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Production and Characterization of Biodiesel from Saturated and Unsaturated Oils Using Acid, Base and Enzyme Catalyst

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ABSTRACT

Biodiesel is produced from the fatty acids found in vegetable oils and is produced using a process known as trans-esterification. A number of biomass can be used in the production of biodiesel. Now a day's fast food industries are converting its used cooking oil into biodiesel which can be the fuel of the future as it provides an option of economical, eco-friendly, alternative renewable energy source. In the present investigation used Sunflower oil, Palm oil and Pongamia, Neem and Jatropha oil were used for production of biodiesel and the catalysts used for the process of trans-esterification of oils were Acidic catalyst (8% HCl), Basic catalyst (1% NaOH) and Enzymatic catalyst (4% of immobilized lipase enzyme). The result shows that although the samples are collected from different sources, there was little difference in chemical and physical properties and compare to other catalyst, Enzymatic catalyst shows highest yield of biodiesel i.e., Acid number 3.64(mg KOH/g), Iodine number 13.20(mg KOH/g), Saponification number 264.10(mg KOH/g), Density 0.92 (g/cm³), Flash point 276(⁰C), Cloud point 16.50(⁰C), Pour point 14.00(⁰C), Viscosity @40⁰C 33.47(mm² /s). Results obtained were found to be within limits set by various International standards for biodiesel.

KEY WORDS: Biodiesel, Transesterification, Bio oils, Enzymatic catalyst

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1. INTRODUCTION

The term bio fuel is referred to as liquid, gas and solid fuels predominantly produced from biomass¹. A number of biomass types can be used in the production of biofuel such as rapeseed, sunflower and palm oil. Another increasing popular section of biodiesel market is the re use of vegetable oils used in the catering industry. Used vegetable 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 atmosphere². Bio fuels have the potential to solve many of the current social problems and concerns, from air pollution and global warming to other environmental improvements and sustainability issues³. These biofuels are being looked to provide employment generation to rural people through plantation of plants which produce non-edible oils². Biofuels is gaining immense importance and awareness across the globe because it is providing energy security and employment to rural community and improved income generation⁴. Biofuels already constitute the major source of energy for over half of the world's population, accounting for more than 90% of the energy consumption in poor developing countries⁵. The oil is filtered and pre-processed before being manufactured into biodiesel. Among non-edible oil feedstock, seeds of castor and jatropha, and microalgae oil are proved to be a one of the highly promising reliable source having high seed oil content⁶.

Biodiesel, defined as a substitute for, or an additive to diesel fuel that is derived from the oils and fats of plants and animals⁷. Biodiesel is an alternative fuel made from renewable biological sources such as vegetable oils both (edible and non edible oil) and animal fats⁸. Biodiesel, an earth friendly choice of consumers and renewable sources of alternative fuel occupies a great volume of the world's fuel sector⁹. Biodiesel is produced from the fatty acids found in vegetable oils and is produced using a process known as trans-esterification, which involves using methanol to create a catalytic reaction which can reduce net carbon-dioxide emissions by 78% on a lifecycle basis when compared to conventional diesel fuel¹⁰. Generally, biodiesel is produced by means of transesterification, it is the reaction of a lipid with an alcohol to form esters and a by-product, glycerol. It is, in principle, the action of one alcohol displacing another from an ester, referred to as alcoholysis (cleavage by an alcohol). Transesterification consists of a sequence of three consecutive reversible reactions. The first step is the conversion of triglycerides to diglycerides, followed by the conversion of diglycerides to monoglycerides and finally monoglycerides into glycerol, yielding one ester molecule from each glyceride at each step. The reactions are reversible, although the equilibrium lies towards the production of fatty acid esters and glycerol³. Biodiesel, (the mono alkyl (mainly methyl) esters of long-chain fatty acids, derived from a renewable lipid feedstock¹¹, the concept of vegetable oils as fuel is not new. It was proposed by

Rudolf diesel at the time of Second World War who used pea nut oil as a fuel in diesel engine. The major obstacle for commercialization of biodiesel is its cost approximately 70-90% of biodiesel cost is arises from the cost of feed stocks¹². The main advantage in biodiesel usage is attributed to lesser exhaust emissions in terms of carbon monoxide, hydrocarbons and particulate matter. Biodiesel is said to be carbon neutral as more carbon dioxide is absorbed by the biodiesel yielding plants than what is added to the atmosphere when used as fuel¹³. Biodiesel is gaining increasing acceptance in the market as an environmental friendly alternative diesel fuel. It is non-toxic, biodegradable, and free of sulphur or any carcinogenic compounds. The demand and cost of edible oils prevents its use in the production of biodiesel. So, a large variety of plants that produce non-edible oils are considered for biodiesel production¹⁴. Other advantages of biodiesel over fossil fuel are higher flash point and higher lubricate¹⁵. Biodiesel fuel is a renewable substitute fuel for petroleum diesel or petro diesel fuel made from vegetable or animal fats; it can be used in any mixture with petro diesel fuel, as it has very similar characteristics, but it has lower exhaust emissions. Biodiesel fuel has better properties than petro diesel fuel; it is renewable, biodegradable, non-toxic, and essentially free of sulphur and aromatics. Biodiesel seems to be a realistic fuel for future; it has become more attractive recently because of its environmental benefits. Biodiesel is an environmentally friendly fuel that can be used in any diesel engine without modification¹.

The present work is focused on the production of biodiesel by transesterification of bio oils from edible and non-edible oilseeds using acidic, alkali and enzymatic methods. The comparison of transesterification efficiency by different methods. The transesterification procedure is carried out using available edible oils such as sunflower oil, palm oil, also from non edible oils such as neem oil and pongamia oil. Jatropha oil and biodiesel is used as the reference standard.

2. MATERIALS AND METHODS

2.1 Collection of oil samples

Sunflower oil (compressed from *Helianthus annuus* seeds) is commercially obtained and subjected for single use and furthered used for transesterification. Palm oil (from mesocarp of *Elaeis guineensis*) is commercially obtained and subjected for single use and reused for transesterification. Pongamia oil was procured from GKVK Balakrishne Gowda laboratory (from seeds of *Pongamia pinnata* Linn) Neem oil (from fruits and stems of *Azadirachta indica*) from ayurvedic shop (Baidhyanath NEEM TEL Batch no: 15602022) Jatropha oil (from *Jatropha curcas*) and Jatropha biodiesel used as standard were collected from GKVK (Prof. Balakrishne Gowda's lab).

