Process to Produce Biodiesel Using Jatropha Curcas Oil (JCO)

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***Abstract*—Plant oil represents the potential substance as new source energy to yield the ester methyl (biodiesel) as substitution of diesel oil. Jatropha curcas is a plant of fast growing species and well known specifically for its tolerance to almost most tropical climate and soil types, hence it is suitable for land conservation. In this study, the biodiesel oil was produced by Jatropha Curcas Oil (JCO) through two stages process. In esterification process, the FFA was successfully lowered to 0.8% by used methanol with molar ratio 16:1, 1% catalyst of acid sulphuric (H2 SO4) at 64.5 ℃ reaction temperature and at 120 minutes of reaction time. The transesterification was performed at 120 minute of reaction time, 1% for the catalyst concentration and molar ratio of 6:1 and 9:1. The physical properties were investigated in term of kinematics viscosity, density, acid value and flash point. The best yield of biodiesel at 92 % was obtained with molar ratio 6:1.**

***Index Terms*— jatropha curcas oil, biodiesel, two stages, yield and renewable energy**

I. Introduction

The name of biodiesel in chemical is fatty acid methyl ester. Biodiesel or fatty acid methyl ester is a clean burning alternative fuel. Biodiesel can be made from any vegetable oil including oils pressed straight from the seed such as soybeans, sunflower, canola, olive oil, and coconut. This biodiesel also can be made from waste cooking oil, animal fats and non-edible oils such Jatropha Curcas Oil (JCO). The concept of using vegetable oil for fuel has been around, as long as the diesel engine. Most vegetable oil can be converted into biodiesel but cost of the vegetable oil feedstock is now a factor in the least cost production of biodiesel. However, one of non-edible oil is JCO have potential to become biodiesel fuel compared with vegetable oil have would disturb the food market.

In facts, JCO cannot be used for nutritional purposes without detoxification this makes its use as energy or fuel source very attractive especially biodiesel. In Madagascar, Cape Verde and Benin, JCO was used as mineral diesel substitute during the Second World War. [1] JCO is a multipurpose bush and small tree belonging to the family of Euphorbiaceaev. It is a plant with many attributes, multiple uses and considerable potential. The plant can be used to prevent and or control erosion, to reclaim land, grown as a live fence, especially to contain or exclude farm animals and be planted as a commercial crop. It is a native of tropical America, but now thrives in many parts of the tropics and sub-tropics in Africa and Asia. The wood and fruit of Jatropha can be used for numerous purposes including fuel. The seeds of Jatropha contain viscous oil, which can be used for manufacture of candles and soap, in cosmetics industry, as a diesel and paraffin substitute or extender. This latter use has important implications for meeting the demand for rural energy services and also exploring practical substitutes for fossil fuels to counter greenhouse gas accumulation in the atmosphere. These characteristics along with its versatility make it of vital importance to developing countries. [2]

In view of these, the Jatropha curcas is suitable and more advantages to converted biodiesel. These vegetable oils are more suitable source for biodiesel production compared to animal fats and waste cooking oil since they are renewable in nature. However, there are concern that biodiesel from vegetable oil would disturb the food market. Oil from Jatropha is an acceptable choice for biodiesel production because it non-edible and can easily grow in harsh environment. [3] Moreover, alkyl ester of JCO meets the standard of biodiesel in many countries.

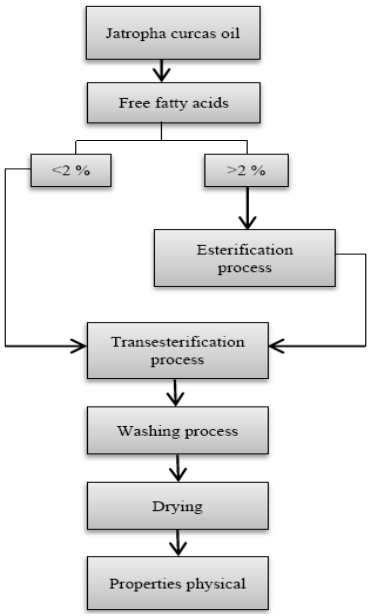

Figure 1. Flow chart to process biodiesel

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II. METHODOLOGY

Fig. 1 describes the steps, processes and methods used to produce biodiesel product. To produce biodiesel its need three steps namely acid catalyze esterification, followed by base catalyze transesterification and washing process.

