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Investigation of the Elemental Analysis of Carbonaceous Kenaf Fiber from HTC Process

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A b s t r a c t

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This paper presents a preliminary investigation on producing carbonaceous product from Kenaf fiber using Hydrothermal Carbonization process also known as HTC. The process was conducted at different pre-treatment time of 2h, 4h, 6h, 8h and 10h at temperature of 225°C. This work aimed to identify the level of optimization of biomass dry weight for the carbonization of Kenaf fiber. The results indicated that HTC has the ability to convert biomass to biochar with high carbon content and lower O/C and H/C ratios. In addition, the lowest carbon content at 4h due to hydrolysis reaction while others operating time enhanced dehydration reaction due to higher carbon produced. In future, the longer operating time will be conducted to determine the optimization percentage of biochar.

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1. Introduction

Kenaf or also known as *Hibiscus Cannabinus L.* is a raw material with environmentally friendly and most economically important crops in non-wood fiber production [1]. Kenaf plants consist of 26% of leaves and 74% of stalks by dry weight [2]. It is a fast growing plant and ready for harvesting after four months after planting. This is the reason Kenaf is suitable for tropical and sub-tropical, which is warm temperature, areas. As an herbaceous plant, Kenaf can produce high content of cellulose in average of 44 to 63.5% and hemicellulose in average between 15 to 23% [3]. Kenaf is suitable raw material for hydrothermal carbonization due to high content of lignin, cellulose and hemicellulose. In Malaysia, Kenaf is a source of raw material and high demand for commercial production of particle board manufacturing to balance the uses of rubber wood [4]. Hydrothermal carbonization process (HTC) is relatively simple method to convert from biomass to biochar. HTC is a pressurized thermal conversion process that contains wet biomass and conducted at temperature range between 150 to 350°C over a period ranging from a few hours to a day at autogenously pressure [5]. Besides, it is an effective and practical conversion technology of biomass to biochar

to keep a reasonable energy balance. HTC involves water throughout the procedure due to environmentally friendly solvent for chemical reaction [6]. Depending on the process condition used HTC can be conducted with catalyst such as citric acid and metal ions [5] but in this study HTC was carried out directly with water and Kenaf fiber without catalyst and continuous stirring according to parameters.

2. Experimental procedures

2.1. Materials and procedures

Kenaf fiber was obtained from Lembaga Kenaf and Tembakau Negara (LKTN), Indera Mahkota in Pahang. Kenaf fiber was processed to a small length in ranging of 15cm to 20cm before grinding to fine pieces (550-600μm). This is to promote the effectiveness of mixing Kenaf fiber during conversion to biochar via HTC process. The HTC process was conducted at different time (2h, 4h, 6h, 8h and 10h) with constant temperature, 225°C by using the supercritical unit Buchiglauster model. 50g of grinded Kenaf fiber was dispersed in 1L of pure water and mixed homogenously before put into the reactor. The reactor was sealed to avoid any pressure released and heated to desired temperature. Residence time was defined when the reactor reached the desired temperature and the stirrer speed was increased to 50rpm. After the process reached the desired time, reactor was set to be cooled to room temperature for 12 hours before the product can be collected. Solid carbonaceous product known as biochar was collected after the drying process.

2.2. Characterization

An elemental analyzer (Vario Macro CHNS Analyzer) was to determine the element values such as carbon, hydrogen and nitrogen in product thus confirming the degree of carbon conversion from the HTC process. A comparison of the percentage of carbon in the product was made to find the optimum HTC operating condition for the biochar.

3. Results and discussion

The characteristic of carbonaceous fiber produced by the HTC process from Kenaf fiber is identified in terms of the changes of the solid materials especially on carbon component. The chemical characteristic of the Kenaf fiber were determined from their elemental contents such as carbon (C), hydrogen (H) and oxygen (O). The percentage of the elements and molecular formula of carbonaceous Kenaf fiber processed at different operating time for 225°C was listed in Table 1.

Table. 1: Percentage of carbon at different time

Sample	Time (h)	C (wt%)	H (wt%)	N (wt%)	*O (wt%)	Molecular formula, CH_xO_y
Kenaf fiber	2	49.94	5.70	6.12	38.24	$CH_{1.37}O_{0.57}$
	4	47.65	5.42	8.15	38.78	$CH_{1.37}O_{0.61}$
	6	55.04	5.23	10.44	29.29	$CH_{1.14}O_{0.4}$
	8	55.07	4.89	15.26	24.78	$CH_{1.06}O_{0.3}$
	10	57.60	4.91	17.55	19.94	$CH_{1.02}O_{0.26}$

*O (wt%) = 100 – C (wt%) – H (wt%) – N (wt%)

Table 1 showed that the amount of carbon content increased as the time increased while the hydrogen and oxygen decreased due to the removal of H and O element in the HTC process. The molecular formulas for carbonaceous Kenaf fiber illustrated longer operating condition will resulted lower H and O atoms attached with one carbon atom. Based on the proximate analysis, it can be assumed that active removal of oxygen and hydrogen elements occurred in the HTC process.