2.2. Physico- chemical properties of oils

The oils were subjected for determination of Physico-chemical properties such as density, viscosity, saponification value, iodine number and acid number. (ANP, 2010)

2.3 Transesterification of oil

The oils were subjected to three types of transesterification Acidic¹⁶, Alkali¹⁷ and Enzymatic¹⁸. In Acid transesterification 8% HCl was used as a catalyst, whereas during alkali transesterification 1% NaOH was used as catalyst and in enzymatic method 4 wt% of immobilized lipase was used as catalyst.

2.4 Analysis of transesterified biodiesel and their properties

The produced biodiesel were quantified and evaluated for their Physico-chemical properties and compared with ASTM and EU standards. The purity of biodiesel sample and presence of methyl esters group was studied by FTIR analysis. For all the comparative analysis Jatropha bio-oil and Jatropha biodiesel was taken as standard.

3 RESULTS

3.1 Physico-chemical properties of bio oils

3.1.1 Weight of bio-oils: The weight of standard Jatropha oil was higher compared to other oil samples (174.08g). Neem oil weight was almost similar to the Jatropha oil (172.64g) and the pongamia oil weight was least compared to the Jatropha (166.48g).

3.1.2 Density of bio-oils: The weight of standard Jatropha oil was higher compared to other oil samples (174.08g). Neem oil weight was almost similar to the Jatropha oil (172.64g) and the Pongamia oil weight was least compared to the Jatropha (166.48g).

3.1.3 Viscosity of bio-oils: The viscosity of non-edible oil such as pongamia was found to be the highest i.e. 41.53 cst, and edible sunflower oil showed least viscosity i.e. 32.38 gm/cc.

3.1.4 Saponification value of bio-oils: The Saponification value non-edible oil such as neem was found to be the highest i.e.199.15 mg KOH/g and pongamia oil shows the least Saponification value i.e. 186.86 mg KOH/g.

3.1.5 Iodine value of bio-oils: The iodine value of non-edible oil such as neem oil was found to be highest i.e. 83.98 gm/100gm and sunflower oil was found to be least i.e. 54.5 g/100g.

3.1.6 Acid value of bio-oils: The acid value of edible oil such as sunflower oil 0.33mgKOH/g and palm oil 0.3mgKOH/g was found to be similar to Jatropha oil 0.3mg KOH/g and non-edible oil such as Pongamia oil was found to have the highest acid value i.e. 0.4mg KOH/g.

3.1.7 Retardation factor of bio-oils: The bands seen in the Pongamia oil and used sunflower oil are similar. The bands seen in neem oil and palm oil are similar. When this bands are compared with the

standard Jatropha oil the bands seen in the Pongamia oil and used sunflower oil are similar to the Jatropha as shown in figure.1.



Fig. 1: Retardation factor of bio-oils, a- Standard Jatropha oil, b- Pongamia oil, c- Used Sunflower oil, d- Neem oil, e- Palm oil

3.2 Transesterification of bio-oil

The separation of bio-oil has been used using acid transesterification, alkali transesterification and enzymatic transesterification as shown in figure 2.

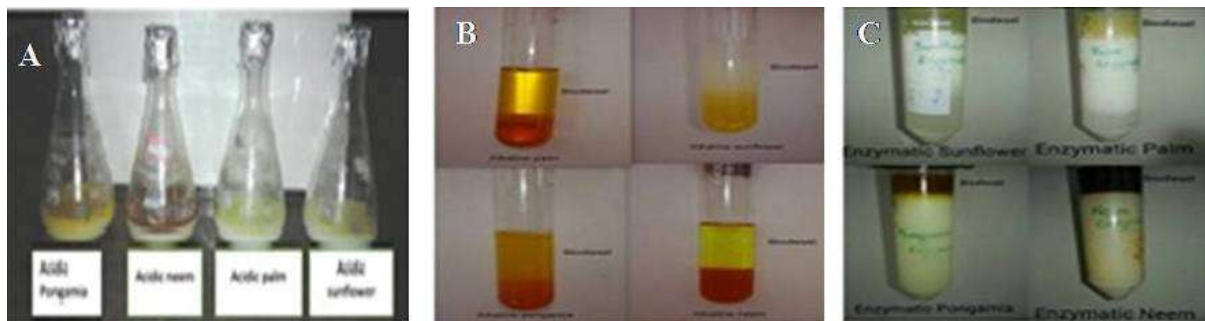


Fig. 2: A. Acid Transesterification, B. Alkali Transesterification, C. Enzymatic Transesterification

3.3 Characterization of biodiesel

3.3.1 Density of biodiesel: The density of alkaline and enzymatic transesterified Jatropha biodiesel showed similar density (1.56 gm/cc and 1.52 gm/cc) and density of acidic transesterified Jatropha biodiesel was little higher (1.62 gm/cc). Pongamia biodiesel and neem biodiesel after alkaline transesterification showed higher density (5.2 gm/cc and 4.85 gm/cc) compared to alkaline transesterified Jatropha biodiesel (1.56 gm/cc). Whereas in case of used palm and used sunflower oil the density of enzymatic transesterified biodiesel was very much high (9.45 gm/cc and 5.56 gm/cc) compared to enzymatic transesterified Jatropha biodiesel (1.52 gm/cc).

