Production of Biodiesel from *Jatropha Curcas* by Microwave Irradiation

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Abstract : - Biodiesel is an potential fuel for diesel engine and is in demand nowdays due to several factors including price stability, limited reserve of carbon fuel, and environmental issue. Jatropha is one of the potential feedstock for biodiesel production due to its high oil content (about 40 – 65 %). It is nonedible, therefore it will not compete with food for fuel. In this study, transesterification process is chosen to transform Jatropha crude oil to fatty acid methyl ester (FAME) or biodiesel. The transesterification was carried out using microwave irradiation with homogenous catalyst. Effects of various parameters such as catalyst ratio of (2-4%) NaOH, reaction time (3-9 minutes) and solvent molarity ratio (1:16, 24 and 30) on conversion have been studied. The FAME conversion was determined using gas chromatography following the ASTM D 6584 method. Compare with the conventional heating method, the process using microwaves irradiation has effectively shortened the reaction time. The optimum FAME production conversion is 86.3%.

Keyword : Jatropha curcas, Microwave irradiation, Fatty Acid Methyl Ester (FAME), Transesterification

1. Introduction

Biodiesel as an alternative fuel for diesel engine is becoming important nowadays due to limited reserve of carbon fuel. The performance of biodiesel are very similar to the sulfur diesel for power, torque and without major changes on engines and infrastructure.[17] Additional advantages of biodiesel compare to mineral diesel are its capability to decreased of unburned hydrocarbon(HC), CO and particulate matter (PM).[16] Its fatty acid methyl ester meets most of biodiesel international standard such as America, German, European standard and was found most suitable for biodiesel.[8]. The usage of Jatropha as a replacement of mineral diesel has been recorded during the world war two in several part of the world such as Madagascar, Cape Verde, and Benin [1]. Jatropha contain phorbol ester which is poisonous, therefore, its uses as biodiesel sources are very attractive as it will not compete for food uses [10]. *Jatropha curcas* is shrub or tree of Euphorbiaceae family. The tree mostly cultivated in Central and South America, Southeast Asia, India and Africa and can withstand extreme climate [15].. *Jatropha curcas* can grow in land with as little as 250-1200 mm rainfall. It will start producing fruit as early as 6 months old, but the optimum oil yield can be obtained from fruit of age 5 years and above. It can live for more than 50 years and can reach 30 ft in height.[6]. All part of the plant such as tree, bark, leaves, fruit, shell and the the flowers can be used for cosmetic, medicine, fertilizer , insecticides, charcoal production, bean sticks and fuel[5]. Crude

jatropha oil is transform to fatty acid methyl ester (FAME) via transesterfication process. In this process triglycerides in the crude oil is reacted with methanol using homogeneous or heterogeneous catalysts. Methanol was used because it is the most common alcohol with the lowest price compare to other alcohol. [18]. Biodiesel produced will have properties similar to carbon diesel and the process will reduce the viscosity. The FAME are the raw materials for the production of long chain carboxylic acids, detergents, alternative fuels for diesel engines (biodiesel) and Mono and diglycerides[9]. Traditionally, transesterification is carried out using conventional heating method which take about one hour to to produce over 95 percent conversion and yield 99% pure biodiese[12]. Microwave irradiation is an alternative heat sources to replace conventional heat to carry out transesterification process. Microwave radiation is located between infrared radiation and radiowaves [7]. In microwave heating system energy interact with a sample in two mechanisms. If the sample has a dipole moment, the dipole will tries to align with applied electric field. Because the electric field is oscillating, the dipoles constantly try to realign to follow this. This resulted in friction and heat. If a molecule is charged, then the electric field component of the microwaves irradiation moves the ions back and forth through the sample while also cooling them into each other. [3]

In this project, biodiesel is produced from jatropha crude oil using microwave.

2. Methodology

2.1. Chemical and Equipment

Jatropha curcas seed is obtained from Bionas Sdn.Bhd (local Malaysian firm). The seeds were cleaned, de-shelled and dried at high temperature of 102˚C for 35 minutes. After the seed kernel were grounded, the seed were crushed using mechanical blender (chopper) and deffated in a soxhlet extractor. Hexane at 60˚C was used as solvent. The extracted oil were then transferred into a the rotary evaporator to recover hexane from oil mixture at 80˚C. Methanol, sodium hydroxide(NaOH), and N-Mehtyl-N-trimethysilytrifluoro-acetamide(MSTFA) were obtained from Aldrich Inc. All the solvents used in this experiment were of analytical reagent grade. Sodium hydroxide was used as catalyst because as alkaline catalyst it can act as an excellent microwave irradiation absorbers, the activity of which is greatly enhanced by microwaves[11]. Microwave unit model MW 650 (Aurora Instruments) was used for transesterification. Analysis for fatty acid methyl ester (FAME) biodiesel from Jatropha curcas were carry out using SRI gas chromatography apparatus.

