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Effect of Temperature on Biochar Product from Rice Husk Biomass

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Abstract- Biochar is a solid material that is produced by heat decomposition of biomass. In this work, rice husk biomass was tested as a suitable fuel source in a direct carbon fuel cell. Rice husk biomass was heated in a muffle furnace at 300oC and 400oC to obtain biochars. The most important properties that provide information about the fuel were proximate such as moisture, ash content, volatile and fixed carbon contents. The fixed carbon content of rice husk biochar (RHB) was measured to be 10.3 mf wt%. The porous nature of RHB was studied by scanning electron microscopy (SEM). The carbon (C) content was observed by Energy Dispersive X-ray spectroscopy (EDX). The functional group of RHB was analyzed by Fourier transform infrared spectroscopy (FTIR).
Keywords – Rice husk biomass, SEM-EDX, FTIR

I. INTRODUCTION

The biomass can be considered as the most easily available and useful bio-material in the current days. Because of the renewable nature, the biomass is widely used for various purposes such as direct source of heat generation, as the feedstock for thermochemical and biological conversion to produce useful fuels or chemicals. [1] Biomass materials agricultural from residues such as straw, bagasse and groundnut shell, coffee husk and rice husk as well as residues from forest-related activities such as wood chips, sawdust and bark having high energy potential. [2,3] These biomass wastes are one of the main assets for renewable energy. Consequently, there are numerous prominent technologies to transform biomass into energy. [4,5] In general agro residues normally have the following compositions on moisture and ash free basis: 50% carbon, 6% hydrogen and 44% oxygen. The moisture content varies over wide range from oven dry to about 90% on wet basis and ash content varies from 0.5 to 22%. [6,7] In the presence investigation, rice husk biomass was characterized for proximate analysis viz. Moisture(M), Ash (A), Volatile Matter (VM) and Fixed Carbon (FC). The rice husk biochar was analyzed through Scanning Electron Microscope (SEM), carbon (C), oxygen(O), and silica (Si) content from the EDX and FTIR spectral anlalysis for identification of functional groups.

II. MATERIALS AND METHODS

2.1 Sample Preparation

The rice husk was received in dry condition. Firstly, rice husk sample was initially weighed. 25g of rice husk was washed with distilled water 1.25ℓ for 2h at 90°C. Then the wet rice husk was dried in room temperature for 48 h. And then rice husk was weighed again. The difference between the initial and final masses of the rice husk represented the water content in the sample. The dried rice husk was grounded and sieved to the average particle size.

2.2 Characterization Methods

The rice husk biomass (RHB) was subjected to carbonization at 300°C and 400°C for 1h. The rice husk biomass and biochar samples were characterized for proximate (Moisture, Volatile Matter, Ash Content and Fixed Carbon). Moisture Content was determined according to MOC63U Moisture Analyzer. Moisture content was also obtained by the sample was placed in the oven at 105°C for 2h. Then the sample was cooled in desiccator and reweighed again. The moisture was less than 10 mf wt%. For volatile matter sample was heated at 950°C for 30 min; this mass loss is attributed to volatile matter. For ash content the sample was heated at 750°C for a minimum 2h. The difference between the initial and final weight of the sample represents the ash content. The weight of the original sample, subtracted byits moisture content, ash content and volatile matter content (as determined by the aforementioned proximate analysis) corresponds to the stable carbon fraction of that sample and hence, his fraction is termed 'fixed carbon or fixed-C fraction'. The rice husk biochar samples were also analyzed by Scanning Electron Microscope (SEM) equipped with an energy dispersion X-ray Spectroscopy (EDX) and FTIR for identification of pore size and functional groups.

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III. RESULTS AND DISCUSSION

3.1 Proximate Analysis

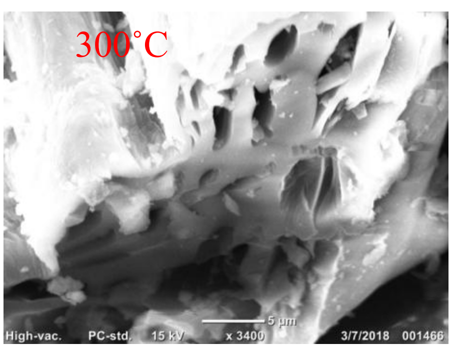
The results of the proximate analysis of rice husk are also presented in moisture-free weight percentage, mf wt %. Table.1 shows the properties of the raw rice husk. From proximate analysis, it is observed that rice husk contains its moisture was less than 10 mf wt %, a large percentage of volatile matter, 72.7 mf wt %, a moderate percentage of ash content, 17 mf wt %, and a small percentage of fixed carbon content 10.3 mf wt %. Generally, a raw biomass has high volatile matter content where 80 - 90 % of biomass is combusted in the form of volatiles. Since most of the energy is stored in the volatiles, volatile matters are highly reactive, which makes the combustion process more difficult to be controlled. [8] Hence, low content of volatile matter is desirable because it is an indication that the combustion process is easier to be controlled. The result suggested that the fixed carbon content was affected by the higher ash content of RHB, which inhibited the formation of aromatic carbon during the thermochemical conversion process. [9] It is a common consensus that high ash content is likely to cause fouling at the current collector in DCFC. In addition, a fixed carbon is one of the important elements that determine the quality of biomass as a fuel cell. From these results were neither bad nor good. Hence, further study it requires to reduce the volatile matter and to more produce fixed carbon.

