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STUDY OF EFFECT OF UNSATURATION OF VARIOUS BIODIESEL ON THE PERFORMANCE OF DIESEL ENGINE

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ABSTRACT

Biodiesel, the methyl ester of vegetable oil is a renewable, low environmental impact and potential as a green alternative fuel for diesel engine. The aim of this present work is to compare the performance and emissions of a diesel engine run on eight bio diesel fuel. A 4 stroke single cylinder direct injection water cooled constant speed diesel engine was run with diesel fuel and then bio-diesels. The performance of all the biodiesels is compared on the basis of brake thermal efficiency and exhaust gas temperature and emissions compared are carbon monoxide and oxides of nitrogen. The oxides of nitrogen are found to be higher for biodiesels but not significantly higher when compared with diesel. It is concluded that the biodiesels can be used as alternative fuel in the Diesel engine without any engine modifications.

Keywords:- *Diesel engine, Emission, Soybean oil methyl ester.*

INTRODUCTION

Petroleum products, the actual base of the world energy matrix, are causing serious problems to the environment. In search for alternative fuels which can be used as a substitute to conventional Petroleum diesel fuels is in demand due to concerns about depletion of fossil fuel reserves and also growing worldwide environmental stringent of pollution. Fuels derived from renewable biological resources for use in diesel engines are known as biodiesel. It is the mono alkyl esters of long chain fatty acids derived from renewable lipid sources [1]. Biodiesel is typically produced through the reaction of a vegetable oil or animal fat with methanol in the presence of a catalyst to yield glycerin and methyl esters [2]. The high value of soybean oil as a food product makes production of a cost-e effective fuel very challenging. However, there are large amounts of low-cost oils, waste and animal fats that could be converted to bio-diesel [3]. With use of biodiesel, CO and HC emissions are reduced whereas N_2O emissions increases with increase in biodiesel content [4]. The process of production of biodiesels is called transesterification which is catalyzed by chemical reaction of oil & alcohol [5]. There are several of species from which biodiesels can be made available. One of the main benefits of using a biodiesel fuel is its increased lubricity over regular diesel fuel and the potential benefits of reduced fuel consumption and engine wear that come with it [6]. Despite the success when diesel engines are operated on vegetable oil for short term performance tests, the real measure of success when using vegetable oil as a diesel fuel extender or replacement depends primarily on the performance of vegetable oils in engines over a long period of time[7], Biodiesel can be harvested and sourced from non edible oils like jatropha, Pongamia, Neem, Azadirachta indica), Mahua, castor, linseed, Kusum (Schlechera trijuga), etc and edible oils like coconut, palm, sun flower, mustered, soybean etc[8-9]. Out of these plants, soybean and Pongamia Pinnata which can grow in arid and wastelands [9].

Biodiesel has some important advantages when compared to diesel fuel. Biodiesel contains almost no sulphur; is biodegradable, nontoxic and a natural lubricant. Biodiesel has a high flashpoint about 130^{0}C (266^{0}F), so it not explodes spontaneously or ignites under normal circumstance. This feature makes biodiesel much safer to transport and store.

Although biodiesel contains 10% less energy per gallon than conventional diesel fuel, it exhibits almost the same performance compared to diesel fuel, because, beyond reduces engine friction between engine parts, biodiesel useable energy is partially offset by approximately 7% increase in the combustion efficiency. Biodiesel has others advantages, compared to conventional diesel fuel, such as: ready availability, renewability, biodegradability, higher Cetane number, ash point, cloud point [9]. Since biodiesel comes from a renewable energy source, its production and use as a replacement for fossil fuel provides three main benefits: reduces economic dependence on petroleum oil; decreases gas emissions that cause the greenhouse effect and diminishes the prolifera on of deceases caused by the pollution of the environment, The use of biodiesel in diesel engines require no hardware modification because vegetable oils have Cetane numbers close to that of diesel fuel. High viscosity of the vegetable oil leads to poor fuel atomization, which in turn may lead to poor combustion, rings sucking, injector cocking, injector deposits, injector pump failure and lubricating oil dilution by crank-case polymerization [10]. Canacki and J,Van.Gerpen conducted an experiment on a diesel engine and observed significant improvement in engine performance and emission characteristics for the biodiesel fuelled engine compared to diesel fuelled engine. Thermal efficiency of the engine improved, brake specific fuel consumption reduced and a considerable reduction in the exhaust smoke opacity was observed [11].

