Carbon Quantum Dots: Sustainable Synthesis and Biomedical Potential

Johnny Chimborazo[1*], David Lara[1], y Marlene Puchaicela[2]

[1]School of Biological Sciences and Engineering, Yachay Tech University, Urcuquí, Imbabura 100115, Ecuador
[2]School of Physical Sciences and Nanotechnology, Yachay Tech University, Urcuquí, Imbabura 100115, Ecuador
*Corresponding author: marlene.puchaicela@yachaytech.edu.ec

Abstract

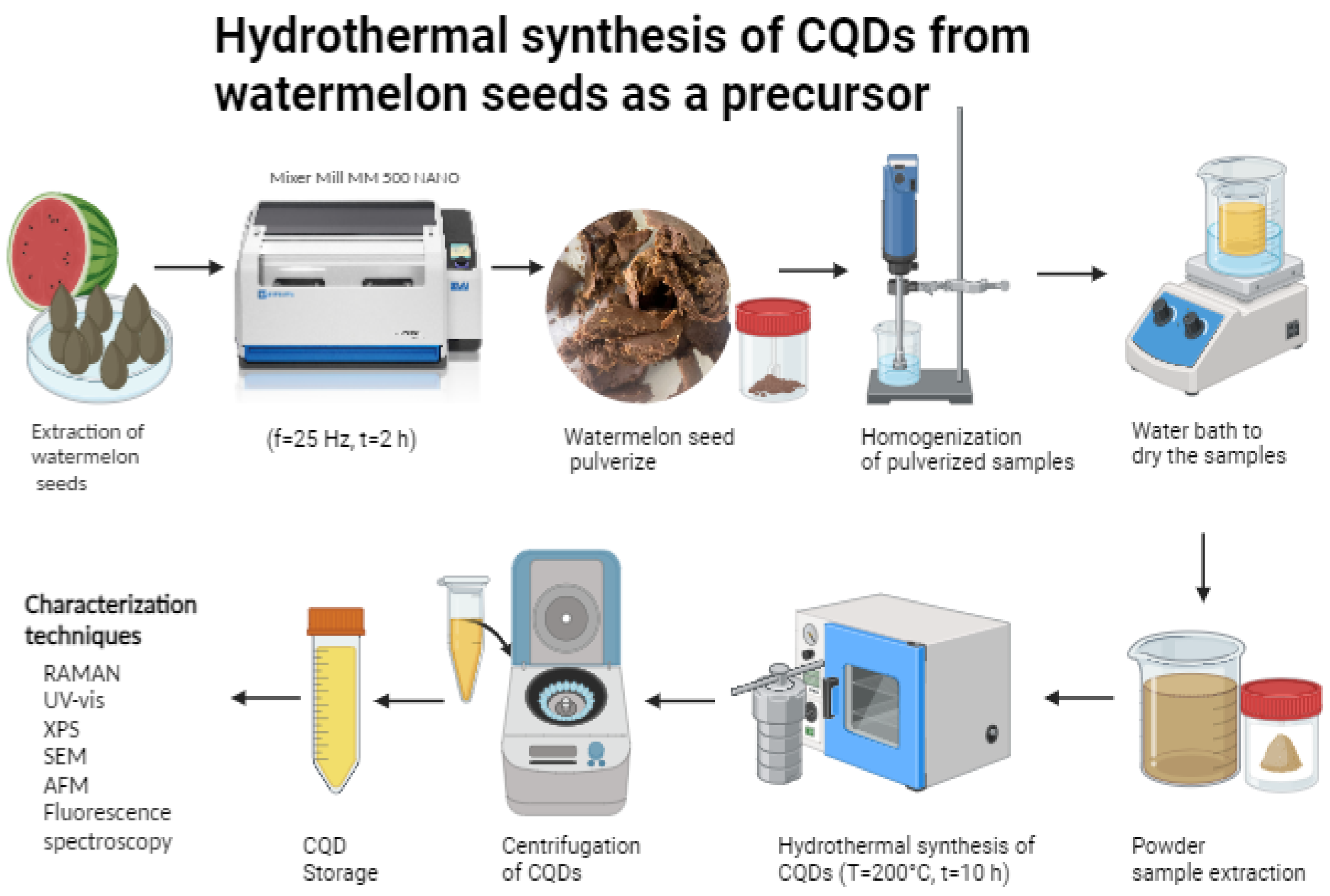
Carbon Quantum Dots (CQDs), representing zero-dimensional carbon nanostructures, have garnered significant attention across a spectrum of scientific disciplines. Their prominence can be attributed to a unique set of attributes, including photoluminescent properties, low toxicity, chemical and physical stability, eco-friendly synthesis routes, multifunctionality, and extraordinary nanoscale dimensions. This study takes a comprehensive approach, seamlessly integrating experimental and theoretical methodologies to provide an in-depth exploration of CQDs. CQDs were synthesized using plant residues as precursors, utilizing materials such as fruit peels and seeds from lemon, avocado, and watermelon, all through a sustainable hydrothermal process. This method, designed to yield CQDs, is both environmentally friendly and characterized by its simplicity and cost-effectiveness. Comprehensive characterization of these nanomaterials was conducted using a wide range of sophisticated spectroscopic techniques, including UV-Vis, FTIR, Raman, SEM, AFM, and XPS, offering profound insights into their molecular composition. Furthermore, Density Functional Theory (DFT) was employed to delve into their spectroscopic behavior. In addition to their intriguing structural and chemical properties, Carbon Quantum Dots (CQDs) also serve as a versatile platform for biocompatible drug delivery, providing precise control and real-time monitoring capabilities. This research bridges the realms of basic, life, and environmental sciences in the context of climate change, biodiversity, and sustainability. It also aligns with the biological applications of chemistry and phytochemistry, showcasing the potential of plant-based materials in the synthesis of eco-friendly nanomaterials with promising biomedical applications.

