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A REVIEW ON BIODIESEL PRODUCTION TECHNIQUE

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Abstract— The limited stock of fossil fuels and its negative effect on the environment, many countries across the world are now looking toward renewable sources. Biodiesel is one kind of biofuel that is renewable, biodegradable and has similar properties of fossil diesel fuel. In this paper, a review has been conducted to shows different related aspects to biodiesel as a fuel. These aspects include biodiesel feedstocks, extraction and production methods. The conversion of edible and non-edible oils into biodiesel is an effective way to overcome all the problems associated with the biodiesel. Dilution, micro-emulsification, pyrolysis, and transesterification are the major techniques applied to solve the problems encountered with the high fuel viscosity. Transesterification is the most common method and leads to monoalkyl esters of vegetable oils and fats. The methyl ester produced by transesterification of different oils has a high cetane number, low viscosity and required heating value.

Keywords— Biodiesel, Transesterification, biofuel, optimization.

I. INTRODUCTION

The increasing uncertainty of current petroleum reserves and the related environmental effects from the usage of fossil fuels has led to a search for renewable energy sources. Biodiesel is currently placed at the forefront as the most reliable alternative fuel for engines. It can be produced from renewable sources through simple and effective ways. The first diesel engine came into its existence in the year 1893 by a great German inventor Dr. Rudolph Diesel [1]. The use of vegetable oil was first started by Rudolph Diesel. He developed the first diesel engine working on peanut oil in Paris, 1900 [2]. Bio diesel is an efficient carrier of solar energy and hence has a positive energy balance ratio. As well as it degrades rapidly in the environment and is non-toxic [3]. A renewable fuel such as biodiesel, with lesser exhaust emissions, is the need of the time. Biodiesel is a mono alkyl ester of fatty acids produced from both edible and nonedible vegetable oils or animal fat and various other bio fuels such as methanol, ethanol etc.[3,4] Hence, researchers and scientific community have focused on development of biodiesel and the optimization of the processes to meet the standards and specifications needed for the fuel to be used commercially without compromising on the durability of engine parts. In last few years, the potential and prospect of biodiesel production from first and second generation feedstock have been extensively reviewed. However there is a need for comparison between the biodiesel produced from first, second generation feedstocks and microalgae as they are foreseen to be the fuel of the future. In fact, microalgae biofuels have been placed globally as one of the leading research fields which can bring enormous benefits to human beings and the environment. This review aims to provide an insight about the processes and methods involved to obtain biodiesel and to give a clear guideline to researchers propelling the biodiesel industry to become economically more viable.

II. POTENTIAL SOURCE OF BIODIESEL

In current times biodiesel has been produced from different sources like vegetable oils, animal fats, soap stock and also recycled frying oils. there are more than 350 oil-bearing crops identified as potential sources for biodiesel production. Oil crops are the main pillar for biodiesel production. It is very important to choose the suitable feedstock for biodiesel production as feedstock. Typical raw materials of biodiesel are rapeseed oil, canola oil, soybean oil, sunflower oil and palm oil. Beef and sheep tallow and poultry oil from animal sources and cooking oil are als sources of raw materials. There are various other biodiesel sources: almond, andiroba (Carapa guianensis), babassu (Orbignia sp.), barley, camelina (Camelina sativa), coconut, copra, cumaru (Dipteryx odorata), Cynara cardunculus, fish oil, groundnut, Jatropha curcas, karanja (Pongamia glabra), laurel, Lesquerella fendleri, Madhuca indica, microalgae (Chlorella vulgaris), oat, piqui (Caryocar sp.), poppy seed, rice, rubber seed, sesame, sorghum, tobacco seed, and wheat [5-10]. In general, biodiesel feedstock can be divided into four main categories as below:-

1. Edible vegetable oil: rapeseed, soybean, peanut, sunflower, palm and coconut oil.
2. Non-edible vegetable oil: jatropha, karanja, sea mango, algae and halophytes.
3. Waste or recycled oil.
4. Animal fats: tallow, yellow grease, chicken fat and by-products from fish oil.

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Table 1 shows the properties of biodiesel.

Table 1: properties of biodiesel [11, 12, 13]

Properties	Values
Specific gravity	0.87 to 0.89
Kinematic viscosity @ 40°C (mm2/s)	3.7 to 5.8
Cetane number	46 to 70
Higher heating value (Btu/lb)	16,928 - 17,996
Lower heating value (Btu/lb)	15,700 - 16,735
Sulphur wt %	0.00 - 0.0024
Cloud point °C	-11 to 16
Pour point °C	-15 to 13
Iodine number	60 – 135
Flash point °C	120-130

III. PRODUCTION OF BIODIESEL

There are many efforts to develop and improve vegetable oil properties in order to approximate the properties of diesel fuels. It has been remarked that high viscosity, low volatility and polyunsaturated characters are the mostly associated problems with crude vegetable oils. Dilution, micro-emulsification, pyrolysis and transesterification are various methods available to reduce viscosity of vegetable oil [14-30].

