Effects of Purification & Filtering on The Fluorescent, Morphology, and Elemental Properties in Carbon Quantum Dot Production

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26th National Electron Microscopy Congress, Eskisehir Technical University, 20-23 September 2023, Eskisehir

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BACKGROUND & EXPERIMENTAL SETUP

Quantum dots (QDs) are semiconductor nanocrystals that have a 1-10 nm radius size and have distinct optical features thanks to the quantum confinement effect such as a broad excitation spectrum, good chemical and light stability, and preferred to be used as sensors, imaging or therapeutic agents. Carbon quantum dots (CQDs) are preferred since they have low toxicity, are easier to make modifications on, and are biocompatible. Within the scope of this project, it was aimed to search the effect of purification and filtering on CQDs' properties such as morphological structure, elemental composition, and fluorescence intensity with Scanning Electron Microscope (SEM), Energy Dispersive X-Ray Spectroscopy (EDS), and fluorescence microscope. The CQDs are synthesized with a newly developed synthesis method [Hot Bubble Synthesis (HBBBS)]. In the newly developed method, a precursor is generated to self-assemble and form CQDs alongside water that turns into water vapor and eventually results in bubble formation in an inert environment (**Fig. 1**). The experimental setup for the synthesis, purification, filtration, and characterization is presented in below (**Fig. 2**).

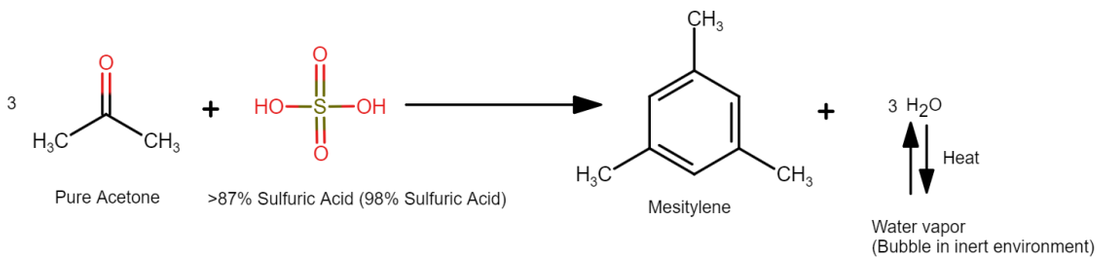

Figure 1: Hot bubble synthesis (HBBBS) method reaction for carbon quantum dot precursor (mesitylene) and water vapor that results in bubble formation.

