JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue

JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)

An International Scholarly Open Access, Peer-reviewed, Refereed Journal

LOW-COST BIO-DIESEL USINGVEGETABLE OIL

D. Senthil Kumar[1], P. Veeradivakar[2], A. Stanley Raj[3], K. Leo Lawrence[4], B. Kanishkar[5]

[1]Associate Professor, Department of Physics, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu. India.

[2, 5] M.Sc. Physics, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu. India.

[3]Assistant Professor, Department of Physics, Loyola College, Chennai, Tamil Nadu, India
Mobile: +919940120058

[4]Assistant Professor, Department of Chemistry, Loyola College, Chennai, Tamil Nadu, India

Email:stanleyraj@loyolacollege.edu

Abstract: Biodiesel production has received considerable attention in the past as a biodegradable and non polluting fuel. The production of biodiesel by transesterification process employing alkali catalyst has been industrially accepted for its high conversion and reaction rates. The use of methoxide as a catalyst to perform the transesterification reaction into biodiesel in this work. The effect of the most relevant variables of the process such as reaction temperature , molar ratio between alcohol and oil, amount of catalyst and amount of free fatty acids fed with oil have been analyzed .for this purpose , an ideal sunflower oil using lauric acid and palm oil, coconut oil also used. The alcohol used was methanol. Fats and oils are chemically reacted with alcohol to produce chemical compounds known as fatty acid methyester (Biodiesel). Glycerol, used in pharmaceuticals and cosmetics industry along with many other applications, is produced in this reaction as a product. The cost of biodiesel, however, is main hurdle in commercialization of the product. The used cooking oil as raw material, adoption of batch transesterification process and recovery of high quality glycerol from biodiesel product stream are primary option to be considered to lower the cost of biodiesel. There are four primary ways to make biodiesel, direct use and blending, micro emulsions, thermal cracking and transesterification. Transesterification reaction is effected by molar ratio of glycerides to alcohol, catalyst, reaction temperature ,reaction time and free fatty acids water content of oils or fats .the process of transesterification and its downstream operations also addressed. The transesterification of free fatty acid using this homogeneous catalyst appears as a great alternative and producing high conversion around 98.2%.fatty acid methyl esters (FAME) were prepared by using methanol in the presence of the1.85%hydrochloric acid at 100 deg C for 1 hour and 25 deg C for 3 hours.

KEYWORDS: Biodiesel, Glycerin, Vegetable Oils, Methanol, HCL.

1. INTRODUCTION:

Biodiesel is a fuel for diesel engines made from plant or animals oils. There are several sources of getting oil which is te raw material needed for biodiesel production and these include non – edible oil, animal fat and vegetable oil. Jatropha plant/oil seed of spice Jatropha curcas which gives non edible oil was cited in 2007, by Goldman Sachs as one of the best candidates for future biodiesel production. Jatropha has a good resistance with pests and drought, ad can produce seeds containing 27 – 40% oil while the residue (press cake) can also be processed and used as biomass feedstock to power electricity plants or used as fertilizer as it contains nitrogen, phosphorus and potassium. Currently in Philippines and in Brazil the oil from jatrophacurcas seeds are used for making biodiesel fuel. Jatropha oil is being promoted as an easily grown bio fuel crop in hundreds of projects throughout the world. The railway line between Mumbai and Delhi is planted with Jatropha and the train itself is being run on 15 – 20% biodiesel. The oil used in biodiesel fuel production can be fresh clean oil or used waste oil that has been earlier used for frying as in this study the fact is lots of energy is stored in oil (liquid) and fat (solid) and biodiesel is all about getting that energy back to power engines/vehicles down the highway. Lately, the emphasis on the production of liquid fuels from enable source has been on the increase and bio diesel has been proposed as one of those fuels because its production can be carbon – neutral. Vegetable oil was first transestrifiedin 1853 by E Duffy and J Patrick in 1893, Rudolph biodiesel's first engine was demonstrated. The biodiesel engine went on to win the grand prix at the world fair of 1900 which took place in Paris.

