

Elemental Analysis of Bamboo Charcoal from *Gigantochloa Albociliata*

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Abstract. Bamboo the most abundant plant in the world has attracted a lot of interests due to their excellent potentials in many ways. The bamboo charcoal itself can be utilized in water purification, electromagnetic wave absorber, blood purification and even dye sensitized solar cell. In Malaysia, elements of bamboo charcoal from *Gigantochloa Albociliata* have not yet been studied. Properties of bamboo charcoal totally depend on the applied temperature and time during carbonization and activation process. In this paper, elemental analysis of carbonized bamboo charcoal at 500 °C and activated bamboo charcoal at 900 °C and 1100 °C has been performed using Fourier Transform Infrared (FTIR) and X-ray Diffraction (XRD) after being prepared in two different mediums; DI water and ethanol. The results show that carbonized samples CS64 TK and CS88M show similar trend of peak in both solvents. Some peaks at 3278 cm⁻¹ and 1637 cm⁻¹ which attribute to O-H (stretching) and C-H (stretching) were broader for both samples in DI water compared to ethanol. In ethanol, some bands like 2886 cm⁻¹ (C-H stretching), 1394 cm⁻¹ (C-H bending), 1057 cm⁻¹ (CO-O-CO stretching) and 872 cm⁻¹ (C-H bending) were clearly observed. Similar results were obtained for activated samples; ABC900 and ABC1100. From the XRD analysis, it was confirmed that carbonized and activated bamboo charcoal were amorphous carbon. As the activation temperature increased up to 1100 °C, the d₀₀₀₂ spacing decreased while the graphite crystallite size LC₍₀₀₀₂₎ increased.

INTRODUCTION

Bamboo is a plant that growth in warm temperate climates and moist tropical countries like China, Japan, Korea, India including Malaysia. In recent years, the use of the bamboo not only limited as animal diets, flowering plant, culinary and others. The potential of bamboo has expanded to the commercial market as an absorber in antenna [1,2], materials for dye sensitized solar cell [3,4], a potent remedy for diarrhea [5], cosmetic, cloth and others. These applications depend on the adsorption properties of the charcoal which controlled by the applied temperature during carbonization and activation process. The carbonization process can be done in traditional kiln or furnace under temperature of 400 °C up to 1000 °C. This process normally involves the decomposition of polymer components, evolution of volatile matters and the development of thermally stable aromatic layers and their arrangement which finally form the carbon structures [6]. For activation process, chemical and thermal approach can be used. It is expected that activation process will increase the microporous properties and surface area of bamboo charcoal which also improve the adsorption properties [7].

In Malaysia, the population of bamboo known as *Buluh Madu* or its scientific name *Gigantochloa Albociliata* is really high. The use of this bamboo is still limited to bamboo craft, culinary and furniture. In order to fully utilize

the potential of this bamboo, understanding the mechanism of carbonization and the elements of bamboo charcoal are highly important. Later, this bamboo charcoal can be applied in many potential applications. Here in, elemental analysis of bamboo charcoal and activated samples using Fourier Transform Infrared (FTIR) and X-ray Diffraction (XRD) were performed and presented.

EXPERIMENTAL PROCEDURES

In this study, two sets of samples were used; (a) carbonized bamboo charcoal and (b) activated bamboo charcoal. The carbonized sample was prepared by the joined company (JitraGrow Resources, Malaysia) using mechanical kiln at the temperature of 500 °C. Two different grinding methods to this sample and the samples are named as CS64 (TK) and CS88 (M) respectively. These samples were further activated in Failure Analysis Lab, School of Microelectronic, Universiti Malaysia Perlis in the furnace at the temperature of 900 °C and 1100 °C under nitrogen environment before grinded to the powder form. The activated bamboo charcoal now will be known as ABC900 and ABC1100. 50 mg of all samples was prepared in 10 mL solvents which were DI water and ethanol before placed in ultrasonic bath in order to perform well dispersed solution for further investigation.

For the purpose of element characterizations, Fourier Transform Infrared Spectroscopy (FTIR) and X-Ray Diffraction (XRD) were used.

RESULT AND DISCUSSION

In the previous study [8], the bamboo has been carbonized at difference temperatures and its dispersibility in DI water and ethanol was investigated. The adsorption properties of these samples under methylene blue were characterized using UV Vis [9]. From the results, it shows that the quality of the lab prepared samples was compatible with the manufactured sample supplied by the JitraGrow Resources.

