# Comparative Analysis of Biowaste-Derived Carbon Dots for Potential Theranostic Uses: A Sustainable Waste to WealthApproach

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## Background

➢Carbon dots (CDs) are carbon-based nanomaterials with exceptional properties and diverse applications. They usually measure less than 10 nm in size and can possess either an amorphous or crystalline structure.
➢CDs possess high QY, multi-wavelength fluorescence, excellent solubility, photostability, biocompatibility, low toxicity, remarkable catalytic activity, luminous efficiency, and strong cell permeability, making them ideal for bioimaging, drug delivery, catalysis, and environmental sensing, with strong potential in nanomedicine due to enhanced drug-loading capacity.
➢CDs can be synthesized from various sources, including biowaste materials. Developing biowaste-mediated CDs from potato peels (PCDs), lemon peels (LCDs), waste tea residues (TCDs), and banana peels (BCDs) serves as a promising prospect and aligns with the "waste-to-wealth" concept, promoting sustainability, environmental conservation, and cost-efficient production.

## Objective

➢Utilization of green source (biowaste) for the synthesis of CDs- A step towards environmental sustainability as well as their prospective theranostic application.
➢Selection and screening of different green sources for synthesizing CDs as well as Developing an eco-friendly carbonization process.
➢Optimization of different green sources synthesized carbon dots in terms of their fluorescence quantum yield, functional groups, carbon content, shape and size, photostability, water solubility and most importantly their cytotoxicity to determine the biomedical safety.
➢Identify the best promising CDs precursor in further theranostic application.

## Methodology

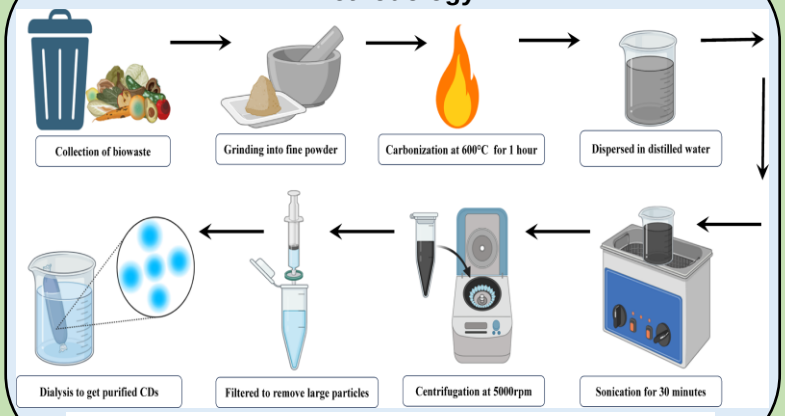


Fig. 1. Schematic representation illustrating the complete process of CDs synthesis.

## Conclusion and Future Perspective

➢The waste tea residue-derived CDs (TCDs) emerging as the most promising due to their highest quantum yield (22.69%), smallest particle size (2.3 nm), superior photostability, and excellent biocompatibility.
➢The synthesized CDs exhibited strong fluorescence, high water solubility, and low cytotoxicity, confirming their potential for bioimaging, drug delivery, and theranostic applications. Moving forward, in vivo biocompatibility studies are needed to validate their safety, while surface functionalization can enhance their targeting capabilities for precision drug delivery.

**References**

1.Tejwan N, Kundu M, Ghosh N, Chatterjee S, Sharma A, Singh TA, Das J, Sil PC. Synthesis of green carbon dots as bioimaging agent and drug delivery system for enhanced antioxidant and antibacterial efficacy. Inorganic Chemistry Communications. 2022 May 1;139:109317.
2.F. Radnia, N. Mohajeri, N. Zarghami, New insight into the engineering of green carbon dots: Possible applications in emerging cancer theranostics, Talanta 209 (2020) 120547, https://doi.org/10.1016/j.talanta.2019.120547.
X. Lin, M. Xiong, J. Zhang, C. He, X. Ma, H. Zhang, Y. Kuang, M. Yang, Q. Huang, Carbon dots based on natural resources: Synthesis and applications in sensors, Microchem. J. 160 (2021)105604, https://doi.org/10.1016/j.microc.2020.105604.

## Results and Discussion

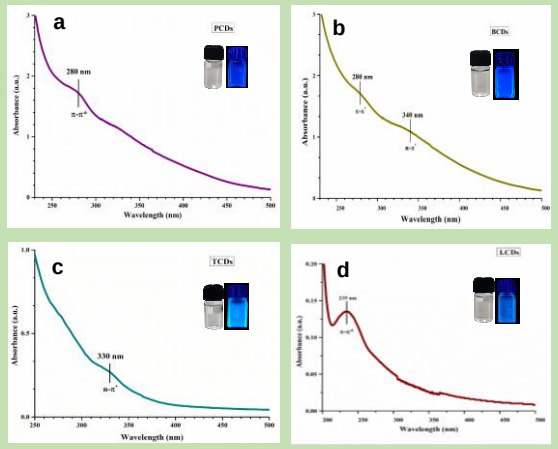


**Fig. 2.** UV-visible absorption properties of four different sources of CDs. Inset presents images of CDs observed under visible light and their fluorescence under UV illumination at 366 nm.