The engine demonstrated in paris ran oil made from peanut. Biodiesel plants have opened in many European countries since the 1980s and some cities have run buses on bio diesel, or blends of petro and biodiesel. It is on record that Peugeot and renauld have approved the use of biodiesel in some of their truck engine bio diesel derived from vegetable oil animal fat by transesterification which alcohol like methanol or ethanol, is recommended for use as a substitute for petroleum based diesel because bio diesel oxygenated, (the gases relised during combustion are essentially the gasses absorbed from the atmosphere whilst the plant was growing.) It is renewable, biodegradable and environmental friendly. Global warming gas emissions such as carbon dioxide, carbon monoxide, hydrocarbon and particulate matter in the exhaust gas is minimised compared with petroleum based diesel fuels. Biodiesel is a better lubricant than petro diesel as it helps to extend the working life of engines.
Biodiesel reduces risks from respiratory problems as it gives fewer particulates[6] when burnt making it easier to ignite than petrol diesel, thereby leading to a complete, efficient combustion. However biodiesel is more expensive to produce than petro diesel and if grown on a wider scale, more plants for oil would be grown as cash crop. This may reduce the amount of food grown to feed the population in less economically developed countries. Biodiesel gels at lower temperatures than petro diesel, so tanks require heating in cooler climates and degrades rubber hoses if used on older engines.

1.1Source of material:

Several sources such as non-edible oil, animal fat and vegetable oil can be used as raw material for biodiesel production as earlier mentioned. However, the vegetable oil extracted from plant that are composed of triglycerides was used because it contains similar fuel properties to diesel fuel except the higher viscosity and low oxidative stability that must be encountered before being converted into biodiesel. So, the vegetable oil mostly used in transesterification reaction include straight vegetable oil and waste vegetable oil as in this case study.

1.2 Straight Vegetable oil

Pure plant oil or commonly known as straight vegetable oil is not a by-product of other industries either coming from domestic usage. The straight vegetable oil is a highly grade oil extracted primarily from plant, usually, seeds of oilseed plants. In addition, this oil is the best starting material compared to waste cooking oil because of the conversion of the triglyceride to the fatty acid component and availability of methyl ester is high making the reaction time relatively short.

1.3 Waste Cooking Oil:

Waste cooking oil is one of the alternative sources among other higher grade or refined oil Waste cooking oil is easy to collect from other industries such as domestic usage and restaurant[7]and also cheaper to produce in small quantities than the refined oil. Hence by using this oil as the raw material, the cost of biodiesel production is drastically reduced, thus, the low cost advantage and prevention of environmental pollution. Many individuals dispose waste cooking oil directly to the environment especially in rural area but this same oil could be used in biodiesel production and generate energy.

1.4 Solvent:

In transesterification process the main solvent used is alcohol. The examples of alcohols that could be used in the transesterification of triglycerides are methanol, ethanol, propernol, butanol and amyl alcohol. Methanol is the most widely used because of its low price and its physical and chemical advantages (polar and shortest chain alcohol) it can quickly react with triglycerides and sodium hydroxide and easily dissolve in it.

1.5 Catalyst:

A catalyst is used to hasten up the process and Sodium hydroxide (NaOH), potassium hydroxide (KOH) and hydrochloric acid (hcl) are the common catalyst used in the reaction process.

