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CANOLA BIODIESEL WITH ZINC OXIDE NANO-PARTICLE:DIESEL ENGINE PERFORMANCE AND EMISSION ANALYSIS

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Abstract
Biodiesel is increasingly perceived as an important component of solutions to the important issues of fossil fuel shortages and environmental pollution. It is prepared by transesterification of animal fats and vegetable oils with methanol, catalysed by strong acids or bases. CANOLA stands for Canadian Oil Low Acid and is a part of the mustard plant family. In this work, the oil extracted by transesterification reaction between CANOLA oil and methanol in presence of sodium hydroxide (NaOH) catalyst . The solution is then blended with 50ppm of Zinc nano particle using a sonicated. In this work, the efficiency and emission properties of zinc nano particles. Particle blended CANOLA biodiesel fuel is studied by conducting experiments on a single cylinder four stroke air cooled diesel engine.

Keywords: Canola oil, Zinc oxide**.**

I. Introduction

The increasing industrialization & modernization of world lead to steep rise in petroleum cost & depletes the petroleum resources in rapid rate. If the existing consumption rate continues the resources supplying petrol fuels may deplete within a decade or two. Keeping this in view, many alternative fuels have been identified & tested in existing engine. However each one possesses few undesirable characteristics & hence failing to replace the fossil fuel completely. In addition the continuous accumulation of green house gases by fossil fuels combustion threats the sphere in terms of global warming. Hence the new replacing fuel should have capability to run the existing engine with or without minor modifications & less polluting. Bio-fuels are derived from the bio-resources & hence the liberation of greenhouse gases will not affect the earth atmosphere. Many resources proved that the bio-fuels are best substitute for existing fossil fuels, but requires considerable modifications. In the present work one such bio-fuel nano particle blended fuel has been taken for investigation.

II. Literature

2.1 Introduction

Due to their few unfavourable fuel properties, the majority of alternative biofuels discovered today are demonstrated to be a partial replacement for existing ones. The various admittance approaches, however, are offering good solutions for applying a significant amount of replacement fuel in an existing engine. Many researchers have concentrated in several issues related to this field & brief accounts of these findings are reviewed under four categories according to the objectives of the research work.

2.2 Potential alternative fuels for diesel engine

In this paragraph, various research works made under the domain of alternate fuels suitable for diesel engines are reviewed to explore the performance & characteristics & the durability issues posed by them. Sorenson et al (1995) used Dimethyl ether (DME)in non-turbocharged DI engine as an alternate to diesel fuel & obtained very satisfactory combustion &performance. This result showed that DME gave better thermal efficiency, much lower NO_X, extremely low smoke & less engine noise versus diesel fuel operation. They also conducted a limited durability study using this fuel for 500 hours to study the long term operational problems. Bari et al (2002) investigated the filter clogging & power

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loss issues while running a diesel engine with waste cooking oil (WCO). In this research they found that heating WCO above 55 degrees effectively prevents clogging. However, Approximately six times as much head loss occurred across the filter than diesel did.. Their results also showed that WCO offered a shorter ignition delay, reduced maximum power, higher CO, NO, SO_2versus diesel fuel operation.

2.3 Neat vegetable oils

Vegetable oils in neat form or esterified form discovered becoming the best substitute for diesel fuel, as they possess high cetane number, high boiling point, better lubricity &availability. However, studies conducted with vegetable oil showed that the vegetable oil in neat form is not suitable for engine application given its high viscosity, poor volatility and high molecular weight. Hence, vegetable oils are admitted into the engine either with the help of diesel vegetable oil blends or esterified vegetable oil (biodiesel). The former is simple & cheap but it doesn't replace the diesel fuel completely. The latter is cumbersome & requires more time for processing and is also expensive. Application of vegetable oil in neat form in diesel engine is more economic but troublesome. However, research is still being done to solve the problems described above brought on by the application of plain vegetable oil. Earlier researches showed that using vegetable oil neat form (more than 20%) caused engine damages, lube oil dilution & registered some durability issues. Hence this portion of literature, reviews the previous works undertaken in vegetable oils neat or esterified, in diesel engines to study the various performance and characteristics.