3.3.2 Viscosity of biodiesel: Jatropha biodiesel showed the highest viscosity after enzymatic transesterification (6.56cst), Jatropha biodiesel produced by acidic and alkaline transesterification showed same viscosity (4.48 cst and 4.46 cst). The viscosity of pongamia biodiesel produced by

alkaline transesterification was found to be higher (5.5 cst) when compared with viscosity of the Jatropha biodiesel produced by alkaline transesterification (4.46 cst). Acidic transesterified neem biodiesel had an higher viscosity (5.6 cst) compared to acidic transesterified Jatropha biodiesel (4.48 cst). Used palm oil biodiesel obtained after acidic transesterification was found to have slightly lesser viscosity (4.33 cst) as Jatropha biodiesel obtained after acidic transesterification (4.48 cst). Viscosity of alkaline transesterified used sunflower oil biodiesel had similar viscosity (4.46 cst) when compared with alkaline transesterified Jatropha biodiesel (4.46 cst)

3.3.3 Iodine number of biodiesel: Jatropha biodiesel obtained after acidic and alkaline transesterification showed almost same iodine value (103 g/100g and 102.9 g/100g) and enzymatic transesterified Jatropha biodiesel had higher iodine number (140 g/100g). Pongamia biodiesel and neem biodiesel produced by acidic transesterification showed a similar iodine value (138 g/100g and 139 g/100g) but when compared to the iodine value of acidic transesterified Jatropha biodiesel (103 g/100g) the iodine value of neem and pongamia biodiesel was found to be higher. Used palm oil biodiesel and sunflower oil biodiesel after enzymatic transesterification showed less iodine value (138 g/100g and 135g/100g) compared to Jatropha biodiesel after enzymatic transesterification (140 g/100g).

3.3.4 Acid value of biodiesel: Alkaline transesterified Jatropha biodiesel showed the highest acid value (0.39 mg KOH/g), the acid and enzymatic transesterified biodiesel showed less acid value (0.34 mg KOH/g and 0.25 mg KOH/g) Pongamia biodiesel transesterified by alkaline method showed almost the similar acid value (0.44 mg KOH/g) as the Jatropha biodiesel produced by alkaline transesterification (0.39 mg KOH/g). Neem biodiesel obtained by acidic transesterification showed the higher acid value (0.65 mg KOH/g) when compared to acidic transesterified Jatropha biodiesel (0.34 mg KOH/g). Palm oil biodiesel obtained by enzymatic transesterification showed highest acid value (0.33 mg KOH/g) compared to enzymatic transesterified Jatropha biodiesel (0.25 mg KOH/g). Used sunflower oil biodiesel produced by alkaline method showed very high acid value (1.8 mg KOH/g) compared to Jatropha biodiesel (0.39 mg KOH/g).

3.3.5 Cetane number of biodiesel: Jatropha biodiesel obtained by acidic and alkaline transesterification showed same cetane number (47.86 and 47.56) and enzymatic transesterified biodiesel showed the higher (50.4) cetane number. Pongamia biodiesel after acidic transesterification showed the highest cetane number (54.6) compared to acidic transesterified jatropha biodiesel (47.86). Enzymatic transesterified neem biodiesel had the maximum cetane number (62.81) compared to enzymatic transesterified jatropha biodiesel (50.4). Used palm oil biodiesel and used sunflower oil biodiesel showed higher value of cetane number by acidic

method of transesterification (59.3 and 54.4) compared with jatropha biodiesel produced by acid method (47.86).

3.3.6 Flash point of biodiesel: Jatropha biodiesel produced by alkaline transesterification was found to be higher (182 °C) compared to acidic (164 °C) and enzymatic (132 °C) transesterification. It was found that flash point of alkaline transesterified pongamia biodiesel (214 °C), neem biodiesel (185 °C), used palm oil biodiesel (154 °C) and used sunflower oil biodiesel (182 °C) had higher flash point compared to acidic and enzymatic transesterification. Pongamia and neem biodiesel after alkaline transesterification had higher flash point (214 °C and 185 °C) whereas palm biodiesel had lesser iodine value (154 °C) compared to Jatropha biodiesel (182 °C). The alkaline transesterified used sunflower biodiesel was found to have similar iodine value as alkaline transesterified Jatropha biodiesel.

3.4 Study of biodiesel by FTIR

3.4.1 Acid transesterification

a. Neem oil: In neem oil nearly eight peaks was observed, chemical bonds C-O comes with the wave length of 1116.92 which may be ether or ester and C-H which may be alkane C-O alcohol, C-N amine and C-F with alkyl halide. At the wave length of 1162.66 chemical bonds corresponds to C-O ester, C-N amine and C-F alkyl halide. When the peak is at 1236.75 C-F may be alkyl halide, C-O acid and C-O ester. 1376.88 peak corresponds only to C-H alkane. Peak 1462.66 corresponds to C=C aromatic compounds. 1742.80 peak shows C=O aldehyde or ester. 2852.64 peak shows C-H alkane and 2922 peak shows C-H alkane as shown in figure 3.

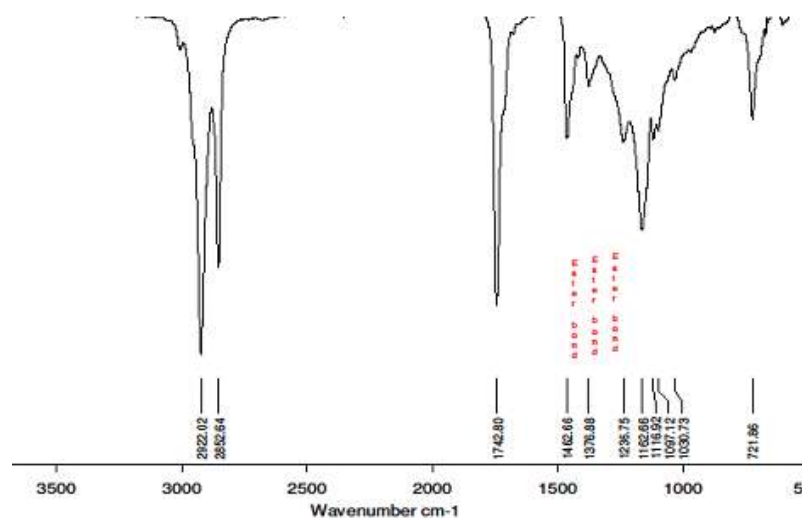


Fig.3: FTIR showing peaks for acid transesterification of neem oil

B. Palm oil: In palm oil transesterification four peaks was observed at peak 665.79 and showed alkyl halide C-Cl. C-F alkyl halide showed at peak 1014.98. Another peak is at 1633.48 showed some N-H

amide or alkene. And the last peak was at 3353.66 shows some N-H amide/N-H amine or alcohol as shown in figure 4.

