International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 11
November 2017

Feedstock, Composition and Transesterification Process of Biodiesel: A Short Review

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ABSTRACT

From the past decades, the continuous depletion of crude oil reservoirs which affect the production of diesel. To sustain the civilization of human society diesel is the most important fuel. Many researcher works on the alternative source to produce diesel from renewable sources to sustain the societal life of human. Renewable sources as vegetable oil, non edible oil, animal fats ect are the potential to produce diesel as biodiesel. Renewable sources having the composition of fatty acids (lipids – C/H ration as methyl linoleate, methyl docosahexaenoate, methyl stearate etc.) which as a basic component to convert into biodiesel under the transesterification reaction. In the present paper a short review of feedstock, composition and transesterification process of biodiesel.

Keywords – Renewable Sources, Vegetable oil, Fatty Acids, Transesterification

INTRODUCTION

Non renewable sources of the crude oil for the production of diesel are very limited. In the coming future may be lacking of diesel to sustain the diesel engine so to find the alternative source for the diesel. Biodiesel is the alternative fuel to resolve these coming problems because of biodiesel because approximate 90-98% of heat contents as that of diesel fuel [1]. Biodiesel use as single product or blending agent in petroleum diesel and can be apply in unmodified diesel engine. Plant Vegetable oil, waste vegetable oil, pure plant vegetable oil has an alternative renewable source for the production of biodiesel. It is green, safe, low polluting, non toxic, free from sulfur/aromatics and biodegradable biofuel from renewable source. Environmental concern of biodiesel, it is 75% cleaner than the diesel from petroleum at the time of burning. The biodiesel has the potential to reduce the level of carcinogens probably and pollutants.

In the century of 1920's & 1940's European countries has interested to produce biodiesel from vegetable oil. Also India, Brazil and China have shown the interest. The name biodiesel defines by the National Soy Diesel Development Board (National Bio Diesel Board) earlier during 1992 in United State. However, by the year 2020, it is predicted that biodiesel production from Brazil, China, India and some South East Asia countries such as Malaysia and Indonesia could contribute as much as 20%. Due to its advantages currently, biodiesel is appreciated as a future alternative fuel.

In the year 2006, nearly total 6.5 billion of litter's biodiesel produced world wise fig.1 in which European Union nearly 4.875 billion, United States nearly 0.845 billion and others 0.78 billion contributed. In the European countries it had possible due to substantial support from the European government such as consumption incentives (fuel tax reduction) and production incentive (tax incentives and loan guarantees) which will further catalyzed the growth of the biodiesel market in the next ten years.

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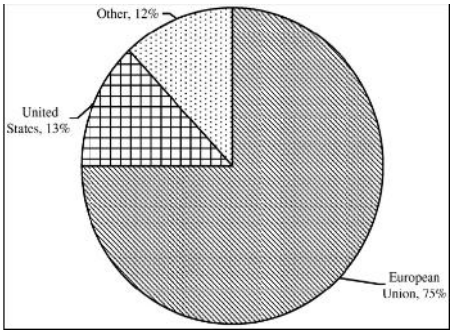

Figure 1 Country wise Biodiesel production in year 2006. Total production: 6.5 billion liters[2]

FEEDSTOCK OF BIODIESEL

Depending on the type and availability of feedstock, production method, catalyst and operating cost decided the overall cost of production of biodiesel. Characteristics of biodiesel has similar to the fossil fuel diesel and therefore strongly recommended as alternative fuel to diesel. For the production of biodiesel have different sources such as Edible oil as soybean, palm, rapeseed, sunflower, linseed, canola and coconut, Non edible oil (non food) as Jatropha, rubber, karanja, mahua, camelina, tobacco, Moringa oleifera oil and jojoba, along with these animal fats as beef tallow, pork lard, algae as microalgae, green algae, gold-enbrown, diatoms, blue green algae and waste cooking oil, restaurant grease, waste acid oil.

As the higher price and nutrition value of edible oil generally, preferred the non edible oil and waste oil as the potential source for the production of biodiesel. The contribution of raw material utilized for commercial production of biodiesel is rapeseed oil 84%, sunflower oil 13%, soybean oil 2% and palm oil 1%.

Table 1 Potential source and their oil yield for biodiesel production

Feedstock	% Yield of FAME	Reference
Edible oil		
Soybean oil	87	[3]
Palm oil	97	[4]
Rapeseed oil	95	[5]
Sunflower oil	90	[6]
Linseed oil	88-98	[7]
Canola oil	90	[8]
Coconut oil	≥ 98	[9]
Non edible oil		
Jatropha oil	98	[10]
Rubber oil	84	[11]
Karanja oil	89.5	[12]
Mahua oil	98	[13]
Camelina oil	95.8 – 98.4	[14]
Tobacco oil	91	[15]
Moringa oleifera oil	82	[16]
Jojoba oil	55	[17]
Animal fats		
Beef tallow	89	[18]
Pork lard oil	98.2	[19]
Algae	90	[20]
Waste cooking oil	26.6 - 99	[21]
Restaurant grease oil		[22]
Waste acid oil	97	[23]

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COMPOSITION OF BIODIESEL

The elemental composition (carbon – C, hydrogen – H and oxygen – O), the C/H ratio and the chemical formula of diesel and biodiesel produced from different feedstock's is shown in Table 2. The compositions of biodiesel are fatty acid methyl and ethyl esters made up of carbon, hydrogen and oxygen atoms that form linear chain molecules with single and double carbon-carbon bonds. The molecules with double bonds are unsaturated. Thus, fatty acid esters take the form C*nc:nd* (lipid numbers), where *nc* is the number of carbon atoms in the fatty acid and *nd* is the number of double bonds in the fatty acid (e.g., 18:1 indicates 18 carbon atoms and one double bond).

