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Characterization of Sustainable Graphitic Biochar from Food Waste via Microwave Irradiation Technique

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Abstract

The significant rise in waste generation caused by global urbanization and industrialization may harm the environment, leading to climate change. According to the Solid garbage and Public Cleansing Management Corporation (SWCorp Malaysia), Malaysia generates an average of 1.17kg of garbage each day, which equates to around 3.5 million tons of food waste (FW) every year. Therefore, by transforming FW into valuable materials like graphite presents an appealing alternative due to high demand for it, particularly in energy-related applications. In this research, we introduce a new method for producing sustainable graphitic carbon from FW using microwave-assisted pyrolysis (MAP). The graphitic carbon obtained via microwave pyrolysis at power supply 1000 W at 5- and 45-minutes radiation time then underwent analysis such as X-ray diffraction (XRD), Thermogravimetric Analysis (TGA) and Fourier-Transform Infrared Spectroscopy (FTIR) to verify its structural characteristics, graphitic properties and chemical composition of graphitic carbon. The findings indicated that the microwave irradiation process successfully pyrolyzed food waste into biochar at 1000 W, 30 minutes, giving 23.9% of biochar yield with lower energy consumption (1800kJ). Whereas, the conversion to graphitic carbon from FW is about 60Gp degree of graphitisation. The new material has an excellent potential for electrical conductivity and mechanical endurance, making it appropriate for a variety of applications such as energy storage devices, catalysts, and composite materials. This investigation underscores the potential of utilizing microwave irradiation as an eco-friendly and effective method for converting food waste into valuable graphitic carbon, contributing to the advancement of a circular economy and diminishing the environmental consequences of waste disposal.

1. Introduction

Food waste (FW) is a major cause of environmental pollution and resource waste. According to study conducted by Solid garbage Management and Public Cleansing Corporation [1]. Malaysians generate around 39,078 tons of solid garbage each day, which equates to approximately 1.17kg per person (SWCorp, 2020). This quantity has a detrimental impact on the environment since it wastes all of the resources used to produce it, including water,

land, energy, and labour. Additionally, FW in landfills emits methane, a strong greenhouse gas that causes to climate change. Traditional disposal techniques, such as landfilling and incineration, are detrimental to the environment. As a result, transforming food waste into useful and high energy compounds such as biochar might reduce these concerns because food waste products are remarkably adaptable, abundant, inexpensive, making them an attractive resource for carbon extraction. Biochar are appealing materials for carbon catalysts because they have a high carbon content and surface area, and minerals found in biochar can function as active sites for catalytic processes. Because of its unique physicochemical features, it has been widely employed in the domains of soil remediation, wastewater treatment, climate change mitigation, and energy generation, as well as in environmental pollution remedies. Furthermore, biochar is increasingly being used for non-soil applications, such as water filtration [2], animal feed [3], as a product substitute for fossil-fuel-derived components used in composite materials [4], and high-tech applications such as supercapacitors [5].

Recent research has examined the preparation, adsorption, and catalytic activity of graphite-like biochar pyrolyzed at temperatures above 700°C [6, 7]. This biochar can convert biomass and amorphous carbon to graphitized carbon. The wide special surface area (SSA), multi-porous structure, high aromaticity, and environmental friendliness of these graphite-like biochar materials make them excellent candidates for utilization as effective adsorbents for environmental organic contaminants [8-10]. This method includes the thermochemical breakdown of biomass in an oxygen-limited environment, which produces a stable form of carbon that may influence the particle size, yield, and carbon content of biochar. These elements will have an impact on the finished product, graphite. If the pyrolysis is done successfully, it produces a charcoal with the maximum carbon concentration and no by-products, making it easier to form a complicated structure like graphite [11].

In particular, several methods for biochar treatment have been devised, and they are often classified into three categories: heat treatment, pre-treatment, and post-treatment modulating the carbonization process [12]. According to the literature, the best option to obtain biochar from FW with high percentage of carbonaceous char produced (vs. pyrolytic oil and gas) is represented by low-to medium-temperature pyrolysis and high residence time [13, 14]. Furthermore, avoiding high temperatures throughout the process promotes the expansion of the specific surface area of the biochar formed from FW, which has positive impacts on adsorption capabilities against pollutants [15]. Wang, Liu [16] found that extended residence time reduces oxygen concentration, increases carbon content, and results in a greater calorific value of the resulting carbonaceous product. Electromagnetic waves radiate energy rather than dissipating it in a heat transfer medium. A classic example is a kitchen microwave oven, which can cook food much faster than thermal heating. Microwave heating has been proposed as a potential energy-efficient graphitization approach. Several research have indicated that heating carbon materials with microwaves improves surface and porosity by eliminating components, including pores, such as renewing activated carbon [17], weld carbon nanotube/polymer composites [18] and exfoliate graphite [9]. However, due to the complex physicochemical structure of food waste, it will resist degradation above 400-700°C, resulting in biochar with a lower surface area, restricted pore capacity, and poor crystallinity [19].