According to Zuo [6], the optimum carbonized temperature was at 600 °C where the process is more complete and aromatic structures is dominant in bamboo charcoal. During this process, the weight loss of oxygen is higher than hydrogen although the number loss of oxygen atom was lower than hydrogen atom. At different carbonization and activation temperature, main elements of bamboo and bamboo charcoals are carbon, oxygen and hydrogen besides a small amount of ash like Si, Mg, Na, Ca and their oxides.

In this work, FTIR analysis of the bamboo charcoal samples was done to obtain information of the chemical structures. Figure 1 and 2 shows the FTIR spectra of CS64 (TK) and CS88 (M); and ABC900 and ABC1100 in two different mediums; DI water and ethanol respectively. The detected elements for all samples were summarized in Table 1.

TABLE 1. FTIR Spectrum Table

BAND POSITION, CM ⁻¹	ELEMENTS	BAND POSITION, CM ⁻¹	ELEMENTS
3858	O-H (stretching)	2345	O=C=O (stretching)
3732	O-H (stretching)	2106	C=C (stretching)
3314	N-H (stretching)	1662	C-H (bending)
3278	O-H (stretching)	1637	C-H (stretching)
2961	C-H (stretching)	1394	C-H (bending)
2886	C-H (stretching)	1057	CO-O-CO (stretching)

