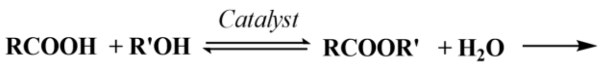
CAN BIODIESEL SUBSTITUTE PETROLEUM DIESEL?

Mudassar Marso
Board of Study in Chemical Sciences

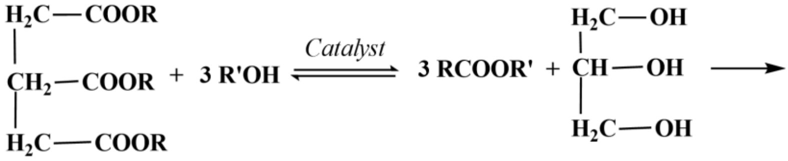
World energy demand is increasing daily, as world population and their living standard go high. According to the International Energy Outlook 2014 [1] of U.S. Energy Information Administration, world liquid fuels consumption increases by more than one-third (33 MMbbl/d), from 87 MMbbl/d in 2010 to 119 MMbbl/d in 2040 (MMbbl - one million barrels). Even though an increment of liquid petroleum fuel consumption is expected, depletion can occur overtime due to non-renewable nature of the source. According to the statistics [2], world oil and gas stocks will be sufficient only for this century and coal for two or few more years. Uncleanliness is another big issue of fossil fuels. It makes huge impact on the human body as well as on the environment. From the mining stage to the final usage, it creates large and concealed damage on both communities. Even though non sustainability and uncleanliness affects petroleum fuel seriously, still world energy consumption mainly depends on petroleum based energy sources due to certain advantages such as its high energy density, easiness to extract, handle and use and its broad areas of applications.

Petroleum fuel is a mixture of a very large number; approximately about 17000 of different organic compounds (dominant Hydrocarbons). Among number of theories about the origin of petroleum fuel, the most acceptable theory is, it derived from ancient fossilized organic materials due to the application of high pressure and temperature. Biofuel is a type of energy source which has an organic composition. It derives from bio masses such as plants and animal materials and it can exist in the forms of solid, liquid or gas. Even though petroleum fuel and bio fuel seem to have a big difference, both fuels have the same organic composition and origin. Therefore there should be a possibility to meet a bio based solution for petroleum fuel.

Petroleum diesel is a part of crude oil and separated via fractional distillation process between 200 °C and 350°C at atmospheric pressure. It is a mixture of carbon chains that typically contain between 8 and 21 carbon atoms per molecule. Biodiesel is an alkyl ester (mainly methyl or ethyl) of naturally occurring long chain fatty acids which is called as Fatty Acid Methyl Ester (FAME).



Scheem 01



Scheem 02

In natural systems, mainly in plant and animal materials contain 18 to 22 carbon atoms components as free fatty acids (FFA) or triglycerides (TG) [3]. During the production of bio diesel, these bio molecules (generally called as

Fats) are converted in to a methyl ester of fatty acids (FAME) catalytically. There esterification (*Scheme 01*) for FFA or transesterification (*Scheme 02*) for TG can be used.

The main idea of synthesis of bio diesel from naturally existing oil is, the reduction of boiling point, in order to make the oil more volatile and then facilitate ignition at low temperature. To fulfill that purpose, structural changes of natural oil are done in chemical processing. As a result of those structural changes, intermolecular interaction types and molecular weight are changed and hence boiling point is reduced. Finally liquid oil having similar properties of petroleum diesel can be obtained. Since number of carbon atoms per molecule of naturally occurring fatty acid does not match with range of carbon atoms in petroleum gasoline (petrol), it is impossible to produce bio gasoline. Gasoline is more volatile and has low flash point than diesel.

Table 01 shows some important physical properties of two common biodiesel feed stocks, Petroleum diesel and Biodiesel (B100). According to the table, it is clear that, reduction of flash point (lowest temperature at which it can vaporize to form an ignitable mixture in air) during chemical processing is expected. Reduction of viscosity is an additional advantage which can be obtained during the chemical processing. This makes easy to apply bio diesel to diesel engines.

