Biodiesel – the Clean, Green Fuel for Diesel Engines

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Abstract:

Natural, renewable resources such as vegetable oils, animal fats and recycled restaurant greases can be chemically transformed into clean-burning biodiesel fuels [(1)] . Just like petroleum diesel, biodiesel operates in combustion-ignition engines. Blends of up to 20% biodiesel (mixed with petroleum diesel fuels) can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment. Using biodiesel in a conventional diesel engine substantially reduces emissions of unburned hydrocarbons, carbon monoxide, sulphates, polycyclic aromatic hydrocarbons, nitrated polycyclic aromatic hydrocarbons, and particulate matter. The use of biodiesel has grown dramatically during the last few years. Egypt has a promising experiment in promoting forestation by cultivation of Jatropha plant especially in luxor and many other sites of the country. The first production of the Egyptian Jatropha seeds oil is now under evaluation to produce a cost-competitive biodiesel fuel.

INTRODUCTION:

Biodiesel (Fatty acid alkyl esters) can be made from many oils and fats such as soy, canola, tallow, mustard, rape palm, sunflower, peanut, olive, jatropha, and restaurant greases. Fats and oils are chemically reacted with an alcohol (methanol is the usual choice) to produce chemical compounds known as fatty acid methyl esters. Biodiesel is the name given to these esters when they are intended for use as fuel. Glycerol is produced as a co-product. Biodiesel can be produced by a variety of esterification technologies. The oil and fats are filtered and preprocessed to remove water and contaminants. The pretreated oil and fats are then mixed with an alcohol and a catalyst usually sodium or potassium hydroxide. The oil molecules (triglycerides) are broken a part and reformed into esters and glycerol, which are then separated from each other and purified.

Approximately 55% of the biodiesel industry can use only any fat or oil feedstock including recycled cooking grease. The other half of the industry is limited to vegetable oils, the least expensive of which is soy oil. The soy industry has been the driving force behind biodiesel commercialization because of excess production capacity, product surpluses, and declining prices. Similar issues apply to the recycled grease and animal fates industry, even though these feed stocks are less expensive compared to soy oils.

Uses and Performance of biodiesel:

Biodiesel is quite similar to conventional diesel fuel in its main characteristics (Table-1). Biodiesel is compatible with conventional diesel and the two can be blended in any proportion.

Table-1

Fuel property	**Diesel**	**Biodiesel**
Fuel standard	**ASTM D975**	**ASTM D6751**
Fuel composition	**C10-C21 HC**	**C12 – C22 FAME**

Lower heating value, Btu/gal	**131295**	**117093**
Kin. Viscosity. @ 40 ^{o}C	**1.9 – 4.1**	**1.9-6.0**
Specific Gravity Kg/1 @ 60^{o}F	**0.85**	**0.88**
Density, lb/gal @ 15^{o}C	**7.079**	**7.328**
Water, % Vol.	**0.05**	**0.05**
Carbon, wt. %	**87**	**77**
Hydrogen, wt. %	**13**	**12**
Oxygen, by dif. wt. %	**0**	**11**
Sulfur, wt. %	**0.05**	**0.05**
Flash point ^{o}C	**60 to 80**	**100 to 170**
Cloud Point ^{o}C	**-15 to 5**	**-3 to 12**
Pour Point ^{o}C	**-35 to -15**	**-15 to 16**
Cetane Number	**40 to 55**	**48 to 60**

Biodiesel can be used 100% pure as a fuel in combustion – ignition engines. Blends of up to 20% biodiesel (mixed with petroleum diesel fuels) can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment. These low level blended (20% and less) don't require any engine modifications and can provide the same payload capacity and range as diesel. Higher blends, even pure biodiesel (100% biodiesel, or B100), can be used in many engines built since 1994 with little or no modification. Transportation and storage, however, require special management.

<u>Biodiesel reduces emissions</u>:

Using biodiesel in a conventional diesel engine substantially reduces emissions of unburned hydrocarbons, carbon monoxide, sulphates, polycylic aromatic hydrocarbons, nitrated polycyclic aromatic hydrocarbons, and particulate matter (Table-2). These reductions increase as the amount of biodiesel blended into diesel fuel increases. The best reductions are seen with B 100. the use of biodiesel decreases the solid carbon fraction of particulate matter (Since the oxygen in biodiesel enables more complete combustion to Co_2) and reduces the sulphate fraction (Biodiesel contains less than 24 ppm sulphur), while the soluble, or hydrocarbon, fraction stays the same or increases. Therefore, biodiesel works well with new technologies such as catalysts, (which reduce the soluble fraction of diesel particulate but not the solid carbon fraction), particulate traps, and exhaust gas recirculation. Emissions of nitrogen oxides increase with the concentration of biodiesel in the fuel. Some biodiesel produces more nitrogen oxides than others, and some additives have shown promise in modifying the increase. More R & D is needed to resolve this issue.

