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Algaeoleum-a third generation biofuel

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The world is undergoing a challenge of meeting severe crisis due to diminishing stock of finite fossil fuel in near future. The world-demand of diesel is about 49.56 MMT according to a survey carried out by International Energy Agency. In coming five years the demand will increase by another 20 MMT. The finite resources are shrinking fast and will not be able to meet such a high demand. The point of concern is not only exhaustion of nonrenewable energy resource but also the unfathomable disaster to the environment caused due to its excessive use. Hence, research for alternative fuel with characteristic such as, capacity to replace the present fuel, protect the environment from obnoxious pollutants and renewable, biodegradable, cost evasive for common man, started.

Development of usage of solar energy is still under progress and several hitches are to be removed. Although an indirect way to use solar energy was proposed by Rudolf Diesel in 1895 and Melvin Calvin in 1974. The idea of using plant biomass as a source of renewable energy was well taken by scientists.

Plant latex, resin and oil are identified as possible hydrocarbons, which can be converted to fossil fuel like products. So far, about 400 plant species belonging to more than 20 families have been identified as petrocrops.

High oil prices, competing demands between foods and other biofuel sources and the world food crisis have ignited interest in algaculture (farming algae) for making vegetable oil, biodiesel, bioethanol, biogasoline, biomethanol, biobutanol and other biofuels. Biofuels obtained from algae are referred as algal fuel, oilgae, algaeoleum, third generation biofuel, etc.

Biodiesel is

- Fatty Acid Alkyl Ester
- Non-toxic and biodegradable substitute for conventional nonrenewable diesel fuel
- Can be synthesized from vegetable oil (edible/ non-edible), animal fats, algal oil, waste vegetable oil, etc.
- Obtained by a process called transesterification

Why to use algal as oil source instead of oil yielding crops:

Algae can produce 15-300 fold more oil per acre than any of the conventional crops, such as soybeans, rapeseed, oil palms, jatropha. This is because almost entire algal organism can use sunlight to produce lipids or oils. As per the current diesel fuel requirement if the algal fuel replaced all the petroleum fuel in the United States, it would require 15000 sq. miles (40000 sq. kms). Algae have harvesting cycle of 1-10 days which permits several harvests in a very short time frame increasing the total yield. Whereas other oil yielding crops has harvesting cycles running in months. Algae can also be grown on land that is not suitable for other established crops. This minimizes the issue of taking away the pieces of land from the cultivation of food crops. Algal fuels do not affect the fresh water resources. These can be produced by using sea water (saline water) as well as wastewater.

Making biodiesel from algae:

– Collection- Amount of algae is collected

– Oil extraction- Algae are ground (with the help of mortar and pestle when production is on small scale) as much as possible. The ground alga is then dried at 80 C for sufficient time period for releasing water. Hexane and ether solution is then mixed with the dried ground algae to extract oil. Then this mixture is kept for 24 hrs for settling.

– Separation- the crude oil and algal biomass are then separated by filtration.

– Heating- The crude oil after filtration is heated to vapor release hexane and ether solution.

– Mixing of catalyst and alcohol- Sodium hydroxide (acts as a catalyst) is mixed with alcohol (generally methanol due to its low cost) and then mixed properly by stirring.

– Processing- The mixture of catalyst and methanol is then poured into algal oil.

– Transesterification- then the whole mixture is

shaken vigorously for 20-30 minutes.

– Settling- after shaking, the solution is kept for 16 hours to settle the biodiesel. The upper layer will be (impure) biodiesel and the lower layer will be glycerol.

– Separation- the impure biodiesel is then separated from the sedimentation by separating funnel

– Washing- The separated impure biodiesel is then washed by distilled water 5 to 6 times to remove the impurities

– Drying- biodiesel is then kept in sunlight for 7-8 days to remove all the water contents from it.

–. This dried biodiesel is now ready for use in diesel vehicles.

Alternative process for biodiesel production:

There are many reports on biodiesel production using enzyme catalysis by free/immobilized lipases. Immobilized lipase is suitable for continuous biodiesel production because of its easy recovery from the reaction mixture. There are two major limitations of lipase catalysed biodiesel synthesis. One is higher cost and another is its inactivation by methanol and glycerol. It has been reported that as methanol is insoluble in vegetable oil, it inhibits the immobilized lipases and thereby decreases the catalytic activity of the transesterification process.

Microalgal biomass production:

Production of microalgal biomass is generally more expensive than growing crops. To minimize expense, biodiesel production must rely on freely available sunlight, despite daily and seasonal variations in light levels. There are two practical methods of large scale production of microalgae:

Raceway ponds:

It is a closed loop recirculation channel that is typically about 0.3 m deep. There is a paddlewheel that mixes and circulates the algal biomass. Raceway channels are built in concrete or compacted earth and generally lined with white plastic. During daylight, the culture is fed continuously in front of the paddlewheel, on completion of the circulation of the paddlewheel operates all the time to prevent sedementation. Raceways are perceived to be less expensive than photobioreactors, because they cost less to build and operate. Although raceways are low-cost they have a less biomass productivity compared with photobioreactors.

Photobioreactors:

Tubular photobioreactor consists of an array of straight transparent tubes that are usually made of plastic or glass. The solar collector tubes are generally 0.1 m or less in diameter. Ube diameter is limited because light does not penetrate too deeply in the dense culture broth. Unlike open raceway ponds, photobioreactors permit essentially monoculture of microalgae for prolonged durations.