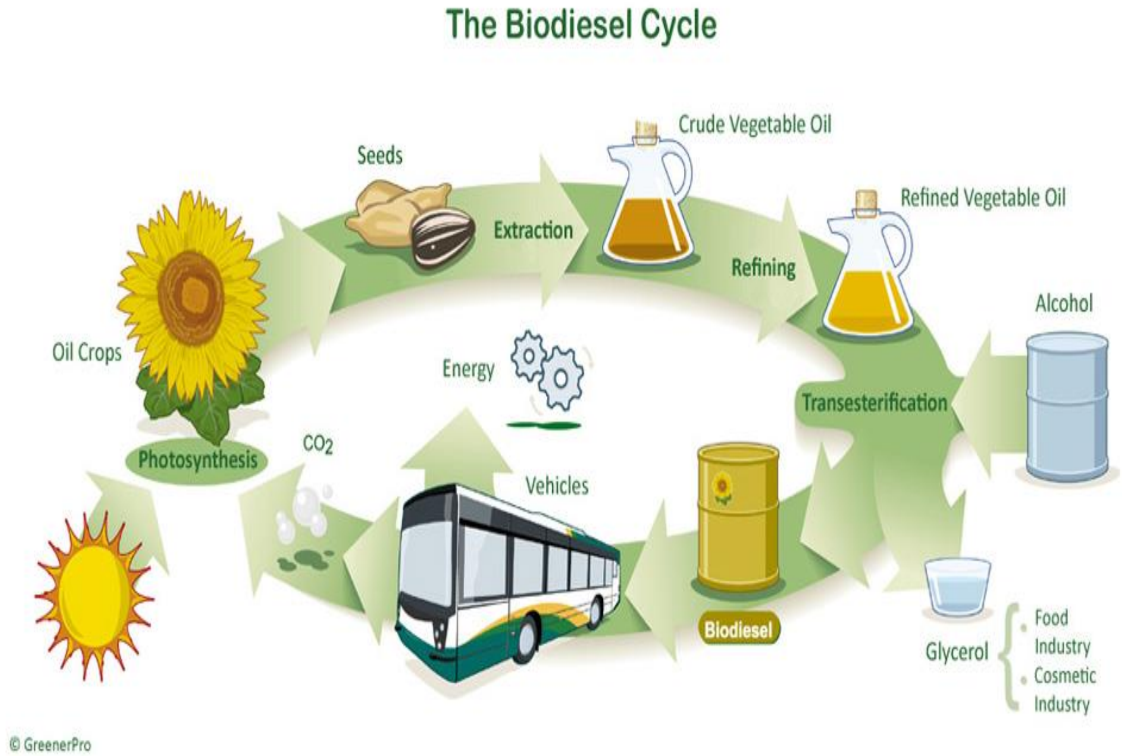

Figure: 1 Biodiesel cycle form

1.6 **Purpose of bio diesel**

The smartest technologies deliver benefits to multiple interest including improved economy and a positive impact on the environment and governmental policies. The role of the biodiesel industry is not to replace petroleum diesel, but to help create a balanced energy policy with the most benefit to the United States. All the diesel engine and vehicle can use biodiesel or biodiesel blends. Certain older vehicle build before 1993 may require replacement of fuel line which contains natural rubber as biodiesel can cause these line to swell or crack.

3. **Raw Materials for Biodiesel Production:**

The raw materials for biodiesel production are vegetable oils, animal fats and short chain alcohols. The oils most used for worldwide biodiesel production are rape seed (mainly in the European Union countries), soybean (Argentina and the United States of America), palm (Asian and Central American countries) and sunflower, although other oils are also used, including peanut, linseed, safflower, used vegetable oils, and also animal fats. Methanol is the most frequently used alcohol although ethanol can also be used. Since cost is the main concern in biodiesel production and trading (mainly due to oil prices), the use of non-edible vegetable oils has been studied for several years with good results. Production besides its lower cost, another undeniable advantage of non-edible oils for biodiesel lies in the fact that no foodstuffs are spent to produce fuel. These and other reasons have led to medium- and large-scale biodiesel production trials in several countries, using non-edible oils such as castor oil, tung, cotton, jojoba and jatropha. Animal fats are also an interesting option, especially in countries with plenty of livestock resources, although it is necessary to carry out preliminary treatment since they are solid; furthermore, highly acidic grease from cattle, pork, poultry, and fish can be used. Microalgae appear to be a very important alternative for future biodiesel production due to their very high oil yield; however, it must be taken into account that only some species are useful for bio fuel production.

Although the properties of oils and fats used as raw materials may differ, the properties of biodiesel must be the same, complying with the requirements set by international standards.

