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PRODUCTION OF BIODIESEL FROM NON EDIBLE NEEM OIL

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Abstract*-Vegetable oil has an excellent potential to be converted into biodiesel. The only obstacle to convert vegetable oil into petroleum derived fuel is the high viscosity and volatility of oil. An alternative way to decrease the viscosity is to crack the glyceride catalytically to smaller compound. In this project, non- edible Neem oil was used. From four methods of making biodiesel, double step transesterification process was used. In acid esterification, sulphuric acid was used as catalyst and in alkaline transesterification, potassium hydroxide was used as catalyst. The flash point, viscosity and calorific value of this product were measured after producing the biodiesel. And finally this value was compared with standard biodiesel and diesel.*

Keywords: Neem oil, NOME, Biodiesel properties, Transesterification

1. INTRODUCTION

Biodiesel is one of the most common alternative fuels which is used already in many countries. The demand of biodiesel especially from non-edible oil as a blending component or direct replacement of diesel fuel is promisingly increasing day by day. Biodiesel is defined as mono alkyl esters of long chain fatty acids derived from a renewable lipid feedstock, such as vegetables oils, animal fats or waste cooking oil [1].

One of the most promising choices of fuel is vegetable oil and their subordinates. Vegetable oils, primary alcohols, biomass, biogas are renewable in nature. These are various sources of fuels. Among these fuels, vegetable oils are widely available, non-toxic, environment friendly and biodegradable. The first utilization of vegetable oil in a compression ignition engine was first shown through Rudolph Diesel who utilized nut oil in his diesel engine. The coconut, sunflower, soybean, peanut, linseed, palm oil among others have been endeavored. The long term utilization of vegetable oil promoted injector coking and the thickening of crankcase oil which brought about piston ring sticking. For this reason, vegetable oils are not used in SI engine [2]. Harvests is considered as feedstock to produce biodiesel. From feedstock, oil is extracted. And this oil is converted into biodiesel. All around, there are in excess of 350 harvests distinguished as potential feedstock for biodiesel industry. It was discovered that 75% of total cost of production of biodiesel depends on feedstock. So, it is essential to find the cheapest feedstock [3, 4].

The first generation feedstock is edible oils such as soybean oil, palm oil etc. Environmental problems such as deforestation and usage of much of the available cultivable land, food versus fuel crisis has been raised by the use of edible oil in biodiesel [5-7].

The second generation feedstock is non-edible vegetable oils, waste or recycled oil such as animal fat [6]. Mahua (Madhuca Indica), Rubber (Hevea brasilensis), silk cotton tree (Ceiba pentandra), Neem (Azadirachta indica), Karjana (Pongamia pinnata) etc. are examples of non-edible oils. Huge market for edible oils as food for rapidly growing population, the higher prices of edible oils than that of fossils fuels and lower cost of non-edible oil cultivation are the reasons to consider non-edible oil as promising alternative fuel [8]. Neem oil is a non-edible oil. It grows different areas in Bangladesh. The height of Neem tree is 12 to 18 meters with a girth of up to 1.8 to 2.4 meters. The seeds have 40% oil which has high potential for the production of biodiesel. It has a higher molecular weight, viscosity, density and flash point than diesel fuel. Neem oil is generally light to dark brown, bitter and has a strong odor that is said to combine the odors of peanut and garlic [9].

The aim of this research is to produce biodiesel from non-edible neem oil using two stages (esterification and transesterification process), optimize the process parameters and then compares with other biodiesel.

2. MATERIALS AND METHOD

2.1 Materials

Magnetic stirrer bits, measuring beakers or cylinders were used for mixing the methanol and oil, a thermometer, 500 ml 3-neck flat bottom conical flask, goggles, gloves and apron were required for safety, and all these components were collected from Taj Scientific, Chittagong, Bangladesh. Neem Oil was collected from Pitambor Shah's shop, Teribazar Chittagong, Bangladesh. Methanol and Sulfuric acid, potassium hydroxide (KOH) and distilled water were collected from our Metallurgy Lab, CUET.