Bailer et al (2002) conducted a short term performance test in DI diesel engine using crude palm oil (CPO). Their investigations revealed that the maximum power of the engines reduces and emits higher NO and CO, after 500 hrs of cumulative running with CPO. At the end of specified duration of operation, the affected parts were removed from the engine and installed in new engine to evaluate the performance of each part. Finally, they identified the list of problems responsible for the performance deterioration of CPO run engine. Hamasaki et al (2001) used vegetable oil methyl ester waste in a diesel engine to investigate and combustion characteristics. The same test was conducted in visual engine to visualize the combustion and behaviour of this fuel. Their investigation revealed that the waste oil methyl ester group shows higher HC and CO than the fresh oil methyl ester. They also reported that the vegetable oil methyl ester waste shows better combustion rates and lowers smoke than the diesel fuel.

2.4 Bio diesel

Haq Nawaz Bhatti et abused the process of transesterification to extract bio diesel from animal fats(dairy cow and beef)by altering process variables like those listed below as catalyst The quantity, kind of catalyst, duration, and temperature of the reaction. To get a sustainable energy source, A.B.M.S. Hossa net al produced bio diesel using leftover Canola cooking oil. Lower alcohol to oil molar ratios were used to trans esterify used canola frying oil in order to assess its viability.

M. Mathiyazhaganetal conducted performance and engine study on diesel engines using biodiesel made from Jatropha curcus oil. In this investigation, biodiesel was created using a two-step catalysed process and blended with diesel at a rate of 10% to 50%.Mahua biodiesel was employed by B.S. Painteta to examine the a performance analysis twin cylinder diesel engine. They made the decision to conduct an experiment to explore the real-world uses of biodiesel and determine the best blending ratio for a dual-cylinder diesel engine that is utilised in generating sets and agricultural applications. Mahua oil and diesel blends at diverse ratios were prepared, assessed, and compared to the performance in respect to this inquiry. Dual cylinder diesel engines operating under various loads were used to conduct the study. Mahua biodiesel is found to have a greater fuel consumption rate than petroleum diesel due to its increased viscosity and flash point. As the mahua production rate in the blend increases, temperature of the exhaust gas with the mixes reduced. The blended fuel is found to have superior cetane, flash point, and lubricity than regular diesel fuel.

III. Bio diesel production

3.1Canola oil

Biodiesel is a non-toxic, biodegradable alternative fuel made from renewable resources that requires little to no modification for use in conventional diesel engines. One of the best and most efficient sources of biodiesel with great cold-flow characteristics is canola oil.. Canola oil's low saturated fat content which is good for the heart is also good for the engine. Canola oil is a more viable source for producing biodiesel than natural oil as a renewable alternative to fossil fuels since genetically engineered rapeseed oil has less harmful and irritating qualities. Canola seeds produce around 44 percent more oil when crushed than soybeans, the most widely used source of biodiesel feedstock, which yield only 18 percent oil. Because there is no waste, canola biodiesel is an efficient option. Glycerin from waste canola oil can be used to make soap, lotion, and other personal care products. Crushed seeds, an excellent source of protein, are used in animal feed.

