Extraction of Carbon Dots from Empty Fruit Bunch Biochar via an Acid-Free Hydrothermal Method

Norhanisah Jamaludin[a], Suraya Andul Rashid[a,b*], Tongling Tan[a]
[a]*Institute of Advanced Technology, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*
[b]*Department of Chemical and Environmental Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*
**Corresponding Author's Email: suraya_ar@upm.edu.my*

Abstract: Carbon dots (CD) have attracted tremendous attention due to its characteristics of good stability, excellent optical properties and low toxicity. Generally, we discuss a facile hydrothermal method in extracting CD from empty fruit bunch (EFB) biochar. The obtained CD was characterized by UV-visible spectroscopy, photoluminescence spectroscopy (PL) and High-resolution electron microscopy (HRTEM). Under a UV light, the extracted CD exhibits a blue luminescence with maximum absorption and emission peak of 348 nm and 430 nm respectively. The TEM images showed CD shape to be nearly spherical and monodispersed with an average diameter of 4.6 nm and lattice spacing of 0.21 nm. The result obtained suggest that the CD could possibly be utilized for further application.
Keywords**:** carbon dots, biochar, extraction, hydrothermal method

INTRODUCTION

CD have attracted tremendous interest among researchers due to their remarkable novel properties such as biocompatibility, low-toxicity and ease of production [1]. CD are categorized as 0D carbon nanomaterials with a size of less than 10 nm [2] and properties of photoluminescence (PL). CD emit various PL colors, depending on its size and also the method of preparation selected. Recently, there is an increasing interest in nanomaterials-based innovations, especially the usage of agro-wastes as a source in preparing nanomaterials [3]. Thus, converting these wastes to biochar may utilizes the residues in a sustainable way and therefore, able to produce nanomaterials out of it. In this study, we developed a hydrothermal process where harsh acids and tedious process is not needed to extract CD from EFB biochar.

MATERIALS AND METHODS

Biochar from empty fruit bunch (EFB) was provided by Pakar Go Green Sdn Bhd. Isopropanol (IPA, assay 98%) was obtained from Merck, Darmstadt, Germany.

Extraction and characterization of carbon dots from EFB biochar

In this work, 0.06 g EFB biochar and 6 mL of IPA were added into a steel tube reactor. It was sonicated for 5 minutes before being placed into an oven at temperature 250°C for 60 minutes. Then, leave it immersed in a water bath to cool down for 4 hours. The black liquid produced was purified using centrifugation to eliminate the residual biochar. The supernatant containing CD was withdrawn and kept for further characterization using UV-visible spectrometer, PL spectrometer and HRTEM microscope.

RESULTS AND DISCUSSION

Optical Studies of CD

The extracted CD solution was light brown and exhibited blue fluorescence under the 365nm UV light source as in the inset Fig. 1(b) and Fig. 1(c). The origin of fluorescence in CD is ascribed to the presence of surface defects and functional groups exposed to the surface [4]. The optical absorption peak of the CD was observed in the UV region with a maximum absorption at 348 nm with its tail extending into the visible range as depicted in Fig. 1(a), attributed to the n-π transition of the C=O band and π-π transition of the conjugated C=C band [5].

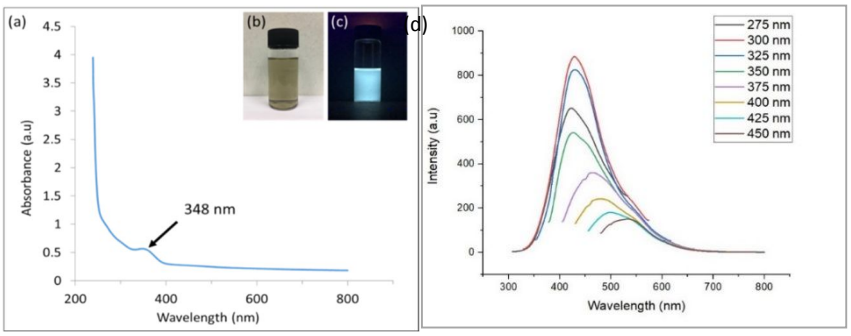

Fig. 1. (a) UV-vis spectra, inset shows the CD under (b) ambient light and (c) UV light at 365 nm and (d) PL spectra of CD

From the Fig. 1 (d), it showed that PL intensity is dependent on excitation wavelength. The strongest PL emission peak located at 430 nm with an excitation wavelength of 300 nm. The PL peaks were at 425 nm and shifted to the right when excitation wavelength is 375 nm. This PL behavior is most likely due to the quantum confinement effect from various size distribution of CD [6].

Morphological Study of EFB Biochar and Extracted CD

Fig. 2 (a) displays a HRTEM micrograph of nearly spherical in shape CD in biochar with an average diameter of 4.5 nm. Fig. 2(b) displays the extracted CD with average size of 4.6 nm. This explained the crystallinity of CD (inset Fig. 2 (a) and Fig. 2 (b)) with lattice spacing of 0.21 nm that corresponds to the (100) planes of graphite, displaying that the obtained carbon might be a kind of graphite (d^{100}=0.213 nm) [7].

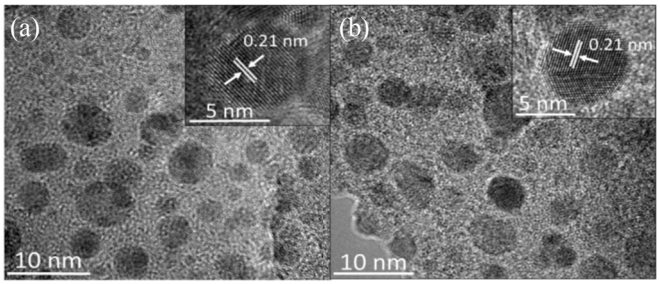

Fig. 2. HRTEM images of (a) EFB biochar and (b) extracted CD

CONCLUSIONS

In summary, the extracted CD displays a bright blue luminescence under an UV-light source and PL spectrum shows an excitation-dependent photoluminescence behavior. The HRTEM images indicates the average diameter size of CD is about 4.6 nm. This method has advantages of being green and facile process which in return produces CD solution with excellent luminescence. Therefore, this CD has a promising potential for both optical and electrical applications.

ACKNOWLEDGMENT: The authors would like to express appreciation for the support of the sponsor by IPB Sub-Project Research Grant, UPM-MTDC Technology Centre, Universiti Putra Malaysia [Project Number = GP-IPB/2016/9515400].

REFERENCES

[1] da Silva JCGE, Goncalves HMR. *Trends Anal. Chem*., 2011, **30**, 1327.
[2] Jia X, Li J, Wang E. *Nanoscale*, 2012, **4**, 5572.
[3] Lu WB, Qin XY, Liu S, Chang GH, Luo YL, Asiri AM, Al-Youbi AO, Sun X. *Analy. Chem*., 2012, 24, 5351.
[4] Mewada A, Vishwakarma R, Patil B, Phadke C, Kalita G, Sharon M. *Carbon Letters*, 2015, **16**, 3, 211.
[5] De B, Karak N. *RSC Advances*, 2013, 3, 8286.
[6] Sharma A, Gadly T, Gupta A, Ballal A, Ghosh SK, Kumbhakar M. J. Phys. Chem. Lett., 2016, **7**, 18, 3695.
[7] Gui R. et al. *Chem. Commun*., 2015.