IOP Conference Series: Materials Science and Engineering

PAPER • **OPEN ACCESS**

Fast pyrolysis corn husk for bio-oil production

To cite this article: L Maulinda *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1098** 022007

Fast pyrolysis corn husk for bio-oil production

L Maulinda[1], H Husin[1,2,*], N Arahman[1,2,] C M Rosnelly[1,2], E Andau[2], W Lestari[2] and J Karo-Karo[3]

[1] School of Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia
[2] Reaction Engineering and Catalysis Laboratory, Department of Chemical Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia
[3] Baristand Industri Medan, Badan Penelitian dan Pengembangan Industri, Kementerian Perindustrian

*husni_husin@che.unsyiah.ac.id

Abstract. The fast pyrolysis of corn husk was studied by using a tube pyrolysis unit. This research aimed to produce bio-oil from corn husk through a fast pyrolysis process. Pyrolysis is a thermochemical decomposition process of biomass at high temperatures with the absence of oxygen. The products in pyrolysis combustion are solids (bio-char), liquids (bio-oil), and gases. The major factors to get excellent products of pyrolysis are temperature and time. The corn husk was dried at 105 °C in the oven to reduce water content. The dried sample was burned at temperatures of 250, 300, 350, 400, 450, and 500 °C by flushing the nitrogen gas inside the tube for two h. The highest yield of bio-oil was reached of 33.3% at a temperature of 400 °C. Bio-oil characteristics such as density (1.007 gr/ml) and viscosity (0.9625 cSt) were observed. The composition of bio-oil was identified using Gas Chromatography-Mass Spectrometry. Its composition was composed of hydrocarbons such as acids, furfural, phenols, and ketones.

1. Introduction

In the last decades, the utilization of biomass as energy is receiving great interest in terms of current energy scenarios. Biomass is one of a promising alternative resource which can be used to substitute the traditional fuel energy. In the present, several methods of biomass conversion have been developed, among a variety of thermal conversion in biomass, pyrolysis is the preferred one [1-3]. Pyrolysis is the thermal degradation process in the absence of oxygen to produce bio-oil [4]. Bio-oil is the dark-brown liquid that is formed from the condensation process after heated [5]. The chemical composition of bio-oil depends on the biomass used because it was formed from decomposition and degradation of hemicellulose, cellulose, lignin, and the other various compounds.

Corn-husk is one of the major agricultural waste which is potential to be converted as a renewable energy resource. Corn-husk has the lignin, cellulose, and hemicellulose content of 4.46%, 57.74%, and 34.03%, respectively Recently, BPS of Indonesia – Aceh, was reported that 38.38% of corn-husk was produced yearly. Up to the present, not many industries benefit the corn-husk maximally. It comes to be polluted to the environment and agricultural waste [6-8].

In this research, we attempt to develop a characterization of bio-oil from corn-husk through a fast pyrolysis process at varying temperatures. The characterization of bio-oil was attended to determine the density and viscosity of bio-oil and for the characterization of it is analyzed using chromatography-mass spectroscopy (GC/MS).

IOP Conf. Series: Materials Science and Engineering 1098 (2021) 022007 doi:10.1088/1757-899X/1098/2/022007

2. Materials and methods

2.1. Material preparation
Corn husk was obtained from the traditional market in the Lambaro, Aceh Besar. Firstly, the corn husk was cleaned up and dried under the sun light until half-dried for 2 days. Afterwards, the half-dried corn husk is dried again in the oven at 105ºC for 12 hours to reduce the water content. After that, the dried corn husk was mashed using grider to reduce to size of sample.

2.2. Bio-oil characterization
The Bio-oil product was characterized using Gas Chromatography-Mass Spectrometry (GC/MS) Seri QP 2010 Plus - Shimadzu and completely with DB-5ms column (for polar compound) seri 998847 to identify the component. Density and viscosity were analyzed according to ASTM D 4052 and ASTM D 445, respectively.

