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Comparative Study of Free Fatty Acid Composition and Physico Chemical Properties of Biodiesel Produced from Various Non Edible Oil Seeds

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Abstract: ***Due to recent petroleum crisis and unavailability of petroleum diesel the demand for petroleum diesel is increasing day by day hence there is a need to find out an appropriate solution. Bio fuels are being given serious consideration as potential sources of energy in the future. Biodiesel is a clean burning alternate fuel, produced from both edible and non-edible oil seeds. It can be used in compression-ignition engines with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics. It can be stored just like petroleum diesel fuel. The use of biodiesel in conventional diesel engines results in substantial reduction of unburnt hydrocarbons, carbon monoxide and particulate matters. Its higher cetane number improves the ignition quality even when blended in petroleum diesel. Various nonedible plants in their seeds contain 30% or more oil. Studies have been undertaken to compare free fatty acid composition and physico chemical properties of biodiesel produced from various nonedible oil seeds such as jatropha, karanja, mahua, rubber, castor, neem etc.***

Keywords: Non-edible oil seeds, Diesel, Biodiesel

1. Introduction

The energy demand of Indian industry is increasing due to growing economic activities. Therefore India is focusing on development of renewable fuels. Biodiesel, an alternative renewable fuel made from transesterification of vegetable oil with alcohol & is becoming more readily available for use in blends with conventional diesel fuel for transportation applications. A national mission on biodiesel has been proposed in India & specifications for diesel have been amended, to allow upto 10% blending of biodiesel in diesel. Biodiesel can be produced from edible as well as non-edible vegetable oil seeds. However India is not self sufficient in edible oils. Non-edible tree borne oilseeds (TBOs) are considered as the source of straight vegetable oil (SVO) and biodiesel. Plant species, which have 30% or more fixed oil in their seeds or kernel, have been identified. In order to explore additional oil resources, studies have been undertaken for screening of various tree borne oil seeds for their potential as biodiesel feed stock such as, Jatropha, Karanja, Castor, Mahua, Neem, Rubber etc.[1]

2. Oil Extraction Process

The seed kernels are to be ground, using mechanical grinder, and defatted in soxhlet apparatus. The extracted oil was obtained by filtering the solvent oil. The extracted oil is to be stored in freezer for subsequent physico chemical properties.[1] The seed oil is to be analyzed for oil content, acid value, Iodine value, Saponification value, Calorific value, kinematic viscosity, flash point, cloud point, fire point, density, cetane number etc. The disadvantages of vegetable oils as diesel fuel are;

- High viscosity
- Low volatility
- High density

This causes several problems during their long duration use in CI engines such as Injector coking and carbon deposits.

There are many ways and procedures to convert vegetable oil into a Diesel like fuel.

a. Pyrolisis
b. Micro emulsification
c. Dilution
d. Transesterification

3. Transesterification Process

The transesterification process was found to be the most viable process. Transesterified oils have proven to be a viable alternative diesel engine fuel with characteristics similar to those of Diesel fuel. Its physical and chemical properties required for operation of diesel engine are similar to petroleum based diesel fuel. Like petroleum diesel, biodiesel operates in compression-ignition engines. Transesterification is a chemical reaction that aims at substituting the glycerol of the glycerides with three molecules of monoalcohols such as Methanol thus leading to three molecules of methyl ester of vegetable oil. Methanol and ethanol is widely used in the transesterification. Methanol is used because of low cost, and physicochemical advantages with triglycerides and sodium hydroxide. The acid catalyst is the choice for transesterification when Low - grade vegetable oil used as raw material because it contains high free fatty acid (FFA) and moisture. Acid catalyst as sulphuric acid (H_2SO_4) is used for esterification process.[2]

4. Various Nonedible Oil Seeds

1) Jatropha (Ratan Jyot) Oil Seeds:[10]

Free fatty acid composition in percentage

Linoleic: 27.25
Oleic: 47.1
Stearic: 8.22
Palmitic: 15.24
Myristic: 1.4-3

Physico chemical properties of jatropha seed oil:

Calorific value (MJ/Kg): 40
Kinematic viscosity mm2/s (40^{0}C): 8.72
Flash point (^{0}C):125
Acid Value (mg KOH): 10.47
Pour point (^{0}C): -12
Fire point (^{0}C): 271
Density (Kg/m^3): 912
Cetane number: 57

Physico chemical properties of jatropha Biodiesel:

Calorific value (MJ/Kg): 40
Kinematic viscosity mm2/s (40^0 C): 4.328
Flash point (^{0}C): 140
Acid Value (mg KOH): 0.32
Fire point (^{0}C): 155
Density (Kg/m^3): 880
Cetane number: 57

2) Karanja (Pongamia Pinnata) oil seeds:[7][8]

Free fatty acid composition in Percentage

Linoleic: 16.64
Linolenic: 11.65
Oleic: 51.59
Stearic: 7.5
Palmitic: 7.9
Lignoceric: 3.5-4.5

