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Properties of 5% Biodiesel Produced by Small Plant using Waste Cooking Oil from a Chip Cracker Factory

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ABSTRACT

Biodiesel is a renewable alternate fuel to diesel engines that could be partially or fully replace or reduce the use of petroleum diesel fuel. Biodiesel is a diesel fuel substitute derived from vegetable oil that has several environmental benefits and both of fuel burn to produce greenhouse gasses like carbon dioxide. In this study waste cooking oil (WCO) as a raw material for biodiesel production is recognized to be an attractive and economic alternative to the use of vegetable oils. However, the presence of free fatty acids, impurities and high viscosity of WCO may require several pretretment before the transesterification but the problem with processing these waste oils is that they often highest amounts of free fatty acids that cannot be converted to biodiesel using an alkaline catalyst. An acid catalyst required to neutralize the FFA before tranesterification process. The transesterification reaction is affected by molar ratio of alcohol, presence of water and Free Fatty Acid content, reaction temperature, catalyst concentration and agitation speed. In this study, the physical properties of biodiesel produced will be test in term of water content, acid value, density, kinematic viscosity, flash point, bomb calorimeter and moisture while the chemical content will be test using gas chromatography. However further increase of alcohol content does not increase the yield of biodiesel but it also increase the cost of alcohol recovery. In this research will be compare B5 from WCO with B5 from petro station in Malaysia. Based on research found that that almost all of the properties in sample of biodiesel produced meet in standard American Society for testing material ASTM D6751(B100), ASTM D7461 (B6-B20) and ASTM 975 (diesel). Finally various properties of biodiesel such as FFA, acid value, density, flash point, kinematic viscosity and water content were measured and compare with standard of biodiesel and diesel. Overall, it can say that the waste cooking oil is very suitable to be used as a raw material in production of biodiesel.

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INTRODUCTION

Biodiesel is an alternative diesel fuel derived from vegetable oils or animal fats. The main components of vegetable oils and animal fats are triglycerides or also known as ester of fatty acid attached to glycerol. One of the main driving force for biodiesel widespread is the greenhouse gas emission (CO2 being the major one). The term waste cooking oil (WCO) refers to vegetable oil has been in food production and which is no longer viable for its intended use. WCO arises from many different sources, including domestic, commercial and industrial. WCO is a potentially problematic waste stream which requires proper management. The disposal of WCO can be problematic when disposed incorrectly.Any fatty acid sources may be used to produce biodiesel. Therefore, any animal or plant lipid should be ready substrate for the production of biodiesel. Waste cooking oil (WCO) used during this study has three (3) different categories which are storage A, B and C. Instorage A, the waste cooking oiliskeptbetween1to 4 weeks. ForstorageBit was keptbetween5 to 20weeks while forstorageC, it was stored up to 21weeks. Eachstoragehas adifferentacidvalues. When a test been conducted to determine amount of Free Fatty Acids (FFA), it was found that the amount of FFA in storage A and B were less than 1% compared to storage C which was more than 2%. Thus, an esterification process needs to be conducted first for storage C.

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Experimentation:

Waste cooking oil (WCO) as a raw material for biodiesel production it was process using small pilot plant were located at Azhar Food factory oil. It has a control board, pre-treatment, esterification tank, transesterification tank, washing&distillation, and separation tank. Yield from this process was produced B100 but only 5% of FAME are used for blending with 95% diesel

Fig. 1: The small Plant Biodiesel.

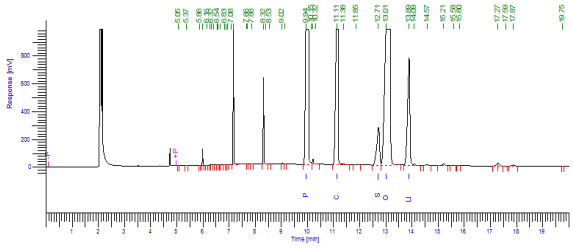

Fig. 2: analysis FAME from WCO using gas chromatography.