Pre-treatment procedures such as KOH activation, NH3 soaking, and microbiological degradation have been widely documented to produce satisfactory results [20]. However, numerous difficulties remain in the way of further popularizing pre-treatment, such as a time-consuming method, high cost, and low efficiency. Post-treatment, specifically acid washing, is a simple and effective approach for improving biochar. There is additional physical treatment in the pre-treatment process, such as filtering, aeration, grinding, or screening to reduce particle size. It has been recommended as a method of improving biochar surface functioning, which is critical in the production of high-quality graphite. Grinding or sifting raw biochar is a typical procedure to enhance surface quality, product homogeneity, and reduce particle size, with the notion that small particles have more porosity and hydrological properties. Some post-processing of biochar is unavoidable, even if essentially passive, such as aeration by exposure to ambient air following pyrolysis. Freshly formed biochar are susceptible to spontaneous combustion, which is mostly caused by volatile organic molecules released during pyrolysis. Ultrasonic therapy is another potential post-treatment approach that has been utilized to clean membranes, destroy bacteria, and degrade organic contaminants [13]. Ultrasound may cause cavitation in water, which can remove organic and inorganic components from biochar through the processes of thermolysis, radical oxidation, and micro-acoustic flow scouring. Ultrasound is also capable of cleaning mineral particles in the porous biochar [21].

Based on existing understanding, only a few research have investigated the synergistic impact of pre-treatment and residence time on graphitic biochar. The findings of this study will aid in the recognition of a pre-treatment process capable of converting FW into a product in the form of graphite-like biochar, which has the potential to be of high graphitic carbon quality and meet the standards of the final applications.

Int. Journal of Integrated Engineering Vol. 17 No. 4 (2025) p. 199-209

2. Materials & Methodology

2.1 Materials

Food waste (FW), a heterogeneous mixture of carbohydrates, proteins, fibres and bones was collected from Hotel UiTM, Shah Alam, Malaysia. Whole ingredients of food waste sample were cooked (60-70°C). The initial weights were measured at room temperature (25°C) where about 50g each of the food group were sampled as stated in Table 1. The average moisture content of FW is about 75-82%. FW samples are well mixed before to the division process. After mixing, the combined sample is divided by using coning and quartering method (ASTM D6323-98). The FW was kept using zip-lock polyethylene bags prior to the experiment to prevent atmospheric dust and moisture contamination and stored in freezer to minimize the bio-degradation of FW and carbon preservation for future processing.

Table 1 *Standard food-waste samples*

Classification	Composition Ratio (wt%)	Food Ingredients	Processing Method
Carbohydrates	25	Cooked rice	Pestle and mortar around 8mm size
Proteins	25	Chicken & beef	
Vegetables & fruits	25	Cabbage, long beans	
Bone & shells	25	Chicken & fish bones	

2.2 Carbonization-microwave Pyrolysis

Pyrolysis studies were conducted utilizing a modified convection microwave oven in a batch mode of operation. Initially, a mixture of FW was taken in a reactor with lid made of quartz. The quartz reactor was connected to the condensation system using a hole provided on the top of the microwave oven cavity. The set up consists of a modified domestic microwave oven of 1000 W, 28L, quartz vessel, thermocouple type T, condensing system and nitrogen line to create inert atmosphere. The set-up allows the recovery of liquid and gas fraction from the carbonization or pyrolysis system, while collecting the biochar in the quartz vessel. The details about the experimental setup can be obtained from the earlier published work [22].

2.3 Pre-treatment of Biochar

FW-based biochar sample is mixed with deionized water and subjected to ultra-sonication. The resulting samples is centrifuged at 2000 rpm for 10 mins, followed by vacuum filtration and consequently vacuum oven dry at 50°C. Finally, pre-treated biochar (BPT) sample is kept in an airtight screwed bottle for further use. While, non-pre-treated biochar (BNPT) sample is directly used for next graphitization process.