Table -1 Characterization of rice husk biochar

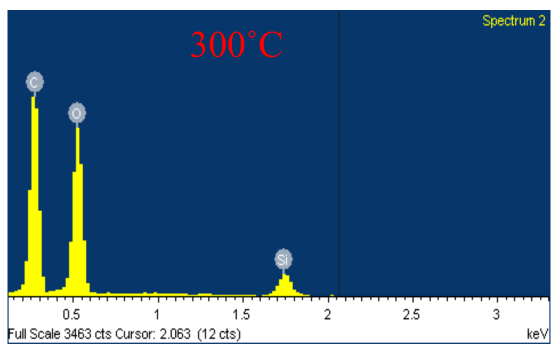
Proximate analysis result of rice husk by iochar (wt% dry basis)			
Moisture content	Volatile matter content	Ash content	Fixed Carbon Content
9.6	72.7	17	10.3

3.2 Scanning Electron Microscopy (SEM-EDX) Analysis

The microstructural properties of RHB powder were observed by SEM analysis. The pore sizes were measured by using well known bar code system. Bar code size is 5 µm with magnification of 3,400. Scanning electron micrographs for external morphology (SEM-EDX) analysis of RHBs at 300oC and 400oC for 1 h were shown in Fig.1(a-b). From SEM images, it was found the surface morphology of biochar changed with temperatures. At 300 °C, the pores of about 5µm diameter were found on some region and there were also flaked layers. The pore area became larger at 400°C biochar. SEM micrograph showed that the adsorbents surface was irregular, rough and highly porous, indicating the possibility of its good adsorption properties. At 400 °C, it composed of highly porous surface, indicating relatively high surface area. This result can be supported by carbon fuel for DCFC. The energy dispersion X-ray spectroscopy (EDX) corresponding to rice husk biochar samples at 300˚C and 400˚C for 1h indicated that the RHBs have more minals C, O and Si. From this result, RHB at 400 ˚C for 1h contains 51.34 wt% of Carbon (C), which is the higher percentage than RHB at 300˚C for 1h. It contains low fractions and absent of various elements such as S, Cl, K, Zn and Mg. This is important to study the influence of these impurities on the DCFC performance because the accumulated ashes would affect the life time of DCFC fuel source, high Carbon (C) content and low Sulphur content required.



(a)



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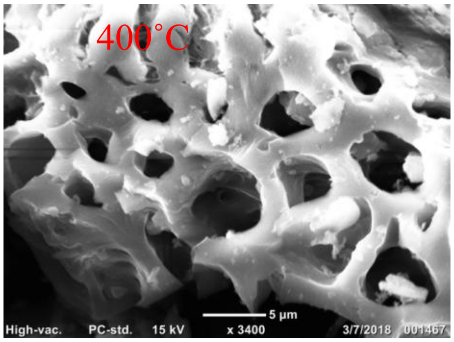

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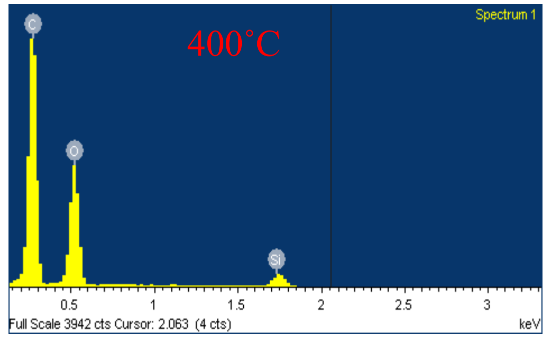


(d)

Figure 1. (a) SEM and EDX spectrom of rice husk biochar at 300 ˚C for 1h (b) SEM and EDX spectrom of rice husk biochar at 400 ˚C for 1h