Dilution

Most of the oils can be diluted with the diesel oil to reduce the viscosity which in turn reduces the engine operational problems such as injector choking and carbon deposits[14]. It was reported that blending of 20 to 25% vegetable oil to diesel oil has been considered to give better performance for diesel engine. However, dilution does not work for long term when used in a direct injection engine and it is observed that the modern diesel engines have sensitive injection systems which may be affected by the viscosity change by using vegetable oils that have high viscosity. the viscosity of J. curcas oil is higher than diesel oil at any temperature. Viscosity values of 50:50 J. curcas oil/diesel fuel and 40:60 J. curcas oil/diesel fuel are close to diesel in the range of 328–333 K and at about 318 K, respectively, whereas the blend containing 30:70 J. curcas oil/diesel fuel has viscosity close to diesel at the range of 308–313 K[15].

Pyrolysis

Pyrolysis is the thermal decomposition of the organic matters in the absence of oxygen and in the presence of a catalyst. The paralyzed material can be vegetable oils, animal fats, natural fatty acids or methyl esters of fatty acids. It is the chemical reaction which is caused by the application of thermal energy in absence of air. The pyrolysis can be carried out at higher temperature 250 ^{0}C-450^0 C. Many investigators have studied the pyrolysis of triglycerides to obtain suitable fuels for diesel engine. Thermal decomposition of triglycerides produces alkanes, alkenes, alkadines, aromatics and carboxylic acids[16].

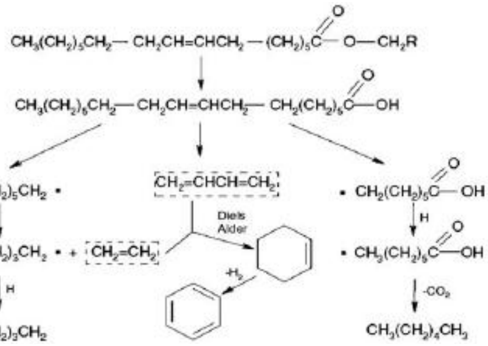

Fig 1: Thermal Decomposition of Triglycerides [16]

Micro-emulsion

Micro emulsion is defined as transparent thermodynamically stable colloidal dispersions. The diameter of the droplet varies from 100 to 1000 A^0. Micro-emulsions using solvents such as methanol, ethanol, hexanol, butanol and 1-butanol have been investigated by many researchers. To reduce of the high viscosity of vegetable oils, microemulsions with immiscible liquids such as methanol and ethanol and ionic or non-ionic amphiphiles have been studied [17].

Transesterification

Transesterification is a chemical reaction between triglyceride and alcohol in the presence of catalyst. Transesterification is also called as alcoholysis. It is a reaction between oil or fat and alcohol. In transesterification process triglycerides are converted to diglycerides and then to monoglycerides. It gives three moles of esters and one mole of glycerol. Fig-2 shows the transesterification reaction of triglycerides [18]. Transesterification can be carried out in presence of catalyst or in absence of catalyst.

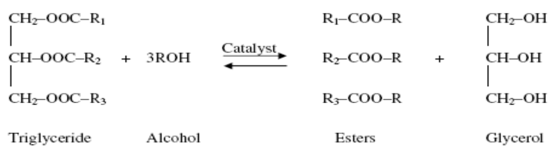

Fig 2: Transesterification of Triglycerides with Alcohol

IV. VARIABLES AFFECTING THE TRANSESTERIFICATION REACTION

Transesterification reaction is affected by number of parameters depending upon the reaction types. The reaction is either incomplete or the yield is reduced to a significant extent if the parameters are not optimized. Every parameter is important to achieve a high quality biodiesel [25-39]. The most important parameters that affect the transesterification process are mentioned below:

1. Free fatty acids, moisture and water content.
2. Type of alcohol and molar ratio.
3. Type and concentration of catalysts.
4. Reaction temperature and time.
5. Rate and mode of stirring.
6. Purification of the final product.
7. Mixing intensity.

8. Effect of using organic co-solvents.
9. Specific gravity.

V. CONCLUSION

The wide variety of feedstock is available for biodiesel production. Selecting the best feedstock is important to ensure low production cost of biodiesel. Biodiesel production is expected to offer new opportunities to diversify income and fuel supply sources and to reduce emissions, boosting the decarbonisation of transportation fuels and increasing the security of energy supply. Biodiesel is derived from a varied range of edible and inedible vegetable oil, animal fats, used frying oil and waste cooking oil. Transesterification is a chemical reaction between triglyceride and alcohol in the presence of catalyst or without catalyst. Methanol is the commonly used alcohol during transesterification reaction. Homogeneous catalysts such as sulfuric acid, sodium hydroxide, potassium hydroxide and heterogeneous catalysts such as calcium oxide, magnesium oxide and others can be used in transesterification reaction. Non-catalyzed transesterification processes are the BIOX process and the supercritical alcohol process. The catalytic transesterification of vegetable oils with methanol is an important industrial used in biodiesel production. Transesterification of vegetable oils in supercritical methanol are carried out without using any catalyst. Supercritical methanol has a high potential for transesterification of triglycerides triglycerides to methyl esters for diesel fuel substitute. Besides, the supercritical transesterification method is more acceptable to the presence of water and FFAs than the conventional catalyzed methods. Finally, biodiesel can play an important role to reduce the global energy demand due to its availability, eco-friendly and renewable properties. Biodiesel is currently not economically feasible, and more research and technological development are needed.

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