The objective of the present study is to compare the performance and emission characteristics of a 4 stroke single cylinder water cooled constant speed diesel engine using eight biodiesel as fuel.

The research was conducted to study the Effect of Unsaturated Composition of Various Biodiesel on the Performance of the DI Diesel Engine. The topic was decided to highlight the significance of using various vegetable oils as fuel and for these purposes eight biodiesel fuels are used to gain knowledge about their properties as well as to investigate the usage of the energy fuels as an alternative source of energy.

Various investigations were done and the results of the experimental values of performance and pollutant emission parameters for different biodiesel fuels taken at full load conditions are shown in Tables.

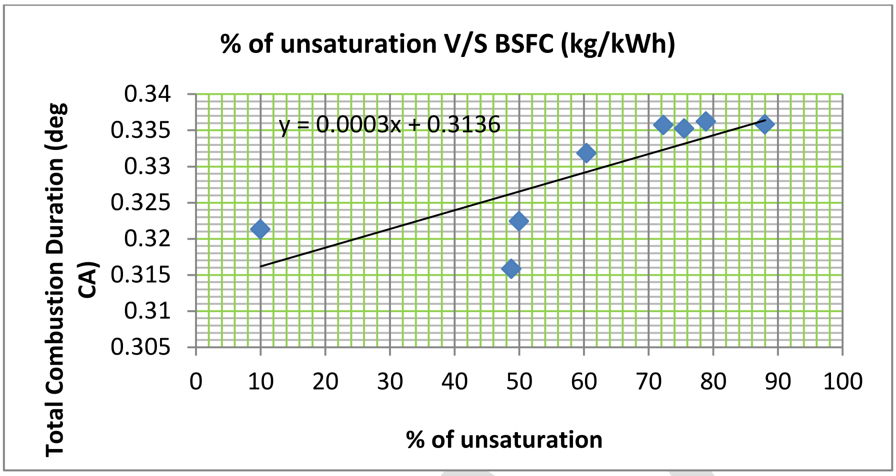
Table: Properties of different biodiesel fuels

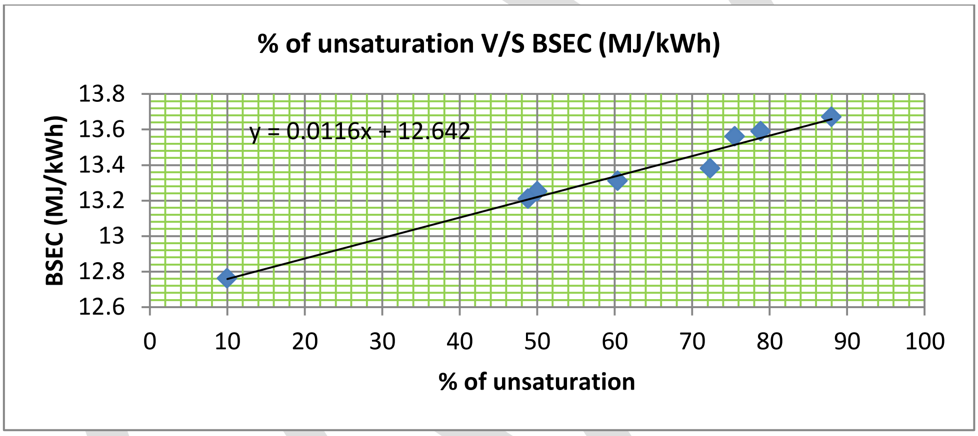
Biodiesel	% of US	BSFC (kg/kWh)	BSEC (MJ/kWh)	Brake Thermal Efficiency (%)	Exhaust Gas Temperature (°C)
SFOME	**88**	0.3358	13.67	27.51	359
ROME	**78.87**	0.3362	13.59	27.61	355
JOME	**75.5**	0.3352	13.56	27.67	358
KOME	**72.32**	0.3357	13.38	28.05	347
NOME	**60.4**	0.3318	13.31	28.16	347
MOME	**50**	0.3224	13.25	28.31	332
POME	**48.8**	0.3158	13.21	28.42	331
COME	**10**	0.3213	12.76	29.51	311