Table 1: Important physical properties (for fuels) of two common biodiesel feed stocks, petroleum diesel and biodiesel (B100)

Parameter	Refined Sunflower Oil	Refined Coconut oil	Petroleum Diesel (ASTM D 975 - 07)	Biodiesel (B 100*) (ASTM D 6751-09)
Density at 25 ^{0}C (kg L^{-1})	0.92	0.924	0.838	0.84-0.90
Kinematic Viscosity (mm^2/s or cSt at 40 ^{0}C)	29.9	27.6	1.9-4.1	3.5-5.0
Flash point (°C)	-	-	75	< 100
Smoke point (°C)	265	175	-	-
Boiling point (°C)	-	-	200- 350	315 - 356
Solidifying point (^{0}C)	-	14 - 25	-50 - 10	-
Total Acid Number (mg KOH/g)	5.38	2.6	< 0.5	< 0.5

** The number following the 'B' stands for the percentage of biodiesel in the fuel*

Figure 1: Biodiesel samples (from left to right: Jatropha, Castor, Rubber, Neem, Domba and Coconut) (Note- These samples were prepared by under a research of Dr C.S.Kalpage and Mr. T.M.M.K. Ranathunga) [4]

Even though biodiesel sounds more optimistic, plenty of serious challenges are associated with the implementation process. As the future directions in the field of biodiesel, it is necessary to pay more attention towards novel feed stocks in favour of increasing the efficiency of the production. There, it must be non edible, high oil bearing and rapid growing. In that hand, nowadays more attention is being paid towards algae as the bio mass source since it is non edible. Algae seem to have above qualification and Table 2 shows the high oil to land ratio of algae than other crops. In addition to above qualification, it shows high nutrient absorption capacity for its growth. The nutrient can supply from water pollutant in aquatic system and hence the culture system can design as a water purification system. Use genetic technology to obtain modified algal species.

Table 2: Comparison of microalgae with other biodiesel feed stocks [5]

Plant source	**Seed oil content (% oil by wt in dry biomass)**	**Oil yield (L oil/ha year)**	**Land use (m^2 year/kg biodiesel)**	**Biodiesel productivity (kg biodiesel/ha year)**
Corn/Maize (*Zea mays L.*)	44	172	66	152
Hemp (*Cannabis sativa L.*)	33	363	31	321
Soybean (*Glycine max L.*)	18	636	18	562
Jatropha (*Jatropha curcas L.*)	28	741	15	656
Camelina (*Camelina sativa L.*)	42	915	12	809
Canola/Rapeseed (*Brassica napus L.*)	41	974	12	862
Sunflower (*Helianthus annuus L.*)	40	1070	11	946
Castor (*Ricinus communis*)	48	1307	9	1156
Palm oil (*Elaeis guineensis*)	36	5366	2	4747
Microalgae (low oil content)	30	58,700	0.2	51,927
Microalgae (medium oil content)	50	97,800	0.1	86,515
Microalgae (high oil content)	70	136,900	0.1	121,104

Development of harvesting and oil extraction techniques is another research area which should be developed more in order to increase efficiency of bio diesel production chain. Catalytic conversion of extracted bio oil into bio diesel is another field which has to be paid immense research and development efforts. There, development of heterogeneous solid nano catalyst is one of interesting topic.

With all the theories and laboratory bench work, it is planned to implement the idea to pilot plant scale and finally to industrial scale in order to get final product economically. Finally, the concept of bio diesel definitely can meet petroleum diesel and it should meet petroleum diesel to overcome future energy crisis. Definitely it will become a sustainable and long term solution.

References

1. *International Energy Outlook 2014: World Petroleum and Other Liquid Fuels- With Projections to 2040.* U.S. Department of Energy, U.S. Energy Information Administration. Washington, DC : s.n., September 2014.
2. *Energy resources and use The present situation and possible paths to te future.* Lior, Noam. s.l. : www.elsevier.com, 2008, ENERGY, Vol. 33, pp. 842-857.
3. *Biodiesel production by microalgal biotechnology.* Huang, GuanHua, et al. s.l. : www.elsevier.com, July 8, 2009, Applied Energy, Vol. 87, pp. 38–46.
4. *Biofue.* s.l. : SAARC Energy Centre, 2008. Proceedings of Biofuel Workshop in Sri Lanka. pp. 44-58.
5. *Microalgae for biodiesel production and other applications: A review.* Mata, Teresa M., Martins, Anto´ nio A. and Caetano, Nidia. S. Portugal : Elsevier, July 13 , 2010, Renewable and Sustainable Energy Reviews, Vol. 14, pp. 217–232.