

# PLANET SCIENCE HOTSPOTS

Questions and Answers supplied by Dr Mohamed Younes El-Saghir Selim

## New Fuel Derived From Jojoba Oil Could Fuel Cars, Trucks and Buses

### **(1) Why are you looking at Jojoba for this application?**

Of the several renewable sources, not yet widely known, Jojoba oil appears to be promising, also with promising scope for cultivation in the relatively hot weather.

### **(2) Does Jojoba have any advantages over other biofuels like sunflower oil, soybean oil etc?**

Jojoba oil is unique in nature. No other plant is known to produce oil like jojoba's. It is used in the cosmetic, medical, pharmaceutical, food products, manufacturing, and automotive industries (as lubricant). And it is a renewable energy resource. Jojoba (pronounced Ho Ho-ba) is not new. It has been used for hundreds of years, being first observed and recorded in 1701. Other oils, both plant and animal, break down, or turn rancid. Jojoba has all the properties of the finest oils. And it is hypoallergenic, non-contaminating, non-toxic, will never turn rancid, and its viscosity will not break down under high temperature and pressure. Jojoba esters are composed entirely of straight chain alcohols. Both the acid and alcohol portions have 20 or 22 carbon atoms and each has one unsaturated bond. Waxes of this type are extremely difficult to synthesize. Thus, jojoba oil is a polyunsaturated liquid wax that is readily obtainable from a renewable resource. Such oil has never been available to industry before and it has not been used before as an engine fuel.

It is remarkable to note that, in spite of the variability in size or where grown, each jojoba seed or nut contains an average of 50% pure oil by volume. Generally, jojoba is shrub-like with profuse lateral branching forming several stems from the root to the crown. Fully mature shrubs or trees can reach a height of 15 feet with a potential natural life span of 100 to 200 years depending on environmental conditions.

### **(3) How did we test the suitability of jojoba as a fuel?**

The following parameters have been tested for Jojoba as a fuel:

- Viscosity (important for injection systems in diesels – comparable to diesel fuel)
- Ignition delay (period from injection to ignition) - Jojoba oil methyl ester has an ignition delay significantly shorter than of Gas Oil and Methanol. Also, blends of such fuel with Gas Oil fuel exhibited shorter delay than Gas Oil; increased percentage of Gas Oil in the blend increased the ignition delay
- Combustion noise (main source of diesel noise) which is related to maximum rate of combustion pressure rise - The pressures and pressure rise rates for pure Jojoba Methyl Ester (JME) are almost

similar to those of gasoil. JME, however, exhibits slightly lower pressure rise rate than gasoil, which appears to be advantageous with the new fuel. Also the smoothness of operation of the engine did not vary as the JME fuel is used instead of the gasoil fuel. In summary the JME fuel was found to be good replacement of gasoil fuel from the point of view of torque and power produced combustion noise or engine roughness and vibration, as well as the cyclic variability and smoothness of engine operation.

- The new fuel derived from Jojoba has an improved properties of flash point (higher than diesel i.e. safer storage), heating value (slight increase than diesel i.e. more energy is available to convert to mechanical energy), less sulphur (no sulphuric acid formed in cylinders i.e. more engine life due to less corrosion and no sulphuric oxides SO<sub>x</sub> in exhaust) and carbon content as compared to gas oil.
- Soot emission is reduced as compared to diesel
- Thermal loading from the engine (heat crossing the combustion chamber to the metal and to coolants) is comparable to diesel

#### **(4) How is jojoba methyl ester fuel made from natural jojoba oil? Is it an expensive process?**

In our work, Jojoba oil was synthesized in the laboratory in order to have control over the synthesis parameters. The process is very cheap and needs low resources. Jojoba Methyl Ester (JME) is prepared by adding a specific volume of Methanol to a specific volume of Jojoba raw oil with a catalyst (1% sodium hydroxide (NaOH)) then heated to a specific temperature with continuous stirring for a specific time. The hot mixture was then quenched with cold water where glycerides separate from the JME. After quenching, the top layer was the separated glycerides followed by the JME; the bottom layer was water. The JME was then withdrawn from the breaker and subsequently dried by anhydrous sodium sulphate.

As esterification is one of the most useful reactions in preparation of organic chemistry, so it is used in this research to produce a Jojoba methyl ester. An ester is usually defined as a compound formed by substituting an organic radical for an ionizable hydrogen of an acid.

The esterification process has been optimized by the research group to give the highest yield ratio (ratio of produced methyl ester to raw oil) by controlling the following parameters: methyl alcohol quantity is used at 0.1-mole/mole raw oil, the reaction temperature is at about 60 °C and the reaction time to be about 1 hr. During this period stirring of the mixture was continued using stirrer coupled to a low speed electric motor. The yield ratio obtained at the above experiment conditions was about 88 %.

