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A REVIEW ON UV-VISIBLE ANALYSIS OF GREEN SYNTHESIZED CARBON DOTS

Khusboo Chaudhary, Najib Muazu Hassan, Sarvaree Bano
Department of Chemistry, Kalinga University, Naya Raipur, Chhattisgarh, India
Sarvaree.bano@kalingauniversity.ac.in

ABSTRACT
One intriguing class of nanomaterials having broad applications in several industries is carbon dots (CDs). This paper offers a thorough analysis of carbon dots made from sweet lime, gooseberry, and lemon with an emphasis on their size and visual qualities. The absorption peaks were examined using UV-visible spectroscopy. We used a number of theoretical techniques using the UV-visible spectroscopic data to clarify the size of these nanoparticles, such as the Effective Mass Approximation (EMA) model,
Particle size and bandgap energy were shown to be inversely related, highlighting the important role that quantum confinement effects play in these nanomaterials. The usefulness and limits of other size assessment techniques, such as the Hyperchromicity approach, were also investigated. The multifaceted approach not only offers insightful information about the optical and structural characteristics of carbon dots formed from fruit, but it also emphasizes how crucial it is to use a variety of analytical techniques when characterizing nanomaterials. Our research adds to the increasing amount of information on carbon dots and their possible uses in everything from optoelectronic devices to bioimaging studies.

Keywords:
Carbon dots (CDs); optical properties; Effective Mass Approximation (EMA) model; Brus equation etc.

INTRODUCTION

Nanomaterials are described as materials with diameter ranging from 1 to 100 nm. Nanomaterial's increased physical, electrical, photonic, and chemical capabilities– exactly proportional to their size – make them ideal candidates for use in transdisciplinary scientific and technological fields. In the last two decades, nanoscience has advanced dramatically by focusing on carbon nanomaterials. Carbon has been one of the most plentiful and adaptable elements found in the biosphere (Afolalu *et al.*, 2024).
It may create allotropes, in which the characteristics are dictated by the structural arrangement of chemical bonds and atoms in molecules. This interesting characteristic enables carbon to create a vast variety of structures with distinct fundamental properties (Patwary, M. A. M. *et al.*, 2024). The archetypal carbon allotropes are hard (example diamond) and soft (example graphite). When carbon nanostructures are produced, they exhibit unique properties like conductivity, photonic features, chemical adaptability, etc. (Ramesh, M., *et al*. 2021). The accessibility of ingredients for multitude synthesis and successful preparation techniques makes them viable for industrial uses as well (Saleh, H. M., *et al.*, 2023). These tailored nanomaterials have found use in optics, electronics, space industries, optoelectronics, drug delivery, catalysis, biomedical sciences, nonlinear optical devices, and other fields (Jagessar, R. *et al*. 2021).

GREEN SYNTHESIS OF CARBON DOTS

Following the innovation of Carbon dots (CDs), many simple, cheap, size-customizable, and multitude synthesis techniques have been proposed for their preparation (Kumar, R. *et al*. 2022). There are two broad categories or techniques for CDs synthesis: (1) top-down, and; (2) bottom-up. Top-down processes disintegrate heavy or flat carbon formations like graphite, carbon soot, activated carbon, and carbon nanotubes (Agrawal, 2024). Such carbon compounds have a flawless sp^2 carbon orbitals with ineffective band gap to exhibit fluorescence characteristics (J. Zhang *et al.*, 2023). The primary procedures for this aim include arc discharge, laser-induced desorption, electrochemical treatment of multiwalled carbon nanotubes, electrochemical oxidization of graphite, chemical

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oxidization of industrially activated carbon, etc (Gu *et al.*, 2024). Bottom-up approach is the effective way to fabricate fluorescent Carbon dots massively (Ayisha Naziba *et al.*, 2024). In this process, biomass, carbs, citrate, and so on are employed as precursors to develop carbon dots by taking a particular energy for the structural alteration in the course of transformation (Pandya *et al.*, 2024). For synthetic methods, multi-element precursors are employed instead of carbonaceous materials. Techniques often used in this category include hydrothermal processing, microwave preparational techniques, ultrasonication, burning/thermal processing, assisted artificial methods, and others (Devi *et al.*, 2021). There are three primary elements to consider while synthesizing Carbon dots: Tailored synthesis or followed-up treatment procedures will be used to reduce the mean diameter of carbon dots to less than 10 nm; adjustments to preparational procedures or followed-up treatment processes should be made without considering the required attributes of CDs for the application; electrochemical synthesis, restricted pyrolysis, and solution chemistry approaches can be used to prevent agglomeration during carbonization.

