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Artikel

Effect of Corn Cob-Sawdust Mixture to Yield and Product Characteristic of Hydrothermal Treatment

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ABSTRACT

Hydrothermal treatment is a thermochemical process that converts biomass into a coal-like material called hydro-char by applying elevated temperature to biomass in suspensions with water under saturated pressure for a certain time. With this conversion process, easy to handle fuel with well-defined properties can be created from biomass residues, even with high moisture content. Biomass is one of the renewable energy resources in Indonesia which has abundant resources potential. In this research, the effect of corn cob-sawdust mixture w/w (100%:0%), (75%:25%), (50%:50%), (25%:75%) and (0%:100%) at initial pressure 1.0 MPa to hydrothermal treatment of biomass were examined. All samples were then characterized in terms of yield, proximate analysis, calorific value, and changes in functional groups by FTIR. Approximately 47-68% of origin material was recovered as a hydro-char. The gross calorific value ranged from 5160-5402 cal/gram. Hydrothermal treatment of sawdust and corncobs mixture with ratio 100% sawdust produced solid with higher heating value of 5402 cal/gram.

Keywords: Hydrothermal Treatment, Sawdust, Corn Cob, Mixture, Solid Fuel

INTRODUCTION

Lignocellulosic biomass is an attractive feedstock for solid fuel production as it is widely considered carbon neutral and can be used as a direct replacement for existing fosil fuels [1]. Sawdust and corn cob are the most abundant lignocellulosic biomass in Indonesia. However, they are still underutilized [2].

Hydrothermal treatment requires the application of heat and pressure to treat biomass in an aqueous medium. It is widely considered as a promising means for converting wet biomass into value-added products (such as biofuels and chemicals) because it obviates the need (capital, energy and time) for feedstock, dewatering and drying [3].

Sawdust and corn cob are biomass wastes with the existence of which are overflow in Indonesia. Sawdust and corn cob for fuel are used directly only produces low calorific value due to their high water content. Based on the above fact, in this research, the researcher tries to study a conversion alternative of biomass waste without being dried up first by using thermal method called hydrothermal treatment. The process of the hydrothermal treatment was done by making use high temperature water. Within the process, the biomass was degraded into solid component (hydro-char), liquid (oil and water), and gas. The produced hydro-char was analyzed to examine the capacity as fuel.

The hydrothermal treatment of biomass in Indonesia is the concern to reduce and recycle waste especially biomass to solid fuel like coal. In fact, the municipal solid waste in Indonesia is being mixed with another component or not homogeny. So that, in this research a mixed biomass was used for hydrothermal treatment.

In the present study, the effect of major biomass component (cellulose, hemicelluloses, and lignin) on yields of hydro-char and heating value at the experimental conditions with an effective separation procedure is also reported. It is performed by hydrothermal treatment at various biomass mixture composition of corn cob and sawdust at 250oC temperatures for 30 minutes residence time and biomass-water ratio 1:10.

METHODS

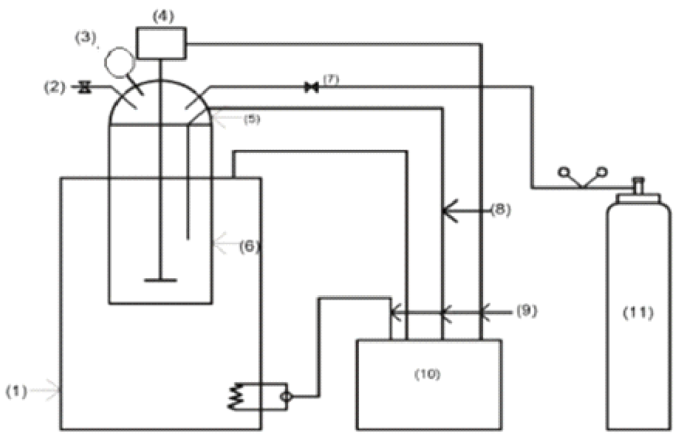
A slurry of 15 g of sawdust and corncobs mixture (25%:75%) and 150 mL of water was loaded into autoclave. A stream of N2 gas was used to purge air from the autoclave and to maintain initial internal pressure into 1 MPa. The autoclave was heated at 250oC. Once the target temperature was reached, the sample was held for a further 30 min before the autoclave was cooled to the ambient conditions. The slurry of hydro-char and water was filtered using vacuum pump. The solid part was dried in an oven at 105oC for 4 hours to yield the final solid product (hydro-char). The experiments repeated for sawdust and corncobs ratio 50%:50%; 75%:25%; 100% sawdust; and 100% corncobs.

