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Prospects and Potential of Producing Biodiesel from Minor Seeds of Forest Origin

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Abstract: ***The world has been confronted with an energy crisis due to depletion fossil resources and increased environmental problems. Such situation has led to the increase of research for an alternative energy such as biofuels from sustainably biomass resources. Among various possible options, fuels derived from vegetable oils present promising greener substitute for biofuels. Among biofuels, biodiesel exhibits fuel properties which are compatible to those of petroleum based diesel which can be used commercially. It is renewable energy fuel for diesel engine and is presently making the research item to mainstream transportation fuel worldwide. Many parts of India is endowed with enormous forest wealth, only a part of it, is utilized and a lot of forest produce goes waste due to unorganized collection. Tree born oilseeds of good potential from forest region should be commercially exploited to narrow down the import of oils. The shortage of vegetable oil supply in recent time period inspired oil technologists for identifying new sources of oils known as minor seeds. There is a vast potential of producing biodiesel from all minor seeds available in different forest belt. The present paper investigates, the minor seeds oil of forest origin such as Jojoba, Milo, Bibwa, Xanthium strumarium, Ziziphus jujube, Sandalwood, Gliricidia sepium etc.***

Keywords: Minor seeds, Diesel, Biodiesel

1. Introduction

Biofuels have become one of the major solutions to issues of sustainable development, energy security and a reduction of greenhouse gas emissions. Biodiesel, an environmental friendly diesel fuel similar to petro-diesel in combustion properties, has received considerable attention in the recent past worldwide, Biodiesel is a methyl or ethyl ester made from renewable biological resources such as vegetable oils (both edible and non-edible), recycled waste vegetable oil and animal fats. The use of vegetable oils as alternative fuels has been in existence long ago but was set aside due to the availability of petroleum products which appears to be cheaper.[2]

Biodiesel is now recognized as an alternative because it has several advantages over conventional diesel. It is safe, renewable and non-toxic. It contains less sulphur compounds and has a high flash point (>130°C). It is almost neutral with regards to carbon dioxide emissions, and emits 80% fewer hydrocarbons and ~50% less particles. It enjoys a positive social impact, by enhancing rural revitalization. It is the only alternative fuel currently available that has an overall positive lifecycle energy balance.

2. Oil Extraction Process

Various techniques such as mechanical extraction, solvent extraction, traditional extraction and super critical fluid extraction are used to obtain the oil from the seeds. The solvent extraction has become the most popular method of extraction of oil because of its high percentage of oil recovery from seeds. Solvent extraction bridges the gap between mechanical extraction which produces oil with high turbidity metal and water content and supercritical fluid extraction which is very expensive to build and maintain its facilities. Temperature is increased for oilseeds after pre-treatments such as cracking,dehulling and milling by heating, roasting and steaming of oilseeds prior to extraction and is termed thermal treatment of oilseeds. Better extraction is achieved by heating, which reduces the oil viscosity and released oil from intact cells, and also reduces moisture in the cells. Temperature plays an active role in the seed treatment for mechanical extraction and ensures an effective solvent process by heating the solvent which hastens the extraction process. At the right temperature and moisture content, the individual oil droplets unite to form a continuous phase and flow out maximizing oil yield. Solvent extraction is the use of chemicals as solvents in the extraction of oil from oilseeds. Solvent extraction is known for its high yielding oil output, ease and swiftness to carry out: relatively cost effective, high overhead cost, and hazardous effects during and after operations. The use of this method requires a complete refining process to ensure traces of the solvents to be removed totally. Solvent extraction of cleaned, cracked, dehulled and conditioned flakes with hexane is commercially practiced to extract oil. [3]

3. Biodiesel Production

Generally two stage transesterification process is used for the production of biodiesel. This process consists of a sequence of three consecutive reversible reaction i.e. conversion of triglycerides to diglycerides followed by diglycerides to monoglyceride. The glycerides were converted into glycerol and one ester molecule at each step. If the oil contains more than 4% free fatty acids (FFA), then a two step transesterification is applicable to convert the high FFA oils to its mono esters. The first step, the acid catalyzed esterification reduces the free fatty acid content of the oil.

$$\text{Vegetable oil} + \text{Alcohol} \xrightleftharpoons{\text{acid}} \text{Triglyceride} + \text{water}$$