2.2 Procedures

2.2.1. Transesterfication assisted by microwave heating

The transesterification reaction were carried out under the microwave heating in order to the see effect of microwave irradiation on the tranesterification process. The stoichiometry of the reaction are 18:1,24:1 and 30:1. The transesterification reaction were carried out using NaOH catalyst (0.5%,1.0%, 1.5%, 2.0%, 3.0% and 4.0%) at various time reaction 3,5,7 and 9 minutes at temperature 328 K. The crude jatropha oil the alcohol-catalyst mixture was fed to the microwave container. At least three experiments were conducted to confirm reproducibility of the results.

2.2.2 Separation of biodiesel from the reaction mixture.

The reaction mixture was centrifuged at 6500 rpm for 15 minutes and the top methyl ester phase was separated from glycerol phase. Then three ml of

purified water were added to the methyl ester, in order to remove the NaOH from the mixture. All process were triplicated.

2.2.3 FAME Analysis

The 0.1 ml methyl esters were firstly derivatized by 100 µlitre of MSTA at 298 K for 20 minutes. After that 8 mL of heptane were added to the solution before a little sample are injected to GC equipped with flame ionization detector at 380˚C and capillary column (30mx0.25mmx0.25mm). The detector temperature was programmed at initial temperature of 50˚C. Hydrogen was used as the carrier gas and the flow rate is set at 3.0 ml/min. The conversion means the concentration ration of transformed oil to initial oil x 100%.

3. Results and discussion

Transesterification reaction with microwave were performed with reaction temperature adjusted at 338K at several reaction time (3,5,7 and 9 minutes), and different ratio of oil to methanol (1:18,24 and 30) and different quantities of 2.0%, 3.0% and 4.0% of NaOH. Table 1, Table 2 and Table 3 show products obtained at mol ratio of 1:18, 1:24 and 1:30 respectively.

Table 1 Biodiesel Conversion with Catalyst of 2%, 3% and 4% of NaOH with oil to methanol 1:18

No	Time (Min)	Catalyst Percentage		
		2%	3%	4%
1	3	13.1%	23.31%	28.75%
2	5	23.14%	27.13%	39.97%
3	7	30.28%	40.62 %	71%
4	9	21%	35%	40%

Table 2 Biodiesel Conversion with Catalyst of 2%, 3% and 4% of NaOH with oil to methanol 1:24

No	Time (Min)	Catalyst Percentage		
		2%	3%	4%
1	3	30%	39.7%	45.4%
2	5	47.6%	59%	70.5%
3	7	50.1%	61.8%	80.5%
4	9	42.6%	48.4%	60.2%

Table 3 Biodiesel Conversion with Catalyst of 2%,3% and 4% of NaOH with oil to methanol 1:30

No	Time (Min)	Catalyst Percentage		
		2%	3%	4%
1	3	35.3%	47.3%	52.2%
2	5	53.2%	67.1%	79.3%
3	7	58.3%	77.9%	86.3 %
4	9	32%	45.9%	50.2%

Molar ratio of Alcohol to Oil

From Table 3, it is shown that maximum biodiesel conversion of 86.3% was obtained at excess methanol. The excess of alcohol was required to achieve a high degree of conversion and good phase separation from the glycerin as confirm by Saifuddin and Chua{13].

Catalyst Concentration

The percentage of conversion is observed to increase with increasing mol ratio of oil to methanol after for reaction time 3, 5 and 7 minute. However for reaction time of 9 minutes, the same trend is not observed as shown in Table 3.

Effect of Reaction Time

From the result, the optimum yield is obtained at reaction time of 7 minutes with 4 % catalyst and molar ratio of 1:30. Conversion will increase when the reaction times are increased except at reaction time of 9 minutes. This could be due to formation of soap during overheating which has destroyed some organic molecules. Compare to the conventional

technique which require heating time of 60 min to 75 min, the microwave irradiated technique proved to be time and cost saving.

The fast and efficient use of microwaves irradiation can be explained that during microwaves irradiation polar molecules such as methanol (in the sample) align with the continuously changing magnetic field generated by microwave that interact with molecular dipoles and charge ion, cause these molecules or ions to have rapid rotation and heat is generated due to friction of this motion. The increase in the reaction rate most probably are due to an evaluated temperature at the catalytic surface which accelerate various chemical, biological and physical processes[13].

Conclusion

Radio frequency microwaves energy was proven to be efficient and time saving method for transesterification reaction. The biodiesel with 99% conversion can be achieved at 7 minutes reaction time. The result obtained also showed high FFA of *Jatropha curcas* is also suitable to be converted to high quality biodiesel without pretreatment. Microwave assisted transesterification offer a fast and safe alternative to the current commercial process.

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