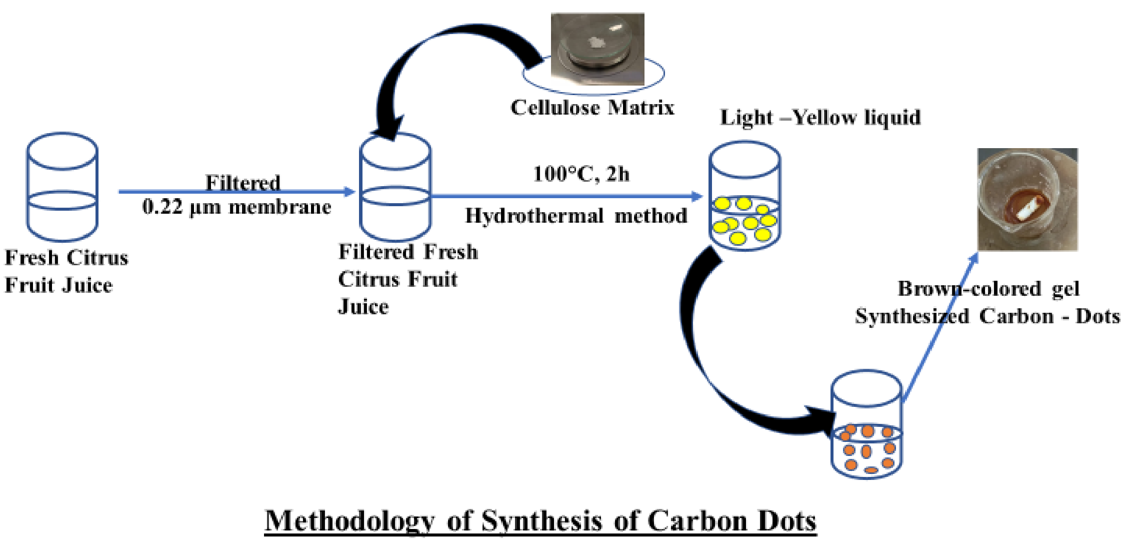

Figure 1: Methodology of Green Synthesis of Carbon Dots

Table 1: Different plants and their parts that are used in green synthesis of Carbon Dots.

S. No.	Plant	Part of Plant	References
1	*Azadirachta indica*	Leave	Gedda *et al.* (2023)
2	*Lawsonia inermis* (Henna)	Leave	Shahshahanipour, *et al.* (2019)
3	*Musa acuminata, Citrus indica, Citrus limetta, Annona squamosa* (L.)	Fruit Peels	Pete *et al.* (2023)
4	Guar gum	Fruit	Bajpai *et al.* (2019)
5	Burned Plants	Plant Soot	Tan *et al.* (2013)
6	Spirulina Plant	leave	Agnol *et al.* (2021)
7	*Polyalthia longifolia*	leave	Zaib, M. *et al.* (2023)
8	*Curcuma longa* (Turmeric leave)	leave	Saravanan *et al.* (2021)
9	*Thymus vulgris L.*	leave	Bayat *et al.* (2019)
10	*Elettaria cardamomum*	leave	Zaib, M. *et al.* (2021)

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STRUCTURAL CHARACTERIZATIONS

UV-Visible spectroscopy is a common method applied to determine the photonic features of carbon dots. Owing to differences in synthesis methods, CDs generally display strong absorbance within the ultraviolet range, but the exact locations of their absorbance maxima may vary. The premise of UV-Vis. spectroscopy lies in the ultraviolet or visible light absorbance by chemical entities to produce distinct spectral fingerprints. This approach is based on the basic interaction of radiation with matter, where light absorption raises the electrons into higher energy levels (excitation), followed by their fall into lower energy states (de-excitation), releasing an observable spectrum (Jing *et al*., 2023). Table 2 shows the UV analysis of CDs reviewed in this paper.

Table 2: UV-Visible Analysis of Synthesized Carbon Dots.

S. No.	Prepared C-Dots	UV Wavelength (nm)	References
1.	C-Dots	240nm-350nm π - π^* and 347 n – π^*	Murru *et al.* (2020)
	GCDS	240nm	
	TCDS	265nm	
	P1CDS	258nm	
	P2CDS	275nm	
2.	$CD_{C\text{-}H}$	250nm - 450nm (π - π^* and n – π^*), 365nm and 225nm	Wang *et al.* (2022)
3.	C-dot	288nm	Kazemifard *et al.* (2020)
4.	C-dot	365nm, 538nm - 875nm., 536nm - 907nm	Mewada *et al.* (2013)
5.	C-dot	530nm	
6.	C-dot	270nm - 290nm π - π^* (C=C), 310nm -400nm n – π^* (C-O),	Vasimalai *et al.* (2018)
	C-dot (Cinnamon)	275nm - 324nm	
	C-dot (Red Chili)	273nm - 315nm	
	C-dot (Turmeric)	282nm - 329nm	
	C-dot (Black Paper)	279nm - 329nm	

CONCLUSION:

In conclusion, this comprehensive study on Carbon dots (CDs) has provided valuable insights into their characterization through UV-visible spectroscopy and various size determination approaches. Plants reported in the fabrication of carbon dots in this review are *Azadirachta indica, Lawsonia inermis* (Henna), *Musa acuminata*, *Citrus indica*, *Citrus limetta*, *Annona squamosa* (L.), Guar gum, Burned Plants, Spirulina Plant, *Polyalthia longifolia*, *Curcuma longa* (Turmeric leave), *Thymus vulgris L.*, and *Elettaria cardamomum.* The UV absorption peak for the various carbon dots reviewed fall within the wavelength range found by previous studies. This confirms the photonic features of CDs and their uses in bioimaging, photocatalysis, sensors, optoeletronics etc.

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