Biodiesel	Brake Specific NOX (g/kWh)	Brake Specific CO (g/kWh)	Brake Specific HC (g/kWh)	Smoke (BSU)	Brake Specific CO2 (g/kWh)
SFOME	14.511	3.675	0.451	0.9	4.12
ROME	14.255	2.641	0.436	1.1	4.52
JOME	13.763	3.161	0.394	1.4	4.26
KOME	13.521	2.645	0.411	1.4	4.92
NOME	12.715	2.124	0.405	1.6	5.11
MOME	12.053	1.611	0.408	1.5	5.26
POME	11.821	1.124	0.348	1.6	5.39
COME	11.122	1.886	0.351	1.6	5.86

RESULT & DISCUSSION

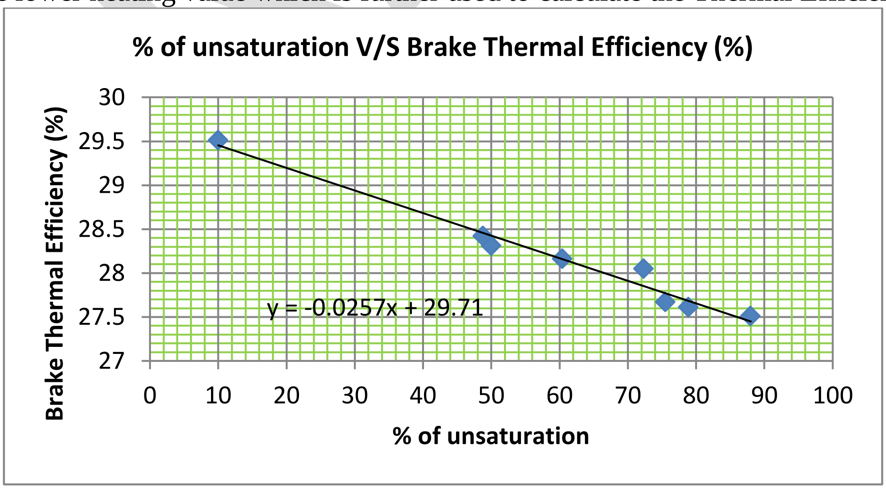
1. **Brake Specific Fuel Consumption (BSFC) & BSEC:** BSEC is defined as the energy required developing a unit power in unit time whereas; BSFC is the quantity of fuel required for developing unit power in unit time.





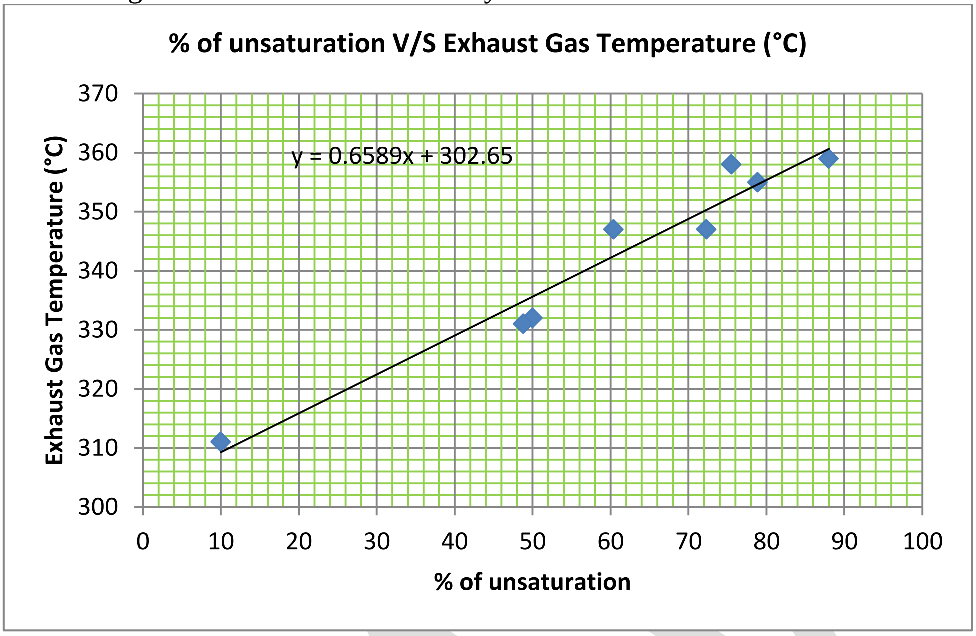
The rise in unsaturation percentage results in a rise in BSFC and BSEC. Every one per cent increase in unsaturation may result in an increase of 0.0003 kg/kWh and 0.011 MJ/kWh in BSFC and BSEC respectively. The reason behind this behavior can be ascribed to the lower heating value and higher density of biodiesel fuel.

