UNIT – III
GASEOUS FUELS

BIODIESEL(VEGETABLE OIL)

Manoj Kumar
Assistant Professor
School of Mechanical Engineering
Galgotias University , Greater Noida

What is biodiesel?

Biodiesel (or biofuel) is the name for a variety of ester-based fuels (fatty esters) generally defined as the monoalkyl esters made from vegetable oils, such as soybean oil, canola or hemp oil, or sometimes from animal fats through a simple transesterification process. This renewable source is as efficient as petroleum diesel in powering unmodified diesel engine.

Name any four-edible vegetable oils for use of I.C. engine fuel.

a. Rape seed oil

b. Sunflower oil

c. Soybean oil

d. Jatropha curcus oil

What is meant by Esterification?

Esterification is a process in which vegetable oil is reached with alcohol at relatively modest reaction temperature of 60°C, in presence of base type catalyst, such as sodium hydroxide, sodium carbonate, which reduces molecular size there by reducing the viscosity and boiling point.

What is meant by Transesterification?

The main reaction for converting oil to biodiesel is called transesterification. In the transesterification process an alcohol (like methanol) reacts with the triglyceride oils contained in vegetable oils, animal fats, or recycled greases, forming fatty acid alkyl esters (biodiesel) and glycerin. The reaction requires heat and a strong base catalyst, such as sodium hydroxide or potassium hydroxide.

The simplified transesterification reaction is shown below.

Triglycerides + Free Fatty Acids (<4%) + Alcohol ——> Alkyl esters + glycerin

What are the advantages of biodiesel?

1. Biodiesel reduces emissions of carbon monoxide (CO) by approximately 50% and carbon dioxide by 78.45% on a net lifecycle basis because the carbon in biodiesel emissions is recycled from carbon that was already in the atmosphere, rather than being new carbon from petroleum that was sequestered in the earth's crust. (Sheehan, 1998)
2. Biodiesel contains fewer aromatic hydrocarbons: benzofluoranthene: 56% reduction; Benzopyrenes: 71% reduction.
3. It also eliminates sulfur emissions (SO_2), because biodiesel does not include sulfur.
4. Biodiesel reduces by as much as 65% the emission of particulates, small particles of solid combustion products.
5. Biodiesel does produce more NO_x emissions than diesel, but these emissions can be reduced through the use of catalytic converters. The increase in NO_x emissions may also be due to the higher cetane rating of biodiesel. Properly designed and tuned engines may eliminate this increase.
6. Biodiesel has a higher cetane rating than diesel, and therefore ignites more rapidly when injected into the engine.
7. Reduction of all major measures of air pollution (except nitrous oxides which show slight increases).

8. Because it is a 100% organic product, biodiesel is biodegradable under normal environmental conditions when spilled (yet very stable when stored properly).
9. Superior lubricating ability of biodiesel will improve life of moving parts in diesel engines and result in reduced maintenance costs, which can be of significant benefit to trucking fleet operations.
10. Significant use of biodiesel nationally could reduce future needs for imported oil to manufacture regular diesel fuel.
11. Cost of biodiesel is likely to remain more stable than fossil fuel costs in the future as fossil fuel supplies decrease over time.
12. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend.

What are the problems of using vegetable oils in diesel engines?

The high viscosity of vegetable oils tends to alter the injector spray pattern inside the engine causing fuel impingement on the piston and other combustion chamber surfaces. This leads to cold starting difficulties and formation of carbon deposits in the engine that eventually result in problems such as stuck piston rings with subsequent engine failures that would not occur when using diesel fuel. These characteristics make vegetable oils impractical for use as transportation fuels in most climates and in most engines.

The poor volatility makes vegetable oils difficult to vaporize and ignite. This leads to thermal cracking resulting in heavy smoke emission and carbon deposits in the combustion chamber. This tendency may be partly due to higher fuel viscosity.

What is the engine modification required for using Biodiesel (vegetable oil) in existing diesel engines?

Almost all modern diesel engines will run biodiesel quite happily provided that the biodiesel is of high enough quality. Generally speaking biodiesel requires much less engine modification.

RUBBER SEALS

With some older vehicles rubber seals used in the fuel lines may require replacing with non-rubber products such as VITONTM. This is due to the way biodiesel reacts with rubber. If a low blend is used (5% biodiesel for example) then the concentration of biodiesel isn't high enough to cause this problem.

