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Simple Method to Produce Carbon from Cassava Peel by Calcination for Future Application

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Abstract – Organic waste is a manageable solid waste to yield benefit and economic material. One of the benefit things is the processing of organic waste to produce carbon. This study has decomposed waste of cassava peel to yield carbon through calcinations. The process of carbonization has been conducted at temperature of thermal decomposition of cassava peel applying TGA and the carbon yield characterized by FTIR and XRD. The FTIR spectra indicates that the carbon yield from calcinations of cassava peel at various temperatures of thermal decomposition still containing some functional groups of organic compounds showed by its characteristic absorption bands. The characteristic FTIR absorption bands become more distinguishable from the spectra of unmanageable cassava peel due to increasing calcination temperatures. The pattern of X-Ray diffraction of carbon samples yielded from calcinations showed amorphous phase of carbon with several crystalline peaks of graphite at C(001), C(102), and C(112) planes.

Keywords – Cassava Peel Carbon, Calcination, Infrared, Thermogravimetry Analysis, X-Ray Diffraction.

I. INTRODUCTION

Solid organic waste might been produced from food processing. This waste generally yielded from domestic household, restaurant, and food industry. Organic waste can be managed to yield benefit and economic material depends on chemical composition existence. The management of organic waste to valuable material becomes the research topic developed in academic institutions such as the processing of organic waste to yield carbon (1).

Carbon is known as economic valuable material can be produced from organic waste containing cellulose, starch, and lignin. The carbon yield from waste is advantageous since it may reduce cost of production. Several organic wastes have been reported as carbon source, e.g. palm bunches, palm leaves, bamboo, sugar waste, tea and empty fruit bunches. They are reported as adsorbent and catalyst to be activated applying an activator.

In laboratorium scale, carbon is obtained through carbonization applying a furnace at high temperature and purging by an inert gas like nitrogen. High temperature processing may produce material with better properties in terms of surface area and pores. The purging gas may prevent volatile matter adhered at surface pores and resist complete carbonization by oxygen discarded from the furnace. Nevertheless, this system is a high cost process due to instrumentation, high temperature process, and gas application during process (2).

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An alternative method is conducted by using a general calcination method to yield carbon through carbonization. Calcination is a heating process at high temperature in the presence of oxygen. The existence of oxygen during calcination process may yield positive or negative impact. The positive impact is related to fast and low temperature process. The negative impact is related to the existence of oxygen causing complete combustion of organic compounds leading to complete carbonization. This process has to be avoided so that the residue is still containing organic components that can be activated by an acid or base for other application. Therefore, both the temperature and time of calcination have to be well controlled.

This investigation has applied calcination method to produce carbon from cassava peel. The temperature of calcination is referred to thermal decomposition of cassava peel applying TGA. The thermal decomposition range of carbon from cassava peel is selected as the various temperatures of calcinations in this study. The carbon samples obtained from calcinations are characterized by FTIR and XRD (1)

II. RESEARCH METHODOLOGY

A. Apparatus and Material

The instruments used in this experiment were evaporating dish, aluminium foil, furnace, desiccator, and mortar and pester. The material used was this research is cassava peel which was obtained from household industrial waste

B. Carbonization of Cassava Peel

Cassava peel waste was dried and grinded into powder prior to calcination. The sample then placed in a desiccator. Afterwards, the sample was calcined in a furnace for an hour by varying calcination temperatures. The temperatures used were selected based on the area of organic compounds decomposition from the result of the TGA analysis.

C. Sample Characterization and Analysis

TGA (*Thermogravimetric Analysis*)

The TGA was used to investigate the thermal stability of cassava peel carbon. Sample characterization was done at 25-600^{o}C with heating rate 30^{o}C/menit (3). Based on the TGA result, the cassava peel was calcined at various temperatures as summarized in Table 1.

Tabel 1. The carbonization of Cassava Peel at various temperatures

No.	Sample	Calcination Temperature (^{o}C)
1	CP	-
2	CPC250C	250^{o}C
3	CPC300C	300^{o}C
4	CPC350C	350^{o}C
5	CPC400C	400^{o}C

FTIR (*Fourier Transform Infrared*)

The carbon used as activated carbon for future application is carbon that was incomplete carbonized. This means that there are still organic compounds that have not undergone decomposition. To identify the existence of functional groups in the resulting carbon, the samples were tested by FTIR. For FTIR characterization, material was prepared as dried solid powder. FTIR characterization conducted at wavenumber range of 4000-600 cm^{-1} (4) (5). FTIR characterization was conducted for cassava peel and carbon yielded from calcinations.