2.2 Production Process of NOME

A 500 ml 3-neck flat bottom conical flask was used as reactor for these experimental purposes. An automatic magnetic stirrer with hot plate arrangement was used for heating and mixing the mixture in the flask. The mixture was stirred at 600 rpm for all test runs. The temperature range of 55-65ºC was maintained during this experiment. The separating funnel was used to separate the methanol-water mixture after acid pretreatment and the glycerol after transesterification. Figure 2.1 shows the experimental setup for biodiesel production.

Oil filtration, acid esterification and alkaline transesterification are the main steps for biodiesel production.

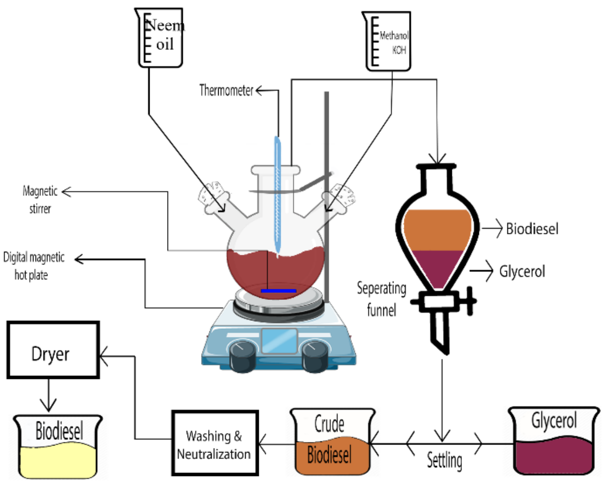

Figure 2.1: Biodiesel production process

Neem oil was filtered by using filter paper to remove ingredients. It might have to warm up a bit first to get into run freely, 60ºC should be enough. 6:1 (molar weight ratio) methanol to oil was taken and the amount of sulphuric acid was 1% (w/w oil). Then neem oil was poured into 3-neck flat bottom conical flask and heated at 60ºC temperature. Then measured amount of methanol was mixed. After some time, when the temperature was fixed at 60ºC, sulphuric acid was poured into the mixture. This mixture was stirred at 600 rpm. This stirring and heating was continuing for one hour.

This 3-neck flat bottom conical flask was merged in a water bath for proper heating. All this setup on the plate of magnetic stirrer. After acid esterification, esterified oil was poured into separator funnel. And separation was continuing for two hours. Then upper layer was collected. Titration was performed on the esterified oil for measuring the acid value.

Acid value of esterified oil was less than 2 so, the esterified oil was ready to go through transesterification process. For transesterification process, 39 gm methanol was taken for 12:1 methanol to oil ratio. And 1.78 gm potassium hydroxide was taken for 2% (w/w oil). Figure 2.2 shows the different steps for transesterification process. First, esterified oil was poured into the 3-neck flat bottom conical flask and heated at 60ºC. Methanol and potassium hydroxide were mixed and warmed up. Then, methanol-catalyst was added to oil carefully. This transesterification was performed on 60ºC because the boiling temperature of methanol is 65ºC and stirring speed was 600 rpm for 1.5 hours [10].

