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Research Article

Synthesis of Carbon Dots from Orange Carrot Juice

Huda R. Mohaisen*, Baker A. Joda* , Adnan Ibrahim Mohammed*,

*Department of Chemistry, Faculty of Science, University of Kerbala, Karbala, Iraq

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Abstract

In this research. scanning Electron Microscopy (SEM) image confirmed that CDs are almost spherical in shape and the size is around 6.40 – 25.76 nm. The energy-dispersive X-ray (EDX) spectrum showed the existence of carbon in the samples. The Fourier-transform infrared (FTIR) spectrum of carrot extract (CE) and CDs is explained that the -C=O peak was found in 1740 and 1650 cm−1 in the CE, but it is completely lost in CDs. This result indicates that the carbonyl group has undergone carbonization and producing luminescent CDs.

Corresponding Author E-mail : : phdchemistry2008@googlemail.com

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1. Introduction

The carbon dots can be defined as luminescent carbon nanomaterials with sizes below 10 nm and they have perfect chemical and optical properties [1,2]. Carbon dots (CDs) were recognized since 2004 through the cleansing of Single Walled Carbon Nanotubes (SWCNTs) through preparative electrophoresis [3-4]. They can be defined as fluorescent small carbon nanoparticles and their sizes are less than 10 nm. The CDs have several applications such as bioimaging, biosensing, drug delivery, disease detection, materials science, and synthetic chemistry [5–8]. These materials are low production costs, water-soluble, photo-chemically, and physiochemically stable. Recently, the applications, production, and of CDs have maintained the attention of many scientists because it is essential to develop different morphologies, sizes, and specific CDs for future research. In addition, CDs were used to develop fluorometric tests regarding enzymes such as β-galactosidase [9–12]. In the last decade, several procedures were used to synthesize CDs for example laser ablation, pyrolysis, acidic treatment, hydrothermal treatments, electrochemical exfoliation, alkaline oxidation, microwave heating, and arc discharge [13–17]. The use of natural bio-resources to produce CDs has several advantages such as being cost-effective, appropriate, and easily available in natural environments such as banana and orange peel. A hydrothermal route was the most popular in the green synthesis of CDs [18–25]. The aim of this study is to prepare the CDs from carrot.

2. Materials and methods

2.1 Materials

The edible carrots were obtained from a supermarket in Karbala. Chemical materials such as Na_3PO_4 (TSP).

2.2 Preparation of carbon dots

In this method, 5 grams of carrot were placed in a flask, then 25 mL of 100 mM Na_3PO_4 (TSP) solution which was added to this flask. The solution was refluxed by fitting a condenser on a round bottom flask, then placed on a magnetic stirrer hot plate. After two hours of heating at 60 ± 5 °C, the solution color was changed from colorless to brown at the end. This result indicates that carbonization yields CDs.

2.3 Instrumentations

Fourier-transform infrared spectroscopy (FTIR) (Shimadzu- 8000); and Scanning Electron Microscopy (SEM were used in this research.

3. Results

The main functional groups of Carbon dots (CDs) were determined by FTIR and compared with those reported for the carrot extract (CE). A scanning electron microscope (SEM) was used to produce images of CDs samples by scanning the surface with a focused beam of electrons. These electrons will interact with atoms in the CDs sample, producing various signals that contain information about the surface topography and composition of the sample.

4. Discussion

4.1 FT-IR analysis

The results of CDs and CE obtained from orange carrots are shown in Figures 2 (a and b). The peaks corresponding to -OH (broad) and -NH (stretching) were seen at 3236 and 3259 cm^{-1}, respectively. The peaks associated with -CH (stretching) were found at 2916, 2850 cm^{-1}, and 2924 cm^{-1}. On the other hand, the peaks associated with bending vibrations of -CH were found at 1396 and 1400 cm^{-1}. The peaks corresponding to the pyranose form of sugar were found at 1045 and 1072 cm^{-1}. The peaks at 1566 and 1585 cm^{-1} are associated with C=C (vibrations). The results indicate that CDs have a sharp peak at 1566 cm^{-1} in comparison to CE. On the other hand, there are two peaks, namely 1728 and 1647 cm^{-1} were found to correspond to -C=O in the carrot extract, while these peaks were lost in CDs. This result indicates that the carbonyl group-including phytonutrients suffer carbonization and produce more sp^2 hybridized carbon.