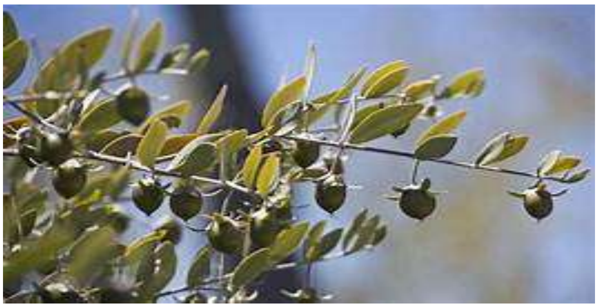
The second step, alkaline transesterification process converts the products of the first step to its mono-esters and glycerol. In this process vegetable oils are heated to temperature of 80-85^{0}C by placing in water bath. Similarly alcohol is heated to 65^{0}C in the presence of alkali catalyst. Both vegetable oil and alcohol are combined together at a temperature of 60-65^{0}C. The reaction results in the formation of esters and glyceride. If water is mixed to the mixture, soap will be formed which reduces the formation of biodiesel. The chemical reaction is

$$\text{Triglyceride} + \text{alcohol} \xrightleftharpoons{\text{alkali}} \text{Glycerol+alkyl esters}$$

Simple alcohols are used for transesterification and this process is usually carried out with a basic catalyst (NaOH, KOH) in the complete absence of water. The bonding of alcohol and organic acid produces ester. An excess of alcohol is needed to accelerate the reaction. With methyl alcohol glycerol separation occurs readily. In the transesterification process alcohol combines with triglyceride molecule from acid to form glycerol and ester. The glycerol is then removed by density separation. Transesterification decreases the viscosity of oil, making it closer to diesel fuel in characteristics. [3]

4. Various Minor Seeds of Forest Origin

1) Simmondsia chinensis (Jojoba) oil seeds:[4][5]



Free fatty acid composition in percentage
Caprylic acid - 8.7
Capric acid - 4.3
Lauric acid - 5.7
Myristic acid - 4.3
Palmitic acid - 8.4
Stearic acid - 0.5
Oliec acid - 5.7
Alpha-Linolenic acid(ALA) - 37.1
Arachidic acid- 2.2
Behenic acid - 6.6
Erucic acid - 2.7
Nervonic acid - 13.8

Physico chemical properties of jojoba seed oil:
Calorific value (MJ/Kg)- 15.34
Kinematic viscosity mm2/s (40^{0}C)- 24.75
Viscosity Index- 233
Flash point (^{0}C)- 295
Density (Kg/m^3)- 863
Cetane number- 53.5

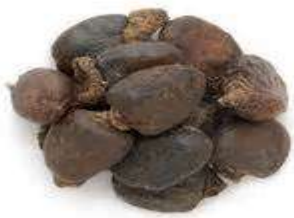
Physico chemical properties of jojoba Biodiesel:
Calorific value (MJ/Kg)- 45.5
Kinematic viscosity mm2/s (40^0 C)- 8.84
Viscosity Index- 191.8
Flash point (^{0}C)- 198
Density (Kg/m^3)- 860.3
Cetane number- 53

2)Thespesia populnea L. (Milo) oil seeds:[6][7]

Free fatty acid composition in Percentage
Myristic acid - 0.5
Palmitic acid - 26.8
Palmitoleic- 0.7
Stearic acid - 4.1
Malvalic- 6.8
Oliec acid - 15.7
Asclepic- 1.8
Linoleic acid- 39.2
Dihydrosterculic- 1.5
Arachidic acid- 0.5
Lignoceric- 0.5
Other- 1.9

Physico chemical properties of milo Biodiesel:
Calorific value (MJ/Kg)- 43.10
Kinematic viscosity mm2/s (40^{0}C)- 4.25
Cloud point (^{0}C)- 8
Pour Point(^{0}C)- 9
Flash point (^{0}C)- 176
Cold Filter plugging point(^{0}C)- 9
Acid Value (mg KOH)- 250
Density (Kg/m^3)- 880
Cetane number- 59.8

3) Semecarpus anacardium (Bibwa) oil seeds:[8][9][10]



Free fatty acid composition in percentage
Lauric acid- 0.18
Myristic acid - 0.25
Palmitic acid - 13.41
Palmitoleic- 0.14
Oliec acid - 51.25
Linoleic acid- 5.639

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α-Linolic- 5.32
Arachidic acid- 3.81
Behinic acid- 5.076
Other- 14.1

Physico chemical properties of Semecarpus anacardium seed oil:
Density (Kg/m^3)- 948
pH - 3.743
Refractive Index- 1.5006
Kinematic viscosity mm2/s (40^0 c)- 860
Acid Value (mg KOH/g)- 14.82
Saponification value (mg KOH)- 137.682
Iodine value (gI2/100g)- 69.987