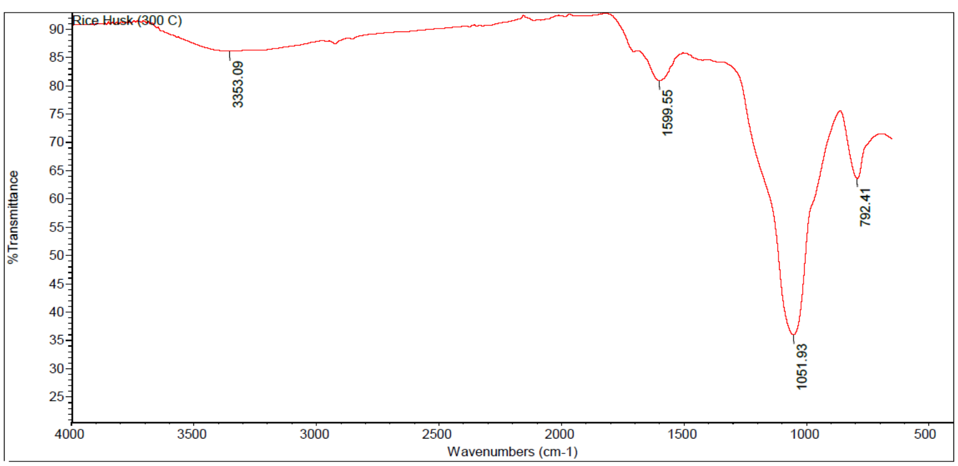
Table -2 Characterization of rice husk biochar

Element	Weight%		Atomic%	
	300°C	400°C	300°C	400°C
C Kα	51.73-37	78.34-51	49.03	62.05
O Kα	38.97	32.78	38.02	29.74
Si Kα	23.31	15.88	12.95	8.21
Totals	100.00			

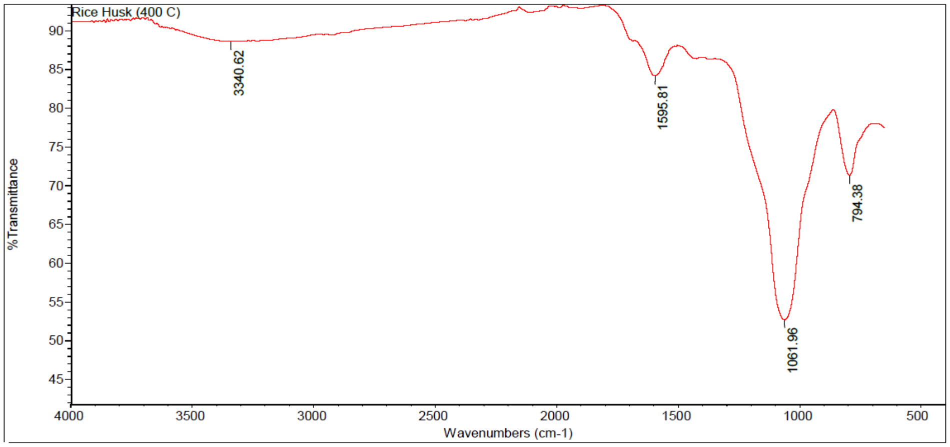
3.3 Fourier Transform Infrared Spectroscopy (FTIR) Analysis

FTIR analysis of RHB sample at 300 °C for surface functional groups are presented in Figure 2 (a). The peaks at located in a wide range of spectra scale. The first peak at 3353.09 cm-1 is for C-H stretching vibration consists of alkene group. The peak in the wide range 1900 – 1600 cm-1 (1599.55 cm-1), indicates the presence of carbonyl group, i.e, >C=O stretching. In addition, the changes in peaks observed at 1051.93 cm-1 and 792.41 cm-1 were indicative of stretching vibration of C-N and C-H bonds of alcohol group and aromatics group.

FTIR result for 400 °C of RHB was shown in Figure 2 (b). The absorbance peaks at located in a wide range of spectra scale. The first peak at 3340.62 cm-1 is for C-H stretching vibration consists of alkene group. The next peak that was located at 1595.81 cm-1 indicates C=C stretching vibration consists of aromatic groups in lignins. In addition, the changes in peaks observed at 1061.96 cm-1 and 794.38 cm-1 were indicative of stretching vibration for C-N and C-H bonds of alcohol group and aromatics group. The presence of functional groups such as the carbonyl, alcohol and aromatics groups suggest that these RHB could be affected in DCFC.



(a)



(b)

Figure 2. (a) Fourier transform infrared (FTIR) spectra of rice husk biochar sample at 300°C for 1h
(b) Fourier transform infrared (FTIR) spectra of rice husk biochar sample at 400°C for 1h

Table -3 FTIR Analysis of RHBs

Sr No.	Chimical bond	300°C Peak position	400°C Peak position
1.	C-H Stretch	3353.09	3340.62
2.	C=C Stretch	1599.55	1595.81
3.	C-N Stretch	1051.93	1061.96
4.	C-H Stretch	792.41	794.38

IV.CONCLUSION

Rice Husk biomass was used as the raw materials to produce biochar. SEM images showed slightly changes in the morphological structure of RHB with the temperature increased. The RHB exhibited the C (Carbon) content of about 51.34% at 400oC, which was the higher than that of RHBs at 300 oC. These results are good agreement with FTIR results. In conclusion, carbon activated RHB (400oC) is quite potential candidate for direct carbon fuel cell (DCFC) application.

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