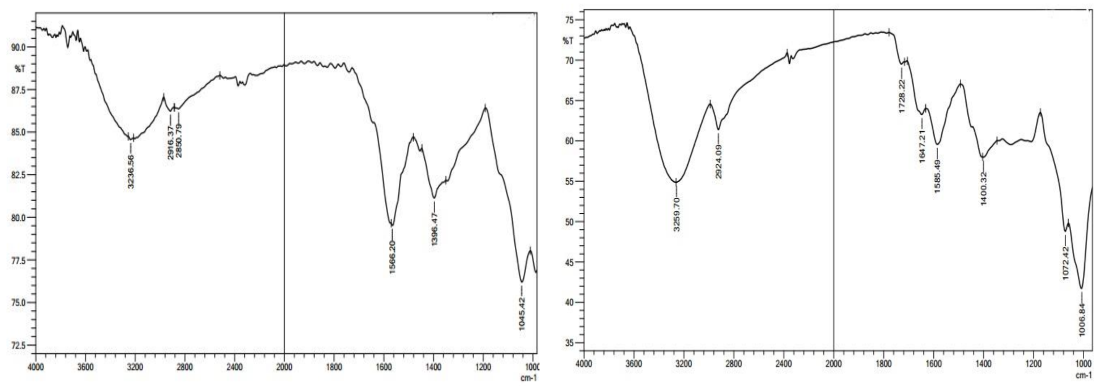

Figure 2. FTIR spectra of (a) carbon dots (CDs) and (b) orange carrot extract (CE).

4.2 SEM analysis

The Scanning electron microscope (SEM) of pure carbon dots (CDs) is shown in Figure 3. The results confirm that the size of CDs obtained from carrot was found in the range of 6.40 – 25.76 nm.

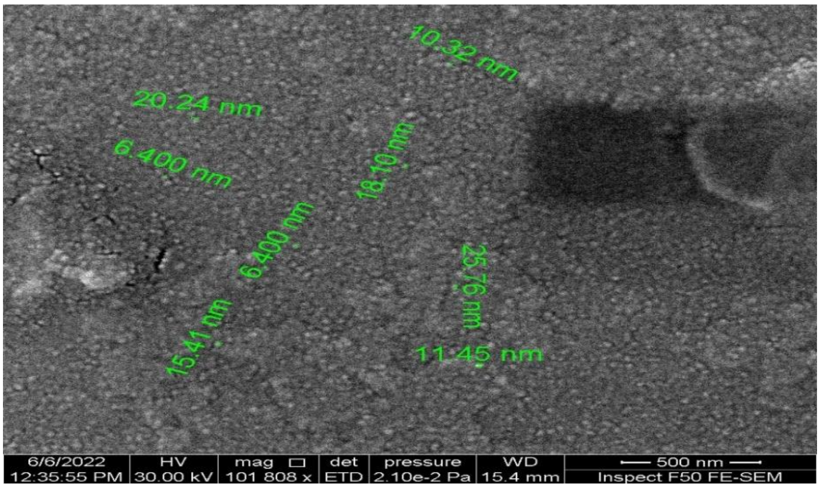

Figure 3. SEM images of CDs

5. Conclusions

An appropriate procedure to synthesize CDs from Iraqi edible carrots was studied by using obtainable chemicals and labware. SEM, and FTIR were used to evaluate the characteristics of prepared CDs.

5. References

[1]. H. Altaee, H.A.H. Alshamsi, B.A. Joda, Reduced graphene oxide supported palladium nanoparticles as an efficient catalyst for aerobic oxidation of benzyl alcohol, AIP Conference Proceeding, 2020, 2290, 0027427.

[2] H. Ding, F. Du, P. Liu, Z. Chen, J. Shen, DNA–carbon dots function as fluorescent vehicles for drug delivery, ACS applied materials & interfaces 7(12) (2015) 6889-6897.

