Bio-Diesel Production from Jatropha

The world's economy depends upon the burning of fossil fuel equivalent of some 180 million barrels of oil each day. The consumption rate is equivalent to an annual burning of what nature took about one million years to accumulated as fossil deposits. The word at present is confronted with the twin crises of fossil fuel depletion and environment degradation. Indiscriminate extraction and lavish consumption of fossil fuel have lead to reduction in underground-based carbon resources. The search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, management, efficiency and environmental preservation, has become highly pronounced in the present context. For the developing countries of the world, fuels of bio-origin can provide a feasible solution of the crises. The fuels of bio-origin may be alcohol, vegetable oils, biomass and biogas. Some of these fuels can be used directly while others need to be formulated to bring the relevant properties close to conventional fuels. The power used in the agricultural and transportation sector is essentially based on diesel fuels and it is therefore, essential that alternatives to diesel fuels be developed.

The present work is carried out using Jatropha plant oil by formulating its properties closer to that of diesel fuel. India is producing around 6.7×106 tons of non-edible oils such as linseed, castor, karanji (Pongamia Glabra), Neem (Azadirachta indica), Palash (Butea monosperma) and kusm (Schelchera Trijuga). Some of these oils produced even now are not being properly utilized and it has been estimated that some other plant based forest derived oils have a much higher production potential. It will be expensive and time consuming to incorporate even a minor design alteration in the system hardware of a large number of existing engines operating in the rural agricultural sector of the country. The plant oils can't be used in their raw form, as it will pose some serious problems to the diesel engines. Thus these plant oils need to be converted to some more engine friendly fuel called BIODIESEL. There are various methods available by which we can convert the plant oils into bio-diesel such as:

1. Pyrolysis 2. Micro-emulsification
3. Dilutin 4. Trans-esterification

Pyrolysis: Pyrolysis refers to a chemical change caused by the application of thermal energy in the absence of air or nitrogen. The liquid fractions of the thermally decomposed vegetable oil are likely to approach diesel fuels. The pyrolyzate had lower viscosity, flash point, and pour point than diesel fuel and equivalent calorific values. The cetane number of the pyrolyzate was lower.

Micro-emulsification: the formation of micro emulsions (co-solvency) is one of the potential solutions for solving the problem of vegetable oil viscosity. Micro-emulsions are defined as transparent, thermodynamically stable colloidal dispersions. The droplet diameters in micro-emulsions range from 100 to 1000 A. A micro-emulsion can be made of vegetable oils with as ester and dispersant (co-solvent), or of vegetable oils, an alcohol and a surfactant and a catane improver, with or without diesel fuels.

Dilution: Dilution of vegetable oils can be accomplished with such materials as diesel fuels, solvent or ethanol.

Trans-esterifications: Trans- esterifications also called alcoholysis is the displacement of alcohol from an ester by another alcohol in a process has been widely used to reduce the viscosity of triglycerides. The trans-etherification reaction is represented by the general equation. RCOOR'+R"= RCOOR"+R'OH. If methanol is used in the above reaction, it is termed methanolysis. The reaction of trglyceride with methanol is represented by the general equation. Triglycerides are readily trans-esterifications. RCOOR′+R′′= RCOOR′+R′OH. If methanol is used in the above reaction, it is termed methanolysis. The reaction of triglyceride with methanol is represented by the general equation. Triglycerides are readily tarnsesterfied in the presence of alkaline catalyst at atmospheric pressure and at atemperature of approximately 60 to 70 degree C with an excess of methanol. The mixture at the end of the reaction is allowed to settle.

It was very heartening to note that the Indian Railways has taken the initiative to promote jatropha cultivation along the railway tracks and to use biodiesel as engine fuel. They have successfully tested the biodisel by running a jana shatabdi Express from Delhi to Chandigarh exclusively on jatropha. Mahindra and Mahindra have successfully conducted large-scale trials of operating their tractors on biodisel and Mercedes Benz is sponsoring jatropha production with a commitment to use biodisel to run their cars. Hence, engineering side of biodisel industry is ready to take off immediately. Use of biodisel at the village level for operating oil engines for pumping water,operating small mechinary and generating electricity is another good opportunity, which will be a boon for our farmers.

Trans-esterification process

The use of biodisel is an effective way of substituting diesel fuel in the long run. One important conclusion that can be drawn from the work done earlier is that the vegetable/plant oils can't be used directly in the diesel engine. Several problems crop up if unmodified fuel is used and viscosity is the major factor. It has been found that transesterification is the most effective way to reduce the viscosity of vegetable/plant oils and to make them fit for their use in the present diesel engines without any modification.

This transesterification method developed is very simple and can be adopted at farm level, thus requires only five to six hours to produce biodiesel. In this method, oil is heated to about 60 oC. On the other hand, alkaline methanol is prepared by dissolving 10 grams of Sodium Hydroxide pellets in about 200 ml of methanol (for every one kg of oil). This alkaline methanol is added to the heated oil and the mixture is stirred manually for 5 minutes. The mixture is then kept for glycerol settlement. After four hours of settlement of glycerol, biodiesel is decanted from top. Then biodiesel is washed three times with water to remove impurities like sodium, etc. it also removes excess methanol. Use of warm water for washing gives better results and reduces number of washings required. After each washing, water is allowed to settle for about 5 minutes. Each time, biodiesel is decanted from the top. At the end of last washing, water is allowed to settle for 15 minutes. The washed biodiesel is then heated for about 5 to 10 minutes to remove leftover traces of moisture so that it becomes almost transparent.