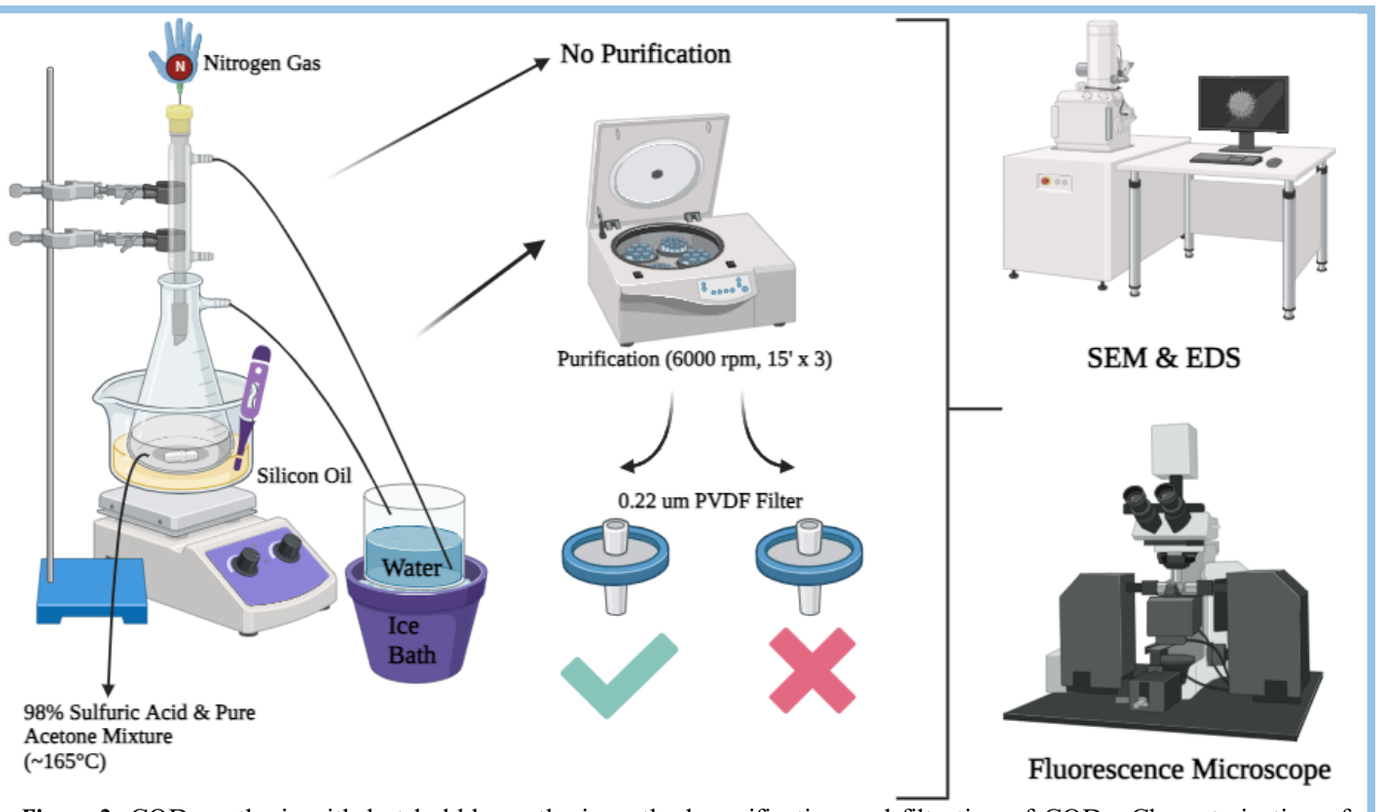

Figure 2: CQD synthesis with hot bubble synthesis method, purification and filtration of CQDs, Characterization of CQDs with SEM, fluorescence microscope, and EDS.

RESULTS

In the fluorescence images, the impure samples had more crystal-like structures compared to the pure samples (Fig. 3 A-B), and material density and luminescence amount differences were observed between the filtered and nonfiltered samples (**Fig. 3 C-D**). Centrifuging the samples resulted in the purification of the CQDs by increasing carbon (C) and decreasing sodium (Na) and sulfur (S) percentages. When the SEM images and the elemental percentages of the pure and non-filtered samples with the pure and filtered were compared, it was observed that the sites that were more condensed and had more salt and crystal-like structure in the filtered sample had higher Na and lower C percentages compared to the non-filtered sample which were less condensed and had less salt crystal-like structure (**Fig. 4**). The FT-IR analysis result that show the functional groups of CQDs is presented in **Fig. 5**. The SEM images of filtered and non-filtered samples are presented below (**Fig. 6**).

Figure 3: CQD samples' fluorescence microscopy images (x400 magnification, 20 µm). **A)** Non-centrifuged sample **B)** Centrifuged sample **C)** Filtered sample **D)** Non-filtered sample.

Figure 4: Filtered and non-filtered CQDs' carbon (C) and sodium (Na) atomic presence-weight percentages (%).

Figure 5: FT-IR analysis result of centrifuged and non-filtered CQD sample (Transmittance % = T%).

Figure 6: CQD samples' SEM images (Scale bar: 1 µm). **A)** Non-filtered sample **B)** Filtered sample.

CONCLUSION

- Purity causes more pronounced luminescence as can be observed in fluorescence images.
- The filtered samples' morphology is more likely to be crystal-like salt structure.
- Non-filtered samples are more spherical morphologically.
- Filtering the CQDs with a 0.22 µm PVDF syringe filter increased the CQDs' impurity by decreasing their C% and increasing their Na%.
- Since in the non-filtered samples the impurity percentage is high (about ~10%) (sulfur% not shown), new purification methods should be developed to get rid of the impurity.

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ACKNOWLEDGEMENTS

This project is funded by Acıbadem University Scientific Research Project Community (ABAPKO) with the project number 71. We would like to thank Dr. Selcuk Birdogan (PhD) for the TEM, SEM imaging and EDS analysis of the CQDs and Bora Guvendiren for his contribution in the synthesis and characterization of CQDs.