Figure 3.1 Canola Oil

3.2 Procedure

In Biodiesel may be used in diesel engines either alone or in conjunction with diesel oil. Alcohol and vegetable or animal fats are used to chemically create it. According to ASTM International (formerly known as the American Society for Testing and Materials), biodiesel is a mixture of long-chain monoallelic esters of fatty acids generated from renewable resources and is designed for use in diesel engines. Making biodiesel is the method of creating biodiesel using the transesterification and esterification chemical reactions. This entails blending vegetable or animal fats and oils with short-chain alcohols (often methanol or ethanol).Biodiesel is usually produced by the transesterification of vegetable oils or animal fats with methanol or ethanol. An appropriate volume (200ml) of alcohol was measured and poured into a 1000ml glass beaker. The catalyst (NaOH) in pellet form was weighed (2 grams) and mixed with alcohol. The mixture was then stirred for about 30minutes using a magnetic stirrer. Since alcohols evaporate easily, the beaker was wrapped with aluminium foil throughout stirring to stop alcohol from evaporating. The oil was poured into the glass beaker containing catalyst-alcohol solution, and this moment was taken as the starting time of the reaction. The alcohol oil mixture was heated up to a temperature of 70°C on heater with an in built magnetic stirrer. The reaction mixture was simultaneously stirred at a fixed speed for 3 hrs. For 30 minutes, the reaction's by-product was left out in the open to let any extra methanol evaporate. After being left to settle for an entire night, the product produced two different liquid phases: a crude ester phase at the top and a glycerol phase at the bottom.

3.3 Transesterification

A process known as transesterification involves switching an ester's organic group R″ for an alcohol's organic group R′. Usually, an acid or a basic catalyst is used to catalyse these reactions. Enzymes (biocatalysts) is also applicable to the procedure, particularly lipases. Both homogeneous and heterogeneous catalysts can catalyse the transesterification process. Alkalis and acids are examples of homogeneous catalysts. The two alkali catalysts that are most frequently utilised are potassium and

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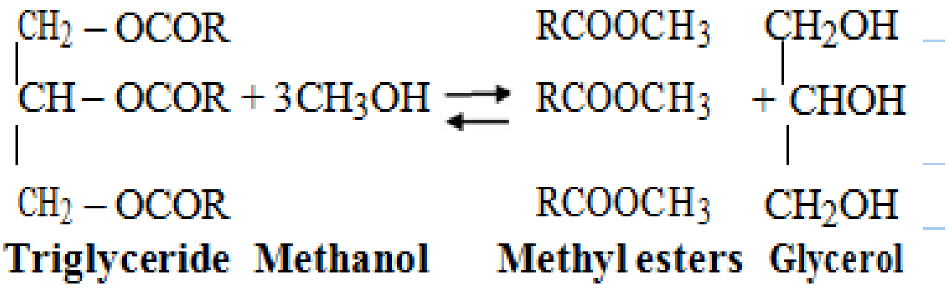
sodium hydroxides. The acid-catalysed process often uses sulphuric acid and hydrochloric acid as catalysts; however, the reaction time is very long, even at reflux of methanol, and a high molar ratio of methanol to oil is needed (30-150:1, by mole). Potassium hydroxide, sodium hydroxide, and their carbonates, as well as potassium and sodium alkoxides such as $NaOCH_3$, are usually used as base catalysts for this reaction. As the catalytic activity of a base superior to that of an acid, and acid catalysts are more corrosive, the base-catalysed process is preferred to the acid catalysed.



Formula for triglyceride transesterification using methanol

Glycerine is a by-product of this process, which involves the replacement of alcohol molecules from an ester by additional alcohol molecules. Using catalysts could speed up the transesterification reaction rate. Both homogeneous and heterogeneous catalysts can catalyse the transesterification process.

Figure 3.3 Transesterification Process

IV. Nano particles

4.1 Introduction

A nano particle is described as a tiny item that, considering its attributes and mobility, functions as a single unit. The diameter is used to further categorise particles. The size of fine particles ranges from 100 to 2,500 nanometres. Between one and one hundred nanometres in size are ultrafine particles, also known as nanoparticles. Due to the vast array of possible applications in the domains of biomedicine, optics, and electronics, nanoparticle research is currently a topic of significant scientific interest.

4.2 Properties of nano particles

Some of the important properties of Nano particle are discussed below.

- The high ratio of surface to volume of nanoparticles provides a tremendous driving force for diffusion, especially at elevated temperatures.
- Adding nano particles does not affect the density of the final product.