XRD (*X-Ray Diffraction*)

XRD characterization is used to examine amorphous and crystal structures of cassava peel and derivate carbon (6). For XRD characterization, sample was prepared as fine powder put smoothly on the holder sample. Characterization was at theta (θ) range of 2^{o} - 60^{o} and wavelength λ = 1. 54 Å at room temperature (3).

III. Results And Discussion

A. Thermal Analysis of Cassava peel

As mention above, the TGA analysis was conducted to obtain temperature range of calcination used for carbonization of cassava peel to yield incomplete carbon. Analysis of cassava peel sample was conducted at 25-600ºC. As seen in Fig.1, the termogram produced can be divided into three parts of condition or parts to be analyzed (Fig. 1). The weight loss in the range of 25-150ºC indicates the cassava peel was underwent water loss. All water on the sample surface, polar solvent and volatile compounds that released during the process were removed from this range (3). At 150-350ºC, sample experienced organic compounds combustioning. At> 500ºC, organic compounds have underwent completely decomposition (3). Based on this finding the calcination process was taken at 250ºC – 400ºC. If the calcination was done at lower than 250ºC it is expected that water content still existed in the cassava peel while above 450ºC it is assumed all organic compounds almost completely decompose.

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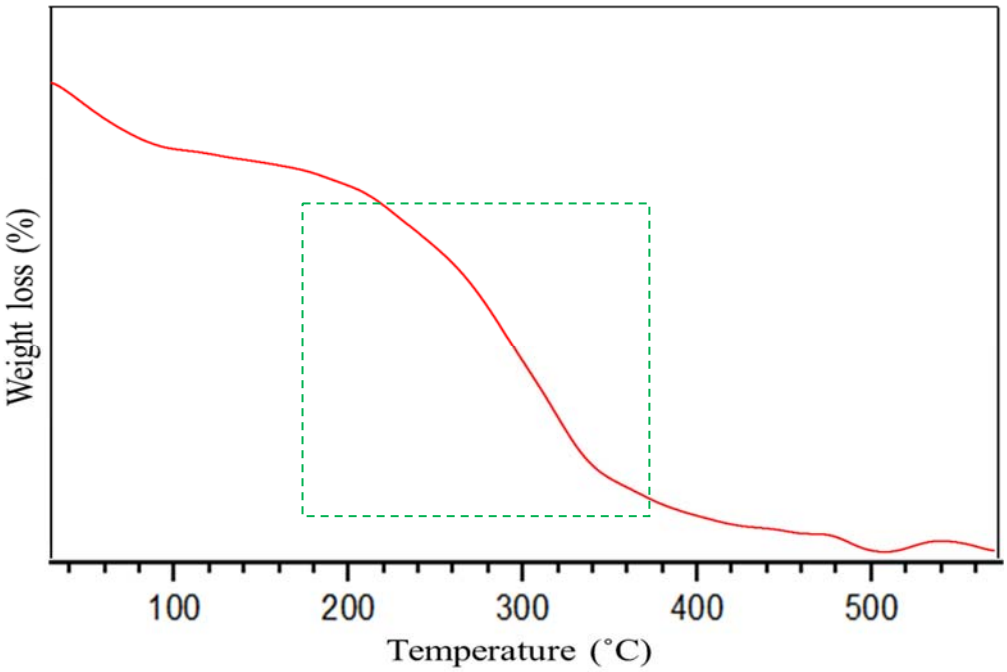

Fig. 1. TGA spectrum of cassava peel

B. FTIR spectra of cassava peel (CP) and cassava peel carbons (CPC)

Previous work reported chemical composition of cassava peel that consisted of protein and amino acids, fatty acids, carbohydrates (starch, cellulose, hemicellulose, and lignin), and small amounts of HCN (7). The existence of these compounds after calcination was characterized by FTIR. The results are shown in Fig. 2 and interpreted in the following paragraphs.

Based on Fig 2, several absorption peaks were detected on the FTIR spectrum of cassava peel. The broad absorption peaks between 3697 – 2985 cm^{-1} indicate the stretching mode of OH-group vibration. The absorption bands at 2991-2841 cm^{-1}, 1811-1753 cm^{-1}, and 1190-935.7 cm^{-1}, are contributed to the C─H, C═O, and C─O stretching vibrations, respectively (8). The absorption band around 1402-1276 cm^{-1} is attributed to asymmetric and symmetric bending of $–CH_2–$ and $–CH_3–$. The absorption peak at 3308

cm^{-1} shows free O─H group and intermolecular tighten. Absorption peak at 2950 cm^{-1} attributed to C–H group, while absorption peak at 1785 cm^{-1} attributed to stretching vibration of C=O from carboxyl group as reported by (9) (10).