Peak #	Component Name	Time [min]	Area [uV*sec]	Height [uV]
1		5.053	723.60	483.66
2		5.372	1652.37	1064.95
3		5.863	280.21	196.66
4		5.985	144300.28	112505.86
5		6.163	362.16	142.73
6		6.273	1202.56	823.38
7		6.317	1375.71	853.80
8		6.401	2089.91	1752.81
9		6.544	2514.58	2090.42
10		6.581	1586.50	1207.72
11		6.645	315.33	237.16
12		6.831	778.61	362.22
13		6.878	1050.30	538.30
14		6.933	1960.03	1130.40
15		7.084	535.47	140.03
16		7.168	1658941.94	972862.24
17		7.658	10256.10	275.65
18		7.707	2105.08	1548.59
19		7.878	1122.15	439.88
20		8.316	1109323.19	624109.14
21		8.400	8949.18	2490.39
22		8.530	4248.17	1870.80
23		9.025	22327.29	9015.81
24		9.121	2059.61	825.32
25	Palmitic	9.941	8474892.97	972071.92
26		10.149	40432.27	13334.92
27		10.210	127024.34	39082.70
28		10.323	15432.47	3538.58
29	C17	11.115	7041100.89	974232.45
30		11.376	45851.08	5736.00
31		11.845	9864.20	1041.57
32	Stearic	12.712	2064014.94	270712.83
33	Oleic	13.008	14651967.93	977162.81
34	Linoleic	13.887	4717564.08	775400.14
35		14.085	68934.38	10979.68
36		14.570	45840.86	7485.38
37		15.210	95074.79	13523.06
38		15.579	9849.47	1661.22
39		15.805	1094.51	176.66
40		17.270	76004.48	20720.33
41		17.289	99922.40	20793.03
42		17.594	5474.04	896.64
43		17.873	75792.97	8684.78
44		19.751	2583.53	1598.54
			40648776.96	5.86e+06

Fig. 3: chromatogram data of methyl ester contents including area of compound in biodiesel from WCO using conversional reactor with 1% NaOH catalyst, 20 kHz agitation speed and molar ratio WCO to MeOH (1:6).

Formula for determine of methyl ester content:

$$C = (€A) \frac{- A_{EI} X}{A_{EI}} \frac{C_{EI} X V_{EI}}{m}$$

$$C = \frac{(41028892.5)-(7041101)}{7041101} \; x \; \frac{10 \frac{mg}{ml} x 5ml}{250 \; mg} \; x \; 100\% \; = 96.54\%$$

From the result showed that the molar ratio of WCO to MeOH of 6:1, NaOH catalyst of 1% and agitation speed 20kHz , produced ester content 96.54% wt.

The result of the experiment using three different storage of waste cooking oil with different molar ratio is shown in the Table 1.

Table 1: Result Properties B5 for All Storage.

Storage	Molar Ratio	Density (g/m^3)	Viscosity (mm^2/s)	Acid Value (mgKOH/g)	Water Content (%)	Flash Point (^oc)
A	6:1	0.830	3.6	0.20	0.0070	97.0
	9:1	0.831	3.6	0.14	0.0067	94.2
	12:1	0.831	30	0.13	0.0060	93.1
B	6:1	0.831	3.5	0.22	0.0080	97.1
	9:1	0.831	3.6	0.14	0.0070	94.1
	12:1	0.834	3.1	0.13	0.0067	93.1
C	6:1	0.831	3.6	0.22	0.0077	97.1
	9:1	0.831	3.7	0.14	0.0067	94.1
	12:1	0.834	3.1	0.13	0.0070	93.1

RESULT AND DISCUSSION

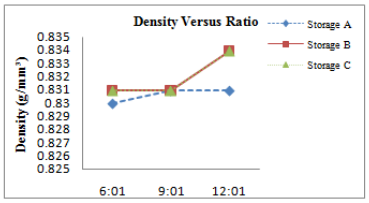

Fig. 2: Density Test Analysis.

