Carbon Quantum Dots for Targeted Therapy of Triple Negative Breast Cancer Cells

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ABSTRACT

Introduction: Triple negative breast cancer (TNBC) accounts for approximately 15-20% of all breast cancers, is prevalent among younger women. Due to lack of specific receptors, treatment options are limited. Metastatic TNBC has a dismal prognosis with an overall survival rate of only 13 months due to drug resistance. Thus, there is an urgent need for new drug delivery systems to improve the therapeutic modality of TNBC. We have synthesized carbon quantum dots (CQD) from biowaste, leveraging anti-proliferative effects on TNBC cells.

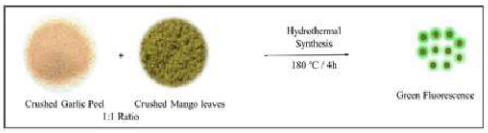
Methods: CQD were synthesized by a hydrothermal process from garlic peel and mango leaves in 1:1 proportion using a stainless-steel autoclave lined with poly(tetrafluoroethylene) (PTFE), heated at 180 °C for 4h under autogenous pressure and filtered. The obtained filtrate was sonicated for 2h and dried in a hot-air oven to produce CQDs. Morphological evaluation and MTT assay of CQD on NIH3T3, MCF7, MDA MB 231 cells was performed.

Results and Discussion: Microscopic evaluation of NIH3T3 cells exhibited no morphological changes upto 500 µg/ml; whereas, MCF7 and MDA MB 231 cells showed morphological changes from concentrations 100 µg/mL and 50 µg/mL respectively. Moreover, MTT assay reveled an increased cytotoxicity from day 3 onwards in both the cell lines, more significantly in MDA MB 231.

Conclusions: The CQDs synthesized using biowaste are biocompatible with non-cancerous cells NIH3T3 whereas exhibits anticancer activity on breast cancer cell line MCF7 markedly in triple negative breast cancer cells MDA MB 231. Hence these CQD can extend the arsenal of functional anti-cancer materials against targeted therapy of TNBC suffering patients.

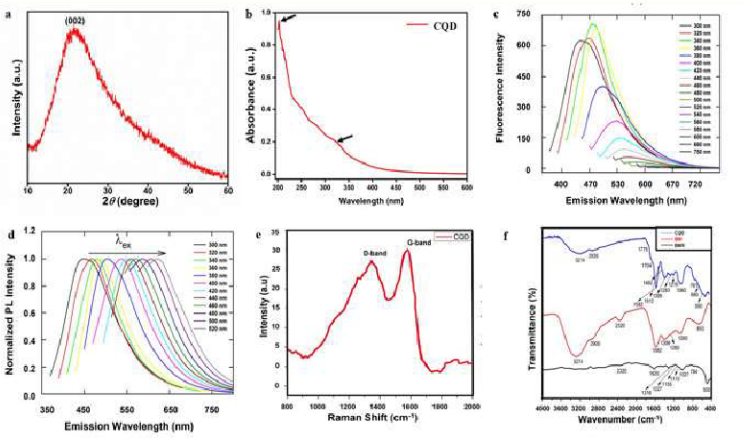
GRAPHICAL ABSTRACT

METHODOLOGY

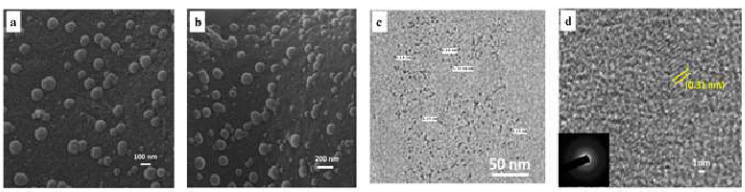


Schematic illustration for the synthesis of CQDs from biomass

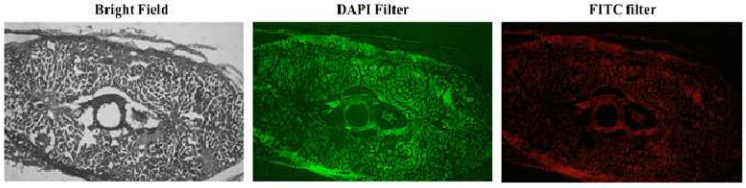
RESULTS



a) Powder X-ray diffraction pattern of CQDs. b) UV visible absorption of dissolved CQDs in water. c) PL spectra under excitation at different wavelengths. d) Normalized PL graph of b. e) Raman spectra of CQDs f) FTIR analysis biowaste (BW), biowaste residue (BWR) and synthesized CQDs (filterate).

