oil. This cutting-edge nanoparticle is made by processing citrus Medica. Biodiesel production might benefit from the introduction of Citrus Medica as a new energy crop. Transesterification catalyzed by green nanoparticles with a design. The last step is to conduct a full chemical and physical analysis of the test fuel samples that have been infused with silver nanoparticles manufactured in-house. The originality of this study lies in the fact that it creates a new tri-compound nano-based fuel that may be used in diesel engines.

Non-edible oil is transformed into biodiesel by mixing, emulsion, pyrolysis, and transesterification; however, transesterification is the most used process because to its high efficiency. Diesel engine efficiency, combustion, and emission characteristics will all be affected by the content and attributes of biodiesel made from vegetable and other resources. Due to biodiesel's lower heating value, caused by its inferior physical qualities like increased viscosity, density, flash point, fire point, etc., increasing the biodiesel component in biodiesel-diesel blends would reduce motor power and increase fuel consumption. The advancement of nanotechnology has yielded several useful outcomes, including the production of remedies to these deficiencies. Considering the enhanced surface area to volume ratio of nanoparticles and the decreased ignition delay, nano-doped substances are presently regarded to be one of the best fuel catalysts to improve fuel attributes.

II. Related Study

To examine the impact of various fuel blending ratios on the spray, combustion, and performance and emission of a diesel engine, this study used an engine fueled by a diesel/methanol/n-butane blend. Using a 3D CFD model in CONVERGE, author [6] was able to confirm their theory with experimental data. The modelling of combustion processes also made use of a refined chemical motion mechanism with 35o plus reactions and 70 plus species. Diesel, methanol, and n-butanol mixtures were shown to be crucial to the fuel spray and combustion method. To be more specific, the diesel/methanol/n-butanol blends have the potential to decrease emissions of NOx, CO, soot, and HC. That's why the mixed fuel of diesel, methanol, and n-butanol might enhance the combustion and emission parameters of the engine.

Once the Mayors Summit 2016 takes place in 2016, some European capitals hope to ban the use of diesel-powered vehicles entirely by 2020 in an effort to combat air pollution. The International Energy Agency (IEA) agrees that bioenergy's share of the global energy mix must rise until 2025, and it predicts that biofuels will account for as much as 30 percent of global road transport fuel by 2040. It is projected that by 2050, biofuel will have increased from its current 2% proportion of total transportation fuel to 27%. According to a research by the European Commission on Future Transport Fuels, cars powered by fuels regarding on animal fats might help meet the 2020 Red target. These global considerations are integral to the paper's goal [7]. The study describes the combustion processes occurring in a diesel engine fed with a mixture of raw animal fats (5% and 10% by volume) and diesel fuel. When using warmed raw animal fats, the in-cylinder pressure drops anywhere from 5% to 12% depending on the animal fats composition, assuming the engine is set up the same. With the addition of animal fats, the combustion time can be extended by 20 CAD, with subsequent cycles achieving the mass fraction burned per cycle. However, at 5% animal fats and 10% animal fats, respectively, the heat release rate is reduced by 16% and 20%, respectively, guaranteeing a 22% reduction in NOx emissions compared to diesel fuel. Smoke opacity is reduced by 22% when blending diesel fuel with 5% animal fats, and by 52% when increasing the animal fats level to 10%. When utilized as a fuel, raw animal fats are a viable alternative biofuel for diesel engines that does not require any substantial structural alterations.

Energy efficiency is crucial to the growth of developing nations like India, and the country's rapid reduction of petroleum supplies, rising petroleum prices, and strict emission rules have prompted scientists to look for new alternatives to diesel. Using a 20% tamarind seed methyl ester (TSME 20) biodiesel mix, the author [8] analyses the impact of adding oxygenated additives such diethyl ether, dimethyl ether, and dimethyl carbonate at 6% and 12% volume concentrations to determine how they affect engine performance. According to the findings of the tests, the braking thermal efficiency of the vehicle was massively enhanced by the inclusion TSME. It has shown favorable combustion and gasification, both experimentally and theoretically, by comparing the findings of the DRK theoretical results with the experimental outcome, done at the identical operating settings.

Due to their superior features, nanomaterials can be employed as extra in diesel fuel to enhance the effectiveness of diesel engines. In order to reduce dangerous diesel discharge and improve engine effectiveness, the author [9] emphasizes the special possibilities of nanomaterials and their usage in diesel engines. Laboratory test findings acquired in the past few years are reviewed in light of the impact of nanomaterial-enriched fuels on engine attributes and engine subsystems, as well as the prospects that arise from this. Of the many nanomaterials used as fuel extra in diesel engines, the optimal combinations are determined using two criteria. This is followed by a discussion of the technological obstacles that must be overcome before nanomaterials may be used as viable gasoline additives in the real world. Last but not least, the dangers to the environment and human health that have been uncovered by current research are discussed. We briefly review possible answers to open questions wherever they apply.