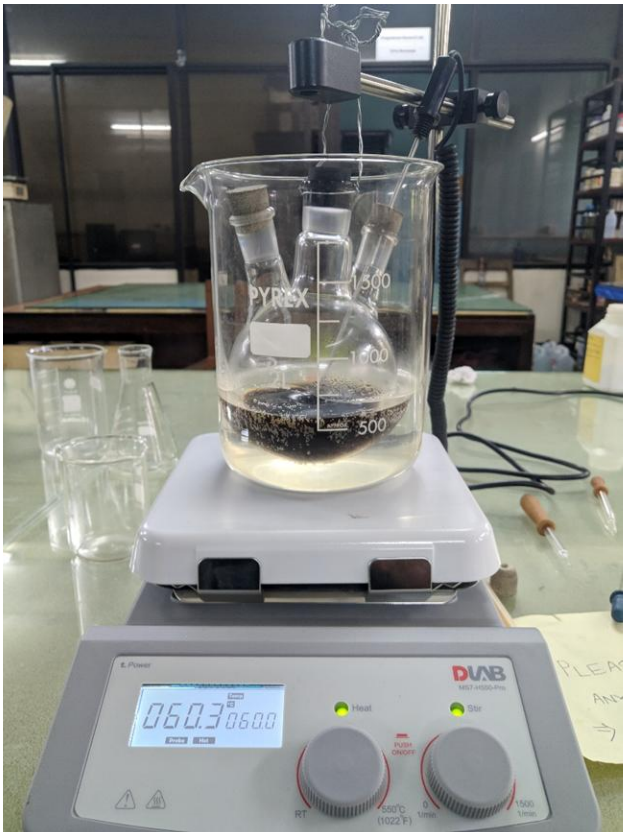

Figure 2.2: Transesterification process

As soon as the transesterification reaction was completed, the mixture was poured into separator funnel for separating glycerol and raw biodiesel. The mixture was allowed to settle 7-8 hours. After separating, there were two phases in the separator funnel with a clear interface. Dark-colored glycerol byproduct was at the bottom with raw biodiesel was on top. The biodiesel varies in color depending on the oil used. The color of produced biodiesel was light brown. The lower layer was drained off. And the upper layer was kept in separator funnel for washing.

Excess methanol, potassium hydroxide and other impurities was found from raw biodiesel. Hot water was used to wash these excess materials. The water was drained from the bottom of the separator funnel. After water washing, washed biodiesel was heated. The cause of heating was to vaporize the impurities. Hence, more pure biodiesel was found.

Production process of biodiesel is shown below by a flow chart.

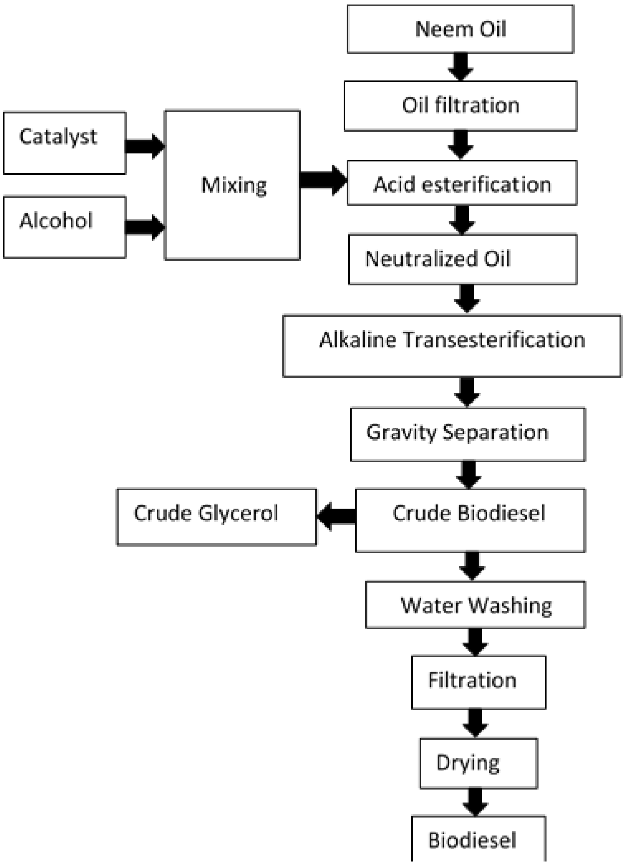

Figure 3. 3: Flowchart for production of biodiesel

Finally biodiesel was obtained from neem oil. From the left in the figure3.4, first is neem oil and second is produced biodiesel from neem oil.

Figure 3. 4: Neem oil (Left) and produced bio diesel from this neem oil (Right)

3. RESULTS AND DISCUSSION

Calorific value, density, viscosity and flash point of produced biodiesel were measured

The calorific value is an important characteristic of the biodiesel. This is now usually expressed in joules per kilogram. This calorific value depends on the state of water in the product of combustion it's refer to higher heating value (HHV) when liquid water exists in the combustion products and lower heating value (LHV) when water vapor exists in the combustion products.

From the figure below, we can compare the calorific value of the biodiesel produced from neem oil with the castor oil methyl ester (COME) and waste cooking oil methyl ester (WCOME).