III. ESTERIFICATION PROCESS

Esterification process was purpose to reduce the free fatty acid (FFA) by converting it into esters. After titration was performed and the feedstock is more than 2%, esterification process will be performed. Theoretically, esterification also will be increase the yield of biodiesel. In this process methanol and sulphuric acid (H_2SO_4) was used as chemical reaction. This process used the alcohol and acid catalyst based on the ratio. The ratio of alcohol and acid catalyst based it used as in previous to reduce FFA. The ratio of methanol to oil is 16:1 and the catalyst is 1%. [4]

In this study, the pre-treatment step was carried out by following the esterification reaction. Firstly, the JCO was heated in the three neck flask reactor. The solution of sulphuric acid (H_2SO_4) in methanol at 1 % was heated at the specified temperature, and then added into the reactor containing the heated JCO. The ratio of methanol to JCO ratio was used is 16:1 and the time of reaction was at 120 minutes. Fig. 2 shows the position of the apparatus during process of esterification.

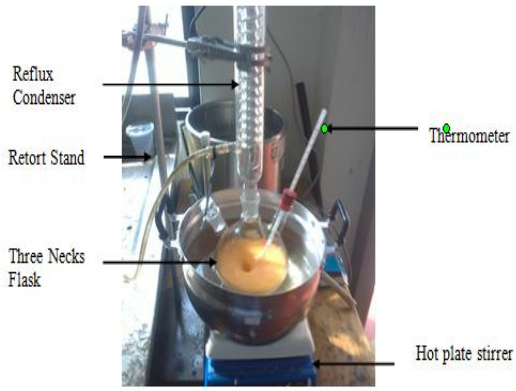

Figure 2. Position of the apparatus during the process of esterification.

IV. SEPARATION 1

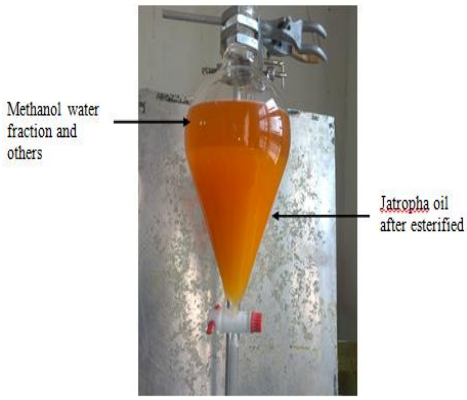

Figure 3. Shows the layers of methanol water fraction and the JCO

Separation needed 3hours to get the top methanol and bottom oil layers of the biodiesel. Two layers could clearly be seen in the successful basic esterification biodiesel. The top layer was mainly methanol. The bottom layer was mainly triglyceride product esterification after remove the water. These processes to reduce free fatty acid until below 2%. The density of the methanol is less than the bottom triglyceride. [4] After the reaction was completed, the mixture was allowed to settle down for three hours and the methanol water fraction at the top layer was removed refer Fig. 3.

V. TRANSESTERIFICATION PROCESS

Transesterification of vegetable oils with alcohol is the best method for biodiesel production. There are two transesterification methods, which are: a) with catalyst and b) without catalyst. The utilization of different types of catalysts improves the rate and yield of biodiesel. The transesterification reaction is reversible and excess alcohol shifts the equilibrium to the product side. [5], [6] Fig. 4 shows the general equation of transesterification reaction. Much different alcohol can be used in this reaction, including methanol, ethanol, propanol and butanol. The methanol application is more feasible because of its low-cost and physical as well as chemical advantages, such as being popular and having the shortest alcohol chains. [5]

$$\underset{\text{Triglyceride}}{RCOOR^1} + \underset{\text{Alcohol}}{R^2OH} \xleftrightarrow{\text{Catalyst}} \underset{\text{Alkyl Ester}}{RCOOR^2} + \underset{\text{Glycerol}}{R^1OH}$$

Figure 4: General transesterification reaction equation

Transesterification is a mixture ester and alcohol to produce methyl ester. In this experiment methanol was used because if lower cost and easily available compared to other alcohol like ethanol and butanol propanol. For the catalyst, sodium hydroxide (NaOH) will be used. This catalyst have been choose because safe to use and fast reaction. In this study transesterification was be performed at 120 minutes reaction time, at 64.5 ℃ with 6:1and 9:1 molar ratio. [5], [6]

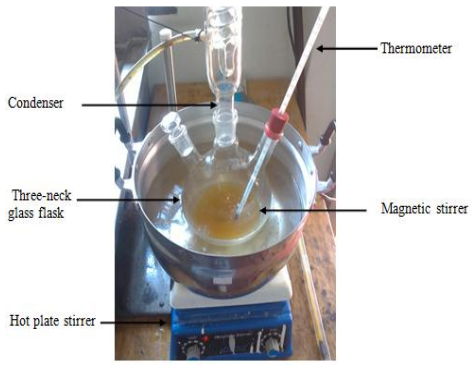

Figure 5: Apparatus of transesterification process

According to two differences catalyst with three differences molar ratio and five of properties test, the

total of samples that have been prepared 18 samples. These samples were test based on the biodiesel standard. The apparatus needed in this process is digital weight scale, three neck flasks, retort stand, water tube, condenser, thermometer, hot plat stirrer, magnetic stirrer, beaker, filter funnel and the pot. Fig. 5 shows apparatus of transesterification process.

