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PRODUCTION OF BIO-DIESEL FROM WASTE COOKING OIL: REVIEW

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ABSTRACT

With the increase in crude oil prices the need for development of economically attractive alternate fuels has increased. Biodiesel from waste cooking oil is one such alternative. Waste cooking oils (WCO), which contain large amounts of free fatty acids produced in restaurants, are collected by the environmental protection agency in many parts of the world and should be disposed in a suitable way. Due to the high cost of the fresh vegetable oil, waste cooking oil attracted researcher to produce bio-diesel from waste cooking oil because it is available with relatively cheap price.

In this research paper, the Transesterification of waste cooking oil with methanol as well as the main uses of the fatty acid methyl esters is reviewed. The cooking oil was transesterified with methanol using potassium hydroxide as catalyst to obtain Fatty Acid Methyl Esters (FAME) with glycerine as a by-product as Mechanical Stirrer production technique was carried out. Properties of the FAME sample including density, viscosity, flash point, pour point, sulphur content, cetane index and calorific value are tested according to ASTM standards and compared with those of standard diesel, establishing the FAME sample as biodiesel.

Results which obtained are significantly comparable to pure diesel and gives better performance than conventional diesel fuel. Thus the production of biodiesel from waste cooking oil offers economic and environmental solutions along with waste management.

Keywords: diesel, FAME, Mechanical stirrer technique, Transesterification process, Waste Cooking oil.

INTRODUCTION

The major part of all energy consumed worldwide comes from fossil fuel sources, which are petroleum, coal and natural gas. The energy demand is majorly fulfilled from the conventional energy. Petroleum based fuel are very limited reserves and only concentrated in certain regions of the world. To meet the global rising of energy demands, more reliable energy sources that are not dependent on fossil fuel are needed. In this perspective, considerable attention has been given towards the production of biodiesel as a diesel substitute as it is derived from renewable biomass sources.

Biodiesel is an oxygenated, sulphur-free, biodegradable, non-toxic and eco-friendly alternative to diesel oil . It is composed of mono-alkyl esters of long chain fatty acids derived from renewable sources like vegetable oil, animal fat and used cooking oil and is designated as B100. For these to be considered as viable transportation fuels, they must meet stringent quality standards. One popular process for producing biodiesel is transesterification.

Biodiesel can also be produced from virgin vegetable oils, rape seed, canola, etc. but the process is not feasible because of high cost of virgin oils. So, biodiesel produced from waste cooking oil is not only economically favourable but also environmentally beneficial as it provides a cleaner way of disposing these products. Biodiesel contains no petroleum but it can be blended with petroleum diesel in any percentage. Biodiesel blends from 2- 20% can be used in most diesel equipment with minor or no modification.

PRODUCTION OF BIODIESEL 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.

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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. Bio-diesel viscosity and calorific value 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 due to lower concentrations of bio-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

REAGENTS AND MATERIALS USED FOR EXPERIMENT

[1] Waste cooking oil for preparing bio-diesel.
[2] Methyl alcohol (CH3OH).
[3] Base catalyst (KOH) for accelerating the reaction mixture.

Experiments Performed

This experiment has been performed to evaluate performance of mechanical stirring method of bio-diesel production in terms of yield (%).Experiment has been performed with the following steps:
1. Waste cooking oil (8 kg) is filtered and then heated to 65oC and kept at this temp for about 05 min to remove impurities and moisture. This reduces the probability of soap formation during the tranesterification reaction because the reaction of transesterification and soap formation is same. The basic difference is that there are requirement of preheating is very important in case of transesterification as compared to soap formation. The sample is then cooled to room temperature.
2. Methyl alcohol (CH3OH) is taken with a molar ratio of (1:4.5 & 1:6) and Catalyst (KOH) is taken as (0.75% and 1% by wt of oil).The mixture of methyl alcohol and KOH is stirred until KOH dissolve in methyl alcohol.