Solid yield is the important parameter in this study which is defined as:

$$\text{Solid yield} = \frac{mass\ of\ dried\ solid\ product}{mass\ of\ dried\ solid\ material} \text{ x } 100\%$$

RESULT AND DISCUSSION

Lignocellulosic content detects the percentage of the most abundant components in lignocellulosic biomass, which are cellulose, hemisellulose, and lignin.



1. Heater
2. Pressure Release Valve
3. Pressure Gauge
4. Stirrer
5. Reactor Cap
6. Autoclave
7. Gas Inlet
8. Thermocouple
9. Electrical Wires
10. Temperature Controller
11. N2 Gas Holder

Figure 1. Schematic Diagram of the Experimental Apparatus

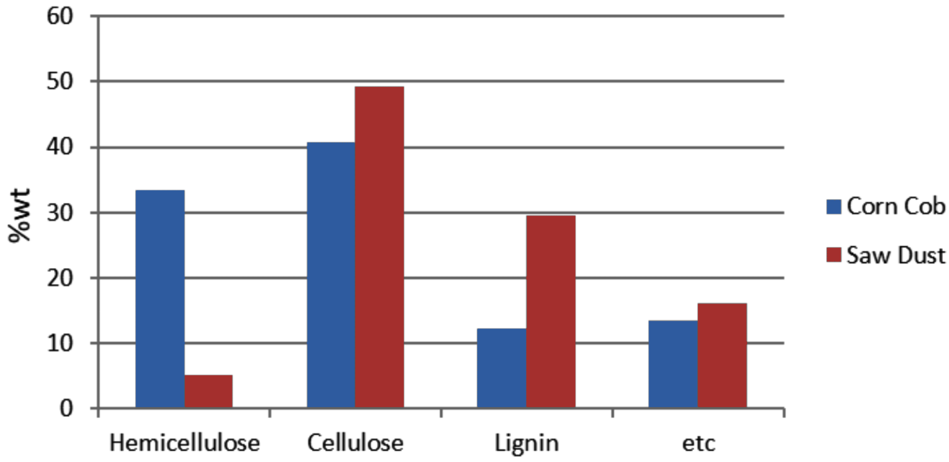


Figure 2. Lignocellulosic content of sawdust and corncobs as Raw Materials

Tabel 1. Proximate analysis of corn cob and sawdust

Proximate Analysis (wt%)	Biomass Mixture Composition (Corn cob : Sawdust)				
	100%:0%	75%:25%	50%:50%	25%:75%	0%:100%
Raw Materials					
- Water Content (%)	10.352	-	-	-	12.258
- Ash Content (d.b) (%)	1.282	-	-	-	1.231
- Volatile Matter (d.a.f) (%)	75.165	-	-	-	73.731
- Fixed Carbon (d.a.f) (%)	24.835	-	-	-	26.269
- Calorific Value (cal/gram)	4467				5180
Corn cob: Sawdust					
- Water Content (%)	3.548	3.270	3.247	3.240	3.173
- Ash Content (d.b) (%)	0.107	0.223	0.291	0.420	0.477
- *Volatile Matter* (d.a.f) (%)	65.978	68.104	68.815	69.515	70.028
- *Fixed Carbon* (d.a.f) (%)	34.022	31.896	31.185	30.485	29.972
- *Calorific Value*	5160	4857	4982	5346	5402

Figure 2 describes that sawdust has the dominant amount of cellulose which is 49.33%, followed by lignin and hemicellulose. Corncob has 40.67% cellulose as a dominant compound, lower than sawdust. The other minor components are ash, silica, and water. Lignocellulosic analysis was done to understand the behavior of biomass during hydrothermal treatment.