Physico chemical properties of Semecarpus anacardium Biodiesel:
Saponification value (mg KOH)- 195.74
Peroxide value (meqO_2/kg)- 11.42
Kinematic viscosity mm2/s (40^0 c)- 290
Acid Value (mg KOH)- 420.25
Iodine value(mgI_2/g)- 647.16
pH- 3.1
Density (Kg/m^3)- 847.6

4) **Xanthium strumarium oil seeds:**[11]

Free fatty acid composition in percentage
Palmitic acid - 6.51
Palmitoleic- 0.08
Stearic acid - 3.80
Oliec acid - 11.37
Linoleic acid- 76.97
Linolenic- 0.74
Arachidic acid- 0.19
Gondoic acid- 0.31

Physico chemical properties of Xanthium strumarium Biodiesel:
Saponification value (mg KOH)- 190.94
Calorific value (MJ/Kg)- 38.52 Calorific value (MJ/Kg)-
Kinematic viscosity mm2/s (40^0 c)- 6.877
Flash point (^{0}C)- 166
Cloud point (^{0}C)- -1
Iodine value(mgI_2/100g)- 144.78
Pour point (^{0}C)- -19
Freezing point(^{0}c)- -22
Density (kg/m^3)- 896.89
Cetane number- 42.3

5) **Ziziphus jujuba oil seeds:**[12][13][14]

Free fatty acid composition in percentage
Lauric acid- 5.76
Myristic acid - 3.29
Palmitic acid - 18.36
Palmitoleic- 8.45
Stearic acid - 7.66
Oliec acid - 32.37
Linoleic acid- 13.6
Linolenic- 0.86
Arachidic acid- 1.64
Gadolic acid- 0.9
Behenic acid- 0.67
Other- 6.44

Physico chemical properties of Ziziphus jujuba seed oil:
Calorific value (MJ/Kg)- 38233
Kinematic viscosity mm2/s (40^0 c)- 4.02
Flash point (^{0}C)- 182
Pour point (^{0}c)- -2
Density (Kg/m3)- 877.7

Physico chemical properties of Ziziphus jujuba Biodiesel:
Calorific value (MJ/Kg)- 42752
Kinematic viscosity mm2/s (40^0 c)- 6.72
Flash point (^{0}C)- 143
Fire point (^{0}C)- 156
Density (kg/m^3)- 886.8
Cetane number- 52.1

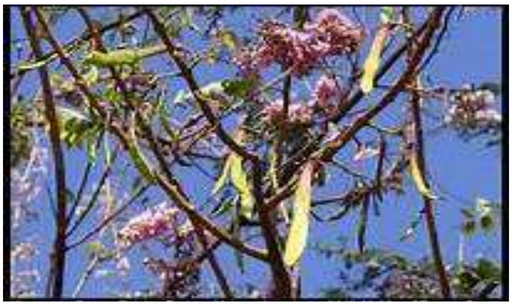
6) **Sandal wood seed oil:** [15][16]

Free fatty acid composition in percentage
Palmitic acid - 3.4
Palmitoleic- 0.7
Stearic acid - 2.7
Oliec acid - 52.7
Linoleic acid- 1.2
Linolenic- 1.3
Ximenynic acid- 30.9
Stearolic acid- 1
Others- 6.1

Physico chemical properties of Sandal wood seed oil:
Density (kg/m^3)- 916.2
Refractive Index- 1.47

Kinematic viscosity mm2/s (40^0 c)- 3.4
Freeze point (^{0}c)- -11
Acid Value (mg KOH/g)- 7.22
Peroxide value- 6.57
Saponification value (mg KOH)- 296.74
Iodine value (gI2/100g)- 89.73

7) Gliricidia sepium seed oil: [17][18]



Free fatty acid composition in percentage
Palmitic acid - 16.2
Palmitoleic- 0.1
Stearic acid - 14.5
Oliec acid - 13.3
Linoleic acid- 48.9
Linolenic- 1.4
Arachidic acid- 2.3
Behenic acid- 1
Lignoceric acid- 0.2
Others- 2.1

Physico chemical properties of Gliricidia sepium seed oil:
Density (kg/m^3)- 876
Refractive Index- 1.40
Acid Value (mg KOH/g)- 1.40
Saponification value (mg KOH)- 94.40
Iodine value (gI2/100g)- 87.60
Peroxide value- 0.40

Physico chemical properties of Gliricidia sepium Biodiesel:
Kinematic viscosity mm2/s (40^0 c)- 4.38
Cloud point (^{0}C)- 21
Pour point (^{0}C)- 19
Density (kg/m^3)- 879.5
Cetane number- 67.5

5. Conclusion

It is found that biodiesel from minor seeds oil of forest origin shows equal opportunities and similarities in almost all respects in various parameters compaired with diesel

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