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Biodiesel Produced From Waste Cooking Oil The Best Alternative For Fossil Fuels. A Review

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Abstract

Petroleum products are one of the major sources of energy which is utilized for sustaining the human race but continuous use of these products has led into scarcity and raised in prices of these products. Therefore, the search for other alternatives with their socio-economical aspects has been considered as priority. In this direction many alternative fuels are being recently explored as potential alternatives for present high-pollutant diesel fuel derived specifically from industrial waste. One of them, biodiesel is the best alternative for this problem and has been successfully implemented. Biodiesel are esters monoalkyl of fatty acids of long chain that are produced from vegetable oil, animal fat or waste cooking oils in a chemical reaction known as trans esterification. It emerges as one of the most energy-efficient environmentally friendly options among modern fuels. Diesel engines operated on biodiesel showed fewer emissions of carbon monoxide, unburned hydrocarbons and particulate matter, than operated on petroleum-based diesel fuel. The country like India which is among the largest fuel importer, the option of biofuel can be helpful in releasing the pressure of fuel demand, with almost no pollution.

Keywords: Petroleum fuels, biodiesel, production and applications

Introduction

The entire world is facing crises of depletion for fossil fuels with problem of environmental degradation. The rapid depletion of fossil fuel reserves with increasing demand and uncertainty in their supply, rapid rise in petroleum prices etc.This stimulated research for other alternatives to fossil fuels. Many alternative fuels are being recently explored as potential alternatives for the present high-pollutant diesel fuel derived from diminishing commercial resources. One such initiative is production of bio-diesel from waste cooking oil. The term waste cooking oil (WCO) refers to vegetable oil which is no longer viable for its intended use. WCO arises from many different sources, including domestic, commercial and industrial. Oil which reaches the water sources increases organic pollution load with forming layers on the water surface to prevent the oxygen exchange and alters ecosystem. The dumping of oil also causes problems in the pipes drain obstructing them, creating odors and increasing the cost of wastewater treatment. For this reason, it has become necessary to create a way to recover this oil and reuse it. This will not only reduces the burden of government in disposing the waste, maintaining public sewers, and treating the oily wastewater and also lower production cost of biodiesel significantly.

Biodiesel emerges as one of the most energy-efficient environmentally friendly options in recent times to full fill future energy needs. The prefix “bio” refers to renewable or biological nature, in contrast to traditional diesel derived from petroleum. While “diesel” refers to fuel or use on diesel engines. These are used primarily for transportation and do not include ethanol blended fuels. Since biodiesel is a mild solvent, it may help to remove engine deposits that settle in the storage tanks of vehicles as well as systems. As a result, fuel filters in vehicles may become plugged; giving a false impression that biodiesel plugs filters, while it actually helps clear out sediments deposited in storage tanks.

ASTM (American Society for Testing and Materials Standard) describes the biodiesel as esters monoalkyl of fatty acids of long chain that are produced from vegetable oil, animal fat or waste cooking oils in a chemical reaction known as trans esterification. It involves mixing the feedstock oil with an alcohol (typically methanol or ethanol) in the presence of a catalyst (sodium hydroxide or potassium hydroxide). The reaction produces methyl esters (if methanol is used) or ethyl esters (if ethanol is used).Which comprises the biodiesel fuel and glycerin. Methanol is typically used for economic reasons, as the physical and chemical properties between methyl esters and ethyl esters are “comparable” according to a University of Idaho study [1].

Diesel engines are operated on biodiesel have lower emissions of carbon monoxide, unburned hydrocarbons, particulate matter, and air toxicin than operated on petroleum-based diesel fuel[2]. The National Biodiesel Board (USA) also has a technical definition of "biodiesel" as a monoalkyl ester[3]. An important distinction needs was made between biodiesel and biodiesel blends. Biodiesel is commonly mixed with diesel No. 2 to form a biodiesel blend. As stated above, a mixture of biodiesel and diesel is not biodiesel, but is referred to as a biodiesel blend. Pure biodiesel, also known as neat biodiesel, is commonly noted as B_{100}, indicating that the fuel has 100 percent biodiesel (noted by the 100) and 0 percent diesel. The most common biodiesel blend is B_{20}, which contains 20 percent biodiesel and 80 percent diesel.