Proximate Analysis

Both raw material solid products were characterized using proximate analysis which is consist of water content, ash content, fixed carbon, and calorific value (table 1). Water content and ash content of treated biomass is lower than that is on raw material. Water content in fuel may cause decreasing in calorific value because the heat used to evaporate the water first. Decreasing of ash content may reduce problems in heat exchanger equipment associated fouling and scaling. This fouling and scaling may decrease the heat exchanger efficiency because it covers the heat exchanger surface.

Hydrothermal treatment can increase a heating value of hydro-char because the complex chemical reaction occurs

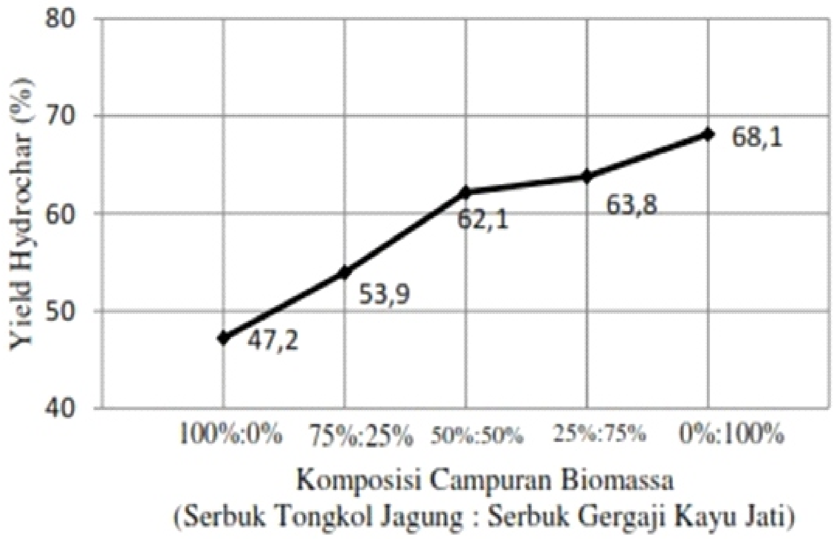


Figure 4. Yield hydro-char at treated sawdust-corncobs mixture

during hydrothermal treatment. The degradation mechanism of hydrothermal treatment are depolymerization of the biomass, degradation of monomers (cleavage, dehydration, and decarboxylation reaction), and recombination of fragmented components [4].

Yield Hydro-char

In addition, as shown by Figure 4, it was observed that the effect of different sawdust-corncobs mixture for hydrothermal treatment process. The hydro-char yields were 47.2%, 53.9%, 62.1%, 63.8%, and 68.1% at corn cob-sawdust ratio 100%:0%; 75%:25%, 50%:50%; 25%:75%, and 0%:100%. The chart shows that by increasing sawdust composition, the yield is increasing as well. It means that the amount of biomass degradation was less at higher sawdust composition. As shown in Figure 6, the result reflected that higher composition of cellulose in sawdust was unable to carbonize biomass to make hydro-char as well.

Cellulose is most abundant matter on earth. It is the main structural constituent of plant and alga cell walls. Cellulose in wood is mixed with many polymers such as hemicelluloses and lignin. Cellulose is unbranched chain and homopolymer of β-D-glucopyranose units linked together by (1-4)-glycosidic bonds with a repeating unit of C6H10O5 strung together by β-glikosidic linkages. The β-linkages in cellulose form long linear chains (called elemental fibril) that are highly stable and resistant to chemical attack because of the high degree of hydrogen bonding that can occur between chains of cellulose. Hemicellulose and lignin cover microfibrils hydrogen bonding between cellulose chains makes the polymers more rigid, inhibiting the flexing of the molecules that must occur in the hydrolytic breaking of glycosidic linkages. Hydrolysis can reduce cellulose to cellobiose repeating unit C12H22O11, and ultimately to glucose [5].