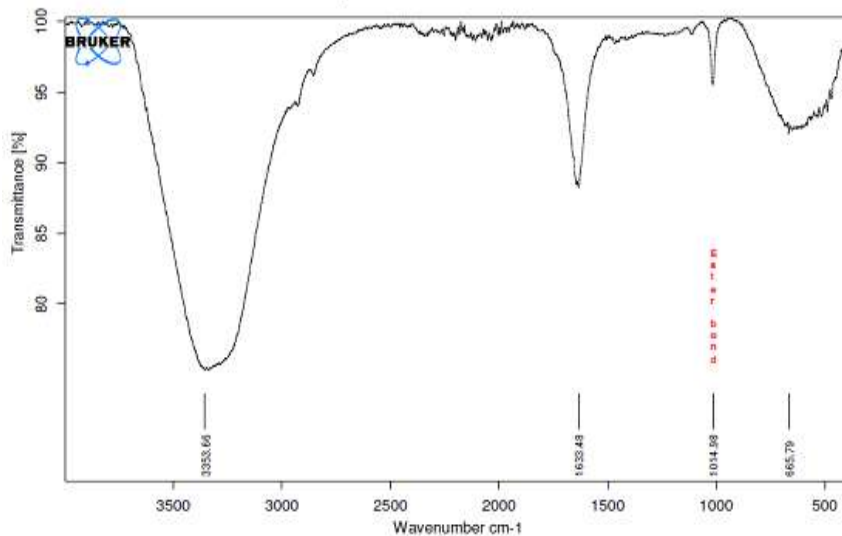


Fig. 4: FTIR showing peaks for acid esterification of palm oil

c. Pongamia oil: In pongamia oil acid transesterification showed eight peaks starting from 700-3000 wave length. Peak at 722.46 chemical bonds showed alkyl halide, when the peak is at 1034 to 92 chemical bonds may be C-O alcohol, C-F alkyl halide, C-N amine/C-O ether. When the peak is at 1165 showed C-O ester, C-N amine or C-F alkyl halide. Peak 1240 showed C-F alkyl halide and peaks 1737, 2853 and 2923 showed C=O, O-H (acid)/C-H (alkane) and C-H alkane respectively as shown in figure 5.

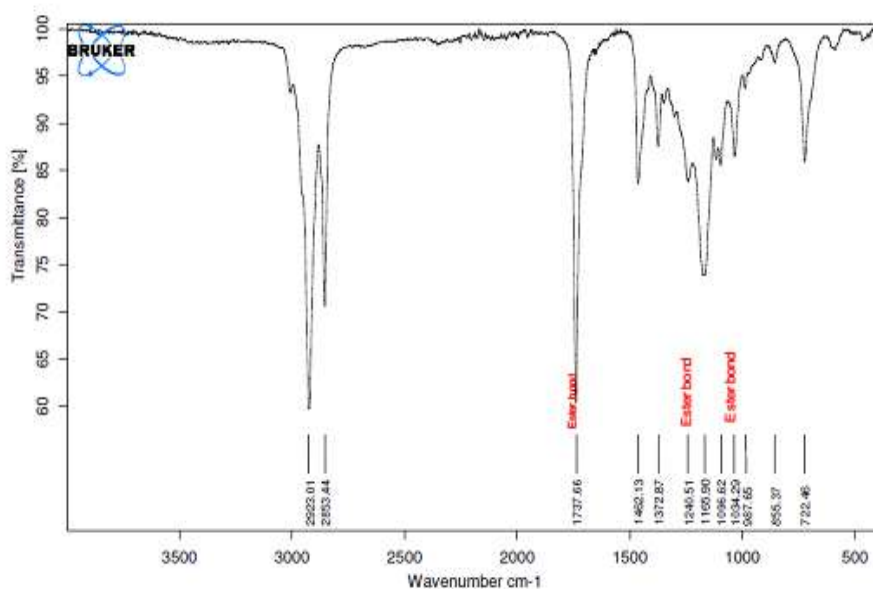


Fig. 5: FTIR showing peaks for acid esterification of pongamia oil

d. Sunflower oil: In sunflower oil transesterification, five peaks were observed which starts from 550 to 3325 peak. When the peak is at 568 chemical bonds were C-Br alkyl halide when the peak is

at 1013 chemical bonds were C-O ester or C-F alkyl halide. Peak 1640 showed C=O amide and C=C alkene and the peak 2950 showed C-H alkane and final peak 3325 showed O-H alcohol or N-H amine or amide as shown in figure 6.

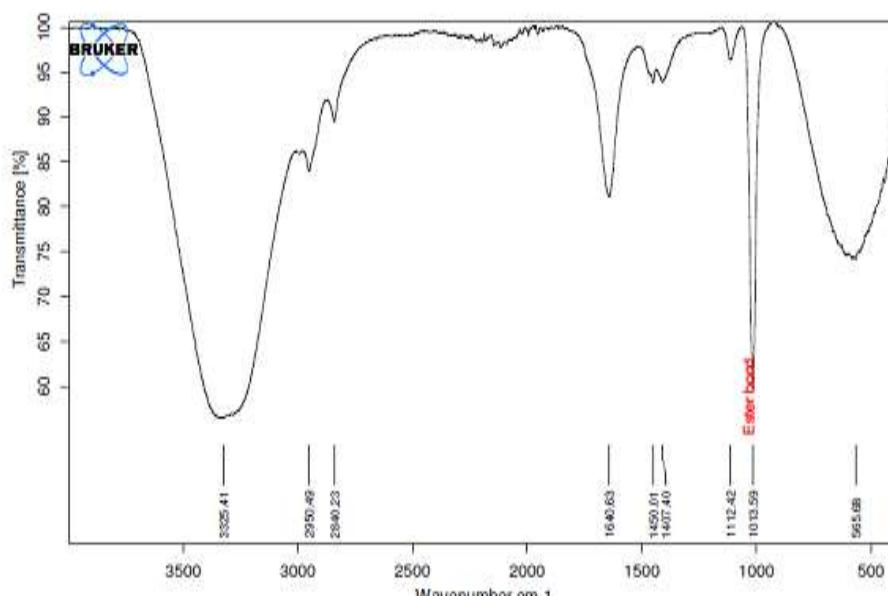


Fig. 6: FTIR showing peaks for acid esterification of sunflower oil.