Key words: Carbon Quantum Dots, Hydrothermal synthesis, Sustainable Synthesis, Plant Residues, Plant Residues.

MOTIVATION

The difficulties to synthesize Carbon Quantum Dots (CQDs) with an economic, and green method made this research to be carried out. Considering the bottom-up approach, which implies assembling single atoms and molecules into larger molecules. a facile and cost effective hydrothermal process was used to obtain CQDs with an spherical morphology and excellent

SYNTHESIS



Conclusons

Organic waste can be used for the creation of CQDs through green synthesis.

UV-Vis spectroscopy. Peak 220 nm attributed to C=C bond.

Peak 285 nm attributed to C=O bond.

Raman spectroscopy shows peaks around 1600 cm-1 confirming the formation of C=C bonds and thus the graphitization of the source, and thus the formation of CQD

The SEM image suggests the formation of spherical particles, around 140 nm in diameter.

The AFM image suggests the formation of spherical nanoparticles, around 2-10 nm in height.

Fluorescence microscope images suggest that CQDs from watermelon seeds could be used for bioimaging.

References

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RESULTS

Characterization of CQDs

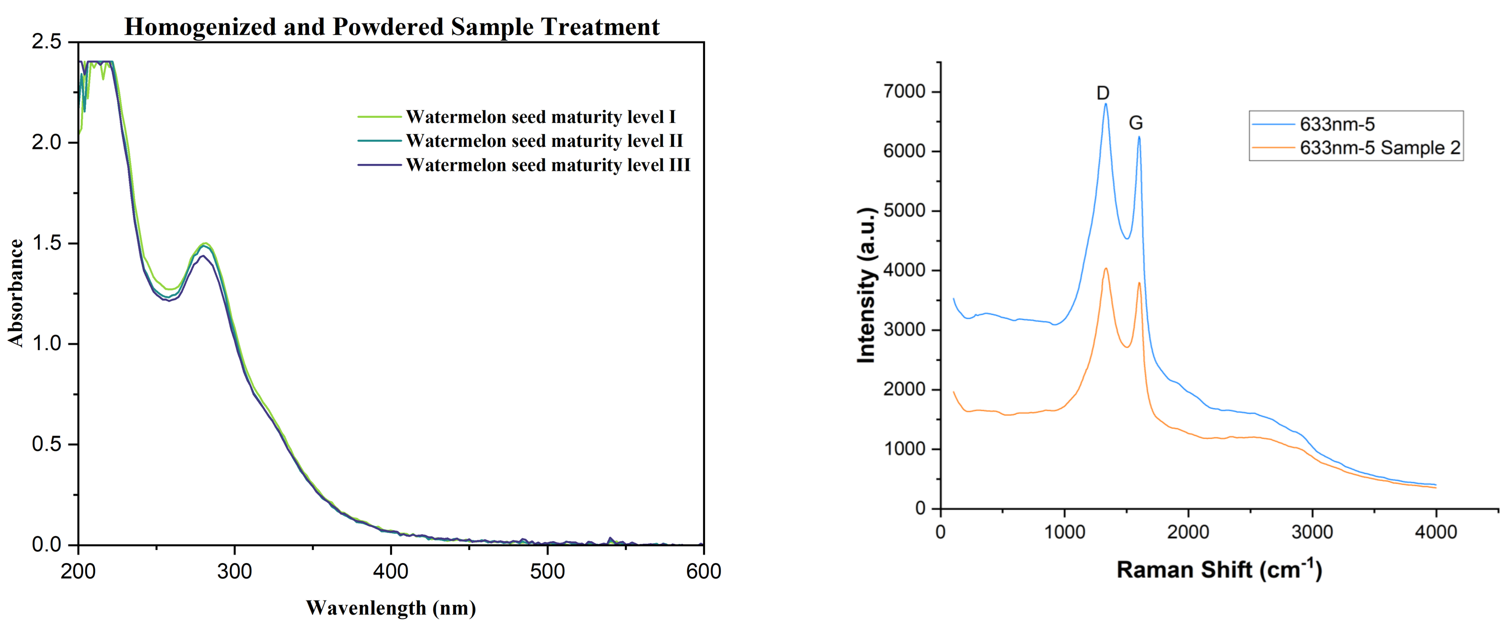


Figure 1. *Left*: UV-VIS for liquid phase after hydrothermal treatment samples with Homogenized and Powdered Treatment. Right: Two predominant peaks can be observed near $1340 cm^{-1}$ and $1590\ cm^{-1}$, which are commonly attributed to the disordered D and crystalline G bands, respectively [2].

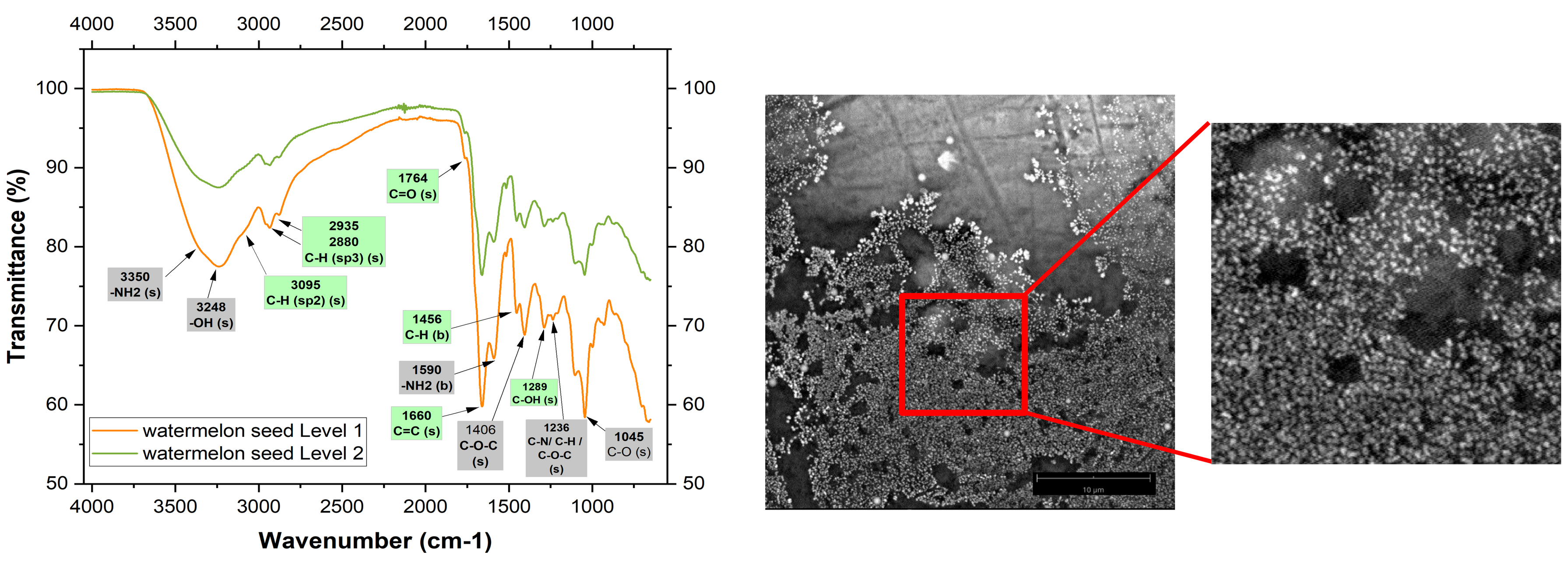


Figure 2. *Left:* The functional groups of CQDs (both level I and II) were characterized by FTIR. *Right:* The CQDs exhibited almost spherical morphology and tended to form agglomerations (SEM).