Nanoparticles of aluminum oxide were investigated by Author [10] for their potential use as Nano fuel enhancers in a diesel/honge oil methyl ester blend. Diffusing aluminum oxide in a Mixture allowed for the creation of a wide variety of Nano fuel mixtures. To keep the nanoparticles of aluminum oxide dispersed uniformly throughout the fuel mixes, sodium dodecyl sulphate (SDS), an anionic surfactant, was utilized. The ultra-sonication method was used to create HOME (B20) fuel with aluminum oxide nanoparticle concentrations of 20, 40, and 60 ppm, utilizing different surfactant to nanoparticle mass ratios from SDS. Diesel, honge oil biodiesel, and nanofuel mixes all met the requirements of ASTM D6751-15 for their respective qualities. Ultraviolet-Visible (UV-Vis) spectroscopy was used to determine and quantify the dispersion and homogeneity. UV-Vis spectrometry showed that as surfactant content was increased, absorbance also rose. The mass fraction of 1:4 showed the highest absolute value of UV-absorbency. Brake thermal efficiency (BTE) increased by 10.57 percent, brake specific fuel consumption (BSFC) decreased by 11.6 percent, and exhaust emissions of HC (26.72), CO (48.43 percent), and smoke (22.84 percent) were all decreased when using fuel with the 2040 target date (HOME2040), while NOx (11 percent) were increased. Experiments showed that proposed model improved the engine's performance in general.

III. METHODOLOGY

Materials and methods

All chemical reagents, including silver nitrate (AgNO3), diphenylpicrylhydrazyl (DPPH), nutritional agar, and nutrient broth for bacteria and fungi, were utilized in their unprocessed forms. Citrus limon (L.) fruit was picked by hand when it was ripe and picked at random from an identical tree on a public-private farm in the region of Ghardaa. Fruits chosen for selection must be golden in color, ripe, tasty, and free of disease. The fruit was cleaned under running water three times and then under deionized water three times to eliminate any atmospheric dust and brown stains, and was then allowed to dry in a room temperature air stream.

After washing and drying 15 grams of lemon zest, the zest was rehydrated in 150 milliliters of deionized water and subjected to a 15-minute reflux in a water bath at 60 degrees Celsius while being vigorously shaken. The solution was a transparent pale yellow tint. Once the extract solution reached room temperature, any suspended particles were filtered out using Whatman No.1 filter paper. Half of the extract was placed in a refrigerator (between 4 and 8 degrees Celsius) for later use, while the other portion was dried out in a vacuum oven (at 40 degrees Celsius) for 48 hours to generate a powdered form of the lemon zest extraction suitable for FTIR analysis.

The green syntheses were carried out with only a few tweaks to the standard protocol. We used a hot plate magnetic stirrer to continuously mix 3 liters of citrus lemon zest extract, 18 grammes of one freshly made silver nitrate aqueous solution (AgNO3), and 600 milliliters of methanol alcohol at 60 degrees Celsius, with a rotation speed of 200 revolutions per minute. After 30 minutes, the colloidal suspension went from yellow to brown, and the mixed solution become turbid and reddish-brown, both of which are indicative of the creation of silver nanoparticles. The mixture was centrifuged at 14,000 rpm for 18 minutes to separate the extract of Citrus lemon zest from the AgNPs, and then cleaned twice with doubly sterilized water and once with methanol to bring the precipitate back to its original dark brown color. Powder precipitate was then dried to produce silver nanoparticles. We adjusted experimental parameters such zest extract concentration, contact duration, and AgNO3 concentration to find the optimal conditions for producing AgNPs using Citrus lemon zest extract. Biodiesel made from food scraps has a positive impact on the economy and the environment, as shown in Figure 1.

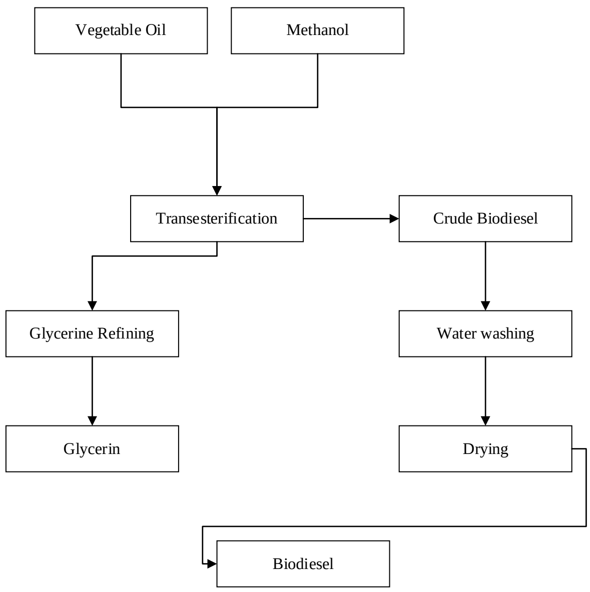

Figure 1. Impact of biodiesel manufacturing on the environment

IV. RESULTS AND DISCUSSIONS

Nano-additives are a promising area of study for enhancing engine performance in terms of both combustion and emissions. Researchers have chosen appropriate nano-additives by considering the viscosity, flash point, and solubility of the fuel mixes. Nano-additives and biodiesel-diesel blends were studied further to determine their effects on engine reliability, ignition, and exhaust emission.