COLD STARTING

Cold starting can sometimes be a problem when using higher blends. This is due to biodiesel thickening more during cold weather than fossil diesel. Arrangements would have to be made for this, either by having a fuel heating system or using biodegradable additives which reduce the viscosity. This effect is only a problem with higher blends.

OIL CHANGING

It was noticed that during many field trials that engines running on biodiesel tended to require more frequent oil changes. This was generally the case with blends above 20%. During an ALTENER project where two Mercedes Benz buses were run on diesel and biodiesel it was found that the bus running on biodiesel required an oil change after 12,000 km compaired to 21,000 km for the bus running fossil diesel. It is worth noting however that the engine had not been significantly affected in any adverse manner.

ENGINE TIMING

For higher blends engine performance will be improved with a slight change to engine timing, 2 or 3 degrees for a 100% blend. The use of advanced injection timing and increased injection pressure has been known to reduce NOx emissions. It is worth noting that catalytic converters are just as effective on biodiesel emissions as on fossil diesel.

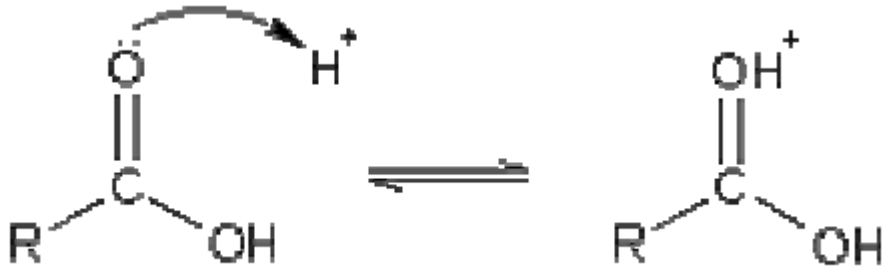
What is meant by esterification?

The basic process of converting vegetable oil to biodiesel is called esterification. Carboxylic acids react readily with alcohols in the presence of catalytic amount of mineral acids to yield compounds called **esters**. The process is called **Esterification**.

The mechanism of the acid-catalyzed esterification is as follows

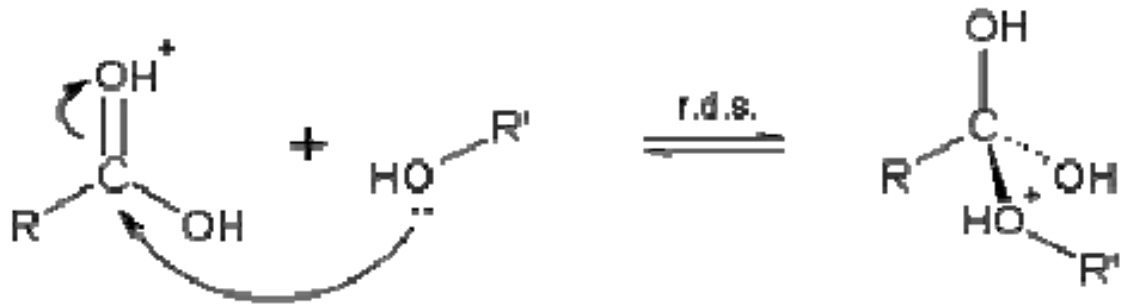
The carbonyl oxygen is protonized so that the carbon can be more likely attacked by the relatively weaker alcohol nucleophile.

(1)



The second step is the rate determining step: the alcoholic oxygen attack the carbonyl carbon to form a tetrahedral intermediate.

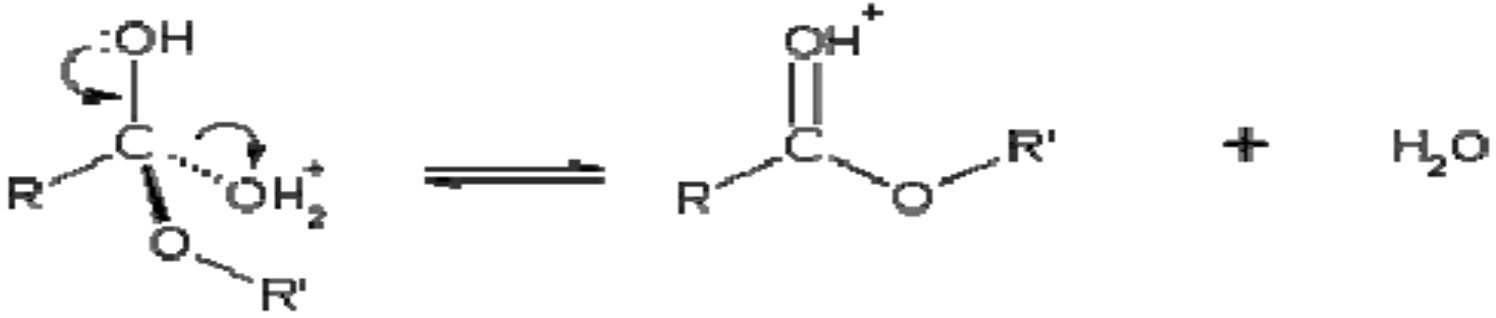
(2)



