© 2019 IJSRST | Volume 6 | Issue 4 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Production of Biodiesel from Used Vegetable Oils

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ABSTRACT

The research emphasizes that Biodiesel can be made from used vegetable oil. Samples were collected from different street food shops around Khulna city, Bangladesh. Vegetable oil (soybean oil, palm oil and super oil) that was used for cooking purpose for several times was collected as samples. It was found that biodiesel can actually be produced and in a good quantity. From the research it was found that among soybean oil, palm oil and super oil best biodiesel is produced from soybean oil.

Keywords : Used Cooking Oils, Trans-Esterification, Biodiesel Production

I. INTRODUCTION

There are various kinds of oil used for cooking purpose which are generally categorized as cooking oil or vegetable oil. Most of the local shops in Bangladesh use palm oil, soybean oil and super oil as they are cheaper than others. They are being used for various cooking purpose in our day to day life like- for making daily meal, fast food, street food etc. Now-a-days we cannot find a single person who doesn't like to eat fast foods and street food such as Singara, Puri, Samucha, different Chops, Burger, Pizza, Fried chicken, French fries etc. These foods are often cheaper in Bangladesh, despite their low price they test so well. The most popular way to make them even testier is to use same vegetable oil again and again for cooking or frying them. However, this process to make food testier is so harmful to human health as it causes many diseases, like acidity, heart disease, alzheimer's and parkinson's disease, irritable throat (due to inhalation) etc. [9]. Reusing oil can create free radicals which cause ailments. These free radicals can be carcinogenic and can cause cancer; Also cause atherosclerosis which can lead to increase in bad cholesterol levels, blocking the arteries [9]. Acidity is a common disease for people of any ages. Also heart blocking is severe among young people. Each of these diseases causes us lots of suffering and money. It's not that reusing used cooking oil (UCO) was the only reason for these diseases but if we stop reusing UCO for cooking purpose, the number of the patient suffering from these diseases will surely decrease. In spite of the harmful effect of reusing UCO, the fast food shops and street food shops are using the same oil again and again, even up to 10 to 15 times for more profit. So it is not an easy task to make them stop reusing same oil unless a profitable alternative is provided. Fortunately, there is an alternative way where vegetable oil can be converted into Biodiesel and Glycerin by trans-esterification process, both products are valuable. In some places, used cooking oil from restaurants were re-used by street sellers to fry their food, this waste oil is termed as second –used cooking oil which can be utilized for conversion to Biodiesel [8]. Biodiesel is briefly defined as the alkyl esters of vegetable oils or animal

fats [5]. Biodiesel refers to a vegetable oil or animal fat-based diesel fuel consisting of long chain alkyl (methyl, propy1, or ethyl) esters. Trans-esterification of a vegetable oil was conducted as early as 1853 by Patrick Duffy, four decades before the first diesel engine became functional. Rudolf Diesel's (inventor of diesel engine) prime model, a single 10ft (3.0 m) iron cylinder with a flywheel at its base, ran on its own power for the first time in Augsburg, Germany, on 10 August 1893 running on nothing but peanut oil [11]. In remembrance of this event, 10 August has been declared "International Biodiesel Day" [11].

The main objective of this research is to on how we can produce biodiesel from used vegetable oil. During combustion biodiesel emits less carbon than diesel. But the price of biodiesel can be little bit higher than the ordinary diesel but not more than the treatment cost required curing the disease caused by reusing same vegetable oil again and again in cooking.

1.1 Process of Biodiesel Production

Vegetable oils need to be modified to bring their combustion-related properties closer to those of mineral diesel. The fuel modification is mainly aimed at reducing the viscosity and increasing the volatility. Considerable efforts have been made to develop vegetable oil derivatives that approximate the properties and performance of the hydrocarbon fuels. The best way to make vegetable oil compatible with existing engines is to convert it into methyl ester (Biodiesel) [1].

One of the main problems with vegetable oil compared to diesel fuel is that it's thicker, or more viscous. This is due to the fact that vegetable oil contains glycerin—a thick, sticky substance in its chemical structure. Every vegetable-oil molecule is composed of three fatty acid chains attached to a molecule of glycerin. Picture a microscopic three-legged creature with a round glycerin head and three long, dangling legs. This is why vegetable oil is described technically as a triglyceride, or three fatty acid chains and glycerin. Although the exact percentage varies somewhat depending on what kind of plant the oil comes from, approximately 20 percent or less of a vegetable-oil molecule is composed of glycerin.

Trans-esterification involves breaking every oil (triglyceride) molecule into three fatty acid chains and a separate (or free) glycerin molecule. During the process, alcohol is added, and each of the fatty acid chains attaches to one of the new alcohol molecules, creating three mono-alkyl esters. This process makes the esters thinner and more suitable for use as diesel fuel. Once separated from the glycerin, the alkyl ester chains then become what is called biodiesel [7]. Mainly, two methods are available for biodiesel production from used cooking oil;- alkali catalyzed trans-esterification and acid catalyzed esterification. Biodiesel is produced commercially using homogenous basic catalysts such as sodium (or potassium) hydroxide or methoxide because the trans-esterification reaction is generally faster, less expensive, and more complete with these materials than with acid catalysts [3].