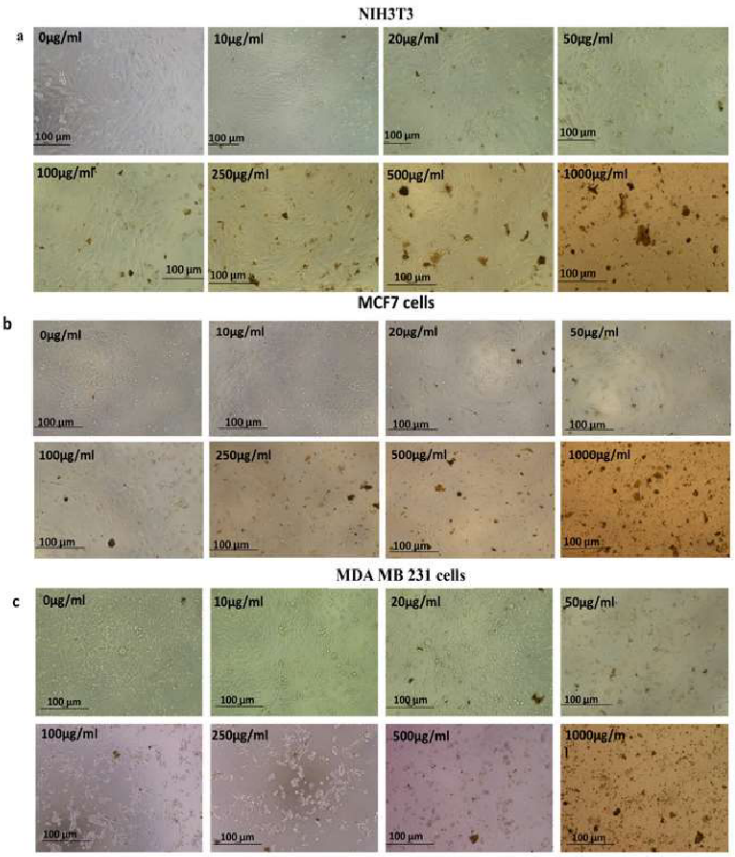


Morphological characterization of CQDs. a) and b) FESEM images of synthesized CQDs. c) and d) HR-TEM images of CQDs along with the distance between the lattice fringes inset SAED pattern of CQDs depicting its polyamorphous nature.

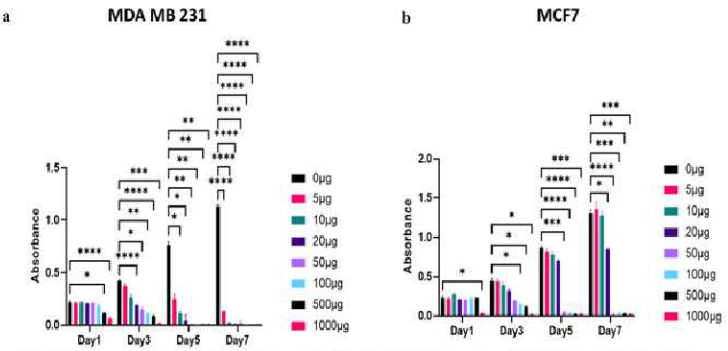


CQD uptake and bioimaging of adult zebrafish under a) bright field b) FITC c) DAPI filters after treatment for 24 h in 100 µg/ml CQDs solutions.

RESULTS



a) NIH3T3 b) MCF 7 c) MDA MB 231 treated with different concentrations of CQDs



a) MTT assay of MDA MB 231 cells treated with CQD b) MTT assay of MCF 7 treated with CQD

CONCLUSION

- Carbon quantum dots (CQDs) were successfully synthesized from a renewable biowaste source.
- The synthesized CQDs demonstrated excellent biocompatibility with non-cancerous NIH3T3 cells, suggesting their potential for biomedical applications.
- The CQDs exhibited potent anticancer property against breast cancer cells MCF 7 and significantly against triple-negative breast cancer cells MDA-MB-231.
- CQDs were efficiently taken up by adult zebrafish, as observed under an epi-fluorescent microscope, indicating their potential as bioimaging agents.
- The combination of biocompatibility, anticancer activity, and bioimaging capabilities positions CQDs as a promising dual-functional material for bioimaging and targeted TNBC therapy.

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