Fourier Transform Infrared Analysis (FTIR)

Figure 5 shows spectra of the hydro-char as solid product. The intensity of the peaks 3350-3340cm-1 attributed to –OH groups of hydro-char treated biomass

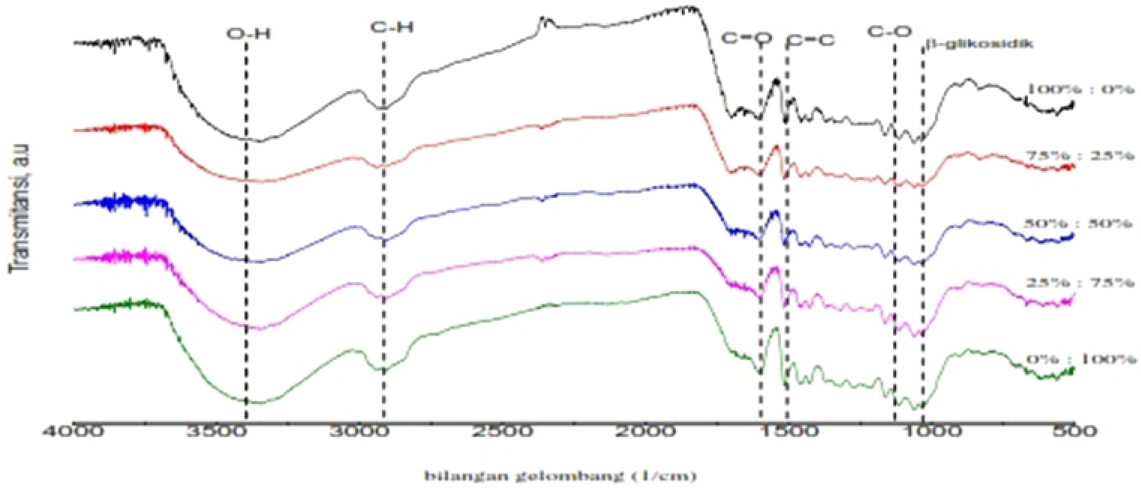


Figure 5. FTIR spectra for hydro-char products of biomass mixture composition

mixture composition. The presence of hydroxyl groups derived from compounds alcohol is evidenced by the C-O absorption near the wave number 1300-1250cm-1. The peak at 2940-2950 cm-1 attributed to aliphatic C-H groups. More distinctive peaks were observed in the region between 1600-1700 cm-1. It represents carbonyl (C=O) stretching vibrations. The peak at 1050 cm-1 attributed to glycosidic bonds, indicating the presence of cellulose, steadily weakened and completely disappeared, indicating that cellulose was totally degraded at operational temperature. The peak between 1520-1510 cm-1 attributed to C=C groups of aromatic compound. Figure 5 shows that at this wavenumber the intensity of the peak was increased with increasing percentage of sawdust composition because sawdust has dominant amount of cellulose.

CONCLUSION

Upgrading waste biomass in the form of sawdust and corncobs mixture was investigated by hydrothermal treatment at 250oC and biomass to water ratio 1:10. Approximately 47-68 wt% of the original material was recovered after the process as solid fuel. Hydrothermal treatment progressively changes the calorific valuesas the fixed carbon content increased sharply due to carbonization. Hydrothermal treatment of sawdust and corncobs mixture with ratio 100% sawdust produced solid with higher heating value of 5402 cal/gram. The composition of the biomass mixture sawdust and corncobs affected hydro-char quality, the result of hydrothermal treatment. Increasing percentage of sawdust will increase the heating value, raising hydro-char yield, and decreasing potassium content. It is occurred because sawdust has more lignin and cellulose content so that increasing the conversion of biomass to hydro-char.

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