2.4 Graphitisation-Microwave Pyrolysis

Measured food waste biochar powder (pre-treated/non-pre-treated) is placed in a quartz sample boat, inserted in the quartz reactor. Quartz reactor will be purged with nitrogen gas for 10 minutes to guarantee total displacement of oxygen in the vessel. The process is set at the selected power, 1000 W and different of irradiation time (5 minutes and 45 minutes). Upon completion, the system will be allowed to cool for approximately 10 minutes before removing the sample, to avoid oxidation of the resulting sample. Temperature reading during the experiment will be taken at regular interval. The final product sample will be kept in an airtight screwed bottle for characterisation. To differentiate between different forms of biochar, the relevant initials were used, followed by the pre-treatment and non-pre-treatment and residence time (5 and 45 minutes), such as GPT5, GNPT5, GPT45, and GNPT 45.

2.5 Characterization of Products

A thermogravimetric analyzer (TGA, Mettler Toledo) was used to determine the proximate analysis according to ASTM D1762-84 of moisture, volatiles, fixed carbon, and ash contents. The final examination of elements C, H, N, and S contents was performed using the Flashea 1112 Series elemental analyzer. In Japan, an X-ray diffractometer with a Cu Ka X-ray source (D/max-3B) is utilized for X-ray diffraction (XRD) examination at a voltage of 40 kV and a current of 40 mA (Hou et al., 2022). The surface functional groups of biochar were determined using a PerkinElmer Spectrum One FT-IR spectrometer with a resolution of 4 cm−1. Each sample had 32 scans from 4000

cm−1 to 400 cm−1. The graphitization index (Gp) is a structural characteristic that may quantitatively describe graphite and turbostratic materials using the equation below:

$$Gp=\frac{0.3440-d002}{0.3440-0.3354} \quad (1)$$

3. Results and Discussion

3.1 Production of Food Waste-Derived Biochar

During the carbonization process, three types of products are typically produced: biochar (solid fraction), bio-oil (liquid fraction), and synthetic gas. However, this study solely reports biochar from the microwave pyrolysis operation. During the microwave pyrolysis process, the preliminary run revealed that pyrolysis of food waste is not possible at a power level of 300 W for up to 60 minutes. According to Table 2 below, the biochar was totally pyrolyzed at 1000 W for 30 minutes, giving 23.9%. The completely pyrolyzed biochar was also discovered when the pyrolysis was carried out at 850 W (40 minutes), with a yield of 24.5 wt.%, somewhat higher than 1000 W (30 minutes). However, the power consumption of 850 W for 40 minutes is much higher, at 2040kJ, compared to 1000W, which calculated just 1800kJ. Even with increased power use, there is no discernible difference in biochar output between the two situations. Pyrolysis of food waste at 600 W (30 minutes) and 1000 W (20 minutes) did not yield a complete conversion to biochar. At this phase, the sample is not entirely pyrolyzed, resulting in a brownish, odorous solid product. A fully pyrolyzed biochar is a blackish-bright, porous material with no foody odor. Figure 1 shows a food waste sample before and after pyrolysis.

The totally pyrolyzed end product (biochar) was seen when the pyrolysis was carried out at 850 W (40 minutes), with a yield of 24.5 wt.%, and at 1000 W for 30 minutes, with a char yield of 23.9 wt.%. This conclusion is consistent with prior study by Januri et al. (2016). The end product does not entirely convert to biochar when the radiation period and microwave power are insufficient to initiate the pyrolysis process. According to Januri et al. (2016), the optimal conditions for microwave pyrolysis of food waste were 1000 W and 30 minutes of radiation exposure. However, for efficient functioning, the sample mass must be considered in relation to the size of the microwave cavity (Monga et al., 2022). Hence, sample mass and operating time are crucial for further testing.