Figure 2: waste cooking oil

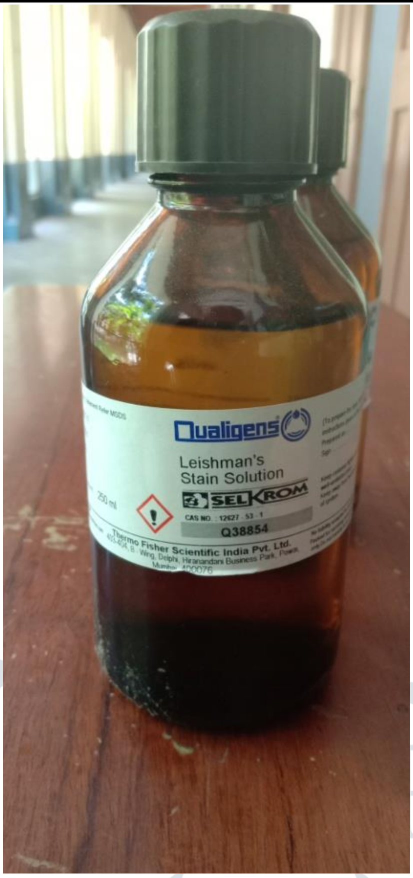

figure 3: methanol

4. Materials and Methods:

The experimental part of the work includes the production of biodiesel from corn oil. Ethanol and methanol has been used in the transesterification. Hydrochloric acid selected as catalyst. The alcohol (methanol or ethanol) and catalyst (hcl) are mixed preferably at the temperature close to the main reaction temperature to avoid significant temperature drop in reactor.

Required things:

- Vegetable oil (waste cooking oil)
- Methanol

Catalyst:

- Sodium hydroxide,
- Potassium hydroxide,
- Hydrochloric acid (acid catalyst).

The performance of the experiments includes the following steps:

- Measure quickly the catalysts
- Mix the alcohol and the catalyst (HCL) in an Erlenmeyer flask under stirring to ensure complete solution.
- Preheat the Erlenmeyer flask with alcohol and catalyst mixture in a water bath to a determined temperature. In this section, it is important to cover the flask with a lid due to vaporization during the reaction
- The oil was filtered to remove any of the debris present. The oil was heated to 100deg C for 20 min to evaporate the water present the oils. A hot plate with magnetic stirrer was used for heating. Then, the temperature of the was bought down to room temperature.
- The waste cooking oil is preheated to the reaction temperature in a electric heater. Then the oil is added to the alcohol/catalyst solution in the Erlenmeyer flask placed in the water bath. The reaction is maintained for 1-2 hours under stirring at the set temperature to get complete conversion.
- The solution is poured into a separation funnel since the reaction is completed, i.e. two large phases are formed. The biodiesel product at the top and the by-product glycerol in the bottom of the funnel.
- Removal and measure of glycerol from biodiesel.
- The product after removal of glycerol is washed with 5wt% phosphoric acid to extract alkaline. A funnel is used in order to separate the washing water and the biodiesel.

Figure 4: RB cube

Production of Bio-diesel by Transesterification Process:

Transesterification is the process of separating the fatty acids from glycerol to form fatty acid esters and free glycerol. Fatty acid esters commonly known as bio-diesel can be produced in batches or continuously by transesterifying triglycerides such as animal fat or vegetable oil with lower molecular weight alcohols in the presence of a base or an acid catalyst. This reaction occurs stepwise, with monoglycerides and diglycerides as intermediate products. The "R" groups are the fatty acids, which are usually 12 to 22 carbons in length. The large vegetable oil molecule is reduced to about 1/3 of its original size, lowering the viscosity making it similar to diesel fuel. The resulting fuel operates similar to diesel fuel in an engine.

CH2-OOC-R1 R1-COO-R' CH2-OH
| Catalyst |
CH-OOC-R2 + 3R'OH R2-COO-R' + CH-OH
| |
CH2-OOC-R3 R3-COO-R' CH2-OH
Glycerides Alcohol Esters Glycerine

Where, term R' represents different alkyl groups.

The process of transesterification brings about drastic change in viscosity of vegetable oil. The bio-diesel thus produced by this process is totally miscible with mineral diesel in any proportion. Biodiesel viscosity comes very close to that of mineral diesel hence no problems in the existing fuel handling system. Flash point of the bio-diesel gets lowered after esterification and the Cetane number gets improved. Even lower concentrations of bio-diesel act as Cetane number improver for bio-diesel blend. Calorific value of bio-diesel is also found to be very close to mineral diesel. The overall process is normally a sequence of three consecutive steps, which are reversible reactions. In the first step from triglycerides, diglycerides are obtained. From diglyceride, monoglyceride is produced and in the last step from monoglycerides, glycerine is obtained. In all these reactions esters are produced. The stoichiometric relation between alcohol and the oil is 3:1. However, an excess of alcohol is usually more appropriate to improve the reaction towards the desired product

Triglycerides + R'OH ⇌ Diglycerides + R'COOR1

Diglycerides + R'OH ⇌ Monoglycerides + R'COOR2

Monoglycerides + R'OH ⇌ Glycerine + R'COOR3

Transesterification (bio-diesel reaction):

The methanol in excess is added to the oil in a beaker serving as a batch reactor. The mixture is then agitated for about 60 to 90 minutes and then left overnight for phase separation to take place due to gravity.