2. **Brake Thermal Efficiency:** The fuel injection is calculated with the help of injected fuel mass flow rate and the lower heating value which is further used to calculate the Thermal Efficiency.



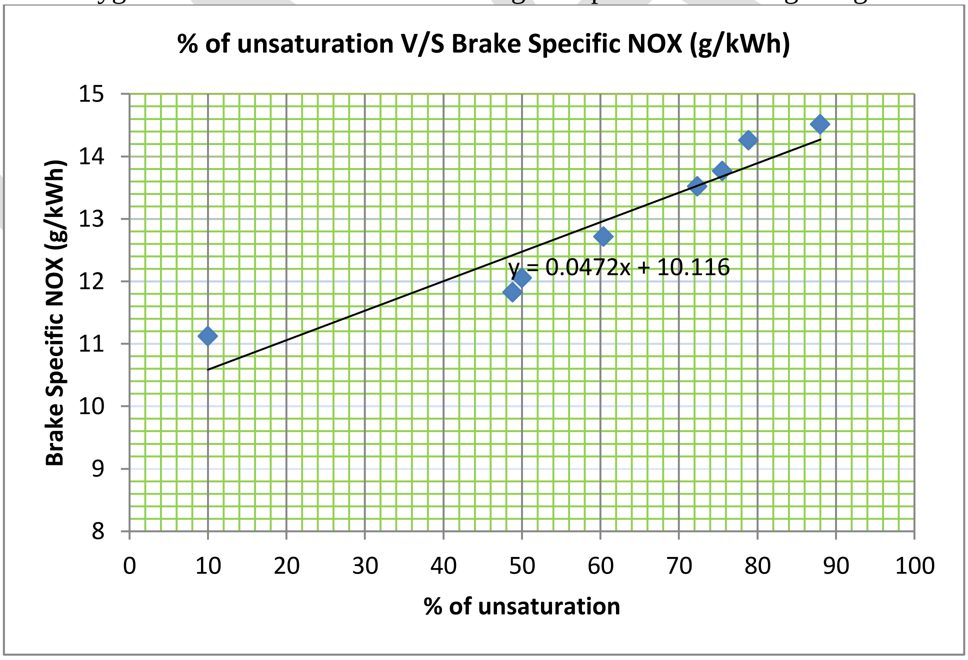
Brake thermal efficiency decreases with increase in percentage of unsaturation. Every one percent increase in unsaturation may result in an increase of 0.025 % in brake thermal efficiency. In the entire test range of unsaturation, the variation in brake thermal efficiency was only 2 %.

3. **Exhaust Gas Temperature:** This is measured for checking the proper and effective use of heat energy by the engine. Higher exhaust temperature indicates the poor energy utilization by the engine, which in turn designates lower thermal efficiency.



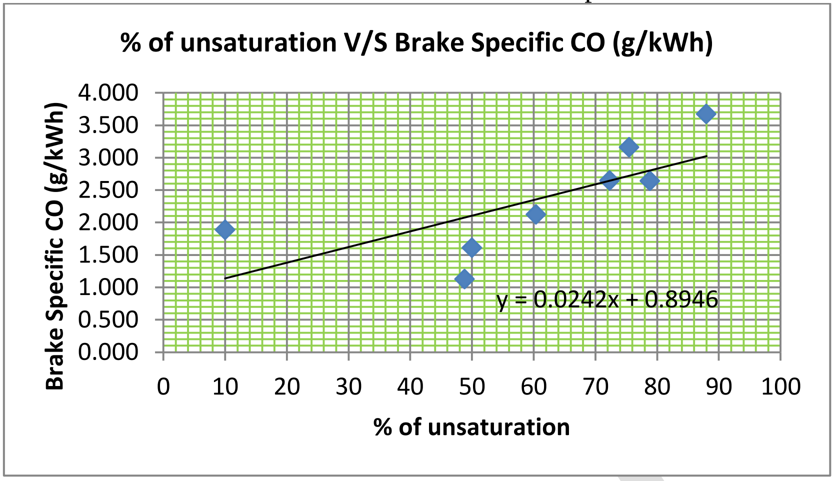
Exhaust gas temperature increases with increase in unsaturation percentage. An increase of 0.658 ^{0}C may be predicted by increasing every one percentage of unsaturation. The variation in exhaust gas temperature is only 50^{0}C in the entire test.

