

From Biowaste to Fluorescent Carbon Quantum Dots

Nikolaos Papaioannou, Magdalena Titirici and Andrei Sapelkin

Motivation

Photoluminescent quantum dots (QDs) are promising candidates to replace fluorophores because they offer high brightness and resistance against photobleaching.

Carbon Quantum Dots (CQDs) a new member in the nanocarbon family. They are biocompatible, can be synthesized in a cheap and environmental friendly way.

Research in QDs began in 60s. So far metal-based (e.g. Cd, Te, Pb) QDs are dominating the field. But they suffer from:

- (Cyto)-Toxicity
- Hydrophobicity
- High cost

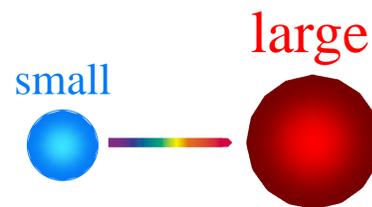
Biomass-derived CQDs for Bioimaging Applications



Our Aim

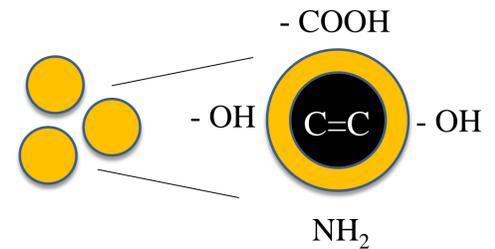
- Develop novel sustainable materials and technologies with use in the biomedical field
- Use low cost and abundant resources in a simple one step synthetic route

Current technology



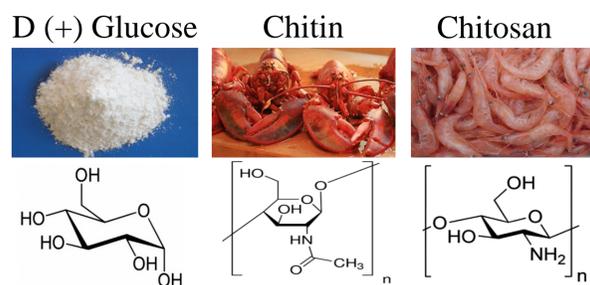
Optical properties of classical QDs are based on their size. Smaller QDs emit at shorter wavelengths and larger at longer wavelengths

The future



Crystalline carbon lattice surrounded by different functional groups which adjust the optical properties. Tailored according to the starting precursor.