By weight, biodiesel contains less carbon, sulfur and water and more oxygen than diesel. The reduced carbon content decreases emissions of carbon monoxide (CO), carbon dioxide (CO_2) and soot (elemental carbon). The lower sulfur content of biodiesel is important for two primary reasons. As low sulfur fuel, it produces little or no emissions of sulfur dioxide (SO_2). SO_2 contributes to respiratory illness, aggravates existing heart and lung diseases, contributes to the formation of acid rain, can impair visibility and can be transported over long distances [4]. EPA regulation says that consumption of biodiesel will reduce the level of sulfur in highway diesel fuel by 97 percent by mid-2006[5]. Biodiesel was already compliant with the 2006 standard of EPA [6]. Biodiesel has higher oxygen content, which allows it to burn more completely than conventional diesel, thereby reducing hydrocarbon and carbon monoxide emissions [7].Feedstock for bio-diesel include animal fat, vegetable oil, soy, hemp, palm oil sunflower oil, jatropha, mahua, mustard, flax, pongamia glabra, mallous philippines, garcinia indica, thumba and karanja etc. Biodiesel from soy oil results, on average, in a 57% reduction in greenhouse gases compared to fossil diesel, and biodiesel produced from waste grease results in an 86% reduction [8]. Biodiesel degrades about four times faster than conventional diesel [9]. European tests of rapeseed-based biodiesel show that it is 99.6 percent biodegradable within 21 days [10].

Moreover, blending biodiesel with diesel fuel accelerates its bio-degradability. For example, B_{20} with a diesel No. 2 base degrades about twice as fast as diesel No. 2 alone [11].Fatty acid composition usually obtained by gas chromatography is the major indicator of the properties of biodiesel [12]. Such composition of oil has an important role in the performance of biodiesel in diesel engines.Saturation fatty acid methyl esters increase the cloud point, cetane number, and improve stability whereasmore polyunsaturation reduce the cloud point, cetane number, and stability[13][14]. Presence of free fatty acids and water in the feedstock result in production of soap in the presence of alkali catalyst. Thus, additional steps to remove water and either the free fatty acids or soap from reaction mixture are required. However, tools of biotechnology could be utilized to modify fatty acid profile of soybean for performance enhancement, which may increase the attractiveness of biodiesel derived from the commodity crop[15].

Various countries are using various kinds of oil as source for bio-diesel production. Such as USA- soyabean, BRAZIL-soyabean, EUROPE- rapeseed oil and sunflower oil, SPAIN- linseed and olive oil, ITALY AND FRANCE- sunflower oil, INDONESIA AND MALAYSIA- palm oil, IRELAND- animal fat,beef tallow,AUSTRALIA- beef tallow, animal fat and rapeseed oil, GERMANY- rapeseed oil, CHINA- guang pi, CANADA- vegetable oil/ animal fat, INDIA- jatropha, GHANA- palm oil, palm nut and coconut oil[16].

Production of biodiesel

This can be illustrated using the generalised flow diagram given below

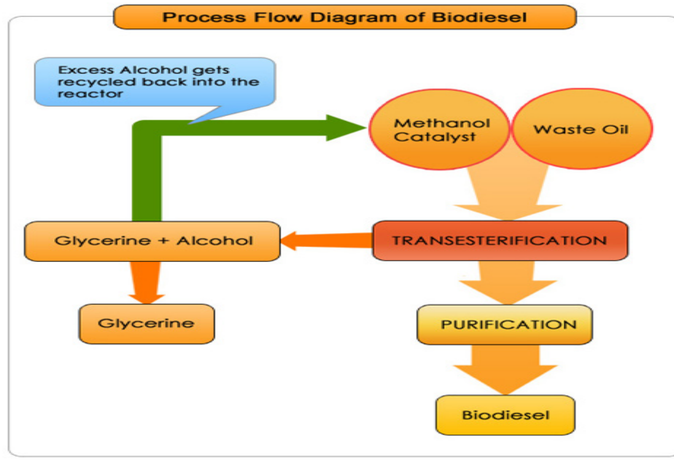

Figure 1: Graphical illustration of Biodiesel plant flow diagram.