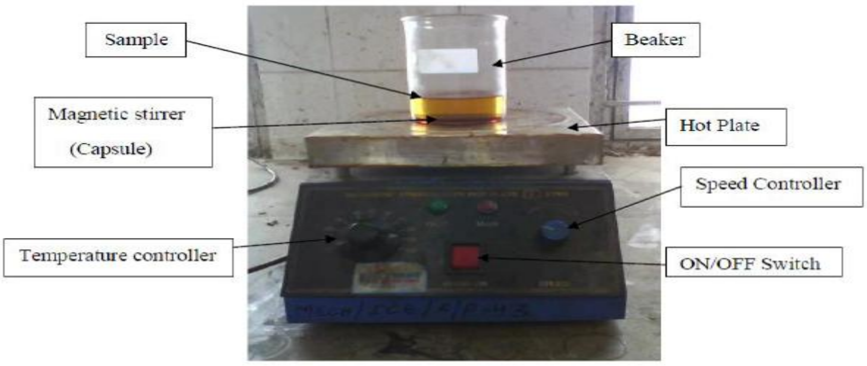

Fig 1: Experimental set-up of biodiesel reactor with mechanical stirrer

3. Now the WCO and mixture of methanol and catalyst are put together into the Beaker and mechanical stirring

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is applied. The methanol is immiscible with the oil.
4. A magnetic capsule is dipped in the mixture of oil, methanol and catalyst and rotated with the help of magnetic stirrer and mechanical stirring is applied for about10 minutes -30 minutes and more.
5. During the reaction the temperature of mixture is kept in between 60-650C.
6. While reaction taking place five samples are drawn each of 100 gm at a time interval of 35 min, 50 min, 65 min, 80 min and 95 min.
7. Samples are then allowed for phase separation of methyl ester and glycerol in separating flasks as shown in Figure 6.Fatty acid has higher specific weight therefore it will settle at bottom. Separation of methyl ester and glycerol will take 8 to 12 hr duration.
8. After complete separation bio-diesel (methyl Ester) is visible in the upper layer and glycerol at the bottom.
9. Bio-diesel is then separated from beaker for purification process and water washed. The catalyst present in the methyl ester is impurity.
10. Excess methanol present in bio-diesel has been removed by vaporization process.
11. To remove impurities and catalyst, water at around 40-50 0C is mixed with the methyl ester and left for settling down.
Water due to its higher specific gravity collected at bottom. This is shown in Figure 3.
12. Excess water is removed by heating the bio-diesel up to 1000C.

Fig 2: Glycerol separation process

Fig 3: Water washing process of bio-diesel

EXPERIMENTAL RESULTS

The experiments are performed with alcohol to oil molar ratio as 6:1 and 4.5:1. The amount of oil, alcohol and catalyst taken is shown in Table 1.

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Table 1.WCO, methanol and catalyst during the experiment

Molar ratio (methanol / oil)	Quantity of waste cooking oil (g)	Quantity of methanol (g)	Catalyst consumed (KOH)	
			1.0 % (Wt %)	0.75 % (Wt %)
6:1	8000	1765	80g	60g
4.5:1	8000	1324	80g	60g

For calculation of molar ratio following data are used Molecular weight of triglycerides from waste cooking oil = 870 g/mole
Molecular weight of methanol = 32
Hence, 1 gm mole of waste cooking oil = 870 g And 1 gm mole of methanol = 32 g ,
Catalyst (KOH) = 0.75% and 1% by weight of oil Amount of methanol for 8000g of WCO
For 1:6 molar ratio = (32 / 870) ×8000 × 6 = 1765.51 g ,
1:4.5 molar ratio = (32 / 870) ×8000 × 4.5 = 1324.13 g Sample Calculation for yield
Quantity of WCO taken = 100 g , Quantity of bio-diesel produced = 90 g (say) ,
Yield % = (Quantity of bio-diesel produced/Quantity of oil taken)*100 = (90/100)*100= 90%

Experimental Data for Mechanical Stirring Method Time and yield of bio-diesel from waste cooking oil for corresponding molar ratio and catalyst (%) are shown in the table 2.

Table 2.Time and yield (%) of waste cooking oil for different molar ratio and catalyst percentage

% of catalyst	Molar ratio 6:1		Molar ratio 4.5:1	
	Time (min.)	Yield %	Time (min.)	Yield%
0.75	35	76.85	35	72.45
	50	81.05	50	77.71
	65	88.46	65	86.05
	80	90.5	80	86.72
	95	91.40	95	87.49
1.0	35	81.95	35	74.95
	50	86.05	50	80.28
	65	91.71	65	87.95
	80	92.67	80	89.28
	95	93.11	95	89.57