3.4.2 Alkaline transesterification

a. Neem oil: In alkaline transesterification of neem oil wavelength ranged from 1117 to 2852 with five peaks. 1117 peak showed C-F alkyl halide or C-N amine or C-O ester. When the wavelength is at 1162 chemical bonds may be alkyl halide or C-N amine or C-O ester bonds were observed. When the peak is at 1462 chemical bonds may be C-O ester or C-N amine or C-F alkyl halide and when the peak is at 1743 the chemical bonds may be C-H alkane/ C=C aromatic bonds and the last peak was at 2852 chemical bonds is at C=O ester or C=O carbonyl or C=O aldehyde as shown in figure 7.

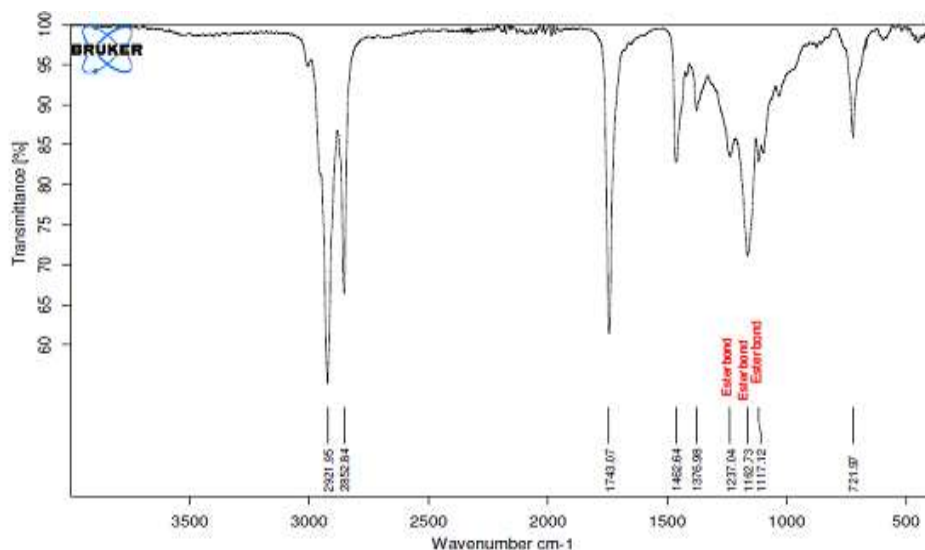


Fig. 7: FTIR showing peaks for alkaline transesterification of neem oil

b. Palm oil: In palm oil wave length ranged from 1016 to 2922 the peak 1016 showed the chemical bonds C-F alkyl halide/ C-N amine or C-O ester. When the peak is at 1117.97 and 1169 showed the chemical bonds C-F of alkyl halide or C/N amine or C-O ester. When the peak is at 1741 the chemical bonds were C-H alkane or C=C aromatic and the peaks 2852 and 2922 showed the chemical bonds at O-H acid/ C-H alkanes as shown in figure 8.

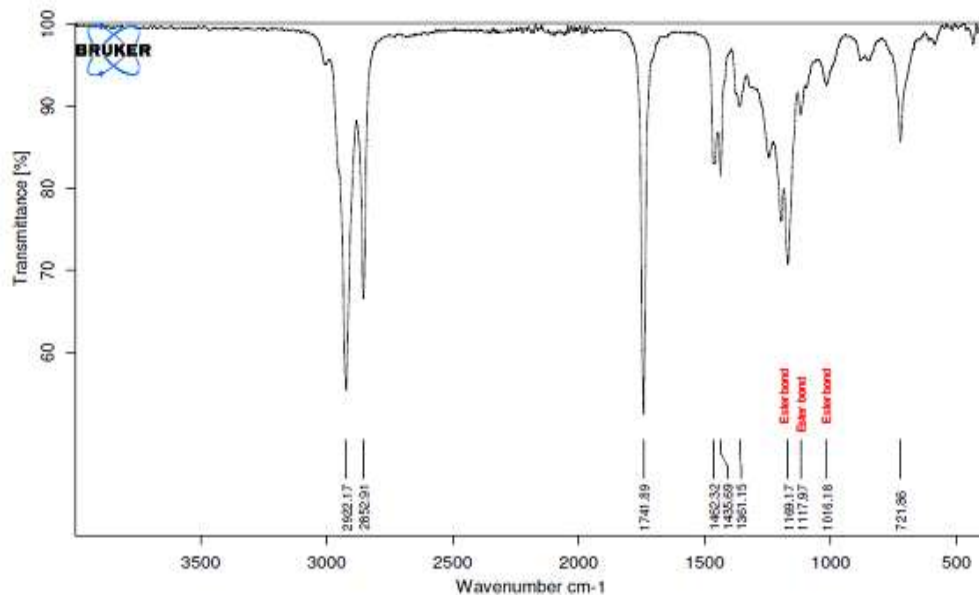


Fig. 8: FTIR showing peaks for alkaline transesterification of palm oil

c. Pongamia oil: In pongamia oil, wave length ranged between 1037 to 2921 when the wave length is at 1037 the chemical bonds were at C-F alkyl halide or C-O ester and the wave length is at 1114 to 1167 chemical bonds were C-F alkyl halide or C-N amine or C-O ester bonds respectively. When the wave length is at 1253 chemical bonds were C-O ester or C-N amine or C-F alkyl halide and the wave length 1557 showed C=C aromatic or C-H alkane and the wave length 1740 the chemical bonds were C=O ester/ C=O carbonyl or aldehyde and final peak 2921 showed O-H acid or C-H alkane as shown in figure 9.