The obtaining cassava peel carbons were characterized also at a wavenumber range of 4000 - 600 cm^{-1}. As shown in Fig. 2, at wavenumber range of 1921-1558 cm^{-1} there is a vibration of C=O in COOH found in cassava peel carbon. The absorption peak at 1799-1496 cm^{-1} indicated a vibration of aromatic C=C attributed to aromatic ring structure in polyaromatic cassava peel carbon due to calcinations. The absorption peak at 1502–1192 cm^{-1} indicated C-O bond from C-O-C functional group related to glycosidic bond in starch (11). The existence of absorption peaks in cassava peel carbon yielded from calcinations indicated that the cassava peel sample was not carbonized completely. From Fig. 2, the vibration of C-O at wavenumber around 1000 cm-1 was removed due to C-O-C glycosidic bonding broken due to calcination temperature increased (12).

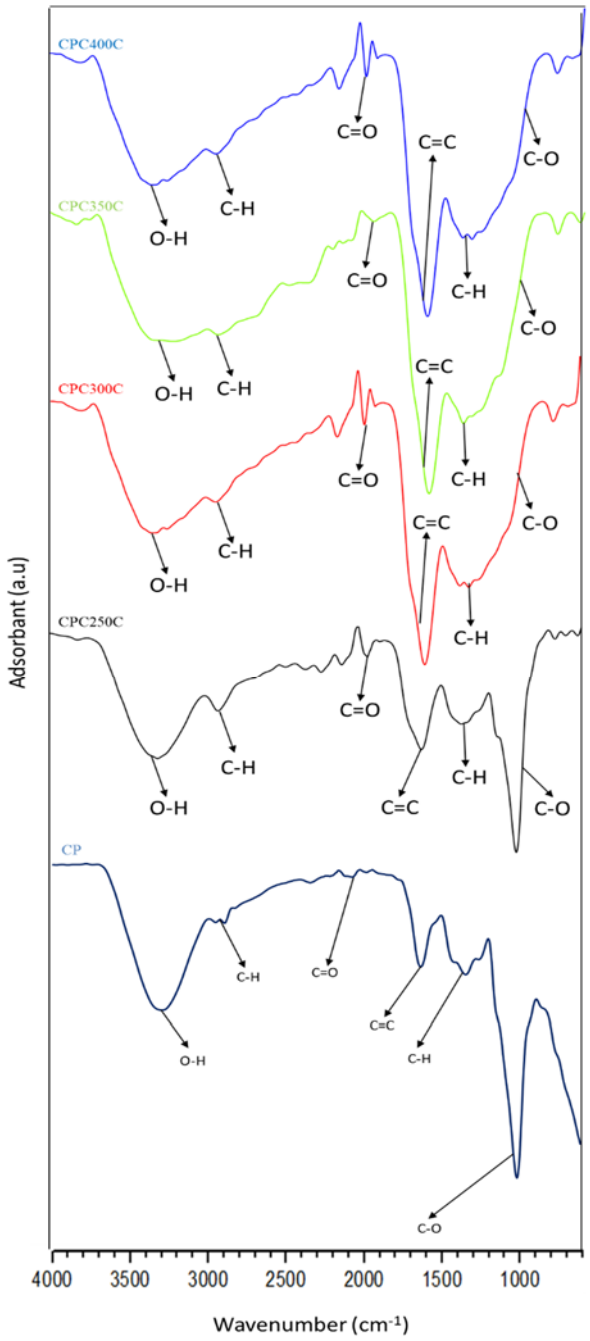

Fig. 2. FTIR spectra of cassava peel (CP) and cassava peel carbon (CPC)

C. XRD diffractogram pattern of cassava peel carbon (CPC)

The patterns of XRD diffractogram show characteristic patterns of cassava peel carbon at calcination temperatures that are illustrated at Fig. 3. Based on Fig. 3, the resulting diffractogram pattern shows the carbon characteristics of the cassava peel at a calcination temperature of 250-400ºC, as illustrated in Figure 3. Based on Figure 3, all samples show a wide amorphous pattern in regions 2θ of 21º. This pattern is commonly found in the organic compounds due to the interconnecting of the constituent monomers. In addition, this amorphous peaks experienced a shift from 2θ of 21º to 2θ of 25º as the temperature increased to 400ºC and formation of crystalline peaks.

