RHEOLOGICAL BEHAVIOUR OF LIQUID FUEL EMULSION BY FOOD WASTE BASED ON CHAR SLURRY AND NON-IONIC SURFACTANT

Noorsyahima Abdul Hamid, IR Normadyzah Ahmad and Fazni Susila Abdul Ghani

Faculty of Chemical Engineering, Universiti Teknologi Mara

***Abstract*— Nowadays, world have facing with many challenging and famous issues that is pollution. Municipal solid waste especially food waste contributes to the greenhouse gas emission via decomposition and life cycle activities process. Landfill is the main causes to the gas emission to the environment and landfill is the first strategies in handling the solid waste. Alternative ways have been recovered to minimize the greenhouse gas emission to the environment by converting the food waste to liquid fuel that are more environmental friendly. The purpose of this research conducted to determine the optimum temperature of pyrolysis to produced biochar using food waste by calculating and analyzing the highest carbon value of char produced. This research also is done to study the rheological behavior of biochar slurry as liquid fuel using non-ionic surfactant. The food waste that are being used in this research is tofu where the tofu was collected from the restaurant near Seksyen 7, Shah Alam. The tofu was pyrolysed at temperature in range 400-600 ºC with time taken 4 and 5 hours respectively. The pyrolysed tofu was grind and analyzed their carbon content, energy density and ash content. The highest carbon content of biochar was selected to analyze the rheological behavior using rheometer. The highest carbon content is obtained at decreased temperature and time taken. From experimental result that has been conducted, the highest carbon content was obtained at temperature 400ºC with time taken 4 hours with 62.7965% of carbon in the biochar.**

***Keywords*— food waste, pyrolysis, liquid fuel emulsion**

I. INTRODUCTION

Food loss or also known as food waste can be defined as decreasing in quality of food through supply chain that leads to edible food for human consumption. Food loss or food waste usually occurred at the end of the food chain such as retail and consumption that relates to the retailer's and consumer's behavior (Parfitt et al, 2010).

According to the Food and Agriculture organization of United Nations (FAO), about 32% of the food produced in the world will be loss or wasted in 2009. Food waste or food loss gives negative impact environment. FAO defined food loss as changes in viability of food, food edibility, wholesomeness of the food and quality of the consumable material that human cannot be consumed the food anymore (Girotto et al, 2015). The food loss usually occurred in the food production, post-harvest and processing time of food ending when it comes to the final consumer (Gustavsson et al, 2011).

Malaysia has population approximately about 27 million people and population density in Malaysia is 79.87 per km. Malaysia achieved a remarkeable economic growth that brought an exponential growth population with high influx of foreign workers. The increase in population in Malaysia will increase the amount of municipal solid waste generated in Malaysia (Kadir A.S et a, 2013).

The average amount of municipal solid waste produced in Malaysia was estimated from 0.5-0.8 kg/person/day in 2013 and will increase to 1.7 kg/person/day (Kathirvale et al, 2003). The Star recorded that Malaysia waste about 15,000 tonnes of food daily including 3,000 tonnes is still fit for human consumption (The Star, 2016). Malaysian Agriculture Research and Development Institute (MARDI) conducted a research on food waste in Malaysia and found that about 28.4% of the paddi produced is wasted while for fruits and vegetables about 20 and 50% is thrown away respectively.

Table 1.
Waste generation in Peninsular Malaysia (tons/year)

States	Population (2000)	Waste generated (2000)	Population (2001)	Waste generated (2001)	Population (2002)	Waste generated (2002)
Johor	2252,882	1915	2309,204	2002	2366,934	2093
Kedah	1557,259	1324	1596,190	1384	1636,095	1447
Kelantan	1216,769	1034	1247,188	1081	1278,368	1131
Melaka	605,361	515	620,495	538	636,007	562
N. Sembilan	890,597	757	912,862	791	935,683	827
Pahang	1126,000	957	1154,150	1001	1183,004	1046
Perak	1126,000	1527	1841,489	1597	1887,527	1669
Perlis	230,000	196	235,750	204	241,644	214
Penang	1279,470	1088	1311,457	1137	1344,243	1189
Selangor	3325,261	2826	3408,393	2955	3493,602	3090
Terengganu	1038,436	883	1064,397	923	1091,007	965
Kuala Lumpur	1400,000	2520	1435,000	2635	1470,875	2755

Source: Ministry of Housing and Local Government (2003).

Figure 1: Waste generation in Penisular Malaysia (tons/year)
Source: Ministry of Housing and Local Government, 2003

Figure 1 showed Selangor has highest solid waste generated about 3090 tons per year in 2003 followed by Kuala Lumpur 2755 tons per year. Perlis has lowest waste generated about 214 tons per year followed by Melaka and Negeri Sembilan that are 562 tons per year and 827 per year.

Hayati Ismail, Director of the Food Aid Foundation said there are three major sources that are causing food waste in Malatysia. The number one source of food waste is from household, second source is from night markets and Ramadhan Bazaars and the third source is from food court then came the food and beverage sector.