In this study, each of the samples produced has been tested atthe temperature of 15°C as set by the Malaysian Standards for Diesel Fuel MS123: 2005, and *American Society for Testing and Materials* ASTMD6751standard. Asseen in Table4.3it is found thatthedensity ofeach sampleproducedranged between 0.83g/m3to0.834g/m3. All samples produced meet the standards set at around0.8395g/m3to0.8448g/m3.The graph inFigure4.5shows a graph of the density used for all storage. Based on the graph above, it is found thatthe density of each storage is decreasing at the ratio of 6:1but increasing at the ratio of12:1. For storage A,the density obtained is lowat the ratio of6:1which is0.83g/m3but changed to0.831g/m3 at the ratio of 9:1and at the ratio of 12:1. Similarly forstorage BandCfor which at theratio of6:1and9:1, the densities obtainedwere the same which is 0.831g/m3and then changed to0.834g/m3density at the ratio of 12:1.Itispossiblethatdue to the high content of free fatty acid (the content oftheacid) ineach of the samplesmay causethe density ofbiodieselis increasing. This is supported in a study by Tatetal., 2000,where the density of the resulting biodiesel is influenced by the FFA.

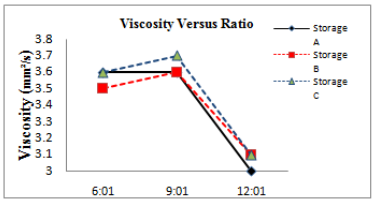

Fig. 3: Viscosity test Analysis.

From the graph in Figure4.9, it was found that the highest level of kinematic viscosity is produced at a ratio of9:1. In the ratio of 9:1 value of kinematic viscosity is the same in storage A and B which is $3.6mm^2/s$ and for the storage C is $3.7mm^2/s$. Mean while, the lowest of value kinematic viscosityat the ratioof 12:1 onstorage A is $3.0mm^2/s$ and on storage B and C is $3.1mm^2/s$. The lower value of the kinematic viscosity on biodiesel that causes it suitable as a fuel for which a high kinematic viscosity will disturb fuel in jection system, and thusinterfere with the operation of combustion engines. For the viscosity of biodiesel produced, the values obtained for each sample is around $3.0mm^2/s$ to $3.7mm^2/s$. Kinematic viscosity is obtained for all samples were allowed to meet the standards. The graph inFigure4.6shows a graph ofthe Kinematic viscosityusedforallstorage and different ratio.

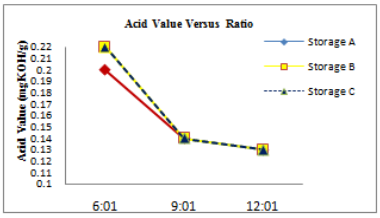

Fig. 4: acid value test Analysis.

Based on the graph plotted, it was found that the all ratios have the same value on all storage where the ratio of 6:1 was recorded a value which is 0.22mgKOH/g and at a ratio of9:1and 12:1respectively recorded values between 0.14mg KOH/g and 0.13mgKOH/g. But in the storage of A, which in the ratio of 6:1there was having little change in acid value of only 0.2mgKOH/g.

This may be caused while doing this experiment, there was an error while taking the readings. Based on the result, it shows that the value of the acid value that's been extracted fulfill the standard value that is the maximum value allowed is 0.8mgKOH/g. The value of acid is very important for a biodiesel production because the high acidity can cause corrosion problem soccur during the process of biodiesel storage. In this study, it was found that the highest value of acid is obtained from a ratio of6:1instorageBandC, which are recorded in the same acid value at 0.2mgKOH/g. In addition, the lower of acid valueat theratio12:1inallstoragewhicheach has been recorded value by 0.13mgKOH/g. The graph in Figure 4.7 shows the reading of the acid value for each storage based on the ratio imposed after the transesterification performed.

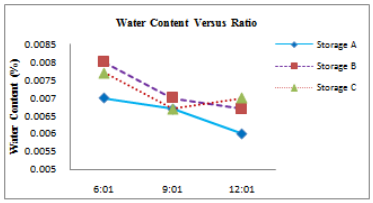

Fig. 5: water content test Analysis.

As seen in the graph, it is observed that the reduction of water content in the sample content in line with the storage of waste cooking oil (WCO) and also the current ratio period during the trasesterification process in produced. The ratio can be seen that the lowest value of water content in biodiesel sample produced in ranged from 0.006% to 0.007% on all storage. The highest value of water content at a sample ratio of 6:1 from the storage B which is 0.008%.Each of the samples produced has been achieved the standards by the Malaysian Standards for Diesel Fuel MS123: 2005, and *American Society for Testing and Materials*ASTMD6751standard.