2.3. Fast pyrolysis process
The fast pyrolysis process was carried out using Tube Furnance Type 21100. Firstly, 20 grams of corn husk is added into the reactor. Prior to the pyrolysis process, N2 gas was transported into the reactor system of 1 L/min for 30 minutes. After that, the process is continued by heating the corn-husk in the varied temperature 250ºC, 300 ºC, 350 ºC, 400 ºC, 450 ºC and 500 ºC for 2 hours. The condensed liquid, as known as bio-oil, will be transported and collected from the outlet of the reactor. The yield of bio-oil was calculated according to Eq (1):

$$\%\text{Yield} = \frac{weight\ of\ bio - oil\ produced}{weight\ of\ corn\ husk\ used}\ x\ 100\% \tag{1}$$

3. Results and discussions

3.1. Bio-oil characterization

3.1.1. Gas Chromatography Mass Spectrometry (GC/MS). The identify the component of bio-oil in this research, an analysis using GC/MS is carried out. The results can be seen at Table 1.

Table 1. The Components contained in corn husk of bio-oil.

R.Time	Area (%)	Compound
4.849	7.22	2-propanone, 1-hydroxy- (CAS) Acetol
5.947	0.99	2-cyclopenten-1 one (CAS) cyclopentenone
6.264	1.90	1-Hydroxy-2-butanone
8.030	59.64	Acetic Acid
8.391	19.80	2-Furancarboxaldehyde (CAS) Furfural
9.775	1.12	Formic acid (CAS) Bilorin
10.303	3.21	Propanoic acid
12.733	1.15	Butanoic acid (CAS) n-butyric acid
13.623	1.84	2-Furanmethanol (CAS) Furfuryl alcohol
19.016	0.90	Phenol, 2-methoxy
22.964	2.25	Phenol (CAS) Izal
	100	

As shown in Table 1, the results of GC/MS analysis on bio-oil indicate that there is a substance of bio-oil component, except the acetic acid content, which can be found at 8.030 (retention time) for 59.64%. This component is unwanted content because it is the potential to give the corrosive properties to the engine when it used. This component is formed by the thermal decomposition of acetyl group [9-11].

3.2. Bio-oil production of fast pyrolysis corn husk

3.2.1. Yields. This work is focussed on investigating the effect of temperature on pyrolysis and the yield of products. The yield of bio-oil is increased as the temperature increased until the optimum conditions. It is because the fast pyrolysis will increase the heating reaction. This process will degrade the lignin compound and decomposed the material to be a volatile compound (gas). But, the yield of bio-oil will be decreased when the pyrolysis process is passed from their optimum conditions. This presumably because the exceeding of temperature (passed the optimum condition) will decompose the material to be secondary volatility compound [12-13]. The yield bio-oil at different temperature are presented in Figure 1.

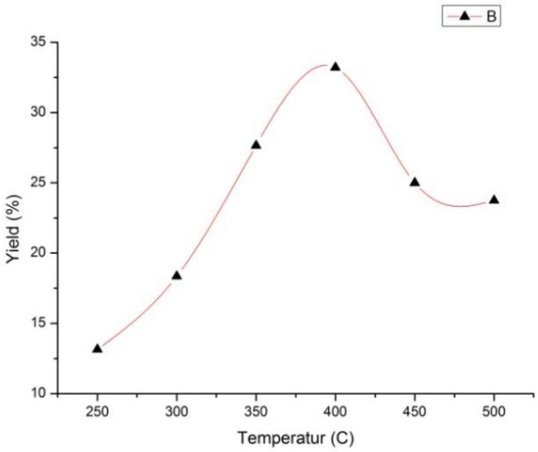

Figure 1. Effect of fast Pyrolysis temperature on products yields.

In Figure 1. it can be seen, the optimum conditions are reached 33.2% at 250^{o}C. Then, when the temperature is passed from the optimum conditions, the yield of bio-oil is decreased and reached 23.75% at 500^{o}C.

3.2.2. Density and viscosity of bio-oil. The density and viscosity measurement is analyzed using picnometer (5 ml) and viscometer canon-fenske. As shown in Table 2, The density and viscosity of bio-oil are in range, according to ASTM D 4052 and ASTM D 445, respectively. The obtained value of bio-oil density is near with the density of water. It indicates that the produced bio-oil using fast-pyrolysis at 400^{o}C still not produce the bio-oil fraction with high molecular weight, because the water content in bio-oil is still high-enough. This presumable because the used corn husk still has high moisture inside them (when used in the pyrolysis process) [14-15].

