Dr ahmad rafizan-LECTURER/Diploma of Chemical Engineering

Torrefaction of sewage sludge

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Abstract

Torrefaction is a treatment which serves to improve the qualities of biomass in relation to thermochemical processing techniques for energy generation.in this study, the torrefaction of sewage sludge, was investigated in a furnace model MF106 at temperature ranging from 150 to 300°C, for torrefaction residence time varying from 5 to 60 min. the torrified sewage sludge product was studied to obtain the energy content and percentage yield.

Keywords: Sewage sludge;torrefaction;energy content;percentage yield

1. Introduction

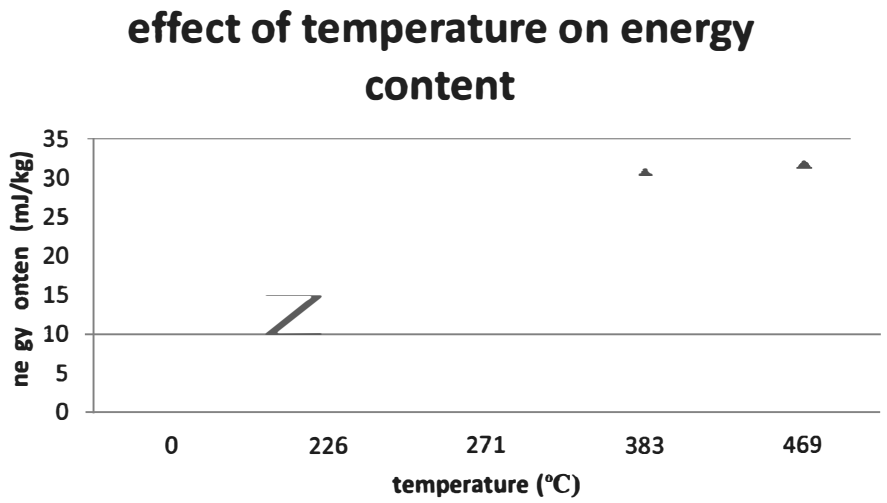
Fuel is really essential in generating energy for human use in any application of life in this world. There is a lot of type of fuel that has been used for world consumption. For example, fossil fuel which is then be processed to be the energy for the vehicle. Nowadays, the fuel source for energy is getting decreasing due to the demand and needs of the world. In fact, the European country still depends on coal combustion for energy industries(Tropek, Cerna, Straka, Cizek, & Konvicka, 2013). The way to overcome this problem is by converting the waste in this world to be the fuel source for the energy. One of the wastes is sewage sludge.

Sewage sludge is a form of biomass that can be formed into charcoal as a source of energy. It can be obtained from wastewater treatment as by-products which consist a mixture of water, inorganic and organic material(Khalid Usman, 2012). The conversion of this biomass into energy lead to eco-friendly environment in which it can prevent global warming as it is also one of the way to promote society to use waste into a useful source of energy effectively(Youichi Koga, 2007).

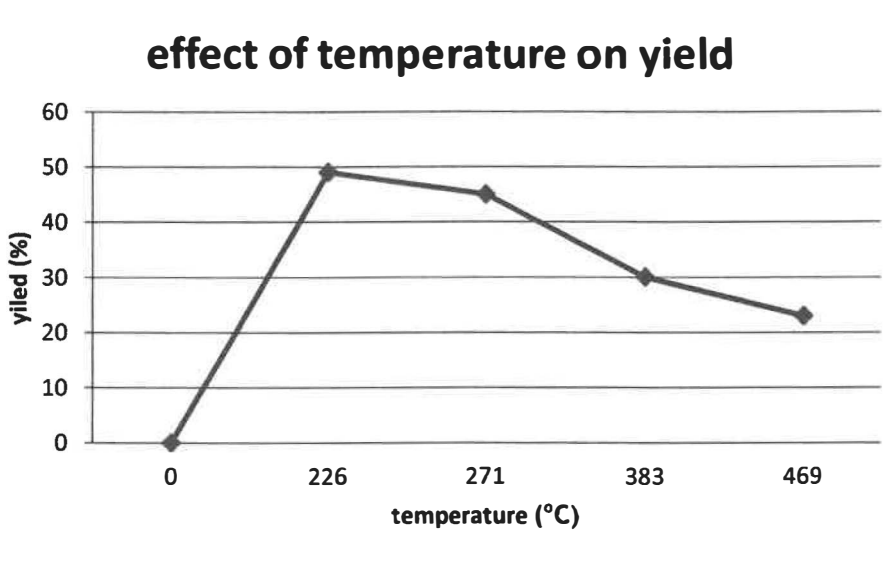
There are some types of process that can be used in turning the sewage sludge into charcoal. The processes are carbonization, pyrolysis, torrefaction and hydrothermal carbonization. Carbonization requires high temperature and occurs in slow and long process. For pyrolysis, it is focusing on thermal process producing liquid extracts from biomass.its temperature ranging from 450 to 850 °C(Inguanzo, Domínguez, Menéndez, Blanco, & Pis, 2002). For hydrothermal carbonization; it is the process of biomass conversion in the presence of water. Its occurs at temperature of 250°C with 15 min residence time(Parshetti, Liu, Jain, Srinivasan, & Balasubramanian, 2013) and takes place in a wet condition of close reactor. Torrefaction is a process of nearly complete degradation of hemicellulose without presence of air in certain amount of time.