Additional esterification parameters have been optimized to make the process more economic. These are the temperature of quenching water and the volumetric ratio between quenching water to methyl ester. Using water at 0 °C gives the highest yield ratio (93.3%), however using slightly warmer water; at 5 °C; will give very close yield ratio (91%). The quenching water quantity is also critical to yield ratio and the best ratio was found to be from 30 to 40%. Therefore the best combination was found to be 5 °C with 30 to 40%

quenching water. To make the process more economic, the sea water has been tried for quenching, and it was found that the sea water gives similar yields as compared to tap water.

**(5) Where jojoba is grown, what kind of plant it is, and how suitable it would be to grow as a fuel source?**

Jojoba has very promising scope for cultivation in the desert even in the relatively hot weather. Its nature withstands the hot weather in summer, warm weather in winter, low fertility of soil and low water resources. It needs less than one quarter the amount of water needed for olives with great ability to withstand the high salt in the soil. The payback for planting Jojoba is encouraging.

The origin of this plant is south west of USA and north west of Mexico, and it is now cultivated in south America and some countries of middle east including Egypt. The FAO organization introduced a program to cultivate the jojoba in the middle east countries during the mid-eighties.

Jojoba is a long life plant (more than 150 years) and produces its seeds of the size of the peanuts covered with thick brown cover. Its pure oil is considered as liquid wax and considered as ideal natural oil.

To be used as a fuel it needs to be cultivated in huge amounts which is easy in desert land in many countries.

**(6) What it is used for at the moment?**

Jojoba oil is a superior lubricant in automotive, high speed machinery, airplanes, tool work, and metal cutting. It requires no refining yet will cause a car to run cooler when added to the crankcase oil. Jojoba oil is also mono-viscous. Because of this quality, jojoba oil significantly reduces friction. It has recently been used as a substitute to engine lubricating oils.

It has also been used in some pharmaceutical, food products industry, and other consumer products industry e.g. in its hydrogenated form, jojoba wax used in furniture and floor waxes, auto polish and long-burning candles. It has also been used in some other manufacturing and cosmetics industries and may be used in some medical applications as a replacement to cortisone. To summarize jojoba's qualities and resulting myriad applications: "1.) its natural purity and molecular simplicity, 2.) its stability, its non-drying quality and resistance to oxidation which permit long-term storage, 3.) its lubricity after sulphurization, 4.) its supply of chemicals, especially acids and alcohols with 20 and 22 atoms, and finally, 5.) its unsaturation (double bonds)." All of this simply means that jojoba is a unique plant with a unique molecular structure resulting in many, diverse applications.

**(7) What is the driving force to finding alternative fuel sources like this?**

The driving force to find such fuel source stems from the need to find an alternative fuel to petroleum oil. In addition to this, the jojoba renewable nature is attractive and can produce less pollution.

**(8) What kind of emissions an engine produces when running on jojoba, compared with normal diesel?**

Jojoba diesel fuel produced no Sulpheric Oxides (SO<sub>x</sub>) in exhaust as the fuel contains no sulphur. Carbon content in JME fuel is lower than that found in gas oil which may reduce the tendency to form particulate matter in the exhaust gases. Noise emission is also less than gasoil.

**(9) Are there any plans to use jojoba as a fuel? If not, what are the problems in adapting this oil for usage?**

The use of Jojoba as a fuel needs huge quantities of the seeds which needs large investment probably supported by the government or private sector. In Egypt now it started to be recognized as fuel after 5 years of research and development in the University of Helwan, as this project is started in the Mechanical Engineering Department, Faculty of Engineering, and now is continued in Egypt and in the United Arab Emirates University, Mechanical Engineering Department. Experimental research is continuing in both Universities. The use of the fuel for the first time in the world as a fuel in a real internal combustion engine has taken place in the UAEU, Heat Engines Lab from the period of 2001 till now.

This research is the fruit of the continuing support of the UAE University and the scientific support the author finds in terms of the available Lab equipment etc.

The researchers welcome any cooperation with research or industrial agent in Europe or any where to carry out further research work.

**(10) What experiments you have to do next and in simple terms what they involve?**

The next experiments to be done on Jojoba fuel is two experimental projects:

(a) Improve the properties of Jojoba Methyl Ester as a diesel fuel such as: (1) pour point temperature , we need to lower this temperature. This will be done by using some commercially available chemicals. The additives used to reduce the fuel pour point improve the pouring properties at lower temperatures and prevent or reduce the formation of wax. Formation of waxy precipitate may block the filter in the fuel injection system. This is particularly important for cold weather countries. (2) Improve the diesel index or ignition delay period for the fuel. This will make the fuel exactly behaves like diesel fuel from the point of view of easy self burning that improves all engine performance parameters and less pollution in exhaust. We are trying to do this by using another commercially available additive (used currently for diesels).

(b) Improve the volatility of this fuel to be used in petrol engines. This will be great step if we can use it as a spark ignition engines fuel for small petrol-fuelled cars. Petrol fuel should be easy to volatile and evaporate to be well mixed with air during the engine intake and compression strokes.

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