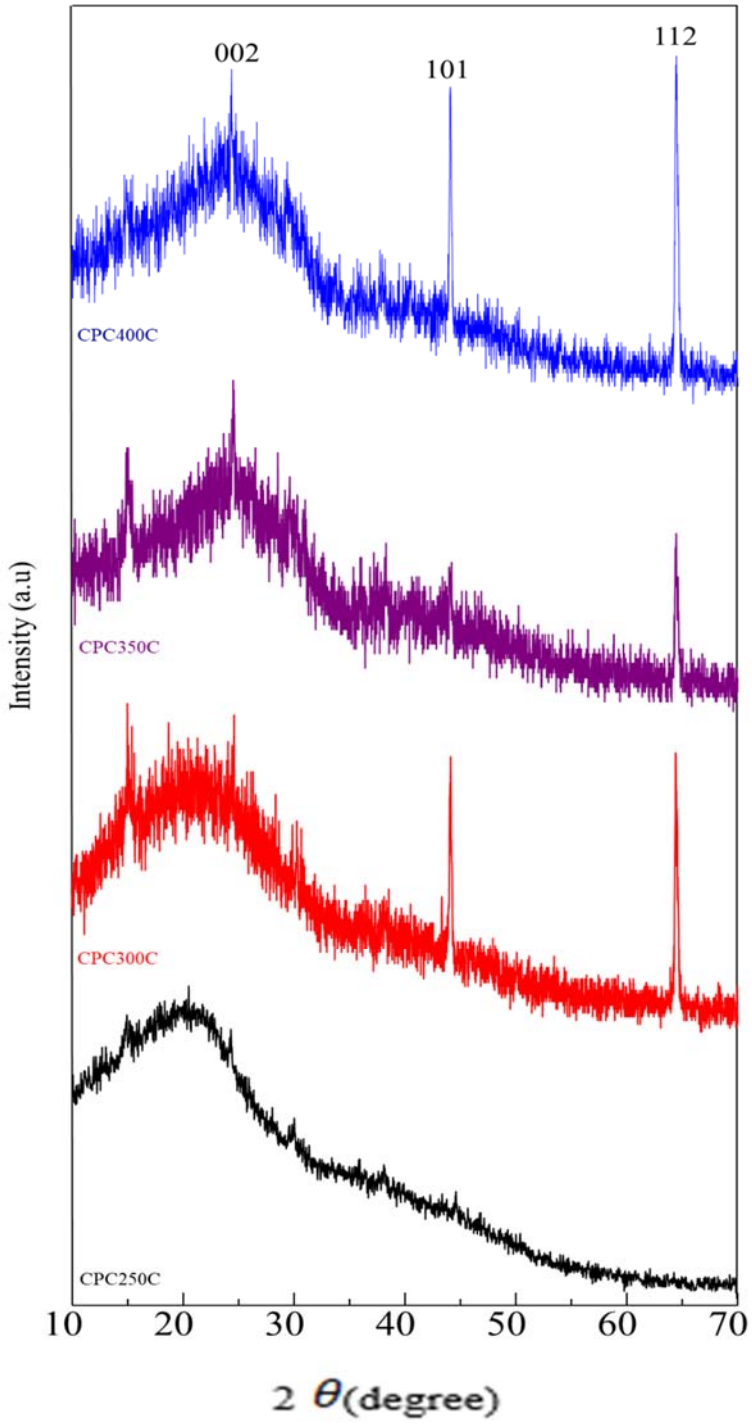

Fig. 3 XRD diffractogram patterns of cassava peel carbon at different calcination temperatures.

At a calcination temperature of 250ºC, the crystalline peaks of carbon in the graphite structure are not clearly observed. This means that not many organic compounds in the sample have undergone carbonization. At temperatures above 250ºC, sharp crystalline peaks appear at 2θ of 20° - 30°, 40 ° - 50 °, and 80º - 90º, with graphite planes C (002), C (101), respectively. , and C (112) (13). These results are consistent with those reported in some literature and have the potential to be developed as activated carbon for adsorption or a carbon source in the synthesis of sulfonated carbon-based catalysts (14).

IV. CONCLUSION

This study shows interested findings related to carbon synthesis using simple calcination method on the basis of TGA examination. Interested features from the analysis of characterization with regard to FTIR and XRD in relation to investigation of functional groups, chemical bonding, and crystalline structure due to escalated calcination temperatures. Therefore, this study can be developed for future application in many field industries.

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