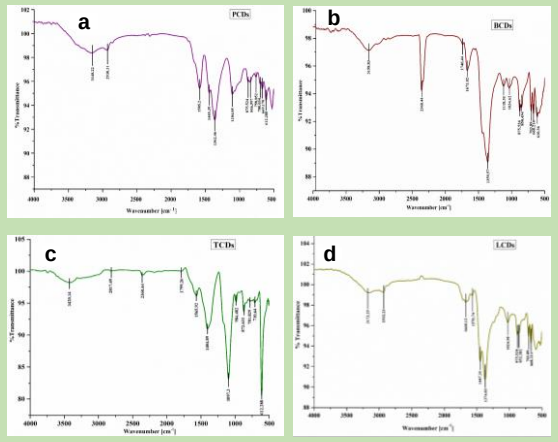


**Fig. 3.** FTIR spectra of four different sources of CDs.

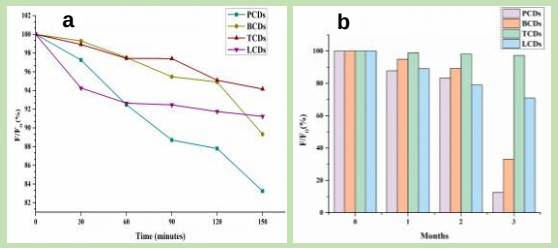


**Fig. 6.** Photostability studies of CDs (a) Fluorescence stability of four different sources of CDs under UV illumination at 366 nm at varying time intervals (b) Fluorescence stability of four different sources of CDs over a period of 3 months

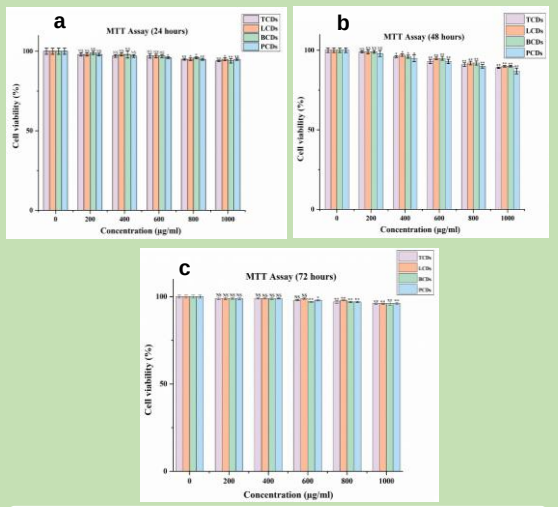


**Fig. 7.** Cell viability of four different sources of CDs estimated from the MTT assay

| Table 1. CHNS/O analysis of various sources of synthesized CDs | | | | | |
|---|---|---|---|---|---|
| **Sample** | **% C** | **% N** | **% S** | **% H** | **% O** |
| **PCDs** | 45.46 | 0.03 | 2.07 | 0.84 | 51.6 |
| **BCDs** | 56.33 | 0.01 | 1.41 | 0.99 | 41.26 |
| **TCDs** | 68.79 | 0.41 | 6.94 | 1.19 | 22.67 |
| **LCDs** | 62.07 | 0.01 | 0.25 | 0.82 | 36.85 |

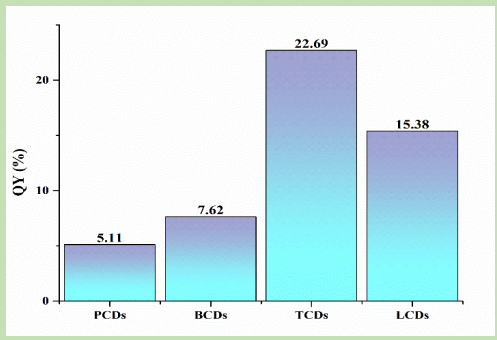


**Fig. 4.** Quantum yield of four different sources of CDs.

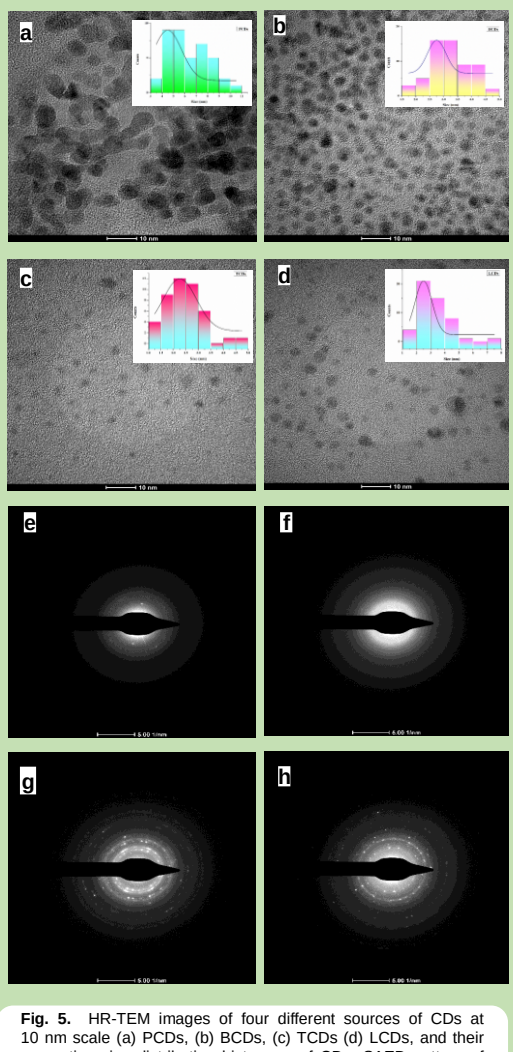


**Fig. 5.** HR-TEM images of four different sources of CDs at 10 nm scale (a) PCDs, (b) BCDs, (c) TCDs (d) LCDs, and their respective size distribution histogram of CDs. SAED pattern of four different sources of CDs (e) PCDs, (f) BCDs, (g) TCDs (h) LCDs.

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