Draining of Glycerol:

After the transesterification reaction, one must wait for the glycerol to settle to the bottom of the container. This happens because Glycerol is heavier then bio-diesel. The settling will begin immediately, but the mixture should be left for minimum of 8 hours to 12 hours.

Washing of Bio-diesel:

The purpose of washing is to wash out the remnants of the catalyst and other impurities. Generally water washing is preferred in which lukewarm water (about one third of raw bio-diesel) is added to raw bio-diesel, stirred for a short duration and then impurities are allowed to settle down at bottom with water.

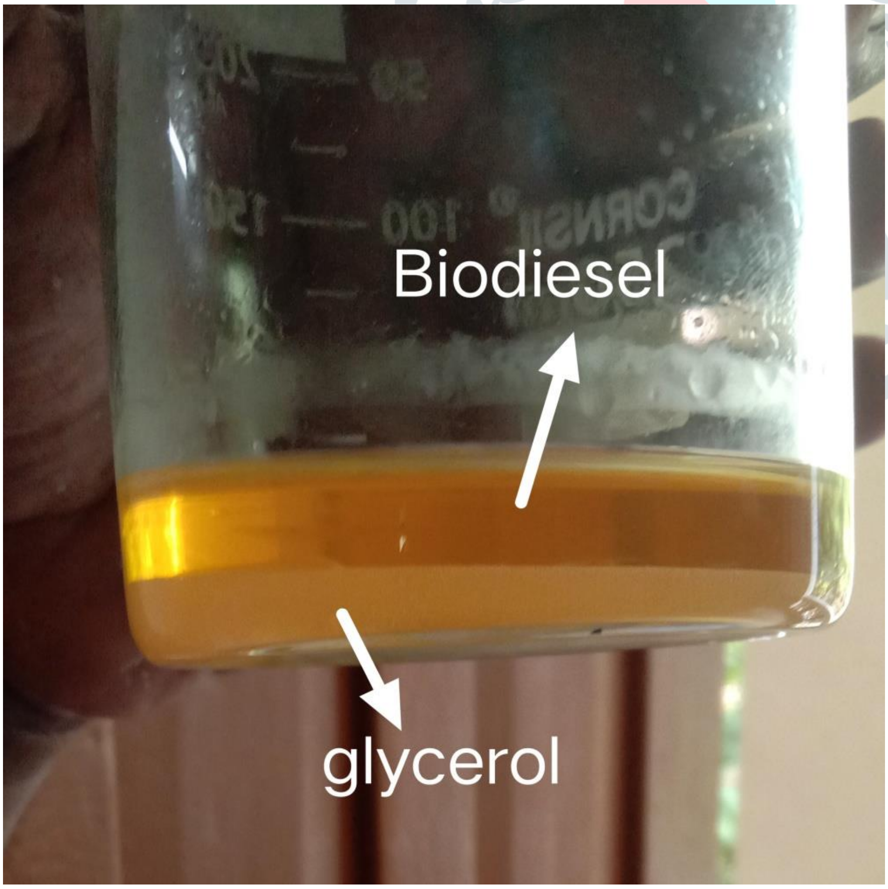

Figure 12: Bio-diesel and glycerol solution

RESULT:

Bio-diesel from vegetable oil or animal fat through a process known as transesterification. This is done by reacting, the oil (triglycerides) with an alcohol (mainly methanol or ethanol) is the presence of a suitable alkali or acid catalyst yielding straight chain molecules of methyl or ethyl esters.

I have developed bio-diesel production using waste cooking oil. Also, i am using hydrochloric acid (HCL) as a catalyst. Finally, i have done a flame test on the bio-diesel. I have prepared its image is below, the result has been smooth.