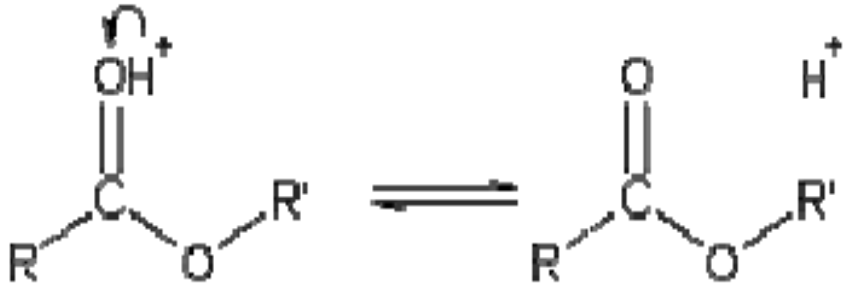
After proton transfer, the water molecule is released.

(3)

(4)



Finally, the proton catalyst is regenerated.

(5) 

Steps (1), (3), (5) are rapid proton transfer steps -- simple acid base reactions. Although bare protons are shown in each case, they are actually solvated by some Lewis bases, which may be ethanol or water. In steps (2) and (4), C-O bonds are formed or broken. These steps have higher activation energies than the proton-transfer steps.

Practically, there are three steps in the process:

1. Reflux - heating a mixture of ingredients in a vessel.
2. Separation - separating the organic layer from the aqueous layer.
3. Purification - obtaining the pure ester, which in this case is biodiesel.

Discuss the Emission Characteristics of the Biodiesel fuel engine.

CARBON MONOXIDE (CO)