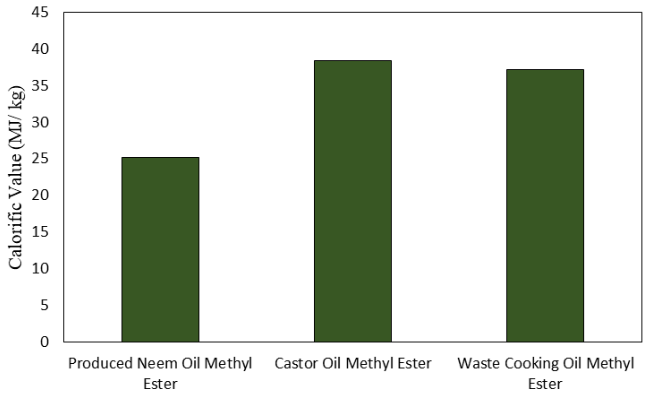

Figure 3. 1: Comparison of calorific values of methyl ester from different bio resources

From the figure 3.2, the density of the produced biodiesel from neem oil can be compared with COME and WCOME.

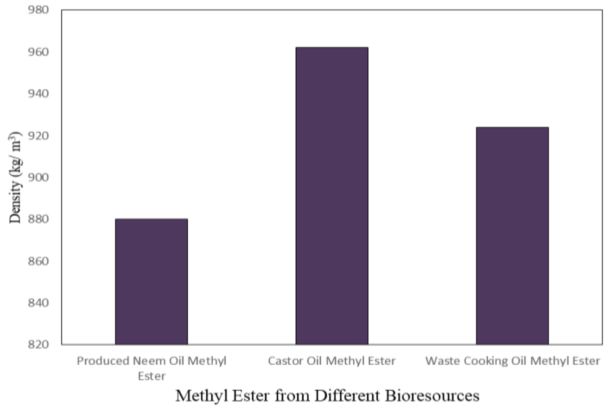

Figure 3. 2: Comparison of density of methyl ester from different bio resources

A fluid's viscosity is the measure of its resistance through shear stress or tensile stress to gradual deformation. Kinematic viscosity is the indicator of the opposition of a fluid to seep when no external force acts on it, apart from gravity. From figure 3.3, the viscosity of produced biodiesel can be compared with other biodiesel.

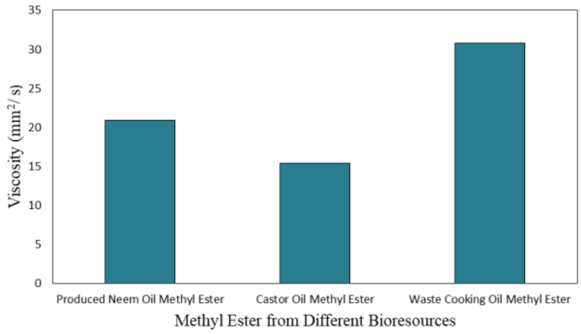

Figure 3. 3: Comparison of viscosity of methyl ester from different bio resources

4. CONCLUSIONS

From the various sources of renewable energy like solid biomass, plant/vegetable oil, animal fat etc. investigated so far, neem oil has been found to be one of the most potential alternate sources for petroleum derived fuels. The major application of petroleum fuel is in the combustion process. Vegetable oils are renewable sources which can be supplied continuously to meet the energy demand when fossils fuel will be depleted or price of fuel will be increased due to scarcity resulting from political unrest or other factors. In an effort to use neem oil as substitutes for mineral oil, difficulties are faced. Because it has high viscosity, high density, extreme clogging of fuel lines rendering the engines inoperative. They cannot be atomized quite well. The calorific value of the produced biodiesel was found 25.15 MJ/ kg. Other parameters such as viscosity was also found on the range of standard value. Environment friendly procedure was tried to maintain while making the biodiesel. The output value of different parameters of produced biodiesel, the value of standard biodiesel that is used in the daily life is shown on the table 4.1.

Table 4.1: Comparison between different parameters of Produced NOME with Diesel and Standard Biodiesel

Parameters	Produced Biodiesel	Standard Biodiesel	Petroleum Diesel
Calorific Value, MJ/kg	25.15	37.27	45.5
Flash point, ℃	156	100-170	60-80
Density, kg/m^3	880	887	745
Viscosity, mm^2/ s	20.90	1.92-6	1.9-4.1

Although Bangladesh is basically an importer of petroleum fuel, it produces some mineral oils from Sylhet. Bangladesh has great aspects of growing plentiful neem oil which can be utilized as an alternative fuel in order to meet the future transport fuel demand partially of the total energy requirement.

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