Review on Different Sources for the Production of Biodiesel

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Abstract— **Biodiesel is generally produced from various seed oils such as soybeans, rapeseed and corn. Such a diesel can be used in cars, trucks, busses, construction equipment, in jet engines and in heating and electricity generating systems, but only through blends with maximum blend up to 25% (v/v) Biofuels burn cleaner than fossil fuels. They don't produce sulphur or aromatics. Main benefit of using biodiesel is that, it reduces nitrogen oxide emissions compared to fossil fuel. This article reviews different sources for the production of biodiesel. Biodiesel is environmentally safer than petro-diesel. It is non-toxic, produces less skin irritation, it degrades four times as fast as petro-diesel, has a flash point significantly higher than that of petro diesel, thus making it safer to store and handle.**

Keywords— **biodiesel; edible sources; non-edible sources; waste cooking oil; transesterification; review;**

I. INTRODUCTION

Biodiesel is used as substitute fuel for diesel engines because it has environmental benefits. Producing biodiesel from waste cooking oil is most easy way and has many environmental benefits. The use of cooking oils produces significant amount of used oils which cause a severe disposal problem. Biodiesel production from waste cooking oil has many advantages because of their low price, availability and less fatty acid content. Used cooking oil is described as a 'renewable fuel' as it does not add any extra carbon dioxide gas to the atmosphere, as opposed to fossil fuels, which cause changes in the atmosphere. Cooking oil from plant sources is the best source to produce biodiesel because the conversion of pure triglyceride to fatty acid methyl ester is high and the reaction time is short. Biodiesel is commonly produced by transesterification process where waste cooking oil reacts with alcohol and catalyst mixture to produce fatty acid methyl esters and glycerol as a by-product.

The cooking oil was first used by Rudolph Diesel for the purpose. He developed the first diesel engine working on peanut oil at the World's Exhibition in Paris, 1900 [1]. Until 1920s cooking oils was being used as the energy source in diesel engines. The factors like profitability, availability, low sulphur content, low aromatic content, biodegradability and renewability makes WCO based biodiesel more favourable over diesel fuel [2].

Biodiesel can be described as 'carbon neutral' as this fuel does not produce carbon dioxide (CO_2). Biodiesel degrades rapidly in the environment and is non-toxic, moreover storing biodiesel is also very safe. Greenhouse gas emissions that are produced by fossil fuels are the prime reasons behind choosing biodiesel as an alternative fuel for those fossil fuels. The biodiesel has plenty of advantages over fossil fuels. It can be used as an excellent alternative fuel for the diesel engine, mainly low carbon content makes it as an alternative to heating oil. With the help of biodiesel we can cycle carbon into the atmosphere instead of releasing stored carbon.

Properties of Biodiesel

Properties	Value
Specific gravity	0.87 to 0.89
Kinematic viscosity at 40°C (mm^2/s)	3.7 to 5.8
Cetane number	46 to 70
Flash point, °C	120-130
Iodine number	60-135
Sulphur wt. %	0.00 – 0.0024

Reference: [3, 4, 5]

II. PROBLEM DEFINITION

Fossils fuels are the major source of energy for today's vehicles. If tomorrow the fuel wells get exhausted, the total economy of "Rapid Developing World" will collapse, thus the need of the substitution is obligatory for the modern world. One of the most promising substitutes for the conventional diesel is biodiesel. It is most valuable form of renewable energy that can be used directly in any existing, unmodified diesel engine. Biodiesel burns more cleanly than gasoline and diesel. Using biodiesel means producing fewer emissions of carbon monoxide, particulates and toxic chemicals that cause smog, aggravate respiratory and heart diseases and contribute to thousands of premature deaths each year.