(a) **(b)**

Fig. 1 *Condition of food waste sample at (a) before; (b) after carbonisation*

Table 2 *Formation of solid char from microwave pyrolysis of food waste*

Power (W)	Radiation time (min)	Char yield (%)	Observation on physical appearance of sample
600	30	-	Not fully pyrolysed
850	40	24.5	Fully pyrolysed
1000	20	-	Not fully pyrolysed
1000	30	23.9	Fully pyrolysed

Int. Journal of Integrated Engineering Vol. 17 No. 4 (2025) p. 199-209

3.2 Proximate and Ultimate Analysis

Proximate analysis uses a thermogravimetric analyzer (TGA) to determine the distribution of essential components such as moisture content, volatile matter, fixed carbon, and ash, which are reported as weight percentages (wt%). The significance of proximate analysis lies in its ability to predict the behavior of materials during combustion and thermal processes, thereby informing their potential applications and efficiency as fuels. In Table 3 of proximate analysis revealed that BPT and GPT45 have the highest moisture content, while GNPT5 has the lowest moisture content is may cause by the surface of the biochar which contains fewer polar functional groups, thus the interaction between steam and biochar is low [23]. According to Yulis Setyawan, Mayang Sabrina Sunyoto [24], the maximum moisture content of biochar is 10%. Therefore, the moisture content of all biochar produced was within the standard for moisture content. All FW samples have a significant amount of volatile matter (VM) ranging from 50-60% in which BPT has the highest VM content, indicating it might have a higher heating value due to its potential for greater energy release. These high amount of VM has also reported by Wang, Yang [25] where VM content in the six kinds of biomass is around 60–70%. The fixed carbon of GPT45 and GNPT45 were the highest showing their carbon stability and high carbon content. For the ash content, BNPT has the highest, indicating it might contain a higher amount of inorganic matter, whereas GPT45 has the lowest ash content, showing a purer organic material.

Table 3 *Proximate analysis in terms of wt% dry biochar basis*

Conditions	Moisture Content	Volatile Matters	Fixed Carbon	Ash Content
BNPT	1.74	54.65	14.92	28.69
BPT	4.29	61.71	17.32	16.68
GNPT5	0.61	52.81	30.85	15.73
GPT5	2.66	55.21	13.58	28.55
GNPT45	0.91	52.67	31.00	15.33
GPT45	3.01	57.82	31.09	8.08

Based on these findings, it can be concluded the potential characteristics and applications of these samples. Samples with high volatile matter content and low ash content, such as BPT and GPT5, may be suitable for use as fuels due to their high heating values and lower ash-related issues. According to Vamvuka and Sfakiotakis [26] amorphous carbon structures can generate micropores. A higher pyrolysis temperature releases volatile materials and develops more pores, as demonstrated by GPT45. However, its ash level was the lowest among all biochar, despite the fact that prior research [27] demonstrated that the ash content of biochar increases with increasing pyrolysis temperature (up to 600°C). This is due to the significant removal of moisture, volatiles, and all organic components. Biochar made from cotton seed hull showed low specific surface areas and ash content (4.7 m^2/g).

Table 4 *Ultimate analysis in terms of wt% dry biochar basis*

Conditions	Elemental Analysis					
	C	H	N	O	H/C	O/C
BNPT	45.64	0.59	4.10	48.13	0.012	1.031
BPT	52.32	5.07	4.26	36.71	0.138	0.702
GNPT5	47.29	4.72	3.84	42.6	0.111	0.901
GPT5	54.10	6.17	4.86	33.33	0.185	0.616
GNPT45	46.55	5.41	3.42	43.06	0.126	0.925
GPT45	50.65	5.20	4.02	38.45	0.135	0.759

Table 4 shows the elemental analysis findings for the following conditions: BNPT, BPT, GNPT5, GPT5, GNPT45, and GPT45. The examination focuses on the carbon (C), hydrogen (H), nitrogen (N), and oxygen (O) contents, as well as the H/C and O/C ratios. The carbon concentration fluctuates according to the circumstances. BPT and GPT5 have the largest carbon content, whilst GNPT5 and GNPT45 have the lowest. The H/C ratio is generally low across all conditions, indicating a relatively high carbon content compared to hydrogen, supported by Mukome, Zhang [28]. The H/C ratio dropped as the pyrolysis temperature climbed. There was a clear variation depending on the pyrolysis temperature, but there was no change based on the salt concentration. Lower H/C and O/C ratios at

higher pyrolysis temperatures imply a stable biochar with a low amount of O-based functional groups due to demethylation and decarboxylation [28].