All of these processes involve in the thermal decomposition of biomass but have differentiation in a method of each process is being conducted and. It differs in term of heating rate, temperature range of heating and also the type of product needed. Among all of these processes, torrefaction method has been proven to be the most effective method in achieving optimum result. This has been proven in data graphical plot for each process and torrefaction gives the optimum result. Graph 1 and shows the data plot for all process describe above.

Graph 1.effect of temperature on energy content



Graph 2.effect of temperature on yield



Torrefaction can be defined as a thermochemical process in a condition of no oxygen or limited amount of air where biomass is being heated slowly within temperature range required and are retained in a stipulated time towards near complete degradation of its hemicellulose content and at the same time maximizing mass and energy yield of solid product(Basu, 2013). The typical temperature for this process is in range 200 to 300 °C (P.C.A Bergman, 2005). Besides, the heating rate for this process must be slow at about less than 50°C/min. The concept of this process is to increase its density of energy by increasing carbon content in the absence or low amount of oxygen.

To be clear, the main objective of this research is to obtain optimum yield percentage and energy content by hydrothermal decomposition of sewage sludge into charcoal through torrefaction.

2. Material and methods

2.1. Raw material

Sewage sludge obtained from wastewater treatment plant in Masai, Johor was used as the raw material in this study. After collection, sample was dried at 105°C for 24 h (Poudel, Ohm, Lee, & Oh, 2015).table 1 shows the properties of the sewage sludge sample used in this study. The moisture content of the raw sewage sludge was 11.09 %.

Table 1.the properties of the sewage sludge sample

Initial weight	306.46 g
Oven-dry weight	275.87 g
Moisture content	11.09 %

2.2. Experimental system

In this study, a furnace model MF 106 was used for torrefaction. A prescribed amount of sample was weighed and put in two crucibles. The first crucible is covered with its own lead. The second one is covered with aluminium foil. The purpose for using the two crucibles with different lead is to identify which lead has the maximum efficiency to prevent oxygen from enters the crucible. The temperature of the furnace was raised to different desired temperatures ranging from 150 to 300°C.

2.3. Experimental design

Two set of experiment was carried out. First experiment is to investigate the influence of temperature towards time with the time is kept constant. The second one is to investigate the influence of time towards temperature with the temperature being the constant variable. Table 2 and 3 shows the set of data for the two set of experiment.

Table 2.effect of temperature on time

Time (min)	Temperature (°C)
30	150
30	200
30	250
30	300

Table 3.effect of time on temperature

Time (min)	Temperature (°C)
5	250
15	250
30	250
60	250

The aim for these two experiments is to identify the optimum condition for torrefaction. When the torrefaction temperature and torrefaction residence time reached the required experimental condition, the heating furnace was immediately stopped. The torrified sample was then instantly removes and was weighed. The purpose in weighing the sample is to know the percentage yield of charcoal from the torrefaction process. The percentage yield are defined by equation 1 as used by (Bridgeman, Jones, Shield, & Williams, 2008)

$$\text{Mass Yield } (Y_{mass}) = \frac{\text{mass after torrefaction}}{\text{mass of raw sample}} \times 100\% \quad (1)$$

Energy content also will be study in this experiment by using bomb calorimeter.

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Research Project Rubric (CHE 364)
(Coursework : 15%)

Title:TORREFACTION OF SEWAGE SLUDGE

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Experimental/Simulation & Modeling Project

Criteria/Allocated marks	**Marks**
Introduction	/10
Methodology	/10
References	/5
Format	/5
TOTAL	**/30**

Evaluator: _____