The alternative diesel fuels must be technically and environmentally acceptable and economically viable. From the viewpoint of these requirements, triglycerides (vegetable oils / animal fats) and their derivatives shall be considered as viable alternatives for diesel fuels. The problems with substituting triglycerides for diesel fuels are mostly associated with their high viscosities, low volatilities and polyunsaturated character[17]. One of the main problems of vegetable oil use in diesel engines is their higher kinematic viscosity because of heavier triglycerides and phospholipids, due to which problems occur in pumping and atomization, ring-sticking, carbon deposits on the piston, cylinder head, ring grooves, etc.

Transesterification is a most suitable process to convert oils and fats into biodiesel. It is most popular reaction used for conversion of vegetable oils into biodiesel in order to reduce its viscosity.

It is reaction of an alcohol, in most cases methanol, with triglycerides present in oils, fats or recycled grease, forming biodiesel (fatty acid alkyl esters) and glycerol. This reaction requires heat and a strong base catalyst, such as sodium hydroxide or potassium hydroxide. The transesterification process involves reacting vegetable oils with alcohols such as methanol or ethanol in the presence of a catalyst (usually sodium hydroxide or potassium hydroxide) at about 70^0 C to give the ester and the byproduct, glycerin and water. It has been reported that the methyl and ethyl esters of vegetable oil can result in superior performance than neat vegetable oils.

Usually 3 parameters have effect over trans esterification

- **Temperature of reaction**
- **Time of reaction**
- **Ratio of oil to alcohol**.

The reaction temperature plays an important role on the quality of the products. Kapilakarn K andPeugtong[18]reported that normally, the range of thetemperature used in the process is between 50^0C – 65^0C. The temperature which is higher than the normal boiling point of methanol (68^0C) causes morevaporization of methanol (loss). On the other hand, the temperature which is lower than 50^0C causes higherviscosity of biodiesel[19].

The ratio of methanol to oil also affects the reaction, the higher molar ratio, thehigher conversion of alcohol. The ratios, normally used, are between 5:1 to 10:1[20]. However using too highexcess methanol can obstruct glycerin separation[21]. It was investigated that the conversionrate into biodiesel using beef tallow, sunflower , and soybean feed stocks wasvery slow during the first minute due to the mixing and dispersion of methanol into beef tallow, the reactionproceeded very fast for the next five minutes.

An approximate yield of 80 % was observed after 1 minute forsoybean and sunflower oils at methanol to oil ratio of 6:1. After 1 hour, the conversions were almost the same(93%-98%).The effect of reaction time for palm oil at 40:1 methanol: oil with 5% H_2SO4 (v/v) at 95 °C for 9hours and obtained a maximum yield of 97 %[22].

After the formation of desired product, following steps are involved:

Separation

Once reaction is complete, two major products exist (glycerin and biodiesel). Each has a substantial amount of excess methanol that was used in reaction. The reacted mixture is sometimes neutralized at this step if needed. Glycerin phase is much more dense than biodiesel phase and these can be gravity separated with glycerin simply drawn off the bottom of the settling vessel. In some cases, a centrifuge is used to separate materials faster.

Alcohol removal

Once glycerin and biodiesel phases have been separated, the excess alcohol in each phase is removed with a flash evaporation process or by distillation. In others systems, the alcohol is removed. Mixture is neutralized before the glycerin and esters have been separated. If the alcohol is recovered using distillation equipment and is re-used withcare of ensuring no water accumulates in the recovered alcohol stream.

Glycerin neutralization

Glycerin (bi-product) contains unused catalyst and soaps that are neutralized with an acid and sent to storage as crude glycerin. In some cases the salt formed during this phase is recovered for use as fertilizer. In most cases salt is left in the glycerin. Water and alcohol are removed to produce 80-88% pure glycerin that is ready to be sold as crude glycerin. In more sophisticated operations, glycerin is distilled to 99% or higher purity and sold into cosmetic and pharmaceutical markets.