3.3 XRD Analysis of Food-Waste-Derived Graphitic Biochar

Figure 2 shows the XRD patterns of all samples including pure graphite as a reference. The positions of these peaks remain insignificantly changed across the different samples, indicating that the crystal structure of the graphitic carbon remains consistent. All FW sample exhibited two characteristic diffraction peaks at 2θ angles of ~31.45◦ (*d*200) and ~45.56◦ (*d*220), whereas pure graphite diffraction peaks at 2θ angles is ~26.56 and ~54.5◦ that has an interplanar distance, of 0.334 nm which attributed to the graphitic carbon planes of (002) and (100). It can be observed samples (b) to (g) exhibit reduced peak intensities and broader peak widths, indicating a decrease in crystallinity or smaller crystallite sizes presence. Besides, there are also presence of additional peaks at lower 2θ angles in six samples indicates the coexistence of other compound or impurities. This can be proved by the quantitative analysis results, there is establishment of halite (NaCl) compound aside from graphite in the biochar produced (Table 5).

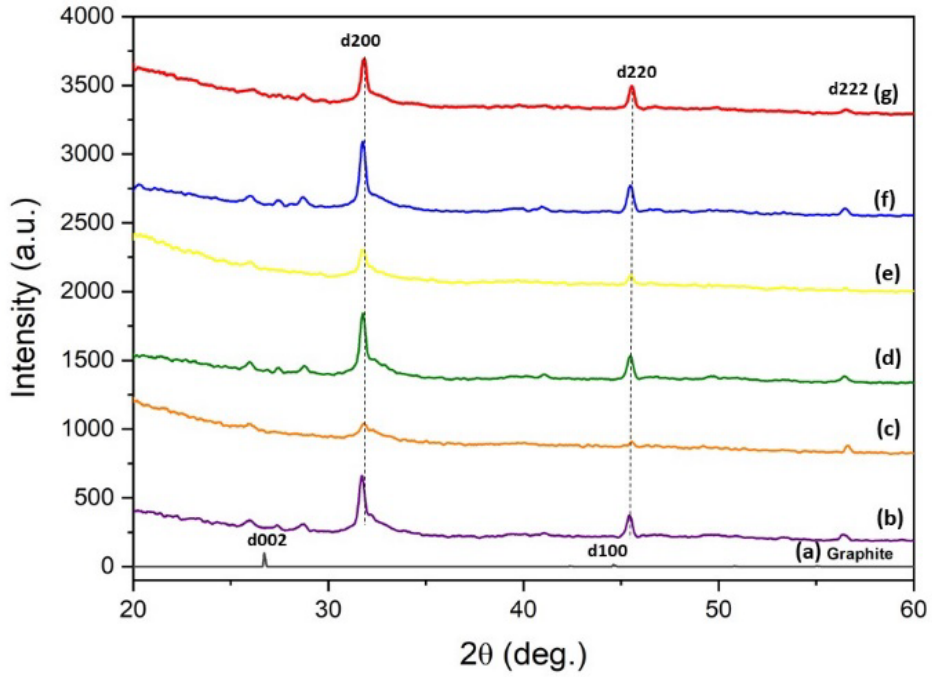

Fig. 2 *X-ray diffraction patterns for (a) pure graphite, (b) BNPT, (c) BPT, (d) GNPT5, (e) GPT5, (f) GNPT45 (g) GPT45*

From the above observation, the peaks observed for these six conditions are not aligned with the diffraction peaks at 2θ angles of graphite. This indicates the process of graphitisation is incomplete and showed slight changes in their crystalline structures. Moreover, thermal pre-treatment significantly changed the crystallinity of food waste-derived biochar under all pre-treatment conditions and a peak broadening has occurred contributed by these processing or treatments [29]. In order to restore crystallinity of graphite materials, Fazeli Sangani, Abrishamkesh and Owens [30] has suggested the addition of organic additive and a catalyst on the pyrolytic process could improve surface area and pore size of biochar which effect the crystallinity of graphitised materials. This is supported by Kim, Lee and Lee [31] the location of the (002) peak of activated carbon shifted to higher angles following microwave irradiation in the absence of NiCl2 (25.80°), but it was substantially lower than the position of graphite (26.50°) or microwave graphitized activated carbon in the presence of NiCl2 (26.50°). Furthermore, the width of the (002) peak remained comparable to that of virgin activated carbon.