Table 2 Major Ester Components of Most Biodiesel Fuels

Source	Fatty Ester	Lipid Number	Empirical Formula
Vegetable oils	Methyl palmitate	C16:0	$CH_3OOC\text{-}(CH_2)_{14}\text{-}CH_3$
	Methyl stearate	C18:0	$CH_3OOC\text{-}(CH_2)_{16}\text{-}CH_3$
	Methyl oleate	C18:1	$CH_3OOC\text{-}(CH_2)_7\text{-}CH{=}CH\text{-}(CH_2)_7\text{-}CH_3$
	Methyl linoleate	C18:2	$CH_3OOC\text{-}(CH_2)_7\text{-}(CH{=}CH\text{-}CH_2)_2\text{-}(CH_2)_3\text{-}CH_3$
	Methyl linolenate	C18:3	$CH_3OOC\text{-}(CH_2)_7\text{-}(CH{=}CH\text{-}CH_2\text{-})_3\text{-}CH_3$
Other oils	Methyl laurate	C12:0	$CH_3OOC\text{-}(CH_2)_{10}\text{-}CH_3$
	Methyl ricinoleate	C18:1	$CH_3OOC\text{-}(CH_2)_7\text{-}CH{=}CH\text{-}CH_2\text{-}CHOH\text{-}(CH_2)_5\text{-}CH_3$
	Methyl eicosapentaenoate	C20:5	$CH_3OOC\text{-}(CH_2)_3\text{-}(CH{=}CH\text{-}CH_2\text{-})_5\text{-}CH_3$
	Methyl docosahexaenoate	C22:6	$CH_3OOC\text{-}(CH_2)_2\text{-}(CH{=}CH\text{-}CH_2\text{-})_6\text{-}CH_3$

Many researchers have studied on the composition of the biodiesel from the various sources in the form of fatty acid as in table 2. Unlike diesel of non-renewable sources, which are composed of pure substances as hundreds of hydrocarbons, but biodiesel is composed solely of some fatty acid ethyl and methyl esters; their number depends on the feedstock used to manufacture biodiesel.

Table 3 Composition of Fatty Acid in biodiesel from various sources [24,25,26]

Oil or Fat	Composition of Fatty Acid (wt. %)						
	12:0	14:0	16:0	18:0	18:1	18:2	18:3
Babassu	44-45	15-17	5.8-9	2.5-5.5	12-16	1.4-3	
Canola			4-5	1-2	55-63	20-31	9-10
Coconut	44-51	13-18.5	7.7-10.5	1-3	5-8.2	1-2.6	
Corn			7-13	2.5-3	30.5-43	39-52	1
Cottonseed		0.8-1.5	22-24	2.6-5	19	50-52.5	
Linseed			6	3.2-4	13-37	5-23	26-60
Olive		1.3	7-18.3	1.4-3.3	55.5-84.5	4-19	
Palm		0.6-2.4	32-46.3	4-6.3	37-53	6-12	
Peanut		0.5	6-12.5	2.5-6	37-61	13-41	
Rapeseed		1.5	1-4.7	1-3.5	13-38	9.5-22	1-10
Safflower			6.4-7	2.4-29	9.7-13.8	75.3-80.5	
Safflower (High oleic)			4-8	2.3-8	73.6-79	11-19	
Sesame			7.2-9.2	5.8-7.7	35-46	35-48	
Soybean			2.3-11	2.4-6	22-30.8	49.53	2-10.5
Sunflower			3.5-6.5	1.3-5.6	14-43	44-68.7	
Tallow (beef)		3-6	25-37	14-29	26-50	1-2.5	
Jatropha			13-15	7-8	34-44	31-43	
Grape		0.1	6.9	3.4	62.8	27.5	0.1

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TRANSESTERIFICATION PROCESSES OF BIODIESEL

Transesterification reaction of plant oil, vegetable oil or animal oil with the simple alcohol has been long preferred method of the biodiesel production. Generally, transesterification reaction carried out in two methods as one is without catalyst and other is with a catalyst.

The transesterification reaction in three consecutive and reversible steps as first - Triglyceride converted to Diglyceride, forwarded second - Diglyceride to Monoglyceride and consecutively third - Monoglyceride to Glycerol with one Methyl Ester molecule formation in each respective step as,

Triglyceride + ROH ←catalyst→ Diglyceride + R^1 COOR

Diglyceride + ROH ←catalyst→ Monoglyceride + R^2 COOR

Monoglyceride + ROH ←catalyst→ Glycerol + R^3 COOR

Where, R^1, R^2 and R^3 are long-chain hydrocarbons which may be the same or different with R = -CH3/C2H5.

CONCLUSION

Many researchers have studied on the composition of the biodiesel from the various sources in the form of fatty acid. Depending on the type and availability of feedstock, production method, catalyst and operating cost decided the overall cost of production of biodiesel. Characteristics of biodiesel has similar to the fossil fuel diesel and therefore strongly recommended as alternative fuel to diesel.

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