Physico chemical properties of Karanja seed oil:

Calorific value (MJ/Kg): 36.60
Kinematic viscosity mm2/s (400C): 40.2
Flash point (0C): 225
Cloud point (0C): 3.5
Pour point (0C): -4
Density (Kg/m3): 927
Saponification Value: 184
Acid Value (mg KOH): 5.40

Physico chemical properties of Karanja Biodiesel:

Calorific value (MJ/Kg): 37
Kinematic viscosity mm2/s (400 c): 4.78
Flash point (0C): 144
Cloud point (0C): 6
Density (Kg/m3): 860
Cetane number: 41.7
Saponification Value: 187
Acid Value (mg KOH): 0.42

2) Mahua (Madhuca Indica) oil seeds:[2][3]

Free fatty acid composition in percentage

Linoleic: 8.9-13.7
Palmitic: 16-28.2
Oleic: 41-51
Stearic: 20-25.1
Arachidic: 0-3.3

Physico chemical properties of mahua seed oil:

Calorific value (MJ/Kg): 36
Kinematic viscosity mm2/s (400 c): 24.58
Flash point (^{0}C): 232
Acid Value (mg KOH): 38
Fire point (^{0}C): 228
Density (Kg/m3): 955

Physico chemical properties of mahua Biodiesel:

Calorific value (MJ/Kg): 39
Kinematic viscosity mm2/s (40^0 c): 3.9
Flash point (^{0}C): 205
Acid Value (mg KOH): 0.5
Pour point (^{0}C): 15
Fire point (^{0}C): 218
Density (Kg/m3): 872
Cetane number: 52

4)Rubber (Hevea Brasiliensis) oil seeds:[9]

Free fatty acid composition in percentage

Linolenic: 16.3
Linoleic: 39.6
Oleic: 24.6
Stearic: 8.7
Palmitic: 10.2

Physico chemical properties of Rubber seed oil:

Calorific value (MJ/Kg): 37.5
Kinematic viscosity mm2/s (400 C): 66.2
Flash point (0C): 198
Acid Value (mg KOH): 34
Fire point (0C): 210
Density (Kg/m3): 910

Physico chemical properties of Rubber Biodiesel:

Calorific value (MJ/Kg): 36.5
Kinematic viscosity mm2/s (400 c): 5.81
Flash point (0C): 130
Acid Value (mg KOH): 0.12
Fire point (0C): 145
Density (Kg/m3): 874
Cetane number: 54

5) Castor (Ricinus Communis) oil seeds:[6][13]

Free fatty acid composition in percentage

Linolenic: 0.33
Linoleic: 0.61
Oleic: 2.28
Stearic: 0.52
Palmitic: 0.46
Recinoleic: 83.97
Dihydroxylstearic: 0.24

Physico chemical properties of castor seed oil:

Calorific value (MJ/Kg): 35.68
Kinematic viscosity mm2/s (400 C): 109.53
Flash point (0C): 298
Cloud point (0C): 15.8
Fire point (0C): 335
Density (Kg/m3): 962.8
Iodine value: 82-88
Saponification Value: 175 - 187
Acid Value (mg KOH): 0.4 – 4

Physico chemical properties of castor Biodiesel:

Calorific value (MJ/Kg): 39.5
Kinematic viscosity mm2/s (400 C): 9.5-10
Flash point (0C): 260
Pour point (0C): -32
Density (Kg/m3): 0.9
Cetane number: 45-65
Iodine value: 80

5)Neem (Azardica Indica) oil seeds:[4][16]

Free fatty acid composition in percentage

Linoleic: 6-16
Oleic: 25-54
Stearic: 9-24
Palmitic: 16-33
Linolenic: 7-12
Palmitoleic: 4-8

Physico chemical properties of neem seed oil:

Calorific value (MJ/Kg): 29.97
Kinematic viscosity mm2/s (400 C): 37.42
Flash point (0C): 150
Pour point (0C): 7
Cetane number: 31
Refractive index: 1.47
Iodine value: 80
Density (Kg/m3): 1024

Physico chemical properties of neem Biodiesel:

Calorific value (MJ/Kg): 39.4
Kinematic viscosity mm^2/s (40^0 C): 4.16
Flash point (^{0}C): 175
Cloud point (^{0}C): 13
Pour point (^{0}C): 10
Density (Kg/m^3): 884.26
Cetane number: 46
Saponification Value: 117
Acid Value (mg KOH):0.26

5. Conclusion

Edible oils are in use in developed nations such as USA and European nations but in developing countries the production of edible oils are not sufficient. In a country like India, there are many plant species whose seeds remain unutilized and underutilized have been tried for biodiesel production. Non-edible oil seeds are the potential feedstock for production of biodiesel in India. These species have shown promises and fulfills various biodiesel standards. India, with its huge waste/non -fertile lands, has taken a well noted lead in the area and commercial production. Proper processing of non-edible oil seeds and transesterification can ascertain the quality of biodiesel and can fulfill the large commercial application.

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