Int. Journal of Integrated Engineering Vol. 17 No. 4 (2025) p. 199-209

Table 5 *Quantitative analysis and degree of graphitisation of food-waste-derived graphitic biochar*

Conditions	Graphite (%)	Halite-NaCl (%)	Degree Of Graphitization (Gp)
BNPT	1	99	22.51
BPT	100	0	60.75
GNPT5	50	50	17.49
GPT5	50	50	19.21
GNPT45	1	99	20.53
GPT45	20	80	33.70

Based on Table 5, the graphitic biochar has shown mixture of NaCl compound that coexistence within the materials which eventually give effect on biochar properties such as porosity, yield and surface area. The average sodium chloride percentage of dry food waste biomass is 3.45% [32]. It is found that BPT has the highest percentage of graphite, 100% illustrated by degree of graphitization, 60.75. Whereas, the lowest percentage of graphite belongs to BNPT and GNPT45 that has 22.51 and 20.53 Gp respectively. A higher degree of graphitization suggests a higher resemblance to pure graphitic structure, while incomplete graphitization produces graphitic materials [31]. Table 5 shows that the high quantity of NaCl reduces the degree of graphitisation, which affects the surface area and pore volume of graphitic biochar generated. In general, adding NaCl concentration increases total pore and mesopore volumes while decreases BET surface area. However, the tendency has decreased when the 20% NaCl level was attained. This is said to have happened because the excess NaCl allowed the clustered NaCl to outnumber the vast dispersion of NaCl. In other words, the higher the NaCl content, the larger the NaCl crystals, resulting in holes of greater breadth and volume when the NaCl is eliminated. In contrast, the BET surface area decreased due to the formation of big mesopores rather than the equal distribution of relatively tiny mesopores [33]. According to the previous study, using the maximum amount of NaCl has an adverse effect on the degree of graphitisation.

Table 6 *Structural and microstructural parameters of the studied samples, interspacing layer d(002) and crystallite size (La)*

Conditions	Interlayer Spacing (d002)	Crystallite size (La)
BNPT	0.0210	23.27
BPT	0.0211	60.82
GNPT5	0.0210	17.51
GPT5	0.0210	19.23
GNPT45	0.0210	20.56
GPT45	0.0211	33.74

Graphite materials are aggregates of crystallites, or polycrystalline graphite, that do not have the same qualities as graphite due to structural differences. To confirm that graphite was formed during the graphitization process, the basic structural unit (BSU) of the material can be measured. Calculations demonstrate that the size of the crystals in graphite has a direct impact on the substance. Specifically, the material's characteristics, which include both thermal and electrical conductivity. From Table 6, BPT has largest crystallite size, 60.82 compared to the rest of graphitic carbon. The electrical conductivity demonstrates a relationship between smaller crystal size and lower electrical conductivity, whereas bigger crystals provide higher electrical conductivity. This is because smaller crystals increase the average free path of electrons in the material. Longer routes in the material increase the time and difficulty for electrons to cross, resulting in decreased electrical conductivity [34]. The journey is longer because the ratio between crystal volume and surface area to traverse is lower than that between bigger crystals and surface area [35, 36]. This number corresponds to the greatest level of graphitisation as stated in the preceding table. As a result, BPT has the potential to produce materials with high electrical conductivity and mechanical endurance.

3.4 Fourier-Transform Infrared Spectroscopy (FTIR)

FTIR spectroscopy was used to detect structural and chemical changes, namely the availability and abundance of functional groups on the surface of the investigated biochar (Figure 3). When biochar is created for a given use, functional groups of interest are frequently examined as a function of biomass supply and content, pyrolytic temperature, processing time, and heat rate. These characteristics have been proved to play a critical role in determining the appropriateness of biochar for a certain usage [37]. Figure 3 shows the FTIR spectra of all graphitic carbon samples investigated in the order listed below. The collected spectra were consistent among biochar produced from the same kind of biomass but with different residence durations and treatment conditions. FTIR spectroscopy was employed to analyze the functional groups of different condition of biochar (BPT, BNPT) and graphitic carbon (GPT5, GNPT5, GPT45, and GNPT45) (Figure 3). There were very few or no changes in the surface chemistry of biochar generated after 5 or 45 minutes at 400°C. Figure 3 shows two major peaks in graphite powder: -OH (3436 cm-1) and C=O (1636 cm-1), which represent O-H stretching of H-bonded hydroxyl groups and carbonyls. Strong peaks at 2924 cm-1 were identified for the obtained graphitic carbon, indicating stretching vibrations. Strong peaks about 2924 cm-1 were detected in the resulting graphitic carbon, indicating stretching vibrations of the C-H functional moieties. The observed peaks at ~1739 is due to C=O stretching vibrations.