[3]. K.B.A. Ahmed, A. Veerappan, A facile method to prepare fluorescent carbon dots and their application in selective colorimetric sensing of silver ion through the formation of silver nanoparticles, Journal of Luminescence 177 (2016) 228-234.

[4] A. Cayuela, M. Soriano, C. Carrillo-Carrión, M. Valcárcel, Semiconductor and carbon-based fluorescent nanodots: the need for consistency, Chemical Communications 52(7) (2016) 1311-1326

[5] X. Xu, R. Ray, Y. Gu, H.J. Ploehn, L. Gearheart, K. Raker, W.A. Scrivens, Electrophoretic analysis and purification of fluorescent single-walled carbon nanotube fragments, Journal of the American Chemical Society 126(40) (2004) 12736-12737.

[6] Z. Qian, X. Shan, L. Chai, J. Ma, J. Chen, H. Feng, Si-doped carbon quantum dots: a facile and general preparation strategy, bioimaging application, and multifunctional sensor, ACS applied materials & interfaces 6(9) (2014) 6797-6805.

[7] Q. Li, T.Y. Ohulchanskyy, R. Liu, K. Koynov, D. Wu, A. Best, R. Kumar, A. Bonoiu, P.N. Prasad, Photoluminescent carbon dots as biocompatible nanoprobes for targeting cancer cells in vitro, The Journal of Physical Chemistry C 114(28) (2010) 12062-12068

[8] Y.-Y. Zhang, M. Wu, Y.-Q. Wang, X.-W. He, W.-Y. Li, X.-Z. Feng, A new hydrothermal refluxing route to strong fluorescent carbon dots and its application as fluorescent imaging agent, Talanta 117 (2013) 196-202

[9] Z. Ma, H. Ming, H. Huang, Y. Liu, Z. Kang, One-step ultrasonic synthesis of fluorescent N-doped carbon dots from glucose and their visible-light sensitive photocatalytic ability, New Journal of Chemistry 36(4) (2012) 861-864.

[10] H. Feng, Z. Qian, Functional carbon quantum dots: a versatile platform for chemosensing and biosensing, The Chemical Record 18(5) (2018) 491-505.

[11] C. Tang, J. Zhou, Z. Qian, Y. Ma, Y. Huang, H. Feng, A universal fluorometric assay strategy for glycosidases based on functional carbon quantum dots: β-galactosidase activity detection in vitro and in living cells, Journal of Materials Chemistry B 5(10) (2017) 1971-1979.

[12] G. Chen, H. Feng, X. Jiang, J. Xu, S. Pan, Z. Qian, Redox-controlled fluorescent nanoswitch based on reversible disulfide and its application in butyrylcholinesterase activity assay, Analytical chemistry 90(3) (2018) 1643-1651.

[13] C.-I. Wang, W.-C. Wu, A.P. Periasamy, H.-T. Chang, Electrochemical synthesis of photoluminescent carbon nanodots from glycine for highly sensitive detection of hemoglobin, Green Chemistry 16(5) (2014) 2509-2514.

[14] Z.M. Abed Al-Kadhim, B.A. Joda, A.K. H. Al-Khalaf, A convenient green method to synthesize nanocellulose from edible fresh potato, AIP Conference Proceeding, 2022, 2547, 040016.

[15] H. Ao, H. Feng, X. Huang, M. Zhao, Z. Qian, A reversible fluorescence nanoswitch based on dynamic covalent B–O bonds using functional carbon quantum dots and its application for α-glucosidase activity monitoring, Journal of Materials Chemistry C 5(11) (2017) 2826-2832.

[16] A.B. Siddique, A.K. Pramanick, S. Chatterjee, M. Ray, Amorphous carbon dots and their remarkable ability to detect 2, 4, 6-trinitrophenol, Scientific reports 8(1) (2018) 9770.