- Nanoparticles are particularly effective for stabilizing s. They can self-assemble at water/oil interfaces and act as solid surfactants.

4.3 Need for nano particles

In an effort to cut NO_x and particulate matter from diesel engines, emulsification techniques are adopted. In this technique, water droplets are suspended in the oil layer by a suitable surfactant and undergo a rapid evaporation of water, which, in turn, avoids the corrosion effect on the engine cylinder surface .Another benefit of the emulsification technique is the occurrence of micro explosion phenomena, where the large fuel droplets break into smaller one and, in turn, results in vigorous vaporization in the engine cylinder. However, emulsification of biodiesels causes ignition difficulty and longer ignition delay at the lower loads. The problem of prolonged ignition delay associated with the fuel leads to the enhancement in premixed combustion phase, high heat release rate, high cylinder peak pressure, and rough engine operation.

To sort out the problem of prolonged ignition delay, potential nano particles are added. Addition of nano particles to fuel will lead to a significant enhancement in the ignition temperature and shorter ignition delay. Furthermore, addition of nano particles causes significant improvement particular fuel usage in the braking and reduced harmful pollutants.

4.4 Zinc oxide nanoparticles

1. Zinc oxide has refractive index.
2. It has high thermal conductivity.
3. It also has binding, antibacterial UV - protection properties.
4. The amphoteric oxide zinc oxide.
5. It is almost insoluble in water, but most acids, including hydrochloric acid, can dissolve it.
6. Although the rare mineral zincates, which is often coloured yellow to red by manganese and other contaminants, is more frequently found in nature than pure zinc oxide, which is a pure white powder.
7. When heated in the air, crystalline White zinc oxide becomes yellow with time. and then back to white. Alkalis will also dissolve solid zinc oxide to produce soluble zincates.
8. Most uses make use of the oxide's reactivity as a base for other zinc compounds used in material science.

4.5 Specification

Size	<50nm
Purity	99.5%
Molecular weight	81.39g
Density at 25ºC	5.6g/cm^3
Packaging	5g in poly bottle
Surface Area	10-15m^2/g

4.6 Sonication

Particles in solution are stirred up via a process called sonication. These disturbances can be employed to quickly combination of solutions or the liquidation of 24a solid. Typically, ultrasonic waves with frequencies above 20 KHz are employed in sonication, and as frequency rises, so does the intensity of the agitation. The reason why the particles in solution vibrate is due of a procedure called cavitation, whereby tiny vacuum bubbles form as a result of pressure cycles and subsequently burst into solution. These vibrations have the power to sabotage molecular connections, disperse particle clumps, and promote mixing.

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Figure 4.1Ultrasonicator

4.7 Preparation of nano particle biodiesel

- The biodiesel is transferred to a glass beaker.
- 50ppm of nanoparticles (Zinc oxide), is then added to the mixed fuel.
- The mixture is then kept in a sonicator for 30 minutes.
- The nanoparticle blended fuel is then removed from the sonicator and transferred into a suitable container.

V. Results

There is no modification made to the diesel engine that is regularly used.
Combustion Parameters:

Specific Gas Constant : 1.00 KJ/kgk
Air Density : 1.17 kg/m^3
Adiabatic Index : 1.41
Polytrophic Index : 1.12
Number of Cycles : 10
Cylinder Pressure Reference : 6

5.1 20% Bio diesel blend (NB 20)

These blending show that there is the amount of 20% of biodiesel mixed with the rest of 80% pure diesel.

Injection Timing : 23^o BTDC
Injection Pressure : 200bar
Calorific Value : 41700KJ/Kg
Density : 862kg/m^3

Table 5.1 NB 20 Result

L oad %	BP kW	IP kW	SFC Kg/kWhr	M E C H %	BTE %	ITE %	CO %	HC ppm	NO p p m
0	0	2.41	∞	0	0	79.24	0.028	21	124
25	1.31	3.77	0.44	34.21	19.72	74.43	0.078	64	437
50	2.63	4.94	0.32	54	28.17	64.99	0.082	91	1021
75	3.91	6.22	0.29	64.93	31.53	61.40	0.091	103	1465
100	5.12	7.25	0.27	73.28	33.23	59.67	0.256	144	1852

5.2 40% Bio diesel blend (NB 40):

In this the amount of 40% of biodiesel mixed with the 60%of ordinary biodiesel.