Researchers have determined that biodiesel's flaws—including its low oxidative stability, better petroleum usage, and increased carbon emission in engine burning can be mitigated with the use of nano-additives. Nano-additives were tested for their impact on engine effectiveness metrics such brake thermal accuracy, petroleum economy, and power output.

Known as the "engine's efficiency quotient," BTE is the proportion of the engine's output energy to the fuel's input heat. Diesel-biodiesel fuel mixes that include nanoparticles can have enhanced radiation, heat, and mass transfer capabilities, leading to more complete burning and greater thermal accuracy. The addition of CeO2 nano-additives with sizes ranging from 30 to 50 nm to mixtures of cottonseed oil methyl esters was studied by Ramarao et al. Researchers discovered that increasing the loading of diesel-biodiesel fuel ensembles with CeO_2 addition enhanced the BTE. At full throttle, the mixed fuel with 0.04 grammes of CeO2 has a BTE that is around 2% greater than diesel. This improves the combining of fuel vapor with air, which in turn increases the likelihood of full combustion.

Looking at the effects of 30 ppm and 60 ppm alumina and MWNTs in a tamarind methyl ester combination. Figure 2 and Table 1 demonstrate that the addition of either nano-additive improves the engine's BTE, and that the BTE grows in tandem with the concentration of nano-particles. The high performance of the burning process can be attributed to the metal nanoparticles, which have a better binding surface area per unit of volume and improved air-fuel interaction. Also, alumina nanoparticle inclusion showed greater BTE than carbon nanotube incorporation under the same circumstances. The addition of 60 ppm alumina nanoparticles to fuel blends produced the greatest BTE, which was 4.48% better than that of the TSME blend under maximum load circumstances. This was because of the higher oxygen content of alumina nanoparticles, which led to a greater number of oxygen atoms being engaged in the process during burning. A comparable improvement in thermal accuracy was seen for greater quantities of alumina oxide nanoparticles in biodiesel, it was found.

Table 1. Thermal efficiency at different engine loads.

Effective pressure	Diesel	TSME20	TSME20ANP30
1	20	15	18
2	23	20	20
3	26	24	25
4	33	30	31
5	36	30	33
6	38	33	35

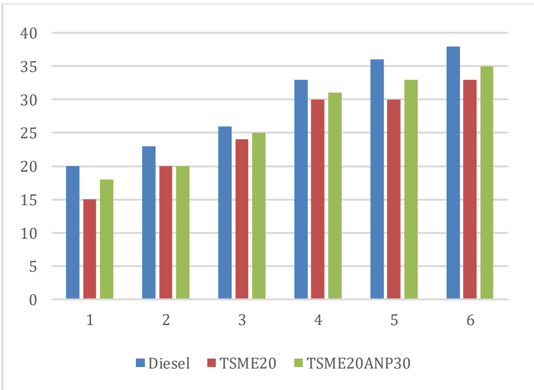

Figure 2. Brake thermal efficiency at various engine loads.

To boot, nano-additives can function as catalysts in a variety of contexts. This is because nano-additives can boost chemical reactivity by increasing surface area and reactive surfaces. Based on their findings, displayed in Figure 3 and Table 2, the use of nano-additives, which aid combustion and atomization, might be to blame for this. Incomplete burning of the fuel and higher thermal accuracy can be achieved by using GNPs to shorten the period of the exhaust stroke during which late combustion occurs.

Table 2. Brake Thermal efficiency vs brake power.

Brake Power	Diesel	B20	B100
1	17	16	15
2	16	23	22
3	29	28	25
4	30	27	26
5	33	29	28
6	35	32	30
7	38	35	33

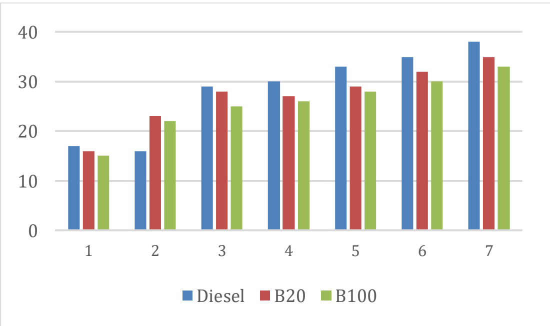

Figure 3. Changes of BTE with Brake power.