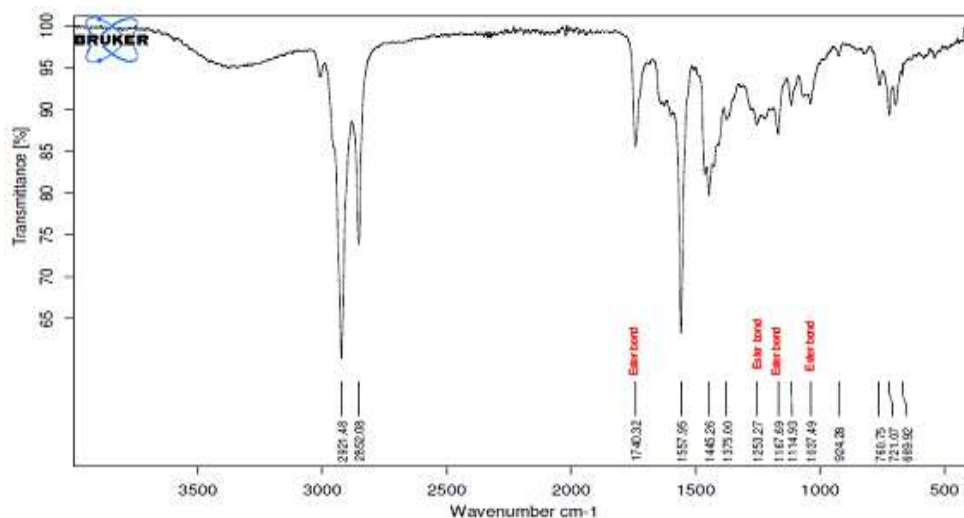


Fig. 9: FTIR showing peaks for alkaline transesterification of pongamia oil

d. Sunflower oil: In sunflower oil wave length ranged from 1015 to 2923 when the wave length is at 1015 chemical bonds were C-F alkyl halide or C-O ester bonds were observed. When the peak is at 1168 the chemical bonds were C-F alkylhalide or C-N amine or C-O ester bonds were observed. 1244 showed C-O ester/ C-N amine or C-F alkyl halide was observed. In the peak 2933 O-H acid or C-H alkane were observed as shown in figure 10.

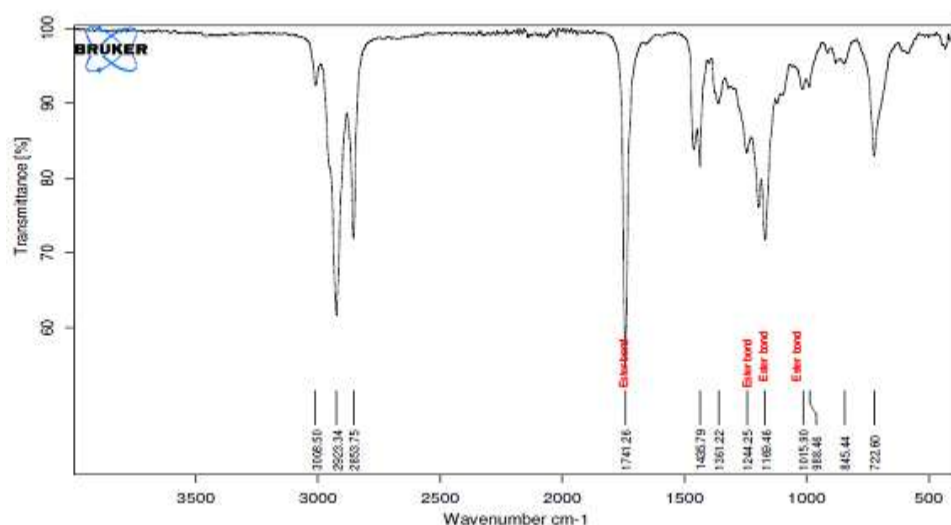


Fig. 10: FTIR showing peaks for alkaline transesterification of sunflower oil

3.4.3 Enzymatic transesterification

a. Neem oil: In neem oil enzyme esterification wave length ranged from 721 to 2922 when the peak is at 721 C-Cl alkyl halide or C-H alkene bonds were observed. When the peak were at 1035 C-F alkyl halide or C-O ester were observed. 1177 showed the C-O ester, 1463 showed C=C aromatic or C-H alkane. 1737 showed C=O carbonyl C=O aldehyde and 2845 and 2922 showed C-H alkane respectively as shown in figure 11.

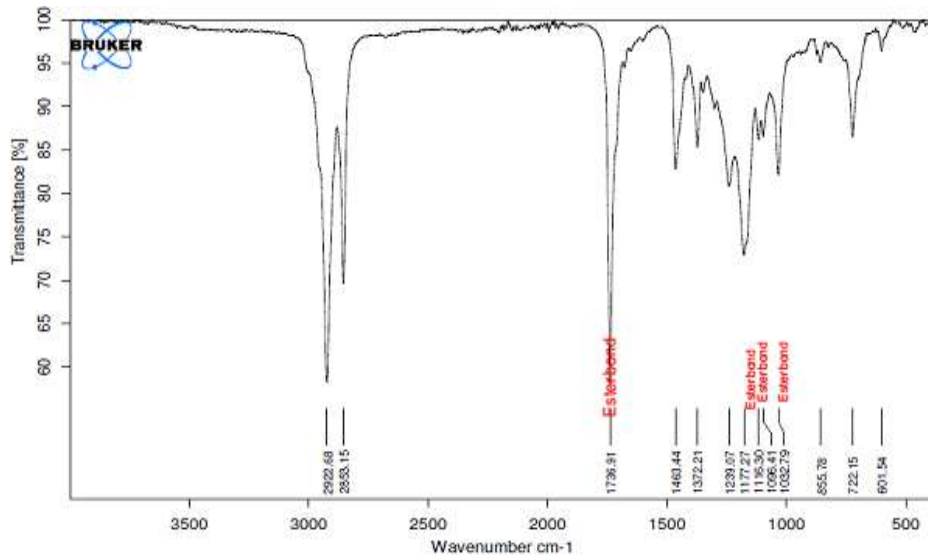


Fig. 11: FTIR showing peaks for enzyme transesterification of neem oil

b. Palm oil: In palm oil the wave length ranged from 721 to 2922 when the wave length is at 721 the chemical bonds were C-Cl alkyl halide or C-H alkene and the peak 1035 and 1177 showed C-O ester bonds were observed. At the peak 1737 C=O carbonyl or aldehyde bonds. The bonds were C-H alkane and O-H acid was observed in 2853 and 2922 showed C-H alkane bonds were observed as shown in figure 12.