Injection Timing : 23^oBTDC
Injection Pressure : 200bar

Calorific Value : 40900KJ/Kg
Density : 869kg/m^3

Table 5.2 NB 40 Results

Load	BP	IP	SFC	MECH	BTE	ITE	CO	HC	NO
%	Kw	Kw	Kg/kWhr	%	%	%	%	Ppm	p p m
0	0.00	2.35	∞	0	0	66.38	0.026	18	116
25	1.32	3.71	0.48	34.8	19.13	66.58	0.062	36	421
50	2.61	4.83	0.35	53.7	27.42	59.57	0.076	76	1014
75	3.86	6.57	0.302	64.84	30.85	61.78	0.084	96	1448
100	5.09	7.12	0.28	73.34	32.57	56.27	0.211	125	1802

5.3 60% Bio diesel blend (NB 60):

This shows that the amount of 60% of biodiesel mixed up with rest of 40% ordinary diesel.

Injection Timing :23^o BTDC
Injection Pressure : 200bar
Calorific Value : 40100KJ/Kg
Density : 886kg/m^3

Table 5.3 NB 60 Results

Load	BP	IP	SFC	MECH	BTE	ITE	CO	HC	NO
%	kW	kW	Kg/kWhr	%	%	%	%	ppm	ppm
0	0	2.38	∞	0	0	78.39	0.025	14	111
25	1.42	3.77	0.49	34.42	18.7	74.48	0.056	32	411
50	2.65	5.07	0.35	55.54	26.92	71.59	0.071	65	1006
75	3.89	6.09	0.31	65.37	29.84	63.32	0.073	73	1433
100	5.07	7.00	0.29	72.36	31.55	60.16	0.161	88	1786

5.4 100% Bio diesel blend (NB 100):

This is the purest form of biodiesel that means non-blended with any of other particles.

Injection Timing : 23^o BTDC
Injection Pressure : 200bar
Calorific Value : 38500KJ/Kg
Density : 908kg/m^3

Table 5.4 NB 100 Results

Load	BP	IP	SFC	MECH	BTE	ITE	CO	HC	NO
%	kW	kW	Kg/kWhr	%	%	%	%	ppm	ppm
0	0	2.73	∞	0	0	90.04	0.023	11	98
25	1.43	4.01	0.49	35.1	18.14	71.93	0.051	27	401
50	2.64	5.15	0.35	53.55	25.41	63.53	0.065	45	986
75	3.92	6.15	0.31	64.63	29.14	60.76	0.061	52	1410
100	5.13	7.16	0.29	72.24	29.75	56.58	0.131	80	1737

VI. Conclusion

The zinc oxide nanoparticle blended emulsified canola oil biodiesel was fuelled to the engine and the performance and characteristics were observed. The obtained results prove that the zinc oxide nanoparticle blended 100%biodiesel (NB100) can be used as an alternative fuel as it produces reduced (NOx, ,CO and HC) with improved efficiency when compared to that of ordinary diesel operation. From the performance characteristics obtained, it is observed that the zinc oxide nanoparticle blended biodiesel fuel performs with an improved efficiency when compared to ordinary biodiesel fuel. The zinc oxide nanoparticle blended 100% biodiesel NB(100) performs with higher brake thermal efficiency , higher indicated thermal efficiency, almost similar specific fuel consumption and mechanical efficiency when compared to an ordinary diesel operation performance. On the whole, it is concluded that the zinc oxide nanoparticle fuel will be a decent substitute for diesel fuel.

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