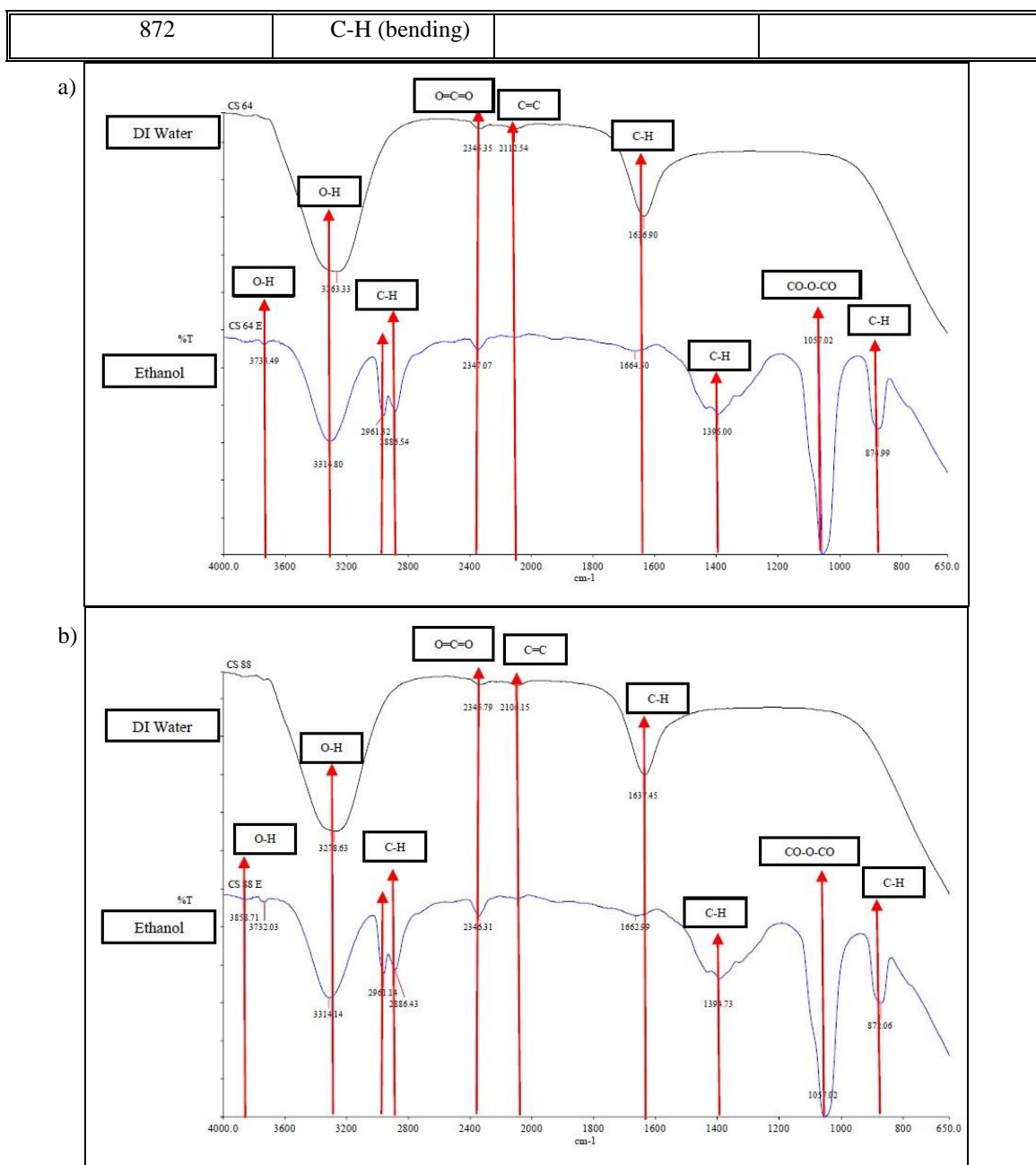


FIGURE 1. FTIR spectra of carbonized bamboo charcoal (a) CS64 (TK) and (b) CS88 (M)

Results from Fig.1 and 2 show similar trends of peaks were obtained for both samples in DI water and ethanol. It shows that deep peak of O-H (stretching) was obtained at 3278 cm^{-1} for both samples in DI water and ethanol attributes by the carboxylic acid. The peak of 1637 cm^{-1} in DI water shows C-H stretching and attributes to skeleton stretching vibration of aromatic rings which are mainly concerned with lignin in bamboo [6]. Some peaks of C-H at 2886 cm^{-1} and 1394 cm^{-1} were only detected at the samples in ethanol. Other than show C-H (stretching) and C-H (bending), these peaks also represent vibration modes of methyl and methylene groups. The absorption of the methyl group near 1395 cm^{-1} shows the relative abundance of CH_2 and CH_3 groups. Other peaks obtained for samples in ethanol are at 1057 cm^{-1} and 872 cm^{-1} which attribute to the CO-O-CO (stretching) and C-H (bending). High

intensity of the band at 1057 cm^{-1} also denotes the presence on bamboo of a high concentration of primary hydroxyl groups which mainly related to the structure of hemicellulose and cellulose in bamboo.

The band at 872 cm^{-1} is compatible with C-H vibration in aromatic ring system having two adjacent hydrogen atoms [6]. No significant different on transmittance percentage and detected elements between carbonized samples and after activated.