From sugars to graphitic nanostructures via Hydrothermal Carbonization



- T = 200 °C
- t = 2-12 h
- P < 10 bar
- H₂O solvent

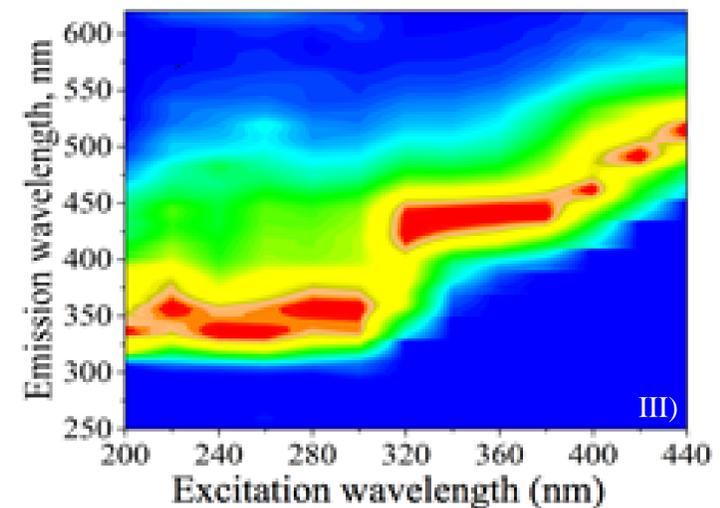
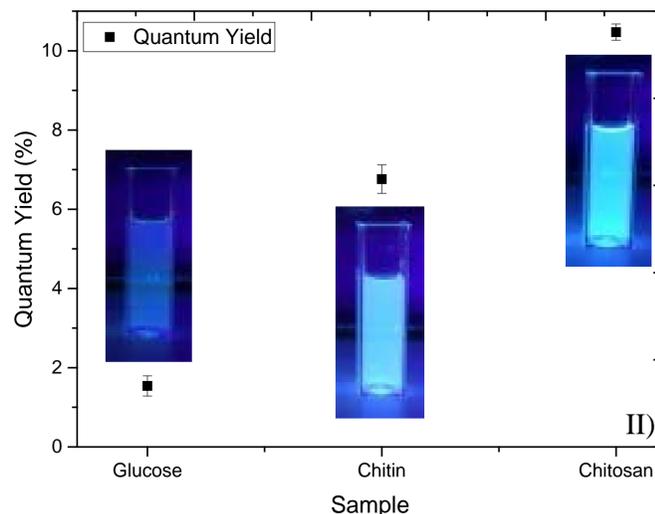
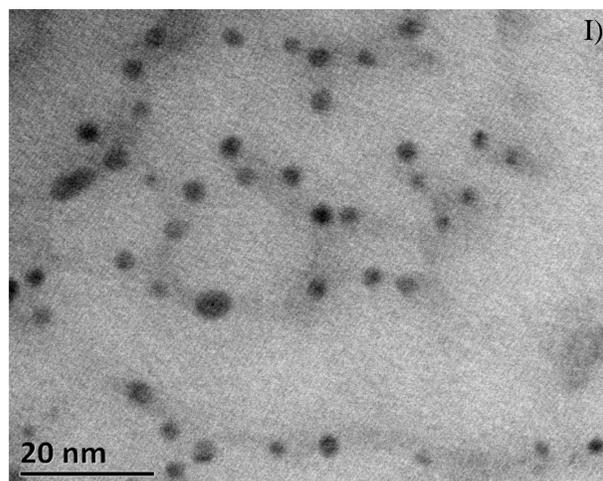


Freeze drying



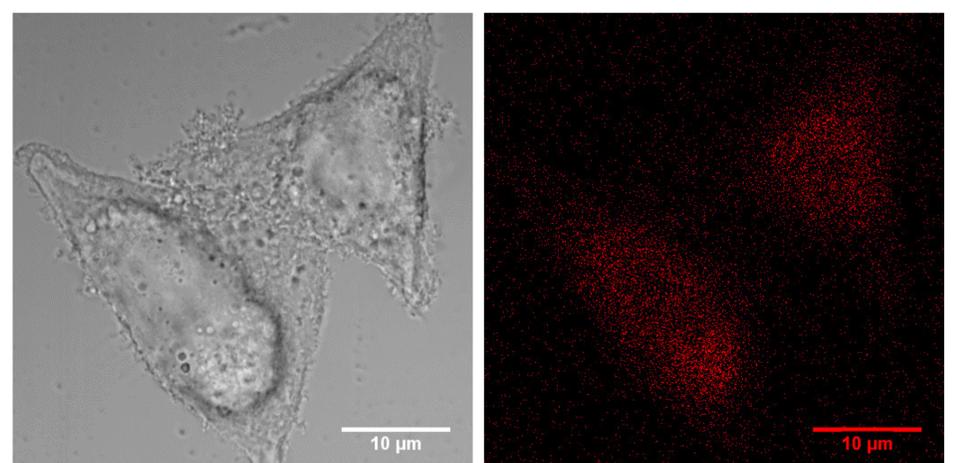
Size & Optical Properties

Figure I below shows a representative TEM image of CQDs (size 3-5 nm). Figure II is an illustration of sample brightness through Quantum Yield measurements. Figure III is an excitation-emission map which show two distinct regions indicating difference in origin of light.



Super-Resolution Microscopy

Our products were successfully applied as fluorescent probes on cancer cells. Through super-resolution (SR) strategies we managed to overcome the diffraction limit of light. Specifically the Figure on the right shows brightfield and fluorescence images of HeLa cells (cervical cancer cells) with CQDs.



Conclusions

- Bright CQDs were synthesized in a one-step synthetic route
- Widely available & cheap biomass precursors were employed
- CQDs were used as probes for cell imaging in SR microscopy