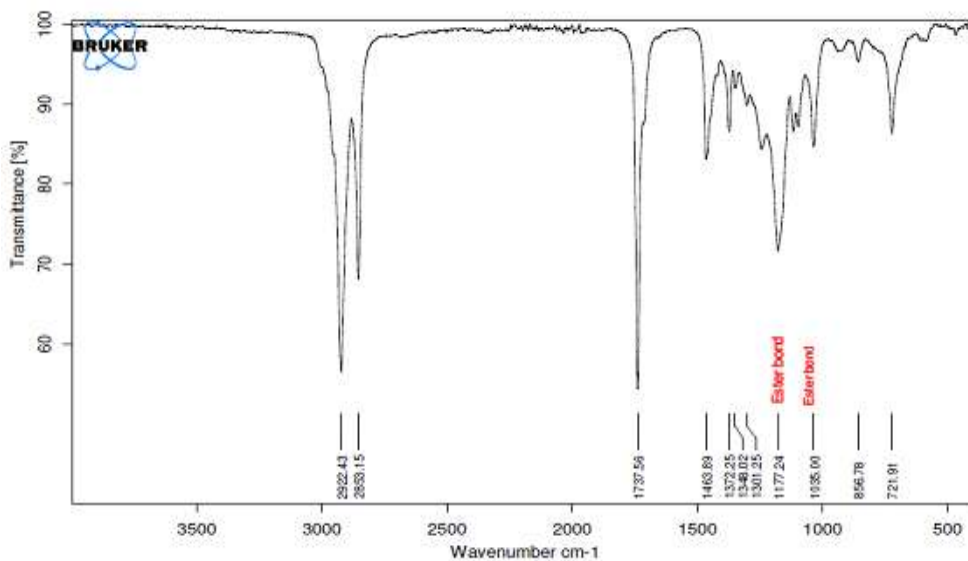


Fig. 12: FTIR showing peaks for enzyme transesterification of palm oil

c. Pongamia oil: In pongamia oil wave length ranged from 1096 to 2922 wave length ranged from C-F alkyl halide C-O ester were observed at 1096 wave length the peak 1115 and 1117 showed C-O ester bond were observed. When the peak was at 1736 C=O carbonyl/ C=O aldehyde or C-O ester and the peak of 2853 and 2922 showed C-H alkane bonds as shown in figure 13.

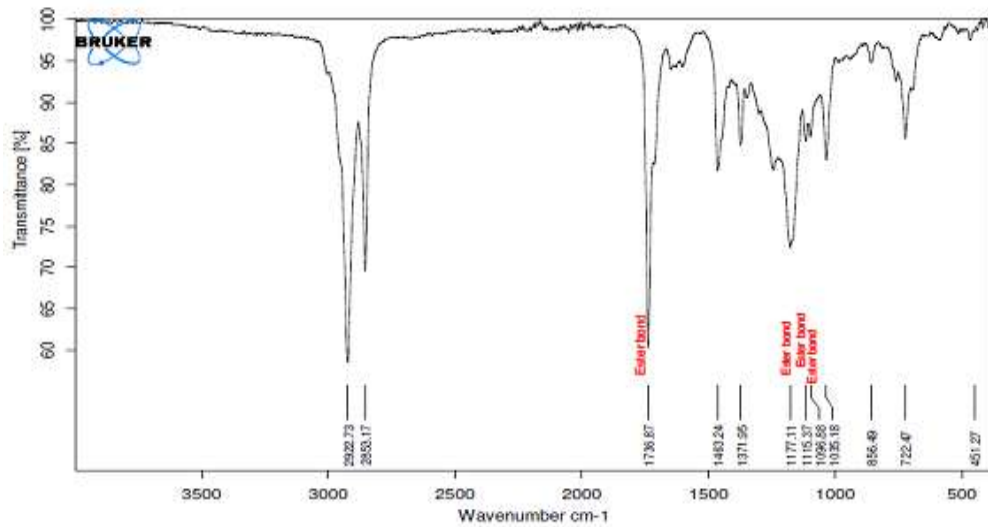


Fig. 13: FTIR showing peaks for enzyme transesterification of pongamia oil

d. Sunflower oil: In sunflower oil wave length ranged from 1034 to 2853 range. When the wave length was at 1034 showed C-F alkyl halide or C-O ester bonds. Peak 1096 showed C-O alcohol/ C-F alkylhalide/ C-N amine or C-O ether bonds were observed. When the peak is at 1178 the chemical bonds were C-F alkylhalide/C-N amine/C-O ester bonds were observed when the peak is at 1736 the chemical bonds were C=O ester or C=O carbonyl or C=O aldehyde and the last peak 2843 showed O-H acid/C-H alkane bonds were observed as shown in figure 14.