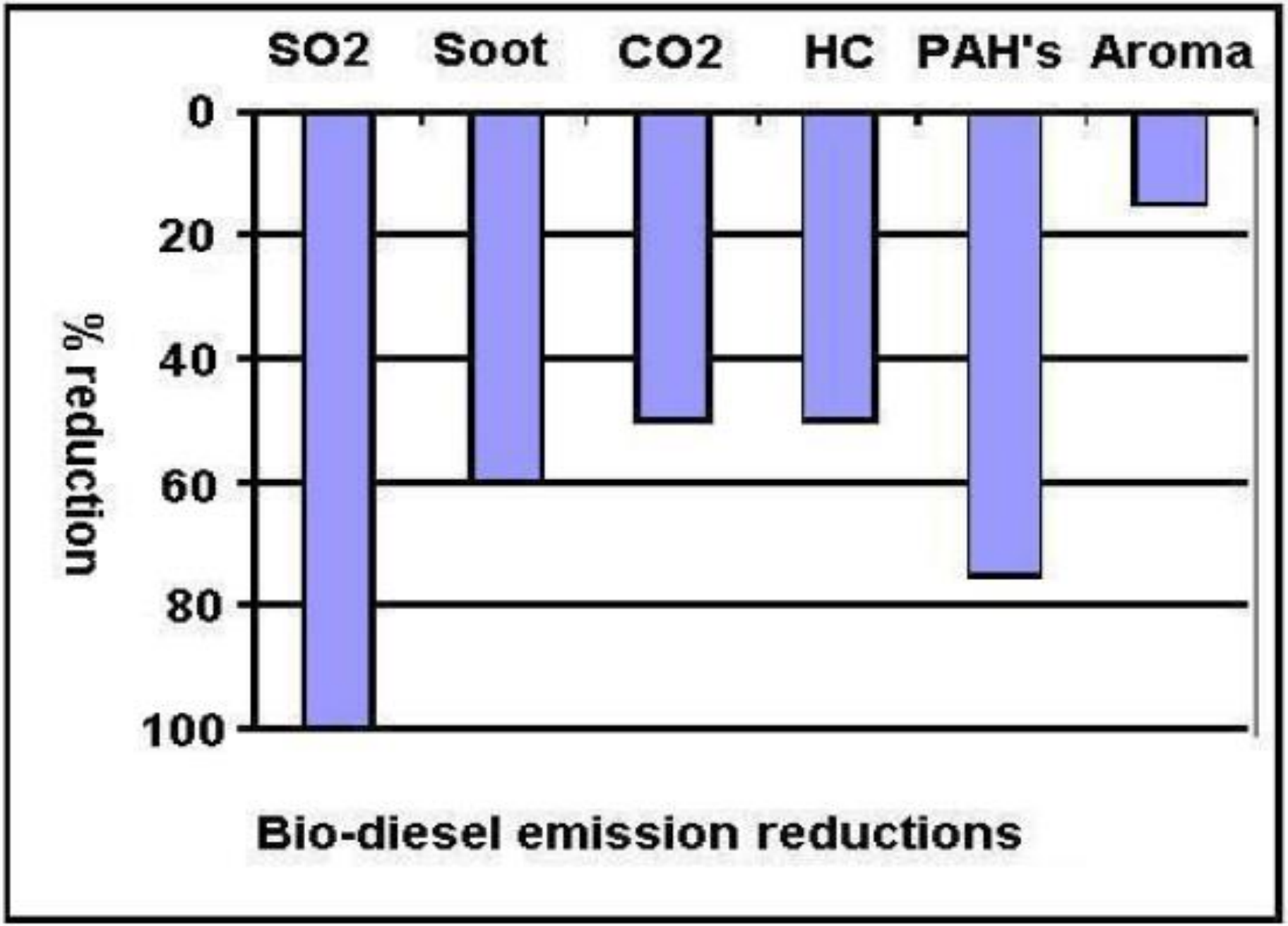
The exhaust emissions of carbon monoxide (a poisonous gas) from biodiesel are on average 48 percent lower than carbon monoxide emissions from diesel.

HYDROCARBONS (HC)

The exhaust emissions of total hydrocarbons (a contributing factor in the localized formation of smog and ozone) are on average 67 percent lower for biodiesel than diesel fuel.

NITROGEN OXIDES (NO_x)