50%

United Nations Food and Agriculture Organization (FAO) estimates roughly about one third of global food production is either lost or wasted is draining natural recourses and contributes to negative environmental impact such as emission of green-house gases via decomposition and life cycle activities process. This is because, landfill is the main causes to the gas emission to the environment and the landfill is the first strategies in the management of solid waste internationally. Municipal solid waste contributes to the green house gas emission approximately about 5%. The 5% of the green house gas emission contains methane gas came from anaerobic decomposition of solid waste and give negative impact to the environment (IPCC, 2006).

The purpose of this research conducted is to reduce the problem by the food waste by converting the food waste to the biodiesel. There are two main objectives of this research that are to determine the optimum temperature of pyrolysis process to produced biochar using food waste by calculating the highest yield and analyzing the carbon value of the char produced. The second objective is to study the rheological behavior of biochar slurry as liquid fuel using non-ionic surfactant.

II. METHODOLOGY

A. *Materials*

1. Preparation of Tofu
   The tofu was collected from the nearest café and restaurant in section 7, Shah Alam and being washed using de-ionized water to remove from other food residue. Next, the tofu is dried using oven at temperature 60 °C for two days in order to lower the moisture content in the tofu until 10%. The tofu was weighed before and after dried and the data was recorded in the table.

2. Pyrolysis
   The dried tofu was pyrolysed using pyrolysis chamber at different temperature and different residence time taken. The temperature used in this pyrolysis process is 400 °C, 500 °C and 600 °C for 4 hours and 5 hours respectively.

3. Carbon Content
   The dried tofu was grinded using grinder machine to lower its surface tension before and after pyrolysis process. Carbon content was analyzed using CHNS analyzer and the result was tabulated according to the temperature and residence time of the pyrolysis process. CHNS analyzer was used to determine the percentages of carbon, hydrogen, nitrogen, sulphur and oxygen of the sample. The sample with highest carbon content will take to proceed to the next step.

4. Ash Content
   The grinded pyrolysed tofu was analyzed its ash content using thermo gravimetric analyzer. The ash content of the sample need analyzed before and after the pyrolysis process to determine its differences of the sample. Thermo gravimetric analyzer gives the information that can be used to select materials for several uses, performances of the product and improved the quality of the product.

5. Energy Density
   The grinded pyrolysed tofu was analyzed its energy density using bomb calorimeter. The energy density need to analyze before and after pyrolysis process. Bomb calorimeter is used to measure the internal energy change between reactant and product. Higher energy density needed to produce good quality of fuel. (US eia, 2013)

6. Production of liquid fuel
   The highest carbon content char powder is selected to produce liquid fuel. About 30%, 40% and 50% of solid residue (char powder) is mixed with non-ionic surfactant to produce the liquid fuel. 50g of liquid fuel is prepared by mixing 30% of solid residue (15g), 30 g methanol and 5g surfactant together. The solid residue was added gradually into the methanol and non-ionic surfactant under low agitation speed. The solution is mixed using

hot plate mixer about one hour to make sure the solution mixed well. The steps were repeated using 40% and 50% of solid residue respectively.

III. RESULTS AND DISCUSSION

A. Carbon content on the sample on different temperature and time.

Biomass contains carbon, oxygen, sulfur, nitrogen, ash and small quantities of few other elements which include alkali metal, alkaline earth metal and heavy metals. The composition of carbon, hydrogen and oxygen in the biomass controls the property of fuel to predict the heating value of biomass. In addition, carbon, hydrogen and oxygen are the main contributors of the energy content of biomass while nitrogen and sulphur found in small quantities. The biomass contains fewer amounts of nitrogen and sulphur compared to the fossil fuel. This make the biomass liquid fuel is more environmental friendly and not cause to acid rain and green house gas emission (Minoj Triphati, 2015).

In order to get a highest carbon content in the char powder, the temperature of pyrolysis process should be decreased. This is because when the temperature increased, more volatile components from carbonaceous structure of the char will be removed. As a result, new porous structure will formed and cause lower carbon content in the char powder (Abdelrahman B. Fadhil et al, 2016).

Besides, increasing the residence time of pyrolysis process will cause decreasing in carbon amount in the char powder. This is because longer residence time in the presence of steam will gasify more carbon particles and resulting lower carbon amount in the char (Abdelrahman B. Fadhil, 2016).

The carbon content of biochar is analyzed using CHNS analyzer where the percentage of hydrogen, carbon, oxygen, nitrogen and sulphur of the biochar was determined. CHNS analyzer followed Dumas Method that involved complete or instantaneous oxidation of the sample by flash combustion. The output signal detected by thermal conductivity is proportional to the concentration of the individual components of the biochar.

