Fast pyrolysis corn husk for bio-oil production

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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).
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 105°C 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 Furnace 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 250°C, 300 °C, 350 °C, 400 °C, 450 °C and 500 °C 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):

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

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.

| 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                          |

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](image)

**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°C. Then, when the temperature is passed from the optimum conditions, the yield of bio-oil is decreased and reached 23.75% at 500°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°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].

| Temperature (°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°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 thank to the the Engineering and Catalysis Laboratory research and Doctoral Program.

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