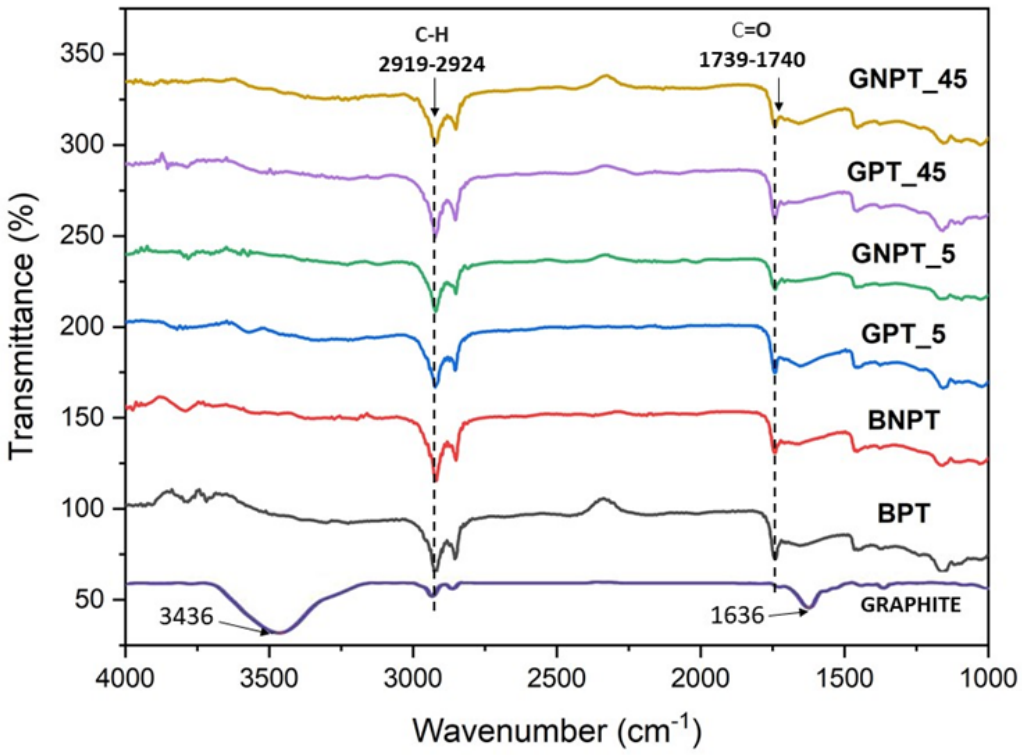

Fig. 3 *FTIR spectra for graphite and all graphitic carbon studied*

Apparently, the parameter "residence time" made no substantial contribution to the description of distinct vibrations. The pyrolysis temperature had a significant influence in characterizing the behavior of C-H-stretching of substituted aromatic C, C=C-stretching of aromatic components and lignin, and C=O-stretching of conjugated ketons and chinons evident at 1740 cm^{-1}.

4. Conclusion

In summary, using an innovative method, we prepared graphitic carbon from heterogenous FW by MAP. This study has shown that the structural, chemical characteristics and graphitization properties of biochars from pre-treatment, residence time by microwave heating has potentially become valuable graphitic carbon that useful in energy storage devices due to significant rate degree of graphitization shown by BPT that has 60Gp degree of graphitization which illustrate the similarity to graphite properties although all of the samples have an interplanar distance (d002) range from 0.0210-0.0211nm, which has huge difference compared to graphitic carbon planes of 0.334 nm. Therefore, in order to improve the quality and functionality of obtained graphitic biochar, reducing size of particle and optimizing MW heating rate with assistance of catalyst for method efficiency can be employed to convert FW to graphitic carbon with excellent energy storage performance. The present findings provide new insights that will promote the effective utilization of FW resources.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:****, Nuraqilah Hishammuddin, Siti Shawalliah Idris;* ***data collection:*** *Nuraqilah Hishammuddin;* ***analysis and interpretation of results:*** *Nuraqilah Hishammudddin****,*** *Siti Shawalliah Idris, Noor Fitrah Abu Bakar;* ***draft manuscript preparation:*** *Nuraqilah Hishammuddin, Siti Shawalliah Idris, ,Norazah Abd Rahman, Noor Fitrah Abu Bakar, Siti Norazian Ismail, Alina Rayahu Mohamed. All authors reviewed the results and approved the final version of the manuscript.*

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