This happens due to the effectiveness of the washing process repeatedly to ensure that the percentage of value water content in a product of biodiesel is lower and can be produced. Other than that, the water content that meets this standard caused by the drying process performed at temperature of120°Cafter washing process carried out. It is intended to remove the water of excess in the sample. Moreover, to ensure the standards of water content is achieved, magnesium sulfate added to the sample to eliminate the percentage of water content in the biodiesel. This shows that the effectiveness of the washing process is very important in ensuring thatthe water content in a product of biodiesel to be produced.

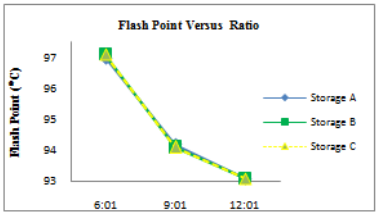

Fig. 6: flash pint test Analysis.

Flash point can be defined as the temperature required by a fuel to start a combustion process. In this study, it was found that the value of flash point obtained is around 93.1°C to97.1°C. The values obtained do not achieve Malaysian Standards for Diesel FuelMS123: 2005 because the minimum of 93.1°C and for the

American Society for Testing and Materials ASTMD6751standard is130°C. Figure 4.9 shows a graph for each sample flash point of biodiesel produced. Based on the graph, it is found that the maximum flash point is given 97.1°Cat a ratio of6:1forstorageB and C. Meanwhile, the minimum value flash point is obtained 93.1°C at a ratio of 12:1 in all storage. The difference between flash point of each sample is due to composition of water inside of biodiesel sample. The presence of water is caused by the remaining methanol, which is in the samples of biodiesel produced. Meanwhile, the higher ratio of methanol will be affected by decreasing value of biodiesel flash point to the value 93.1°C. In this graph it is seen that the flash point do not comply to the standards, because may be have errors in equipment or biodiesel. For storage in excess of the standards, biodiesel is secure in terms of storage time. The water elimination process and the methanol need to be done further to ensure compliance to standards.

Conclusion:

It can be concluded that the objective of the study on the processing of biodiesel in the pilot plant and biodiesel properties based on waste cooking oil is achieved. A total of 9sampleswere successfully produced biodiesel fuel, which used three different ratios which is at6:1, 9:1and12:1witha reaction time of120minutes.The reaction temperature was set at around 60°C. The experimental data have been collected and recorded according to properties that were tested such as the density, kinematic viscosity, water content, flash point and acid value. In order to produce biodiesel, storage C needs to undergo esterification process first. However for storage A and B only transesterification process was carried out. This process was done after the tests on the free fatty acid (FFA). The value of percentage in the FFA plays a role in determining the process to be initiated. Inesterification process, the two layers will be produced, namely triglyceride sand methanol. The higher the ratio that we used, the higher the quantity of triglycerides produced, however it will cause biggesusage of to produce biodiesel .For the test of density, each sample meets the standards set at around0.81g/m3to0.87g/m3 and also has to meet the standards of ASTM D7461(B100), ASTM 6751(B6-B20) and ASTM D 975(diesel) American standard for testing and Material .Meanwhile, the value of kinematic viscosity of each biodiesel sample produced is important because it was related to the transesterification process. This is because the process of transesterification is to reduce value of the kinematic viscosity. While for the testing of acid value and water content, both met the required standards. For flash point, the value generated exceeds the standard set of93.0°C. This may happen due to any fault on the equipment. Flash point in excess of the standards is safe in terms of storage. The difference betweenB5biodieselfrom waste cooking oil (WCO), pure diesel and B5 (Petron) is only at the ratio of12:1because at the other ratios they are almost similar in terms of properties. It was found that the properties of biodiesel produce by waste cooking oil (WCO) are similar to petroleum diesel. Overall, it can be said that the waste cooking oil (WCO) is very suitable to be used as raw materials. Besides, it must undergo a process of free fatty acid FFA to reduce the percentage of2% before starting of the biodiesel process.

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