VI. Separation 2

Transesterification process and any methanol evaporation the resultant biodiesels were left to lie for at least 8 hours. Separations were used to separate the top (methyl ester) and bottom (glycerol) layers of the biodiesel samples. Two layers could clearly be seen in the successful basic transesterification biodiesel samples. The top layer was mainly composed of free fatty acid methyl esters. The bottom deposit was mostly made up of glycerol, salts, soap, other impurities and excess methanol as it is a very polar compound i.e. it partitions more with polar glycerol as opposed to the non-polar methyl esters. [7] Fig. 6 shows two phases formed in transesterification process.

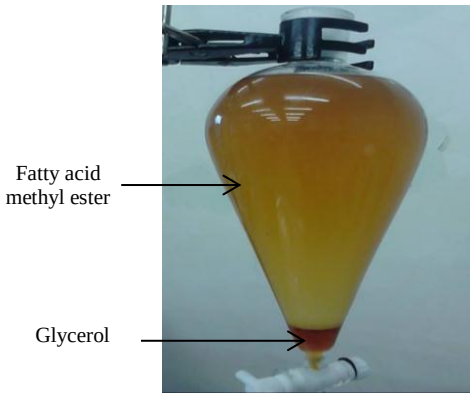

Figure 6: Two phases layer in transesterification process

VII. Washing and Separation Process

The biodiesel fuel that has been separated from glycerin was sieved by adding warm water to eliminate the remnants of catalyst or soap. Then, it was dried and kept. This is the last process in order to get the pale yellow colour of biodiesel and same concentrate as petro-diesel. There are many ways to wash biodiesel like bubble washing and mixing with water. In this study the used mixing with warm water. This process was performed after esterification and transesterification process. First of all, water was heated to washing [8] [9].

After that, water was poured into the biodiesel in the beaker. Then, mixture is stirred using mechanical stirring at slow speed until two phases formed. At the bottom phase is warm water and above phase is biodiesel. It is shown the biodiesel has a lower specific gravity than water, the water was eventually separate and settles to the bottom and the biodiesel was remained at the top.

In this point separation was took place between water and any impurities was removed from beaker. PH paper was used for the checking PH value. This process was stopped until PH paper show 7 or natural condition. [10]

For the final step in washing process is the sample oil biodiesel waste heated at 100 ℃. This step vaporized the water in the oil into the air. Fig. 7 shows two phases formed in the washing process.

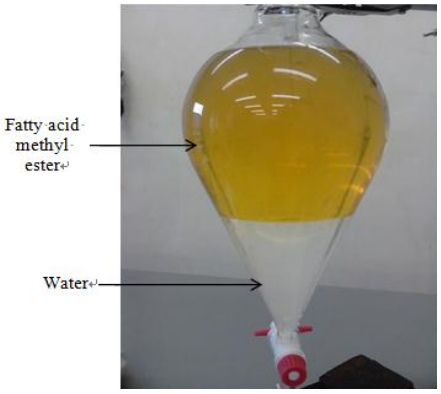

Figure 7: Two phases layer is formed in washing process

After washing process for get the pure biodiesel, fatty acid methyl ester (FAME) must heat 5 hours or above at 100°C in oven. Fig. 8 shows the biodiesel pure.

Figure 8: Biodiesel pure

VIII. Result and Discussion

The result of all testing done each of biodiesel samples for 120 minute reaction time with different molar ratio of methanol are tabulated. The result included the kinematic viscosity, density, yield of biodiesel, flash point and acid value. The results of all testing for each biodiesel samples are shown in Table I.

TABLE I. Result of all Testing for Each Biodiesel Sample

Molar ratio	Biodiesel yield (%)	Kinematic viscosity (mm/sec2)	Acid value (mgKOH/g)	Density (g/cm3)	Flash point (°C)
6:1	92%	4.23	0.39	0.9036	160
9:1	90%	3.73	0.42	0.856	160

There are many factors that could affect the yield of biodiesel. The factor such as types of feedstock, content of free fatty acid, the amount of alcohol, molar ratio, types and concentration catalyst use, reaction time and reaction temperature. In this study, the molar ratio was used as a constraint on JCO to produce the biodiesel. [11]

IX. Conclusion

As the conclusion, Jatropha curcas oil represents the potential substance as new source energy to yield the

ester methyl (biodiesel) as substitution of diesel oil. Furthermore, all the physical properties of biodiesel from Jatropha oil meet the standard of biodiesel in many countries. That shows the Jatropha curcas is suitable and more advantages to converted biodiesel. There are concern that biodiesel from vegetable oil would disturb the food market. Oil from Jatropha is an acceptable choice for biodiesel production because it non-edible and can easily grow in harsh environment. [3]

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