Figure5: bio-diesel and cotton

Figure 14: flame test

CONCLUSION:

Biodiesel has attracted extensive attention in the world as it is a renewable, biodegradable, nontoxic and environmentally friendly new alternative transportation fuel. It can be made from different feedstock containing fatty acids such as animal fats, non edible oils, waste cooking oils, by products of the refining vegetables oils and algae etc. Transesterification process is a commonly employed for its formation. Heterogeneous catalysts are recommended the best catalysts in biodiesel production. Cost of biodiesel can be reduced by using waste cooking oil as feed stock. High fatty acid content in waste cooking oil can be reduced by pre-treating waste cooking oil with acid catalyst. Water produced during the esterification process may inhibit acid catalyst. It can be removed by stepwise reaction mechanism. Methanol is the most suitable alcohol because of its low cost and easy separation from bio fuel. But still there is need to improve the biodiesel process economically using environmentally friendly catalysts and selecting the best process technology.

ACKNOWLEDGEMENT:

The author VEERADIVAKAR. P truthfully acknowledged the guidance and support rendered by Dr. A. Stanley Raj, Assistant Professor of Physics, Loyola College, Chennai and Dr. D. Senthil Kumar, Project Supervisor, Department of Physics, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Avadi, Chennai during the course of the project. This work is carried out in the Department of Physics, Loyola College, Chennai.

REFERENCE:

1. Rao G Lakshmi Narayana, Sampath S., Rajagopal K 2008. "Experimental Studies on the Combustion and Emission Characteristics of a Diesel Engine Fuelled with Used Cooking Oil Methyl Ester and its Diesel Blends." International Journal of Engineering and Applied Sciences 4: pp. 64-70.

2. Banapurmath NR., Tewari PG., Hosmath RS. (2008) "Performance and emission characteristics of a DI compression ignition engine operated on Honge, Jatropha and sesame oil methyl esters." Renewable Energy 33, pp. 1982–1988.

3. Qi DH., Geng LM., Bian YZH., Liu J., Ren XCH. (2009) "Combustion and performance evaluation of a diesel engine fueled with bio diesel produced from soybean crude oil." Renewable Energy 34, pp. 2706– 2713.

4. Nabi Md. Nurun, Rahman Md. Mustafizur, Akhter Md. Shamim. (2009) "Bio-diesel from cotton seed oil and its effect on engine performance and exhaust emissions." Applied Thermal Engineering 29, pp. 2265–2270.

5. Ghai Sudhir, Das LM. and Babu MK. Gajendra. , October 2008 "Emissions and performance study with sunflower methyl ester as diesel engine fuel." ARPN Journal of Engineering and Applied Sciences vol. 3, no. 5, pp.75-80.

6. Nagarhalli M.V., Nandedkar V.M. and Mohite K.C. , February 2010 "Emission and performance characteristics of karanja bio-diesel and its blends in a C.I. engine and it's economics." ARPN Journal of Engineering and Applied Sciences vol. 5, no. 2, pp. 52- 56.

7. Sureshkumar K.,Velraj R.,Ganesan R. (2008) "Performance and exhaust emission characteristics of a CI engine fueled with Pongamia pinnata methyl ester (PPME) and its blends with diesel." Renewable Energy 33, pp. 2294– 2302.

8. Gvidonas Labeckas, Stasys Slavinskas. (2006) "The effect of rapeseed oil methyl ester on direct injection Diesel engine performance and exhaust emissions." Energy Conversion and Management 47, pp. 1954–1967.

9. Feasibility Report on "Small Scale Bio-diesel Production" by Waste Management and Research Centre (WMRC).

10. Gogate PR, Tayal RK, Pandit AB. (2006) "Cavitation: A technology on the horizon." Current Science 91(12) December 35- 46.

11. Agarwal Avinash Kumar, (2007), "Biofuels (alcohols and bio-diesel) applications as fuels for internal combustion engines." Progress in Energy and Combustion Science 33 pp. 233 271.

12. Karnwal Ashish, Kumar Naveen, and Hasan Mohd. Muzaffarul, Jan 2011, " Performance evaluation `of amedium capacity diesesl engine on thumba bio-diesel and diesel blend." New Frontiers in Biofuels International conference pp. 90.- 99.

13. Kumar Naveen and Sharma P B, Nov-2005, "Jatropha – a sustainable source for bio-diesel production." Journal of Scientific and Industrial Research, vol.64, pp.883-889.