III. LITERATURE REVIEW

In recent years, biodiesel has been produced from edible and nonedible sources, animal fats, soap stock, recycled frying oils and also from macro and micro algae. In order to know which sources (Edible or non-edible sources) are the suitable for the production of biodiesel, the factors that need to be considered include geography, climatic conditions and economics. From the edible sources, cooking oils are considered as the renewable forms of fuel as they are made from renewable resources and therefore they are more attractive giving more environmental benefits. Cooking oil potentially forms the unlimited source of energy; with an energy content equivalent to that of diesel fuel. Direct use of cooking oil in diesel engines gives rise to many problems such as jamming and gumming of filters, lines and injectors; engine knocking; starting problem during cold weather; coking of injectors on piston and head of engine; extreme engine wear; carbon deposition on piston and head of engine [6].

Cooking oils are of high viscosity and in order to reduce their viscosity and to overcome their problems to enable their use in many diesel engines, a process called trans-esterification must be carried out. The product so formed after trans-esterification is called the biodiesel. Mostly there are higher heating values of biodiesel. When biodiesel is 100% pure then it is been referred as "neat fuel" or "B100". Biodiesel with high heating values (HHV's) ranges from 39 to 41MJ/Kg. Biodiesel can be effectively used by blending with petra-diesel and those blends are referred as BXX where XX represents the amount of biodiesel in the blend whereas the pure biodiesel may be denoted as B100 [7].

IV. EDIBLE SOURCES

Biodiesel may be produced from many lipids such as cooking oil feedstock, waste cooking oil, soybean oil and non-edible oils such as jatropha oil, neem oil, castor oil, soap-nut oil etc. [8].

Apart from edible and non-edible sources, algae are contemplated as an important source for the production of biodiesel. The yield from algal oil is above 200 times the yield from that of cooking oils of biodiesel [9].

Vegetables sources such as cotton seed oil, soybean oil, sunflower oil, palm oil and animal sources and rapeseed oil are also being used. Few other sources for the production of biodiesel are tobacco seed, sorghum, jatropha, pongamia, micra as well as microalgae (Chlorella vulgaris), oat, piqui (Caryocar sp.), Cynara cardunculus, fish oil, groundnut almond, andiroba (Carapa guianensis), babassu (Orbignia sp.), barley, and wheat [10].

For the production of biodiesel, mainly used edible oils are Coconut (copra), corn (maize), cottonseed, canola (a variety of rapeseed), olive, peanut (groundnut), safflower, sesame, soybean, sunflower seed oils, nut oils, almond, cashew, hazelnut, macadamia, pecan, pistachio and walnut. Whereas amaranth, apricot, argan, artichoke, avocado, babassu, bay laurel, beech nut, ben, borneo tallow nut, carob pod (algaroba), cohune, coriander seed, false flax, grape seed, hemp, kapok seed, lallemantia, lemon seed, macauba fruit (Acrocomia sclerocarpa), meadowfoam seed, mustard, okra seed (hibiscus seed), perilla seed, pequi, (Caryocar brasiliensis seed), pine nut, poppy seed, prune kernel, quinoa, ramtil (Guizotia abyssinica seed or Niger pea), rice bran, tallow, tea (camellia), thistle (Silybum marianum seed) and wheat are other sources to obtain edible oils [11].

A. *Biodiesel Production from Waste Cooking Oil*

Waste cooking oils are the most attractive. interesting and common source for the production of biodiesel due to their low cost. From large food processing units and service facilities, waste cooking oil may be collected in huge proportion. All such units include several chemical reactions such as hydrolysis, polymerization and oxidation during food frying process, which result in increasing efficiency of fatty acids [12].

Only edible oils are used for cooking purposes, after which the oil is usually thrown away in the nature. The amount of heat and water increases the hydrolysis of triglycerides and the percent of free fatty acid (FFA) in the oil [13]. If water and FFA content are in higher proportion, direct trans-esterification reaction is unable to conduct [13, 14] and in order to reduce FFA, esterification process has to needs to be carried out. The WCO (waste cooking oil) price is two to three times cheaper than cooking oils and it also reduces the cost of waste product removal and treatment [15]. The WCO has been categorized by the FFA content into two groups: (a) yellow grease (<15%) and (b) brown grease (>15%) [16].