Biodiesel characteristics
Several tests were conducted in order to find out the physical characteristics of biodiesel. Various physical properties tested were, viscosity, flash point, density, pour point, calorific value.

The process of transesterification brings about a drastic change in the physical properties of Jatropha raw oil and its methyl ester and thus bringing the properties quite closer to that of diesel fuel. The Jatropha oil has very high viscosity than that of diesel which make it unfit for its use in CI engines. By converting Jatropha oil into Jatropha methyl esters, the viscosity has come quite closer tp that of diesel fuel. The viscosity of diesel fuel is generally between 3 to 4 cSt at 40 oC and it varies depending upon its constituents. Thus fuel handling systems in the existing diesel engines. Hence, no hardware modifications are required for the handling of this fuel in the existing system. This property makes it suitable fuel for its use in the existing diesel engines.

The flash point of Jatropha raw oil is also much higher than that of diesel fuel, which is brought under desirable limits after transesterification. High flash point of Jatropha methyl ester makes it fir for easy transportation than diesel fuel. Pour point is a criterion used for low temperature performance of the fuels. Pour point analysis results suggest that the performance of biodiesel is as good as diesel oil in clod surroundings.

Economics Of Jatropha Cultivation
Oil can be extracted from a variety of plants and oilseeds. Under Indian condition only such plant sources can be considered for biodisel production which are not edible oil in appreciable quantity and which can be grown on large scale on wastelands. Moreover, some plants and seeds in India have tremendous medicinal value, considering these plants for biodiesel production may not be a viable and wise option. Considering all the above options, probable biodisel yielding trees in India are:

- Jatropha curcas or ratanyot
- Pongamiapinnata or karanj
- Calophyllum inophyllum or Nagchampa
- hevea brasiliensis or Rubber seeds
- calotropis gigantia or Ark

Of all the above prospective plant candidates as biodiesel yielding sources, jatropha curcas stands at the top and sufficient information on this plant is already available.

Jatropha curcas is a bushy plant belonging to castor family, grows about 3 to 5 m high. It is tropical specie that thrives well in hot climatic conditions. It has been grown in some of the southern states as a border plant along the fences. It is a cross-pollinated crop and yield starts in 2nd year. Productivity stabilizes in 7-8 years. Economic life can be upto 40 years also if cultured and maintained well. It is propagated by seeds, can also be propagated vegetatively from cuttings. In commercial plantation at a space 2-3 meters from plant to plant depending upon the fertility of the plant soil and rainfall of the area.

Economics of Biodiesel Production

In India, it is estimated that cost of Biodiesel produced by trans-esterification of oil obtained from Jatropha Curcas oils seed shall be approximately same as that of petroleum diesel. The bye products of biodiesel from jatropha seed are the seed oil cake and glycerol, which have good commercial value. The seed oil cake is very good compost being rich in plant nutrients. It can also yield biogas, which can be used as compost. Hence oil cake will fetch good price. Glycerol is produces as a bye product in the trans-esterification of oil. These bye-products shall reduce the cost of biodiesel to make it at par with petroleum diesel. The cost components of biodiesel are the price of seed, seed collection and oil extraction, trans-esterification of oil, transport of seed and oil. As mentioned earlier, cost recovery will be through sale of oil-cake and of glycerol. The use of biodiesel is economically feasible. The cost components are price of seed, seed collection and oil extraction, oil trans-esterification, transport of seed and oil. Cost recovery will be through sale of cake and of glycerol. Taking these elements in to account the price of Biodiesel has been worked out, assuming a net return of Rs.3 per kg to the seed producer, the price of glycerol between Rs.20 and 30 per kg and the price of oil cake @ Re1 per kg, the cost of biodiesel works out to Rs.19.24 to Rs.21.10 per liter ex-transeserification plant. Thus are plantation, oil extraction and production of biodiesel are economically feasible.

Conclusion

Search for alternative fuels for an IC engine has assumed great significance in view of the threats of supply instabilities, cost instabilities, cost escalations and air pollution caused by the conventional petroleum fuels. Use of renewable biomass based fuels appears to a viable alternative to the commercial liquid fuels, particularly for non-farm use in tractors, self propelled machines like combine harvester and stationary CI engines. Available literature indicates that among biomass based fuel, plant oils offer several distinct advantages for use in alternative fuels in CI engines. However, some operational problems like unusual carbon deposits on engine parts have been reported while using the crude plant oils, straight or blended with diesel fuel in unmodified existing CI engines. High kinematic viscosity has been reported to be the major cause responsible for these problems. Use of biodiesel has been recommendation to reduce the kinematic viscosity. The performance of CI engine using biodiesel is reported to be compared to that of using diesel fuel. Detailed studies on exhaust emissions of CI engines using bio-diesel are limited.

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