Benefits of using biodiesel:

– Biodiesel is able to directly replace conventional diesel fuel without any modification in most modern diesel engines (made after 1993).

– Biodiesel can also be used as a blend in any proportion with petroleum diesel.

– Biodiesel reduces any country's dependence on foreign oil

– Biodiesel has lower toxicity when compared with conventional petroleum diesel fuel. Use of biodiesel reduces emission of the green house gases, carbon monoxide, particulate matter, sulphates, hydrocarbons and other toxic air pollutants.

– Biodiesel is safer to handle as compared to petroleum diesel fuel.

– Use of biodiesel reduces noise pollution to a considerable amount.

– Biodiesel has better lubricating properties extending the engine life.

– Since it has good solvent properties the motor piping is kept clean from cinder.

– Combustion of biodiesel is more effective because of its higher oxygen content.

Losses caused by using biodiesel:

– Vehicles using biodiesel may emit slightly more nitrogen oxides (NOx) about 2% for B20 and 10% for B100.

– The natural rubber sleeves (still used in old engines) are dissolved by biodiesel. But this can be easily avoided as those parts are made today by synthetic rubber.

– Growing algae in a controlled manner and harvesting it efficiently for the oil production is much more difficult when compared with oil extraction from oil yielding plants.

– Biodiesel is 2% less efficient than petrodiesel.

– The energy emission of biodiesel is about 5-8% less than petrodiesel.

– Biodiesel vehicles can also have problems starting at very cold temperatures. But this is more of an issue for higher percentage blends like B100 and easily solved in the same way as with conventionally fueled vehicles – by using engine block or fuel filter heaters or storing the

Microalga	Oil content % dry wt
Botrycoccus braunii	25-75
Chlorella	28-32
Crypthecodinium cohnii	20
Cylindrotheca	16-37
Dunaliella primolecta	23
Isochrysis	25-33
Monallanthus salina	20
Nannocloris	20-35
Nannochloropsis	31-68
Neochloris oleoabundans	35-54
Nitzschia	45-47
Phaeodactylum tricornutum	20-30
Schizochytrium	50-77
Tetraselmis sueica	15-23
Arthrospora platensis	32-37

Crop	Liters oil per hectare per year
Soybean oil	400
Sunflower oil	800
Canola	1600
Jatropha	2000
Palm oil	6000
Microalgae	60000-240000

vehicles in a building.

Performance of biodiesel:

Vehicles have similar horsepower and torque as conventional diesel when running on biodiesel. Chemically speaking biodiesel has a higher cetane number, but slightly lower energy content than perodiesel. To the average driver, this means better engine performance and lubrication, but a small decrease in fuel economy (2-8 %). Biodiesel vehicles can also have problems starting at very cold temperatures.

Maintenance:

Generally, the use of biodiesel does not cause many maintenance issues. However, when used for the first time, biodiesel can release deposits accumulated on tank walls and pipes from previous diesel fuel, initially causing fuel filter clogs. As a result, vehicle owners should change the fuel filters after their first tank of biodiesel. Also biodiesel can degrade rubber fuel system, such as hoses and pump seals. This is especially true with higher percentage blends and older vehicles.

Biodiesel – Facts:

– Any biogenic fat or oil can be converted into biodiesel..!!

– The alcohol only constitutes about 10% of the volume of the biodiesel..!!

– Biodiesel is not a vegetable oil.

– Biodiesel quality is governed by ASTMD 6751 quality parameters.

– Pacific Biodiesel Technologies is the first biodiesel industry built in U.S.(1996), establishing a biodiesel production operation to recycle used cooking oil into biodiesel on the island Maui in Hawaii.

– Biodiesel contains monoalkylic esers hydrocarbon chains in the range of 14-22 C-atoms.

– Biodiesel can be produced from more than 300 vegetable plant species.

– Biodiesel typically contains upto 14 different types of FAMEs (Fatty Acid Methyl Esters).

– The transesterification process so called alcoholysis is the displacement of an alcohol in the ester molecule by another alcohol as in a hydrolysis reaction, using alcohol instead of water.

– Suitable alcohols for transesterification are methanol, ethanol, propanol, butanol and amyl alcohol. Methanol is most commonly used because of its low cost and good physicochemical properties.

– Transesterification of oils reduces the viscosity of triglycerides.

– Producing biodiesel from microalgae may be the only way to produce enough automotive fuel to replace current gasoline usage.

– The green waste left over from the algae oil extraction can be used to produce biobutanol and bioethanol.

– Parry nutraceuticals Ltd. Is the first Indian industry to produce algal biodiesel from *Arthrospira platensis* (spirulina).

– Making biodiesel is relatively simple and easier than making beer.

– Biodiesel has higher pour point than petrodiesel (the temperature at which the fuel will no longer pour is called as the pour point or gel point).

Theoretically, biodiesel produced from the algae appears to be the only feasible solution today for replacing petrodiesel completely. No other feedstock has the oil yield high enough for it to be in the position to produce such large volumes of oil. The current state of technology is not yet capable of achieving yields as high as theoretically possible, and the economics need further improvement. Producing low cost microalgal biodiesel requires primarily improvements to algal biology through

genetic and metabolic engineering. Use of the biorefinery concept and advances in photobioreactor engineering will further lower the cost of production. If the microalgal biodiesel concept could be adapted to a country like ours, it could become a highly distributed source of fuel oil giving a further push to economy.