Some negative effects of WCO utilization for biodiesel production include separation of fatty acid esters and glycerol and formation of di-meric and polymeric acids and glycerides. Consequently the viscosity of cooking oil increases, while the saponification process decreases the molecular mass and iodine values [17, 18, 19]. Meanwhile, soap formation partially consumes the catalyst and reduces the final yield. There is no appropriate method for collecting waste cooking oils from households yet. The amount of WCO dumped through drains leads to water pollution. More than 80% of WCO is produced in households and controlling its disposal involves huge investments such as waste oil disposal and high water treatment cost [20, 21]. Therefore, using WCO for producing biodiesel is an important act of from environment care stand point.

There are various methods for biodiesel production from waste cooking oil which can be divided into three main groups: Homogeneous, Heterogonous and Non-catalytic trans-esterification.

B. *Biodiesel Production from Soap stock*

Soap stock is generally the by-product of refined cooking oils. It is an additional low value feedstock for biodiesel production which contains an extensive amount of water of about 44.2%. These contain less free fatty acids because of alkaline nature of aqueous emulsion of lipids. However these have the fatty constituents such as soaps, mono, di, tri-glycerides and phosphatides which can be easily converted into fatty acid methyl esters [22].

V. Non Edible Sources

Biodiesel production from edible sources such as cooking oil and animal fats has become more expensive as they compete with food materials. In recent years the cooking oils being from edible sources, their demand has been higher and hence they are not preferred much for biodiesel production. Some of the sources like *Pongamia glabra, Lesquerella fendleri, Madhuca indica, Chlorella vulgaris*, oat, rice, rubber seed, sesame, tobacco seed, Dipteryx odorata, Cynara cardunculus, fish oil, groundnut, wheat, almond, Carapa guianensis, barley, *Camelina sativa*, coconut, copra, jatropha, soapnut, algae, babassu tree, copaiba, honge, jatropha or ratanjyote, jojoba, karanja or honge, mahua, milk bush, nagchampa, neem, petroleum nut, rubber seed tree, silk cotton tree and tallare are used as non-edible plant oil sources for biodiesel production [23,24].

A. Biodiesel Production from Jatropha Oil

Jatropha curcas L. is a plant belongs to Euphorbiaceae family, where its seeds produces huge amount of oil. Jatropha curcas L. plant has been widespread in arid, semi-arid and tropical regions of the world, Jatropha is a drought resistant perennial tree that grows in marginal lands and can live over 50 years [25]. As per the weight of the seed, the oil content in jatropha seed ranges from 30 to 50% and ranges from 45 to 60% weight of the kernel itself [26]. *Jatropha curcas L.* has favourable properties for the production of biodiesel because of its calorific value and cetane number [27].

Many studies have revealed that plant sources have immense potential for the production of biodiesel. Azam et al. [28] studied the prospects of fatty acid methyl esters (FAME) of some 26 non-traditional plant seed oils including jatropha to use as potential biodiesel in India. Among them, *Azadirachta indica, Calophyllum inophyllum, J. curcas* and *Pongamia pinnata* were found most suitable for use as biodiesel and they meet the major specification of biodiesel for use in diesel engine. Moreover, they reported that 75 oil bearing plants contain 30% or more oil in their seed, fruit or nut. Subramanian et al. [29] reported that there are over 300 different species of trees which produce oil bearing seeds. Thus, there is a significant potential for non-edible oil source from different plants for biodiesel production as an alternative to petro diesel.

According to the reports, *Jatropha curcas L.* is found as the best source for the production of biodiesel. A study made by Azam et al., says that Biodiesel made from Jatropha and biodiesel from palm oil when blended at about 20-40% will improve oxidation stability and low temperature property [30]. Biodiesel from jatropha and biodiesel from palm has good low temperature oxidative stability respectively and also it was initiated that antioxidant dosage could be reduced by 80-90%. According to Sarin et al. jatropha seed can produce huge amount of oil for biodiesel production [31]. This is the significant source of from non-edible oils32].

B. Biodiesel Production from Soap nut oil

Soapnut plant grows well in deep loamy soils and leached soils, so nurturing of soapnut in such soil evades probable soil erosion. As well as it helps to produce more seeds and this acts as a feedstock for biodiesel production [33].