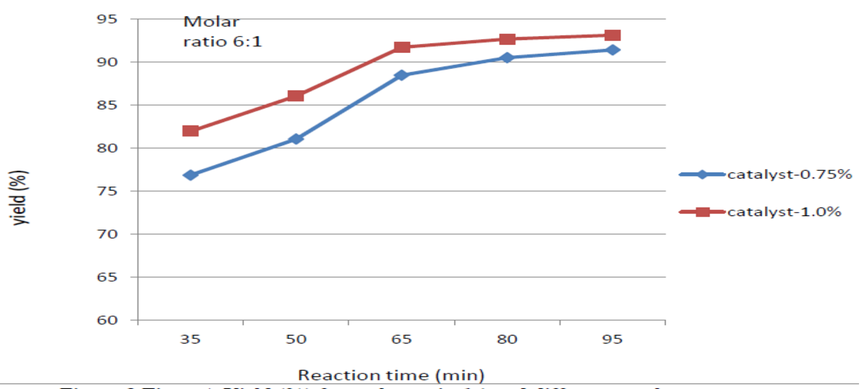

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Fig 4.Time v/s Yield (%) for molar ratio 6:1 and different catalyst percentage

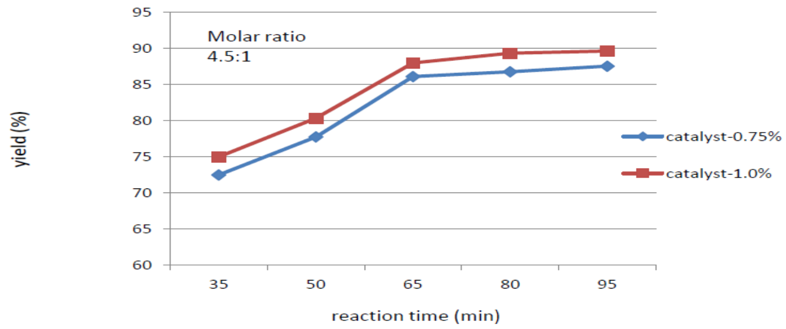

Fig 5.Time v/s Yield (%) for molar ratio 4.5:1 and different catalyst percentage

useable, and fully described information. For example, a specimen's chemical composition need not be reported if the main purpose of a paper is to introduce a new measurement technique. Authors should expect to be challenged by reviewers if the results are not supported by adequate data and critical details.
Fig 5. Papers that describe ongoing work or announce the latest technical achievement, which are suitable for presentation at a professional conference, may not be appropriate for publication in the Transactions.

CONCLUSION

The important conclusions are as follows: As shown in fig 4 and 5,

[1] It is found that in mechanical stirring the yield obtained at 1% KOH is higher as compare to 0.75% KOH.
[2] Bio-diesel yield increases as reaction time increases and eventually it becomes slight constant after 80 min of reaction time.
[3] The yield is more for molar ratio 6:1 and 1 % catalyst (max value is 93.11%) as compared to molar ratio 4.5:1 and 0.75% catalyst (max value is 91.40%).

The used cooking oil that generally goes to waste can be utilized for producing biodiesel, which is both economically and environmentally favorable. Compared to petroleum based diesel, biodiesel has a more favorable combustion emission profile, such as low emission of carbon monoxide, particulate matter and unburned hydrocarbons. Carbon dioxide produced by combustion of biodiesel can be recycled by photosynthesis, thereby minimizing the impact of biodiesel combustion on the greenhouse effect. It provides lubricating properties that can reduce engine wear and extend engine life. In brief, these merits of biodiesel make it a good alternative to petroleum based fuel and have led to its use in many countries especially in environmentally sensitive areas.

REFERENCES

[1] M. Canakci, J. Van Gerpen, 'Biodiesel Production From Oils And Fats With High Free Fatty Acids.
[2] Haq Nawaz Bhatti, Muhammad Asif Hanif, Umar Faruq, Munir Ahmad Sheikh, 'Acid and Base Catalyzed Transesterification of Animal Fats to Biodiesel' 2008.
[3] S. D. Romano and P. A. Sorichetti, 'Dielectric Spectroscopy in Biodiesel Production and Characterization', 2011 .
[4] www.ijera.com/
[5] Y. Zhang, M.A. Dube, D.D. McLean, M. Kates, 'Biodiesel production from waste cooking oil: 1. Process design and technological assessment' 21 January 2003.
[6] http://www.hielscher.com/ultrasonics/bio-diesel_transesterification_01.htm
[7] www.intechopen.com/