Table 2. Physical properties of bio-oil from corn husk.

Temperature (^{o}C)	Density (gr/mL)	Viskositas (cSt)
250	1.0014	0,954
300	0.9921	0.7701
350	1.0051	0.8466
400	1.0071	0.9625
450	1.0039	0.7920
500	0.9892	0.7128

4. Conclusions

Corn husk can be converted into bio-oil as an alternative energy source using the fast pyrolysis process. The highest and the optimum yield of corn husk bio-oil produced at a temperature of 400^{o}C is reached of 33.2%, with a density of 1.0071 gr/ml and viscosity of 0.9625 cSt. Bio-oil from fast pyrolysis cornhusk is acidic because it contains high acetic acid, which is 59.64%.

Acknowledgments
We thanks to the the Engineering and Catalysis Laboratory research and Doctoral Program.

References

[1] Park J Y, Kim J K, Oh C H, Park J W and Kwon E E 2019 Production of bio-oil from fast pyrolysis of biomass using a pilot-scale circulating fluidized bed reactor and its characterization *Journal of environmental management* **234** 138-144
[2] Zhang F, Yang H, Guo D, Zhang S and Chen H 2019 Effects of biomass pyrolysis derived wood vinegar (WVG) on extracellular polymeric substances and performances of activated sludge *Bioresource technology* **274** 25-32
[3] Asnawi T M, Husin H, Adisalamun A, Rinaldi W, Zaki M and Hasfita F 2019 Activated Carbons from Palm Kernels Shells Prepared by Physical and Chemical Activation for Copper Removal from Aqueous Solution *IOP Conference Series: Materials Science and Engineering* **543** 1 012096
[4] Tóth P, Ögren Y, Sepman A, Vikström T, Gren P and Wiinikka H 2019 Spray combustion of biomass fast pyrolysis oil: Experiments and modeling *Fuel* **237** 580-591
[5] Sobek S and Werle S 2019 Solar pyrolysis of waste biomass: Part 1 reactor design *Renewable Energy* **143** 1939-1948
[6] Fagbemigun T K, Fagbemi O D, Otitoju O, Mgbachiuzor E and Igwe C C 2014 Pulp and paper-making potential of corn husk *Int. J. AgriScience* **4** 4 209-213
[7] Guan B, Latif P A and Yap T 2013 Physical preparation of activated carbon from sugarcane bagasse and corn husk and its physical and chemical characteristics *Int. J. Eng. Res. Sci. Technol*. **2** 1-14
[8] Lihua L V, Bi J, Fang Y E, Yongfang Q I A N, Yuping Z H A O, Ru C H E N and Xinggen S U 2017 Extraction Of Discarded Corn Husk Fibers And Its Flame Retarded Composites *Journal of Textile and Apparel/Tekstil ve Konfeksiyon* **27** 4
[9] Acıkgoz C, Onay O and Kockar O M 2004 Fast pyrolysis of linseed: product yields and compositions *Journal of analytical and applied pyrolysis* **71** 2 417-429
[10] Uzun B B, Pütün A E and Pütün E 2006 Fast pyrolysis of soybean cake: product yields and compositions *Bioresource technology* **97** 4 569-576
[11] Garcia-Perez M, Wang X S, Shen J, Rhodes M J, Tian F, Lee W J and Li C Z 2008 Fast pyrolysis of oil mallee woody biomass: effect of temperature on the yield and quality of pyrolysis products *Industrial and engineering chemistry research* **47** 6 1846-1854
[12] Mohan D, Pittman Jr C U, and Steele P H 2006 Pyrolysis of wood/biomass for bio-oil: a critical review *Energy and fuels* **20** 3 848-889
[13] Demirbaş A 2000 Mechanisms of liquefaction and pyrolysis reactions of biomass *Energy conversion and management* **41** 6 633-646
[14] Collard F X, Blin J, Bensakhria A and Valette J 2012 Influence of impregnated metal on the pyrolysis conversion of biomass constituents *Journal of Analytical and Applied Pyrolysis* **95** 213-226
[15] Kan T, Strezov V and Evans T J 2016 Lignocellulosic biomass pyrolysis: A review of product properties and effects of pyrolysis parameters *Renewable and Sustainable Energy Reviews* **57** 1126-1140