The majority of biodiesel today is produced through homogeneous alkali-catalyzed trans-esterification of edible vegetable oils. Homogeneous catalysts are those which are soluble during the reaction, they may be liquid or gaseous. They are of two types: Acidic and alkaline. Acidic catalysts like H_2SO_4 are used widely for esterification while alkaline catalysts like NaOH and KOH are used for trans-esterification. The advantages of homogenous catalysts are-

- Ability to catalyze reaction at lower reaction temperature and atmospheric pressure,

- High conversion can be achieved in less time and
- Availability and it is economical.

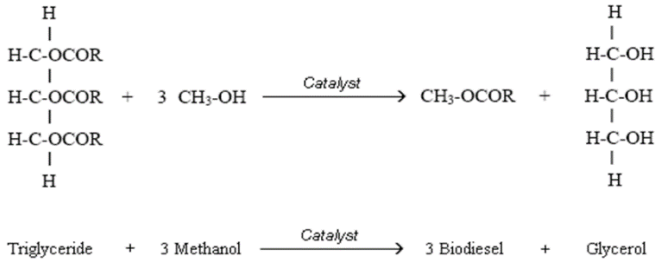

Figure-1: Trans-esterification reaction

This process enables a good product quality and a relatively shorter reaction time. This also increases the overall Biodiesel production cost as catalyst is difficult to recover and catalysts may cause reactor corrosion. The triglyceride and alcohol should be anhydrous and a low free fatty acid (FFA) content of raw material is required to avoid the soap production (by alkaline catalyst consumption) and low product yields. Waste cooking oil with higher FFA content results in decrease in the overall yield. In this case, esterification is to be done before Trans-esterification [8]. Trans-esterification is a reversible reaction. Thus excess alcohol is used to increase the yields of the alkyl esters and to allow its phase separation from the glycerol formed. Conversion of vegetable oil to biodiesel is affected by several parameters; time of reaction, alcohol to oil molar ratio, catalyst type, catalyst amount and reaction temperature [10].

II. METHODS AND MATERIAL

A research was conducted in the laboratory of Soil, Water and Environment Discipline, Khulna University to ensure that Biodiesel can actually be made from used vegetable oil (Soybean, Palm and Super).

2.1 Collection of Oil Samples

Samples were collected from different street food shops around Khulna city, Bangladesh. Vegetable oil that was used for cooking purpose for several times was collected as sample. Three samples of each kind of oil were collected from 3 different street shops except soybean oil. Because small local shop don't use soybean oil for its high price. So it was collected from only one big fast food shop and divide into three samples. The three types of oil collected – are soybean oil, palm oil and super oil. Table 1 represents the sample coding of the 3 oil samples.

Table-1: Sample coding of different types of oil

Oil	Sample 1	Sample 2	Sample 3
Soybean oil	S1	S2	S3
Palm oil	P1	P2	P3
Super oil	SP1	SP2	SP3

2.2 Pre-treatment of Oil Samples

100ml oil was taken from the different oil samples and filtered with a normal cloth sieve to remove solid particles. Then, it heated up at 54.4°C to 57.2°C. Adequate heat is required for the trans-esterification reaction.

2.3 Procedure

22ml methanol and 1.1g potassium hydroxide were mixed with the hot oil and shaken for several minutes. Then it was placed in a cool and dry place for 24 hours.

Separation: After trans-esterification two separate layers were created where the upper layer is biodiesel and the glycerol was formed the lower layer. The biodiesel was separated with the help of a separating funnel and collected for further treatment.

Purification: As some unreacted alcohol could still be present in the biodiesel so washing with distilled water was done as alcohol is soluble in water. Then heat was applied to remove the excess water if present in biodiesel.

Measurement of the amount: After purification when the biodiesel became cool then it was measured. Measurement was done using a 100ml measuring cylinder.

2.4 Measuring of Flame Height and Combustion Time

25ml of each kind of biodiesel was taken into 3 different Bunsen burner and fired up for combustion. Their flame height and combustion time was measured. Flame height was measured using steal scale and time was measured using stop watch.

III. RESULTS AND DISCUSSION

A laboratory investigation was conducted to see that can we actually produce biodiesel from used vegetable oil or not and to control the reuse (again and again) of vegetable oils for cooking purposes. And after laboratory experiment it was found that we can make biodiesel from used vegetable oil. And with government help it can be produced in mass scale with low cost.

3.1 Quantity of Biodiesel

Table 2 contains the amount of biodiesel produced from 3 different kinds of vegetable oil.

Table-2: Amount of Biodiesel made from different vegetable oils

Soybean oil	Amount(ml)	Palm oil	Amount(ml)	Super oil	Amount(ml)
S1	91	P1	94	SP1	86
S2	94	P2	90	SP2	95
S3	90	P3	88	SP3	93
Average	**91.67**	**Average**	**90.67**	**Average**	**91.33**

From Table 2 we can see that on an average a good amount of biodiesel can be extracted from soybean oil and palm oil yield the lowest among these three different oils.