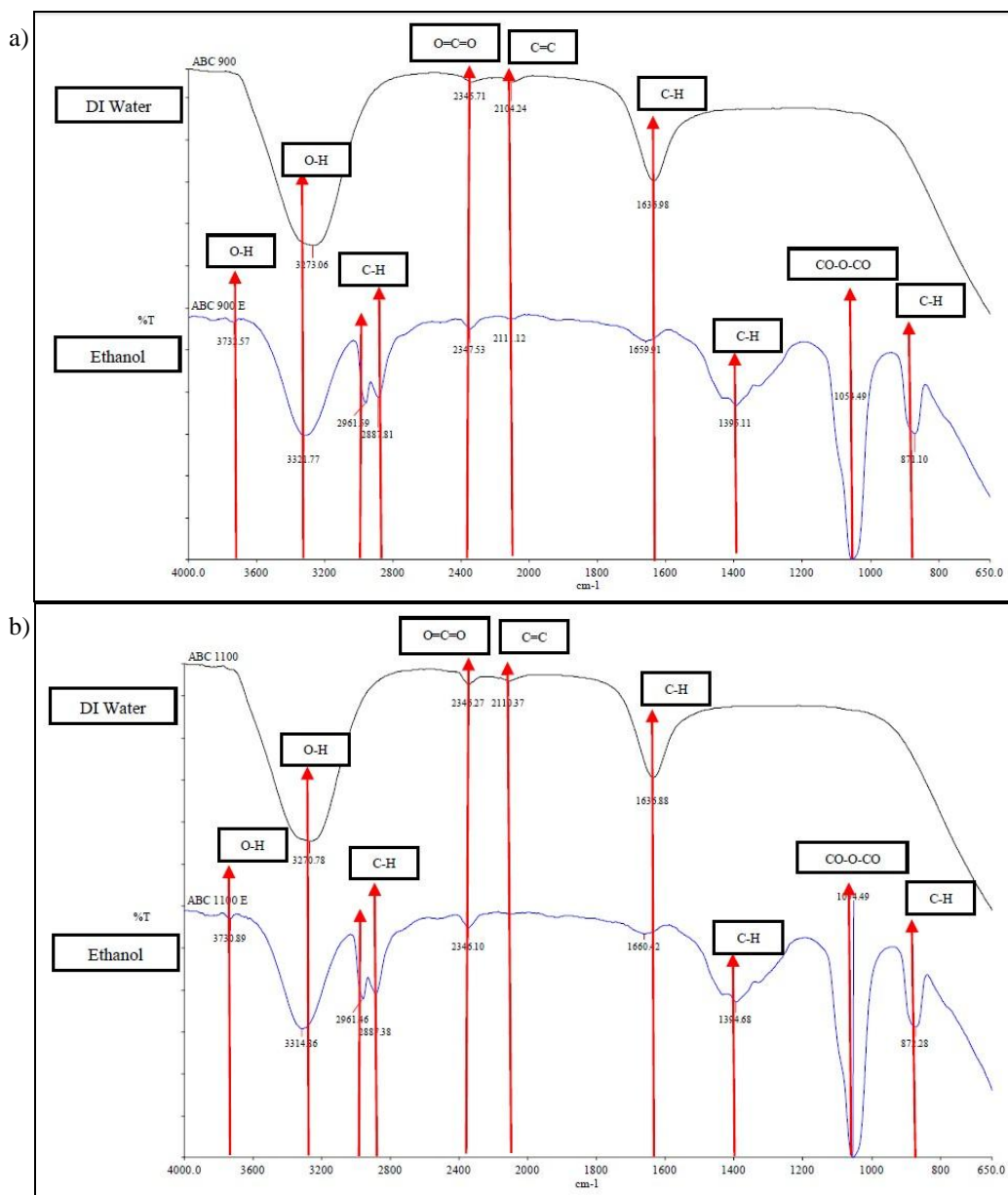


FIGURE 2. FTIR spectra of activated bamboo charcoal (a) ABC900 and (b) ABC1100.

Figure 3 shows the XRD patterns of carbonized bamboo charcoal (CS64 TK) from the company which labeled in red and the activated bamboo charcoal (ABC1100) which labeled in black. There were only two broad peaks located at 22° and 43° were observed which represent the C(0002) and C(0004) of the bamboo charcoal. These indicate that

the bamboo charcoal was mainly an amorphous carbon. The d_{0002} spacing of the bamboo charcoal decreased while the apparent graphite crystallite size $L_{C(0002)}$ increased with the increasing of graphitization temperature.

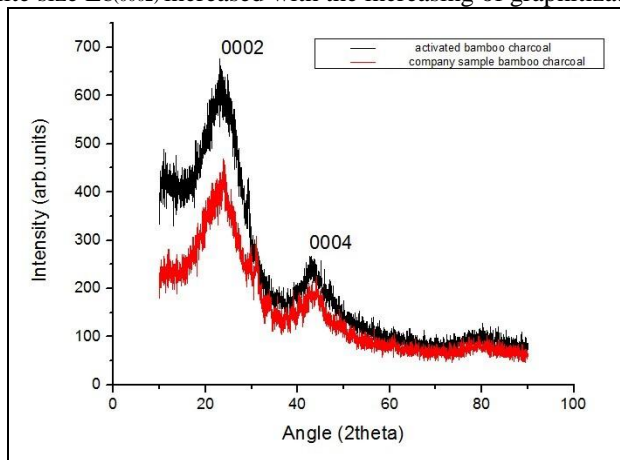


FIGURE 3. XRD spectra of CS64 TK (red) and ABC1100 (black).

CONCLUSION

In this work, carbonized bamboo charcoal produced using mechanical kiln (provided by the joint company) was further activated in the lab furnace at the temperature of 900 °C and 1100 °C in controlled nitrogen environment. The carbonized samples were grinded to powder form using two unnamed methods. These bamboo charcoal and activated bamboo charcoal (in powder form) was prepared in two solvents; DI water and ethanol. FTIR spectra for carbonized samples (CS64 TK) and (CS88 M) show same trend of peaks for DI water and ethanol. Peaks at 3278 cm^{-1} (O-H stretching) and 1637 cm^{-1} (C-H stretching) were broader for both samples in DI water compared to ethanol. Some bands at 2886 cm^{-1} (C-H stretching), 1394 cm^{-1} (C-H bending), 1057 cm^{-1} (CO-O-CO stretching) and 872 cm^{-1} (C-H bending) were only observed at the samples in ethanol. Similar results were obtained for activated samples ABC900 and ABC1100 in both solvents. The XRD spectra shows both carbonized and activated bamboo charcoal were amorphous carbon. As the temperature increased during activation process, the d_{0002} spacing decreased while the graphite crystallite size $L_{C(0002)}$ increased. In order to investigate the change of functional groups in the bamboo products due to the carbonization temperature, further analysis using FTIR will be done in the next project.

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