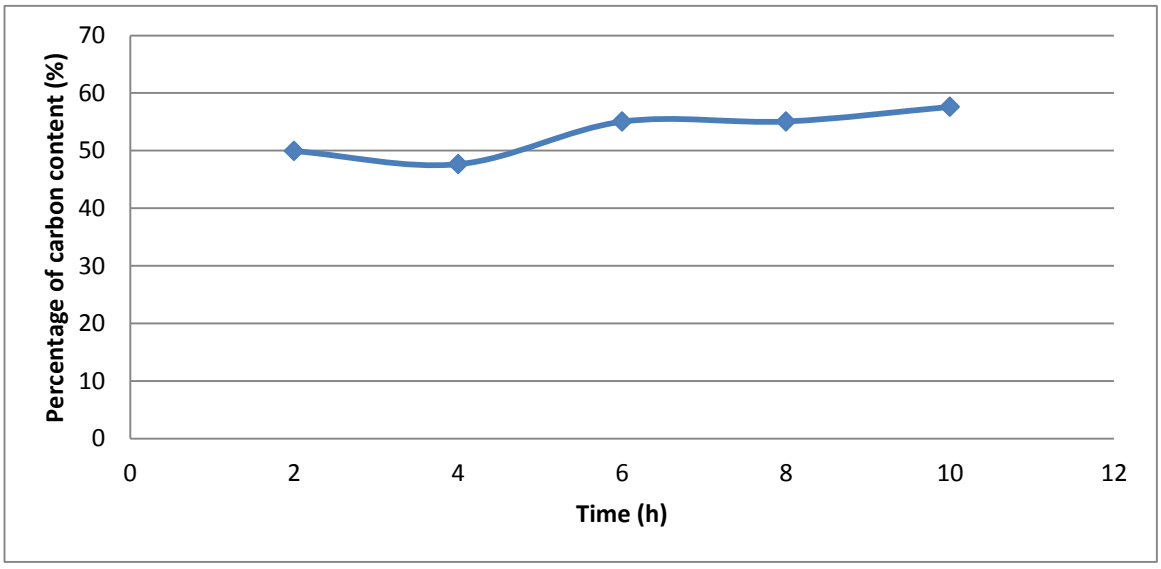

Fig. 1. Percentage of carbon content (%) vs desired time (h)

Figure 1offers a clear view of transformation of biochar in terms of chemical reaction. The carbon content increased approximately 58% when the operating time at 10 hours. As can see from the figure, the trend of the graph is not proportionally increase between the percentage of carbon and the operating time. At 4 hours operating time, the decrement of carbon values was plotted which predicted that HTC process promote hydrolysis reaction. The HTC process generally happened in three reactions which are hydrolysis, dehydration and carboxylation process throughout the conversion of Kenaf fiber (complex lignocellulose structure) into biochar [7].

4. Conclusions

The hydrothermal carbonization process of Kenaf fiber provided 40% to 60% carbon content depending on the operating time. Biochar were obtained from the increment of operating time of the HTC process. For the future work, longer operating time will be conducted to determine the optimum production of biochar.

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References

[1] Zhang G, Qi J, Zhang X, et al. A Genetic Linkage Map of Kenaf (Hibiscus cannabinus L.) Based on SRAP, ISSR and RAPD Markers. *Agriculture Science in China*. 2011;10(9):1346-1353.

[2] Iii CLW, Bledsoe VK, Bledsoe RE. Kenaf Harvesting and Processing. 2002;(Dempsey 1975):340-347.

[3] Zainuddin SYZ, Ahmad I, Kargarzadeh H, Abdullah I, Dufresne A. Potential of using multiscale kenaf fibers as reinforcing filler in cassava starch-kenaf biocomposites. *Carbohydrate Polymer*. 2013;92(2):2299-305.

[4] Paridah MT, Juliana a. H, El-Shekeil Y a., Jawaid M, Alothman OY. Measurement of mechanical and physical properties of particleboard by hybridization of kenaf with rubberwood particles. *Measurement*. 2014;56:70-80.

[5] Parshetti GK, Kent Hoekman S, Balasubramanian R. Chemical, structural and combustion characteristics of carbonaceous products obtained by hydrothermal carbonization of palm empty fruit bunches. *Bioresource Technology*. 2013;135:683-9.

[6] Aida TM, Sato Y, Watanabe M, et al. Dehydration of d-glucose in high temperature water at pressures up to 80MPa. *Journal of Supercrital Fluids*. 2007;40(3):381-388.

[7] Funke, A. & Ziegler, F. Hydrothermal Carbonization of Biomass: A Summary and Discussion of Chemical Mechanisms for Process Engineering. *Biofuels, Bioproducts and Biorefining*. 2010; 4: 160-177.