Sample	Temperature (°C)	Time taken (hours)
Tofu 1	400	4
Tofu 2	400	5
Tofu 3	500	4
Tofu 4	500	5
Tofu 5	600	4
Tofu 6	600	5

Table 2: Temperature and time taken of pyrolysis process

Sample	Nitrogen (%)	Carbon (%)	Hydrogen (%)	Sulphur (%)
Tofu 1	9.1806	62.7965	5.1426	0
Tofu 2	8.7483	56.0656	4.1552	0
Tofu 3	8.0284	47.5897	1.3819	0
Tofu 4	7.9155	49.5488	3.6243	0
Tofu 5	5.5508	38.0141	1.5660	0
Tofu 6	4.9986	30.6103	1.2917	0

Table 3: Chemical composition of pyrolysed sample at different temperature and time

Table 2 shows the temperature used and time taken for pyrolysis process to determine the optimum temperature while table 3 shows the chemical composition of biochar at different temperature and time taken. As we can see, the percentage of carbon content in the biochar higher when the temperature and time taken of pyrolysis process decreased.

B. Energy Density on sample with different time and temperature

Energy densities of the samples were analyzed using bomb calorimeter. The energy densities of the samples were analyzed before and after pyrolysis process. Table below shows the energy densities of each sample with different time and temperature.

Sample	Energy density (J/g)
Tofu 1	29,108
Tofu 2	25,961
Tofu 3	22,519
Tofu 4	17,942
Tofu 5	17,714
Tofu 6	16,452

Table 4: Energy densities of the sample at different time and temperature

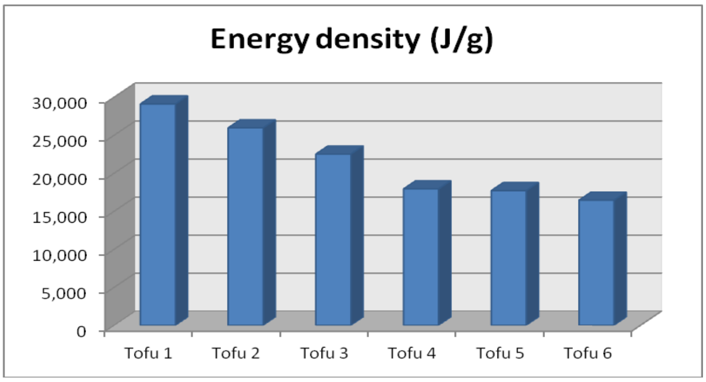

Figure 2: Graph of energy densities of sample at different temperature and time

The graph shows energy density of tofu 1 is highest compared to other samples. Tofu 1 was pyrolysed at temperature 400 degree Celsius with time taken 4 hours. The lowest energy density was tofu 6 in which temperature used was 600 degree Celsius with time taken 5 hours.

Energy density of the sample will increase as the temperature and time taken for pyrolysis process decreased. It have been proved in figure 1 which the highest energy density of sample was tofu 1 where temperature used was 400 degree Celsius with time taken 4 hours. As conclusion, tofu 1 is the most suitable sample for preparing liquid fuel emulsion because tofu 1 have highest value in carbon content and energy density compared to others sample.

C. Rheological behavior of liquid fuel emulsion

IV. Conclusion

In this study, rheological behavior of the fuel emulsion using food waste based char by non-ionic surfactant was carried out. The rheological behavior of liquid fuel emulsion was analyzed using rheometer. There two objectives that need to be achieved at the end of this study. The first objectives of this study is to determine the optimum temperature of pyrolysis process to produced biochar using food waste by calculating the higher yield and analyzing the highest carbon value of char produced. The second objective is to study the rheological behavior of biochar slurry as liquid fuel using non-ionic surfactant. In order to get highest carbon value and energy density of biochar, lower pyrolysis temperature and shorter residence time must be used. 50% of solid loading (biochar powder) from 50 g of liquid fuel is not compatible with non-ionic surfactant due to the fluctuated pattern on the graph of viscosity versus time. 40% and 30% of solid loading (biochar powder) from 50 g of liquid fuel is suitable to produce liquid fuel emulsion since their viscosity decreased with time. The rheological behavior of the liquid fuel emulsion based char using food waste with non-ionic surfactant is pseudo-plastics behavior and suitable for fuel combustion.

V. RECOMMENDATIONS

In order to get accurate results, some recommendations should be considered while conducting this research. The moisture content of food waste must be lowered until 10% in order to get accurate result in carbon value and energy density. This research has only investigated the rheological behavior of food waste that is tofu with non-ionic surfactant. Some recommendations should be considered for further study by changing the food waste used as raw material in producing char slurry. In this research, non-ionic surfactant that was used is Triton X100, therefore different types of non-ionic surfactant can be used to study the rheological behavior of liquid fuel emulsion. There are three types of surfactant that are non-ionic surfactant, cationic surfactant and anionic surfactant. This research only focused on the non-ionic surfactant. So that for further study, cationic surfactant and anionic surfactant can be used in order to get results with flying colour. In this research, the production of liquid fuel using food waste with non-ionic surfactant was carried out. For further studies, the rheological behavior of liquid fuel emulsion based char using food waste without surfactant can be analyzed to determine the rheological behavior of the liquid fuel.

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