[17] M.Jayanthi, S.Megarajan, S.B.Subramaniyan, R.K.Kamlekar, V.Anbazhagan, A convenient green method to synthesize luminescent carbon dots from edible carrot and its application in bioimaging and preparation of nanocatalyst, Journal of Molecular Liquids, 278 (2019) 175–182.

[18] B.A. Joda, Z.M. Abed Al-Kadhim, H.J. Ahmed, A.K. Al-Khalaf, A convenient green method to synthesize β-carotene from edible carrot and nanoparticle formation, Karbala International Journal of Modern Science 8(1) (2022) 20-27.

[19] F.A. Stevie, C.L. Donley, Introduction to x-ray photoelectron spectroscopy, Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films 38(6) (2020) 063204.

[20] B. Shirley, E. Jarochowska, Chemical characterisation is rough: the impact of topography and measurement parameters on energy-dispersive X-ray spectroscopy in biominerals, Facies 68(2) (2022) 7.

[21] M.-M. Titirici, M. Antonietti, N. Baccile, Hydrothermal carbon from biomass: a comparison of the local structure from poly-to monosaccharides and pentoses/hexoses, Green Chemistry 10(11) (2008) 1204-1212.

[22] P.-C. Hsu, H.-T. Chang, Synthesis of high-quality carbon nanodots from hydrophilic compounds: role of functional groups, Chemical communications 48(33) (2012) 3984-3986.

[23] N. Wang, Y. Wang, T. Guo, T. Yang, M. Chen, J. Wang, Green preparation of carbon dots with papaya as carbon source for effective fluorescent sensing of Iron (III) and Escherichia coli, Biosensors and Bioelectronics 85 (2016) 68-75.

[24] S. Han, H. Zhang, Y. Xie, L. Liu, C. Shan, X. Li, W. Liu, Y. Tang, Application of cow milk-derived carbon dots/Ag NPs composite as the antibacterial agent, Applied Surface Science 328 (2015) 368-373.

[25] V.N. Mehta, S. Jha, H. Basu, R.K. Singhal, S.K. Kailasa, One-step hydrothermal approach to fabricate carbon dots from apple juice for imaging of mycobacterium and fungal cells, Sensors and Actuators B: Chemical 213 (2015) 434-443.

[26] M. Nasrollahzadeh, M.S. Sajadi, M. Atarod, M. Sajjadi, Z. Isaabadi, An introduction to green nanotechnology, Academic Press2019.

[27] X. Feng, Y. Jiang, J. Zhao, M. Miao, S. Cao, J. Fang, L. Shi, Easy synthesis of photoluminescent N-doped carbon dots from winter melon for bio-imaging, Rsc Advances 5(40) (2015) 31250-31254.

[28] C. Zhu, J. Zhai, S. Dong, Bifunctional fluorescent carbon nanodots: green synthesis via soy milk and application as metal-free electrocatalysts for oxygen reduction, Chemical communications 48(75) (2012) 9367-9369.

[29] S. Sahu, B. Behera, T.K. Maiti, S. Mohapatra, Simple one-step synthesis of highly luminescent carbon dots from orange juice: application as excellent bio-imaging agents, Chemical communications 48(70) (2012) 8835-8837.

[30] B. De, N. Karak, A green and facile approach for the synthesis of water-soluble fluorescent carbon dots from banana juice, Rsc Advances 3(22) (2013) 8286-8290.

[31] K. Schröder, G. Bettermann, T. Staffel, T. Klein, T. Hofmann, Phosphoric Acid and Phosphates, Ullmann's Encyclopedia of Industrial Chemistry, Wiley-Vch, Weinheim, Germany, 1998.

[32] M.I. Alarcón-Flores, R. Romero-González, J.L.M. Vidal, F.J.E. González, A.G. Frenich, Monitoring of phytochemicals in fresh and fresh-cut vegetables: A comparison, Food Chemistry 142 (2014) 392-399

[33] C. Liu, P. Zhang, F. Tian, W. Li, F. Li, W. Liu, One-step synthesis of surface passivated carbon nanodots by microwave assisted pyrolysis for enhanced multicolor photoluminescence and bioimaging, Journal of Materials Chemistry 21(35) (2011) 13163-13167.