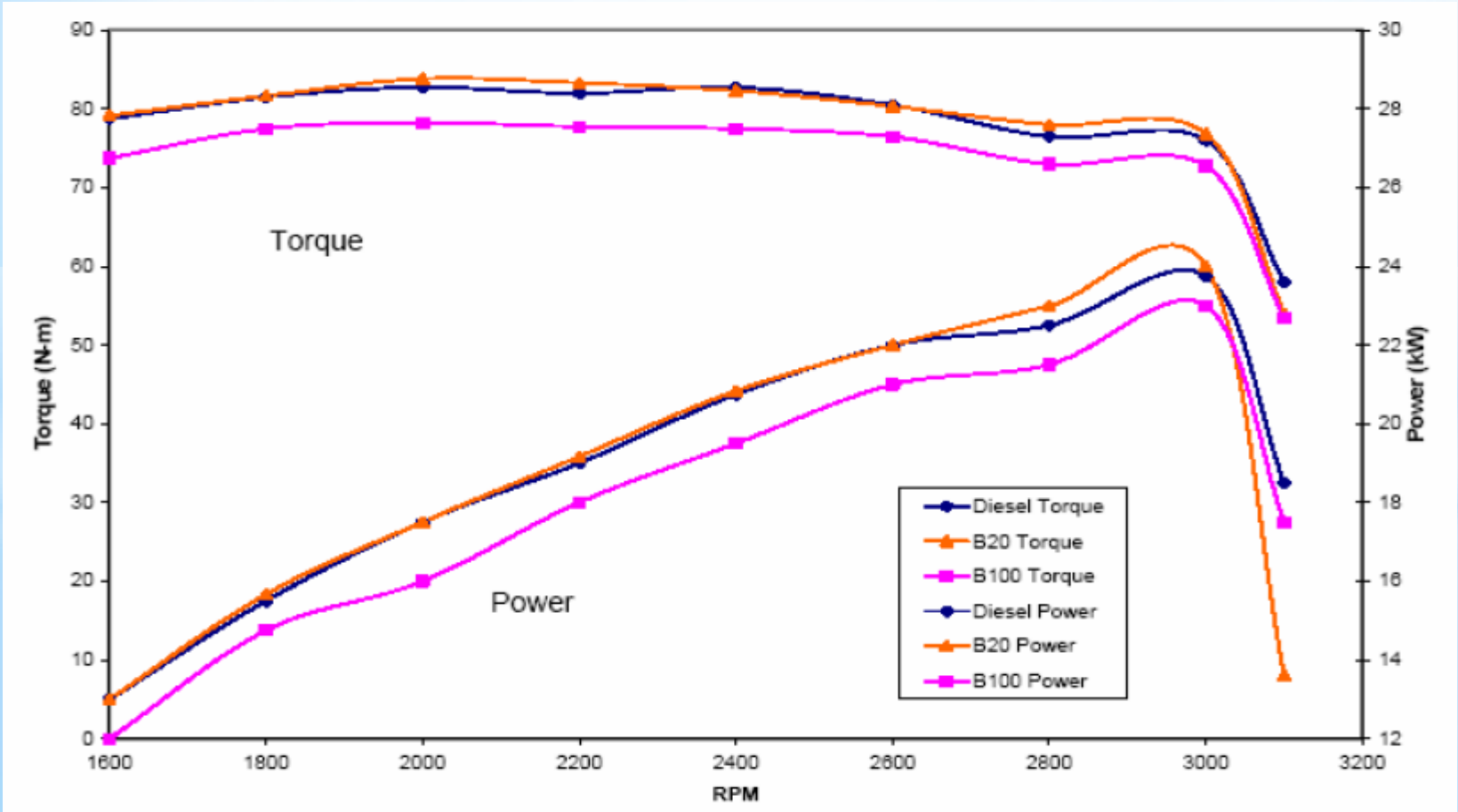
Nitrogen Oxides emissions from biodiesel increase or decrease depending on the engine family and testing procedures. NOx emissions (a contributing factor in the localized formation of smog and ozone) from pure (100%) biodiesel increase on average by 10 percent. However, biodiesel's lack of sulfur allows the use of NOx control technologies that cannot be used with conventional diesel. Additionally, some companies have successfully developed additives to reduce Nox emissions in biodiesel blends.


SO2
Soot
CO2
HC
PAH's
Aroma
0
20
40
60
80
100
% reduction
Bio-diesel emission reductions

Discuss the engine performance with vegetable oils.

TORQUE AND POWER

The wide-open-throttle torque and power curves for diesel, B20, and B100 are shown below. Note the power axis is on the right side.



Comparison of Torque and Power with different Fuels

There appears to be little difference in performance between regular diesel and the B20 mixture. The B100 displays about a 5% reduction in power from diesel, actually less than the expected 10% reduction.

FUEL CONSUMPTION

The B100 fuel has a 17% higher fuel flow rate than diesel, and 25% higher specific fuel consumption. This means that more fuel is consumed, and less power is output. This is to be expected, as the lower heating value of biodiesel is about 10% less than that of diesel. For B20, the fuel flow rate is 9% higher and the specific fuel consumption is 6.8% higher than when using diesel.

The thermal efficiency is 29.6% when using diesel, is 28.8% when using neat biodiesel, and is 28.3% when using the B20 blend.

9. Discuss the properties of vegetable oils with conventional fuels.

In some respects the properties of vegetable oils are very close to those of diesel oil but in others they ate quite different.

1. The densities of the vegetable oils are slightly higher compared to diesel fuels.
2. The calorific value is slightly lower on mass basis.
3. Viscosities at room temperature are much higher compared to diesel oil.
4. The cetane number is slightly lower than diesel oil.
5. The flash point is very high making them quite safe to store.
6. Volatility is quite low.
7. Carbon residue is very high.

It can be seen that vegetable oils have very poor volatility. This fact rules out their use in spark ignition engines. By their main properties vegetable oils are more suited to diesel engines than to spark ignition engines. Vegetable oils also mix freely in any proportion with diesel oil ad hence can be used as diesel supplements also. The most serious drawbacks of vegetable oils, however, are their high viscosity and the high carbon residue. The high viscosity makes it very difficult to pump in diesel engines. Their exhaust is smokier than diesel oil.

THANK YOU