The methyl ester of Staphylococcus brucei algal oil was combined with CuO2 nano-additives at concentrations of 25 parts per trillion (ppt), 50 ppt, 75 ppt, and 100 ppt.

The experimental findings demonstrate that under different fuel blends, BTE improved with increasing load. BTE was consistently greater in diesel-biodiesel blended with 100 ppm CuO2 compared to B20. The increased efficiency of burning may be allows for effective atomization. (Figure 4 and Table 3).

Table 3. BTE vs load.

Load	B20	B20+25PPM	B20+50PPM
25	17	18	19
50	26	27	28
75	31	32	33
100	34	35	36
125	36	38	39
150	38	40	42
175	40	43	45
200	43	45	48
225	45	48	50

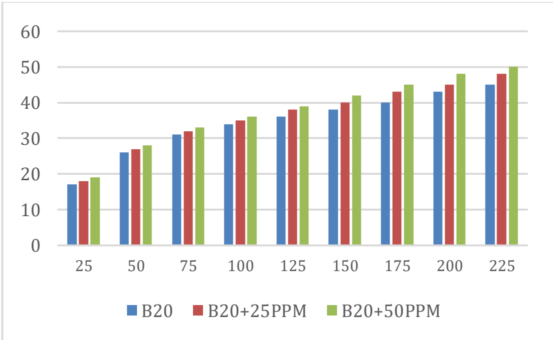

Figure 4. Changes of BTE with load.

The fuel efficiency ratio (BSFC) measures how much energy is produced in comparison to how much time has passed. Because diesel biodiesel fuel has a lower calorific value than diesel when the engine output is held constant, more fuel is required to provide the same level of power, leading to a higher BSFC. Adding nanomaterials to gasoline was proven to be an effective way to boost BSFC in the engine. Here, we look into how different nano-additives to diesel biodiesel affect BSFC.

Nano-fuel blends were created by Fayaz et al. by dispersing three distinct nanoparticles into diesel-biodiesel fuel blends. Full-load BSFC varies from 1050 rpm to 2300 rpm, as shown in Figure 5 and Table 4. The results reveal that the BSFC drops with increasing velocity, and that gasoline with nano-additions has a much lower BSFC than diesel, with the best results coming from additives containing Al2O3. Diesel-biodiesel containing nanoparticles was shown to have an enhanced air-fuel ratio, which solved the problems of clogging and poor atomization. In furthermore, the increased surface area to volume ratio brought forth by all of these nanoparticles improves combustion while simultaneously decreasing fuel requirements.

Engine speed	**Diesel**	**B30**	**B30+CNT**
1050	0.48	0.49	0.47
1300	0.47	0.48	0.46
1550	0.46	0.47	0.42
1800	0.42	0.43	0.42
2050	0.40	0.41	0.39
2300	0.38	0.39	0.35

Table 4. BSFC vs engine speed.

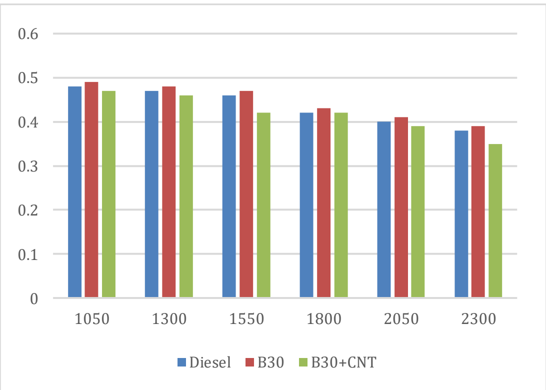

Figure 5. Variation of BSFC with Engine speed.

V. Conclusion and Future Scope

In this analysis, we find that using a biodiesel-blended nano-additive in a diesel engine improves the engine's efficiency, combustion, and emission properties. Transesterification is preferred because it results in a greater quantity of usable ester when compared to other biodiesel manufacturing processes. In comparison to other biodiesel-diesel mixes, the results are superior when using a biodiesel-diesel blend of 20% volume with plain diesel. This analysis concluded that biodiesel laced with nanoparticles is a viable alternative and environmentally friendly fuel technology that requires few engine adaptations. When nano-additives in internal combustion engines produce noticeable outcomes, there is reason to worry about unintended consequences. Nano-particles that were not directly engaged in the combustion process are discharged into the environment when an engine burns fuel, contributing significantly to air pollution and human toxicity. In addition, LCA has been used to thoroughly assess the advantages and disadvantages of biofuels in terms of human health and environmental impact. The future of nano-additives in diesel-biodiesel engines is promising. It's worth noting that incorporating nano-additives into diesel-biodiesel fuel ensembles is widely regarded as a promising strategy for doing both.

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