Methyl ester wash

Once separated from the glycerin, the biodiesel is sometimes purified by washing gently with warm water to remove residual catalyst or soaps, dried, and sent to storage. In some processes this step is unnecessary. This is normally the end of the production process resulting in a clear amber-yellow liquid with a viscosity similar to petro-diesel. In some systems, biodiesel is distilled in an additional step to remove small amounts of color bodies to produce a colorless biodiesel.

Product quality

Prior to use as a commercial fuel, the finished biodiesel is analyzed using sophisticated analytical equipment to ensure it meets all required specifications. The most important aspects of biodiesel production to ensure trouble free operation in diesel engines are:

- Complete Reaction
- Removal of Glycerin
- Removal of Catalyst
- Removal of Alcohol
- Absence of Free Fatty Acid

Applications of bio-diesel

The smartest technologies deliver benefits to multiple interests, including improved economy and a positive impact on the environment and govt. policies. Compared to other alternative fuels, biodiesel fuel supports some unique features and qualities. Unlike other alternative fuels, it has successfully passed all the health effects testing requirements, meeting the standards of the 1990 Clean Air Act Amendments. The role of bio-diesel industry is not to replace petroleum diesel, but to create such an alternative which is efficient and less polluting.

Bio-diesel produces less toxic pollutants and greenhouse gases than petroleum diesel. It has helped several countries in reducing their dependence on foreign oil reserves as it is domestically produced and can be used in any diesel engine with little or no modification to the engine or the fuel system and can replace fossil fuels to become the most preferred primary transport energy source.

Biodiesel can be used in 100% (B100) or in blends with petroleum diesel. For example, B20 is called as 20% blend of biodiesel with 80% diesel fuel. It improves engine lubrication and increase engine life since it is virtually sulphur free. The lack of sulphur extends the life of catalytic converters.

A 1998 biodiesel life cycle study, jointly sponsored by DOE and the U.S. Department of Agriculture, concluded biodiesel reduces net carbon dioxide emissions by 78% compared to petroleum diesel. All outdoor air pollution is estimated to pose 1% of our cancer risk. Scientific research confirms that biodiesel exhaust has a less harmful impact on human health than petroleum diesel fuel. Biodiesel emissions have roughly 45-90% lower toxic emissions compared to diesel.

1. Producing hydrogen for fuel-cell vehicles
2. Cleaning up of spills- Biodiesel is environmentally benign and is known to clean up oil spills and has meant to increase the recovery of crude oil from artificial sand columns (i.e. beach).
3. Generating electricity- Biodiesel is used in conventional power generation. In addition to production of hydrogen, it can be used in backup systems where the substantial reduction in emissions really matters: hospitals, schools, etc.
4. Heating home- It can be used as home heating oil in domestic and commercial boilers. It can also be used to supplement solar power in off- the grid homes.
5. Cleaning up tools and grease- B100 is a good solvent that can clean dirty or greasy engine or other machine parts. Biodiesel makes an awesome bike- chain degreaser/ lubricator. It can also be used to clean metal, which is advantageous due to lack of toxicity or environmental impacts.
6. Hand cleaner
7. Corrosion preventive

Conclusion

Biofuels are going to play an extremely important role in meeting and full filling India's energy needs with improving the quality of life. India is among largest importers of oil and prospect will increase imports in future too. But biodiesel will have significant potential for reducing import of fuels in our country. Biofuels have been, and will continue to be, an important part of our ever developing society.

Biodiesel, from the family of biofuel, has been described in this review as a fuel with necessary potentials to replace fossil diesel in future. The trials of biodiesel and its blend have undergone a confirmatory test to all advantages including environmental benefits to be accrued. It thereby plays a vital role inmeeting future fuel requirements. The availability of major feedstock namely oil from biosources and simplicity of the transesterifcation technology has ensures its conversion to biodiesel are added advantage interms of the future needs of biodiesel. The use of inedible oil and waste frying/cooking oil will equally assistedin establishing a balance between energy and food security. However, serious efforts have to be intensified ondesign of large scale biorefineriesfor future biodiesel production.

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