4. **Oxides of Nitrogen (NO_X):** NO_X emission is a result of non-equilibrium chemical reaction between nitrogen and oxygen atoms and molecules in the high temperature burned gas regions.



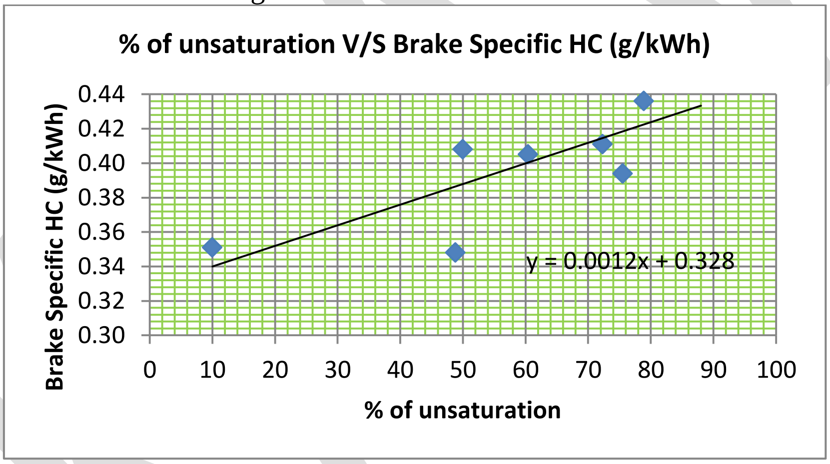
Oxides of nitrogen increase with increase in percentage of unsaturation, density and iodine value. Because of the increase in the density of biodiesels there is a high increase in this variable. An increase of 0.047 g/kWh in brake specific NO_X can be anticipated for each percentage increase in percentage on unsaturation.

5. **Carbon Monoxide (CO):** The fuel oxidation resulting in the hydro carbonation forms Carbon monoxide in diesel engines. During combustion, the oxidation of CO to CO_2 occurs through recombination reaction between CO and the different oxidants present.



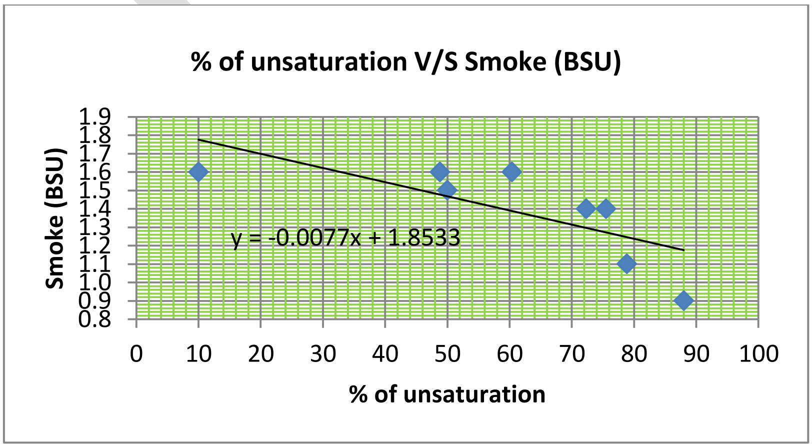
Carbon monoxide emissions increased with increase in percentage of unsaturation. Every one percent increase in unsaturation may cause an increase of 0.024 g/kWh in brake specific CO. The reason behind this behavior can be understood by the local air-fuel ratio of the mixture.

6. **Unburned Hydrocarbon (UBHC):** The heterogeneous nature of diesel combustion process is complex which is shown in the diagram below.