14. V. Lertsathapornsuk, R. Pairintra, K. Aryusuk, K. Krisnangkura, (2008) Microwave assisted in continuous bio-diesel production from waste frying palm oil and its performance in a 100 kW diesel generator, Fuel Processing Technology 89 (12) 1330–1336.

15. S. Altun, H. Bulut, C. Öner, (2008) The comparison of engine performance and exhaust emission characteristics of sesame oil–diesel fuel mixture with diesel fuel in a direct injection diesel engine, Renewable Energy 33 1791–1795.

16. Z. Utlu,M.S. Koçak, (2008) The effect of bio-diesel fuel obtained from waste frying oil on direct injection diesel engine performance and exhaust emissions, Renewable Energy 33 1936–1941.

17. Rakopoulos, C. D., Antonopoulos, K. A., &Rakopoulos, D. C. (2007). Development and application of multi-zone model for combustion and pollutants formation in direct injection diesel engine running with vegetable oil or its bio-diesel. Energy conversion and management, 48(7), 1881-1901.

18. Rakopoulos, D. C., Rakopoulos, C. D., &Giakoumis, E. G. (2015). Impact of properties of vegetable oil, bio-diesel, ethanol and n-butanol on the combustion and emissions of turbocharged HDDI diesel engine operating under steady and transient conditions. Fuel, 156, 1-19.

19. Rakopoulos, D. C., Rakopoulos, C. D., Giakoumis, E. G., Papagiannakis, R. G., & Kyritsis, D. C. (2014). Influence of properties of various common bio-fuels on the combustion and emission characteristics of high-speed DI (direct injection) diesel engine: Vegetable oil, bio-diesel, ethanol, n-butanol, diethyl ether. Energy, 73, 354-366.

20. Yadav, A., Singh, Y., Singh, S., & Negi, P. (2021). Sustainability of vegetable oil based bio-diesel as dielectric fluid during EDM process–a review. Materials Today: Proceedings, 46, 11155-11158.

21. Balat, M., &Balat, H. (2008). A critical review of bio-diesel as a vehicular fuel. Energy conversion and management, 49(10), 2727-2741.

22. Prabu, S. S., Asokan, M. A., Roy, R., Francis, S., &Sreelekh, M. K. (2017). Performance, combustion and emission characteristics of diesel engine fuelled with waste cooking oil bio-diesel/diesel blends with additives. Energy, 122, 638-648.

23. Sharma, R. B., Pal, A., &Sharaf, J. (2013). Production of bio-diesel from waste cooking oil. Journal of Engineering Research and Applications, 4(6), 1629-1636

24. Yadav, A., Singh, Y., Singh, S., & Negi, P. (2021). Sustainability of vegetable oil based bio-diesel as dielectric fluid during EDM process–a review. Materials Today: Proceedings, 46, 11155-11158.

25. Gopan, S. N., Rajan, A. V., & Krishnan, B. R. (2021). Review of Bio-diesel production from waste cooking oil and analyze the IC engine performance. Materials Today: Proceedings, 37, 1208-1211.

26. Fujita, H., Nakano, K., Matsuo, H., &Hambali, E. (2018, December). Carbon Footprint of Strait Vegetable Oil and Bio Diesel Fuel Produced from Used Cooking Oil. In IOP Conference Series: Earth and Environmental Science (Vol. 209, No. 1, p. 012001). IOP Publishing.

27. Stratta, J. (2000). Biocombustibles: Los aceites vegetales como constituyentes principales del biodiesel. http://www.bvsde.paho.org/bvsacd/cd52/biocom.pdf. Access August 2012

28. Zullaikah, Siti ; Lai, Chao-chin ; Vali, Shaik Ramjan ; Ju, Yi-hsu, (2009). A two-step acid-catalyzed process for the production of biodiesel from rice brain oil, Bioresource technology, Vol.100(1), pp.299-302

29. Meng, X., Chen, G., Wang, Y. (2008). Biodiesel production from waste cooking oil via alkali catalyst and its engine test. Fuel Processing Technology 89 (9): p. 851-857.

30. Mittelbach, M., Remschmidt, C. (2004). Biodiesel - The comprehensive handbook. 1st ed. Graz: Mittelbach, M. p.