3.2 Quality of Biodiesel

The quality of biodiesel is determined by the flame height, color and combustion time, flame temperature, acid number, ash, sulfated residue, carbon residue, RMS, %WT, cetane number, cloud point, copper corrosion, strip, distillation, flash point, glycerin, (free & total), oxidation stability, sediment & water, sulfur content, spectrochemical, pour point, viscosity etc. [4].

In our research due to lack of laboratory facility we can only examine flame height, color and combustion time. All of them gave oxidized flame. The bigger flame means the more the burning capacity of the fuel. Table 3 contains the flame height and combustion time for 25ml biodiesel of each kind.

Table-3: Flame height and combustion time of each kind of Biodiesel [4].

Biodiesel derived from	Flame height (cm)	Combustion time
Soybean oil	1.20	3 hours and 39 min
Palm oil	2.00	3 hours and 32 min
Super oil	1.65	3 hours and 35 min

In a flame there are two parts. One is reduced part which is blue in color and exhibits high heat energy. And the other is oxidized part which is yellowish in color and exhibits less energy [6]. Palm oil derived biodiesel had bigger flame and the oxidized portion was greater than reduced portion. So it produces less heat energy. In the experiment it is found that it burns quickly and also causes much carbon accumulation on any surface. On the other hand soybeans derived biodiesel had smallest flame and oxidized and reduced portions were almost equal. So it produces more heat energy. It is found that it burns slowly and causes less carbon accumulation on any surface. And super oil derived biodiesel was medium in quality among these three.

Figure-3: Flame height and color of biodiesel derived from soybean, super and palm oil (from left to right)

3.3 Price Comparison

As Bangladesh doesn't have the market for selling biodiesel so here a global price is shown. The cooking oil price is about 300-700 $/Ton, used cooking oil 120-600$/Ton methanol 980-1380 $/Ton, KOH pellet 900-1200 $/Ton and biodiesel is 800-1000 $/Ton [2]. These prices will increase if we want to make it in small scale. We have many fast food or street food shops so large scale production can be accomplished with government help. The shops are buying oil at 0.50 cents per liter. If we offer them 0.36 cents to buy the used oil not more than 2 times they will surely agree to sell oil. According to my finding from 1 liter used cooking oil on an average 910ml biodiesel can be produced.

Table-4: Cost of Biodiesel production and price of biodiesel in dollar

Price paid for per liter used cooking oil	Cost of 220ml Methanol	Cost of 11g Potassium hydroxide	Other cost (electricity, transport etc.)	Total cost	Price of 910ml Biodiesel
0.36	0.26	0.013	0.05	0.683	0.82

There is a net profit of 0.14$ in per liter biodiesel. So building of a biodiesel producing factory in Bangladesh will not only be profitable but also environment friendly as it produce less carbon. Also glycerin that can be produced from cooking oil will increase the profit. Price of per liter glycerin can be 0.95$ or more.

IV. SUMMARY AND CONCLUSION

An investigation was conducted to see that can biodiesel actually be made from used vegetable oil or not. The result shows that biodiesel can actually be produced and in a good quantity. Though the initial experimental cost is higher but further research may invent new processes which will reduce its cost. From the research it was found that among soybean oil, palm oil and super oil best biodiesel is produced from soybean oil. It produces more heat energy than other two. Super oil is second and palm oil is third in term of efficiency.

Reusing vegetable oil in cooking purpose can cause serious problems to our health. Diseases cost us lots of money and the sufferings cannot be quantify. So making biodiesel can be a good solution to this problem. Again fast food or street food seller will agree to give the used oil because both biodiesel and glycerol is profitable product from where they can get a good amount of money which will cover their losses.

Increasing carbon is an alarming issue today. It causes global warming. So using biodiesel will also slow down the carbon emission rate to the atmosphere. Further researches should be conducted to make biodiesel cheaper and more efficient. Also making glycerin from used cooking oil which cannot be done due to lack of laboratory facilities should also be experimented.

V. ACKNOWLEDGEMENT

At first I would like to convey my heartiest gratitude to almighty ALLAH for the successful completion of thesis in time. Sincerely thanks to my supervisor Khandoker Qudrata Kibria, Professor, Soil, Water and Environment Discipline, Khulna University. His constructive guidance, valuable advices, supports and encouragement throughout the period of research work has given the thesis even a better finishing. My family deserves my heartiest thanks for their patience and encouragement towards my studies and for providing me the best possible education facilities so that I can concentrate upon my research. I am thankful to my all friends for encouraging me to do this research.

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Cite this article as :

Badhon Ahmmed, Omega Upochay Samaddar, Khandoker Qudrata Kibria, "Production of Biodiesel from Used Vegetable Oils", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 6 Issue 4, pp. 86-92, July-August 2019.
Journal URL : http://ijsrst.com/IJSRST196410