Soapnut is a fruit of the soapnut tree found in tropical and sub-tropical areas in various parts of the world. Soapnut oil is also another favourable non-edible sources for the production of biodiesel [34].

Chhetri et al. [35] covered all important points and studied deeply on the uses of various parts of the soapnut tree. Soapnut has many applications from the field of medicinal treatments to soap and surfactant. Soapnut fruit shells have been in use as natural laundry detergents from ancient times for washing fabrics, bathing and traditional medicines. Mandava [36] reported that saponins from Soapnut shells can be used for treatment of soil contaminants. Many studies also reported that soapnut is a natural surfactant which can be used for washing soil contaminants with organic compounds [37; 38]. According to a study, the external use of saponin does not have any toxic effects on human skin and eyes [39]. The seeds of soapnut are totally a waste because all these application make use of the pericarp shell only. Therefore, the waste soapnut seeds become a favourable source for the production of biodiesel. Furthermore, planting soapnut trees in community forestry and in barren lands provides sink for carbon sequestration as well as feedstock for biodiesel production.

C. Microorganisms as a source for biodiesel production

Lipomyces starkeyi, Rhodotorula glutinis, Yarrowia Cryptococcus curvatus, Lipomyces lipofera, lipolytica, Rhodococcus, and Nocardia are capable of producing intracellular triacylglycerides [40].

These microorganisms contain fats up to 80% of the cellular dry weight [41]. Microorganisms comprise of a broad string of substrates like carbon source, sugars, organic acids, alcohols, oils and different waste products such as whey and agro-industrial waste for triacylglyceride synthesis [22].

D. Grease as a source for biodiesel production

Greases are regarded as cheap feedstocks for biodiesel production. They include triglycerides (TG), di-glycerides (DG), monoglycerides (MG), and free fatty acids (FFA) of about 8 to 40%. A grease with 8-12 wt. % FFA is sorted as yellow grease, and a grease containing >35 wt. % FFA is sorted as a brown grease [42].

E. Microalgae as a source for biodiesel production

Microalgae, the small microorganisms, can grow in fresh, marine, waste and saline water. Microalgae have the potential to produce 136,900 litres while jatropha can produce 1,892 litres oil per acre. Microalgae can fix large amount of carbon dioxide (CO_2) and contribute about 40-50% oxygen in the atmosphere, thereby, supporting biological life on our planet by producing food, medicines, chemicals etc. for human consumption [43].

Use of microalgae for biodiesel production has numerous advantages in contrast with other accessible feedstocks [44]. Microalgae also offer feedstock for quite a few types of renewable fuels such as biodiesel, methane, hydrogen, ethanol etc. Microalgae biodiesel acts well as petroleum diesel, at the same time it decreases the productions of particulate matter such as CO, hydrocarbons, and SOx. [45].

Microalgae can be grown vigorously everywhere and throughout the year, some species of it can be reaped daily, it is suitable for cold environment due to presence of polyunsaturates and so it is mostly preferred as the best source for the production of biodiesel [46].

VI. CONCLUSION

Fossils fuels are non-renewable forms of energy resources and they are depleting day by day and will get depleted soon. So the demand for biofuels such as biodiesel is increasing rapidly. Biofuels like biodiesel are renewable, eco-friendly and non-toxic energy resources. Most studies reveal that biodiesel properties are mostly similar to petroleum diesel properties but biodiesel emits negligible amount of CO_2, sulphur and particulates as compared to petroleum diesel. In summary, WCO, grease, and soap stock are potential feedstock for biodiesel production, which can lower the cost of biodiesel since they are inexpensive, whereas from non-edible sources like microalgae and soapnut are also the most favourable sources for biodiesel production. But from different studies, we arrive at a strong conclusion that microalgae are the best source for biodiesel production because microalgae have many advantages over other conventional sources. A rigorous research movement may be strengthened for the production of biodiesel from various possible sources to produce the same as an important bio-fuel.

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