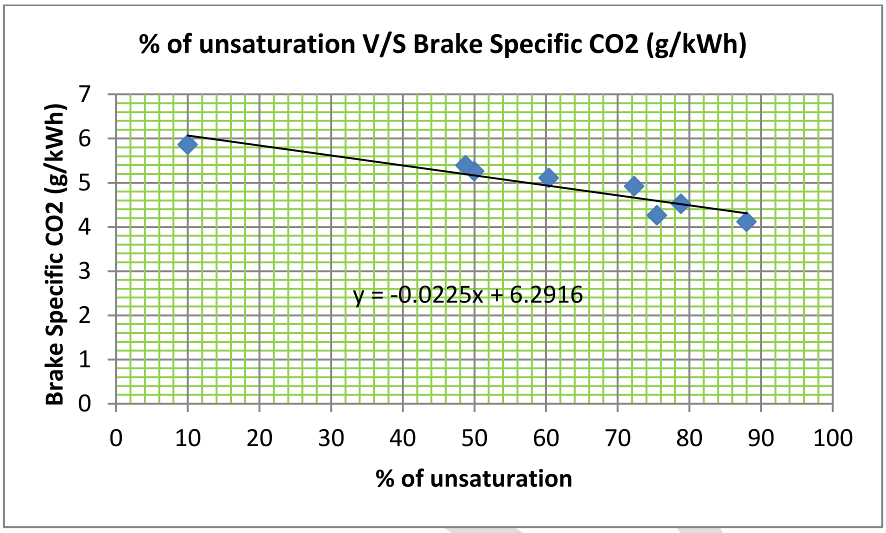
UN burnt hydrocarbon emissions increased with increase in percentage of unsaturation.

7. **Smoke:** Smoke is emitted as a product of the incomplete combustion process, particularly at maximum loads.



Smoke decreases with increase in unsaturation. This is due to the oxidation reaction and local oxygen availability.

8. **Brake Specific Carbon Dioxide:** The CO_2 emission from a compression ignition engine is the result of better combustion, while HC and CO is of poorer combustion.



Carbon dioxide emissions decreased with increase in percentage of unsaturation and it is expected for every one percent increase in unsaturation.

Some of the major findings of the investigation are:

1. The rise in unsaturation percentage results in a rise in BSFC and BSEC. Every one per cent increase in unsaturation may result in an increase of 0.0003 kg/kWh and 0.012 MJ/kWh in BSFC and BSEC respectively. The reason behind this behavior can be ascribed to the lower heating value and higher density of biodiesel fuel.
2. Brake thermal efficiency decreases with increase in percentage of unsaturation. Every one percent increase in unsaturation may result in an increase of 0.025 % in brake thermal efficiency. In the entire test range of unsaturation, the variation in brake thermal efficiency was only 2 %.
3. Exhaust gas temperature increases with increase in unsaturation percentage. An increase of 0.658 ºC may be predicted by increasing every one percentage of unsaturation. The variation in exhaust gas temperature is only 50 ºC in the entire test.

EMISSIONS

- Oxides of nitrogen increase with increase in percentage of unsaturation, density and iodine value. Because of the increase in the density of biodiesels there is a high increase in this variable. An increase of 0.049 g/kWh in brake specific NOX can be anticipated for each percentage increase in percentage on unsaturation.
- Carbon monoxide emissions increased with increase in percentage of unsaturation. Every one percent increase in unsaturation may cause an increase of 0.023 g/kWh in brake specific CO. The reason behind this behavior can be understood by the local air-fuel ratio of the mixture.
- Unburnt hydrocarbon emissions increased with increase in percentage of unsaturation.
- Smoke decreases with increase in unsaturation. This is due to the oxidation reaction and local oxygen availability.
- Carbon dioxide emissions decreased with increase in percentage of unsaturation and it is expected for every one percent increase in unsaturation.

CONCLUSION

The biodiesel fatty acid ester composition can have considerable influence on the biodiesel fuel properties with relation to the combustion, performance and emission parameters. From the present study, it can be observed that almost all the properties/parameters are adversely affected by unsaturated fatty acids. But still unsaturated fatty acids cannot be completely eliminated. Because some of the previous researches reveal that the unsaturated fatty acids can improve the cold flow properties of biodiesel. It therefore appears reasonable to enrich a certain fatty acid ester(s) with desirable properties in the fuel in order to improve the properties of the whole fuel. It may be possible in the future to improve the properties of biodiesel by means of genetic engineering of the parent oils, which could eventually lead to a fuel enriched with a certain fatty acid (s) that exhibits a combination of improved fuel properties.

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