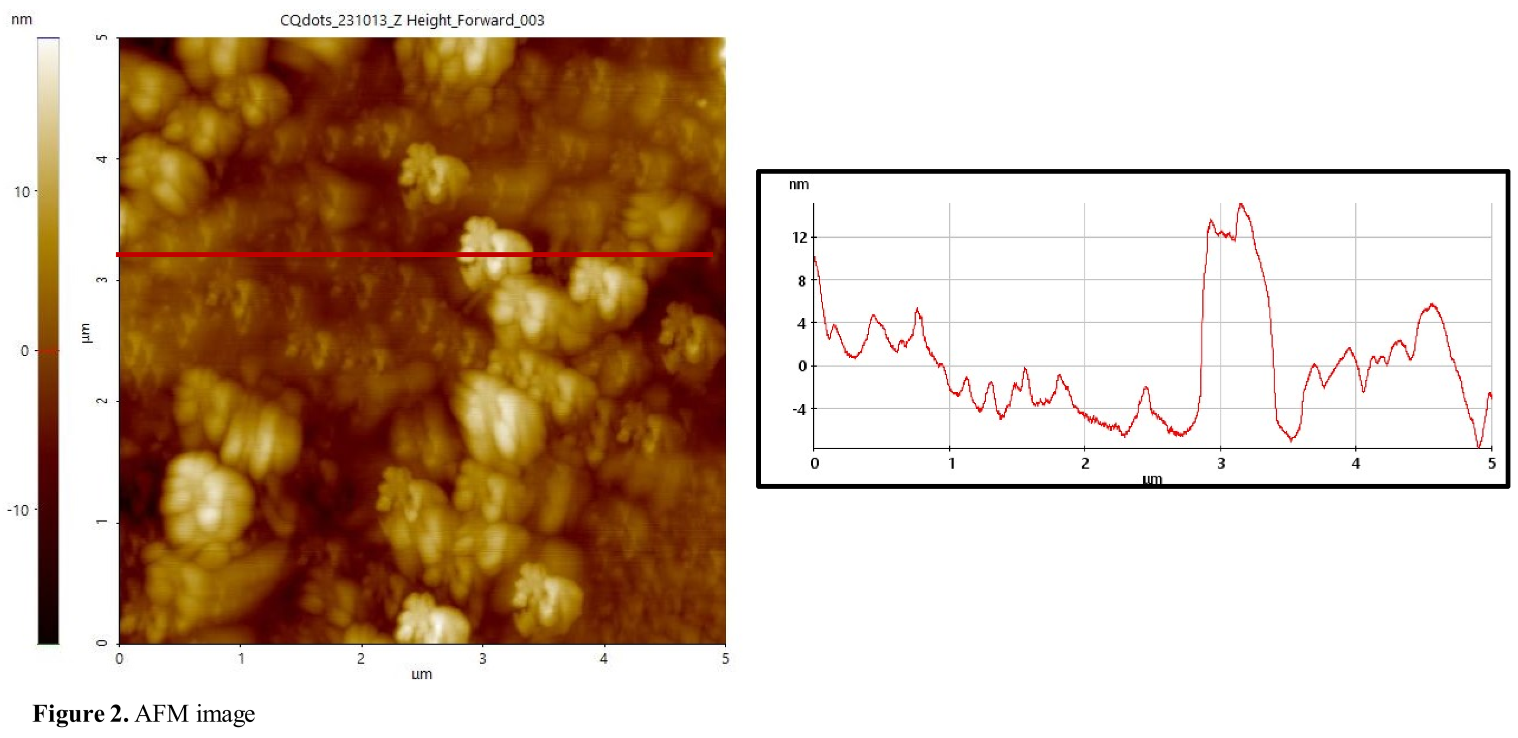
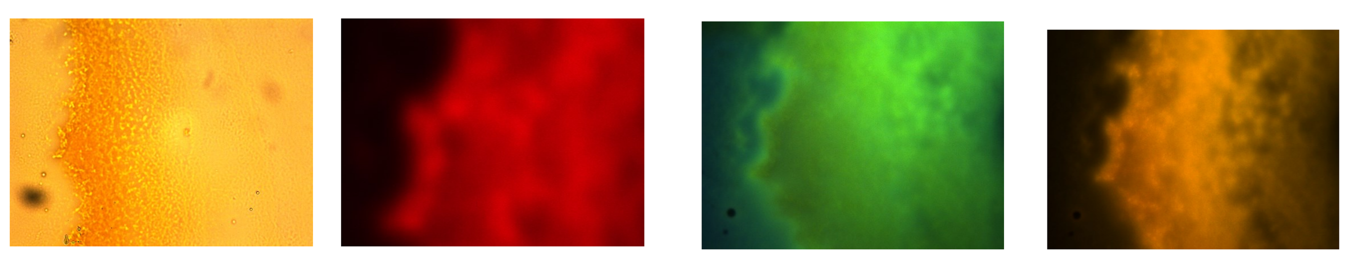


Figure 2. AFM image



Unfiltered | Yellow Filter | Green Filter | Blue Filter

Figure 5. Fluorescence Microscope Image whit different Filters.