Table-2

Biodiesel reduces Emissions		
Emission	**B_{100}**	**B_{20}**
Carbon Monoxide	-43.2%	-12.6%
Hydrocarbons	-56.3%	-11.0%
Particulates	-55.4%	-18.0%
Nitrogen Oxides	+5.8%	+1.2%
Air Toxics	-60% - 90%	-12 % - 20%
Mutagenicity	-80% - 90%	-20%

Compared to EPA certification diesel fuel

<u>Biodiesel Fuel market</u>:

The use of biodiesel has grown dramatically during the last few years. According to the American Biofuels association, biodiesel sales could reach about 2 billion gallons per year, or about 8% of highway diesel consumption. Biodiesel currently costs between $ 1 and $ 2 per gallon and Could compete with low sulphur diesel fuels. The cost of biodiesel can be reduced if we consider non-edible oils, used – frying oils and acid oils instead of edible oils. Non – edible oils such as neem, nahua, Karanja, babassu, Jatropha, etc. are easily available in many parts of the world and very cheap compared to edible oils.

<u>Jatropha as Non-Conventional Energy Crop</u>:

Jatropha curcas is a plant that can grow almost anywhere even on gravelly, sandy & saline soils. It has hardly any special requirement with regard to climate and soil. It can thrive on the poorest stony soil. It can grow even in the crevices of rocks. Because of its excellent drought resistance, Jatropha curcas is also suitable for preventing soil erosion and shifting of sand dunes. It makes an ideal choice for ecological as well as economic development of wastelands in the tropical and sub-tropical regions of the world.

Jatropha oil is an environmentally safe, Cost-effective and renewable source of Non-Conventional energy as a promising substitute to hydel power. Diesel, Kerosene. L.P.G., coal and firewood etc. This non-Conventional source of energy will save considerable foreign exchange and help in removing regional imbalance in energy use by making energy available all over India in a decentralized manner. For this kind of use there will be unlimited potential to take care of its production on a massive scale.

The cultivation of Jatropha Curcas in Egypt:

The "Greening" of Egypt represents a huge challenge for the government. Afforestation has a very important role in meeting this challenge. Several initiatives have been taken in recent years in different parts of the country to promote afforestation. The central Administration for Afforestation (MOALR) is now taking up cultivation of Jatropha curcas in many sites of the country, especially in the south.

EXPERIMENTAL:

Five kilogram of jatropha seeds was collected from the first phase plantation of jatroha curcas in luxor. A yield of 480 gm oil was extracted by using classical pressing and then purified by using special filter. The filtered oil was refluxed for 3 hrs with methyl alcohol in the presence of sodium hydroxide as a catalyst. The resulted product was filtered giving methyl ester of the oil.

Results and Discussion:

The produced oil was compared with the standard jatropha oil produced worldwide specially in India (table - 3) and was found nearly similar in characteristics but the yield is lower in quantity which may be attributed to :

1- The way of irrigation.

2- The first phase of plantation.

3- Extraction method.

Extra analyses of the oil show that this type of oil can be used also in different industries other than biodiesel such as :

1- Grease and detergents.

2- Metal process oils.

3- Paint oils.

Table - 3

Test	Egyptian Jatropha oil	Jatropha oil (refrenced[5]
Kin. Viscosity. @ 30 ^oC		52
Kin. Viscosity. @ 40 ^oC	32.82	
Specific Gravity Kg/1 @ 60^oF	0.9157	0.920
Flash point ^oC	318	236
Acidity value	0.9	0.92
Saponification Value	208.46	
Antioxidant Stability min	100	
Extraction %	20%	20%to 40%

The produced methyl ester of the oil (biodiesel) correlated with that produced from jatropha in India is under more studies and investigations to evaluate its performance and economics.

Conclusions:

Alternate fuels for diesel engines have become increasingly important due to decreasing petroleum reserves and the environmental consequences of exhaust gases from petroleum – fuelled engines.

From the reported literature on biodiesel, several conclusions have been recognized as valid. These include:

- Conventional diesel engines can be operated without much, if any, modification on biodiesel.
- Biodiesel can be used pure or in a mixture with hydrocarbon – based diesel fuels.
- Biodiesel is nontoxic, safe to handle and biodegradable.
- No evaporation of low-boiling components takes place.
- Exhaust gas is free of SO_2 and halogens.
- There is substantial reduction of soot, unburnt hydrocarbons, and also of carbon monoxide (when an oxidation catalyst is used) in the exhaust gases.
- No_x emissions increase slightly if there are no changes in the engine setting.
- Good performance in auto-ignition of fatty esters results in smooth running diesel engine.
- Biodiesel consumption is similar to hydrocarbon-based diesel fuels.

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