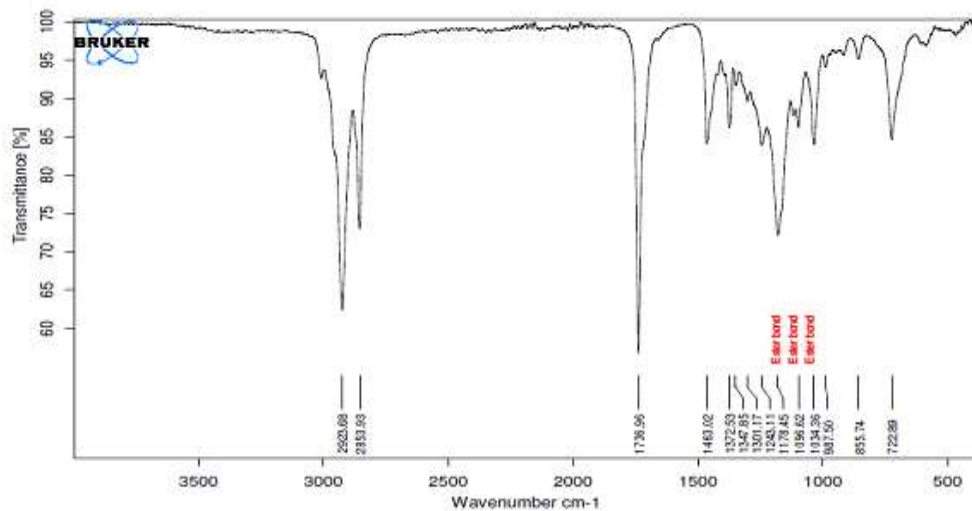


Fig. 14: FTIR showing peaks for enzyme transesterification of sunflower oil

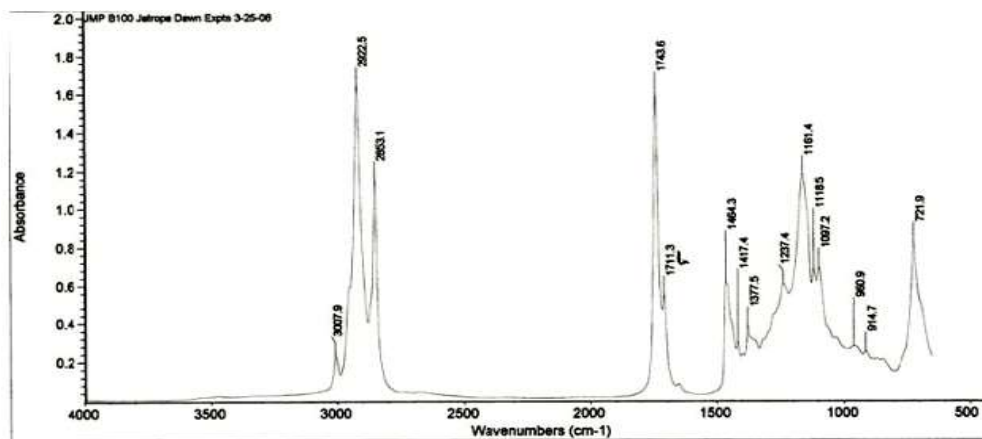
STANDARD JATROPHA OIL:

Fig. 15: FTIR showing peaks for standard Jatropha oil

Standard Jatropha showed the wave length from 1097 to 2922. When the peak is at 1097 wave length, chemical bonds showed C-F alkyl halide/ C-O ester. When the wave length was 1118 and 1161 chemical bonds showed were C-O esters. When the wave length were 1464 chemical bonds observed were C=C aromatic/ C-H alkane. At wave length 1743 chemical bonds were C=O carbonyl/C=O aldehyde and when the peak observed at 2853 and 2922 the chemical bonds were C-H alkane/O-H acid or alkane.

4. DISCUSSION

Biodiesel production from vegetable (edible and non edible oils) increasing popular section of biodiesel market is the re use of vegetable oils used in the catering industry. Used vegetable 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 atmosphere². In our present work we have analyzed FTIR for pongamia, neem, sunflower and palm oil which were compared with standard Jatropha oil. The most characteristic peaks on a biodiesel spectrum is one at 1000-1300 cm^{-1} which is related to O-CH₃ vibrations. Comparing figures (03) to figure (14) shows that the peak characterized by O-CH₃ vibrations is prominent in all spectra. The peak gives an indication of the attachment of the alkali group of the alcohol to the fatty acid group in the triglycerides, those forming esters. In addition there are bands appearing between 1150-1450 cm^{-1} attribute to C-O ester stretching vibrations and 1735-1750 cm^{-1} both attribute to C=O ester stretching vibrations.⁸Reported the peak for biodiesel may ranges from 900-2950 wave length from renewable biological sources such as vegetable oils both (edible and non edible oil) and animal fats our results also correlates with the same results and almost edible ranged 950 to 3000. 1000-1400 cm^{-1} attribute to alkyl halide C-F stretching vibrations, 1080-1360 cm^{-1} attribute to amine group C-N stretching vibrations, 2850-3000 cm^{-1} attribute to alkene C-H stretching vibrations, 1720-1740 cm^{-1} attribute

to aldehyde group C=O stretching vibrations, 1670-1820 cm^{-1} attributes to ester carbonyl C=O stretching vibrations, 2500-3300 cm^{-1} attributes to acid group O-H stretching vibrations and 1400-1600 cm^{-1} attributes to aromatic groups C=C stretching vibrations.

The analysis confirms the purity of the respective biodiesel samples with the presence of methyl ester groups. It could be concluded that the Fatty acid methyl esters are confirming with ASTM and EU standards of biodiesel.

5. CONCLUSION

Concluding the work as, by determined with Physico-Chemical parameters of bio-oils and compared with the standard jatropha oil, By determining the density of bio-oils it was found that neem oil having the value 0.92 g/cc was similar to jatropha, whereas pongamia showed more 0.94 g/cc, sunflower and palm oil showed the least. For viscosity it was found that all edible and non-edible oils showed least value but pongamia oil showed least but nearer value i.e. 41.53 Cst when compared to standard Jatropha having 46.54 Cst. For saponification value it was found that neem oil showed highest but nearer value i.e. 199.15 mg KOH/g when standard jatropha having 197.51 mg KOH/g. For acid value it was found that all the oils showed variation where as palm oil having 0.3mg KOH/g was found to be similar when compared with standard jatropha oil having 0.3mg KOH/g. For iodine value it was found that all edible and non-edible oils having the least value but pongamia and neem showed least but nearer value when compared to standard jatropha. When determined the physico-chemical characters of biodiesel obtained from acidic, alkaline and enzymatic method it was found that, For density in acidic, alkaline and enzymatic method all biodiesel samples showed different range of values. for viscosity all the biodiesel samples showed different range of values but pongamia and palm biodiesel showed similarity in acidic method, sunflower and palm biodiesel showed similarity in alkaline method and palm biodiesel showed similarity in enzymatic methods, For acid value, all biodiesel showed different range of values where pongamia showed similarity in both acidic and alkaline method. For cetane number all the biodiesel samples showed wide range of values but pongamia biodiesel showed almost nearer similarity in all three methods, neem biodiesel showed similarity in alkaline method and sunflower biodiesel showed similarity in enzymatic method. For iodine value all the biodiesel samples showed different range of values but in alkaline method pongamia and sunflower biodiesel showed similarity and in enzymatic method sunflower and pongamia showed similarity. For flash point all biodiesel samples different range of values but neem and sunflower biodiesel showed similarity with standard jatropha in alkaline method and palm biodiesel showed similarity in enzymatic method. The produced biodiesel from oils by the above process were quantified by FTIR analysis. Accordingly acidic transesterification was found to be more efficient

process for the production of biodiesel as an alternative fuel has become the novelty of the research work. Based on the above comment we can conclude by saying that alkaline method is the best suitable for biodiesel production followed by enzymatic method. The biodiesel obtained from pongamia oil and used sunflower oil has the ability to be served as alternative fuels in the form of blends.

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