



SYNTHESIS AND CHARACTERIZATION OF GRAPHENE QUANTUM DOTS UNDER HEAT BY ELECTROCHEMICAL PROCESS



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Abstract

This research focuses on the synthesis, characterization, and potential applications of graphene quantum dots (GQDs), with a particular emphasis on their optical and electronic properties to achieve high-quality GQDs with tunable characteristics. In this study, an electrochemical synthesis process was used to synthesize GQDs, employing an EE pencil rod as the electrode. The precursor solution consisted of 0.1 M citric acid with varying KCl concentrations of 0.15 M, 0.25 M, 0.30 M, 0.35 M, and 0.45 M, with synthesis conducted at temperatures of 50°C and 80°C.

The results indicate that GQD sizes remain consistent across all conditions, as determined by the absorption band edge from the Tauc plot, which falls within the range of approximately 3.2–3.6 eV. Photon emission varies depending on synthesis conditions, with the highest photon emission observed at 0.15 M KCl and 50°C, reaching approximately 250,000 photon counts per second. Additionally, hydrodynamic size is influenced by temperature, particularly when KCl concentration exceeds 0.3 M, leading to a significant

Introduction

Graphene Quantum Dots (GQDs) are a rapidly emerging nanomaterial that have gained significant interest among scientists and researchers worldwide. GQDs are nanoscale fragments of graphene, typically less than 20 nanometers in size, that exhibit unique quantum confinement and edge effects. These properties arise due to their small dimensions and specific atomic arrangement, making them distinct from larger graphene particles and other carbon nanostructures. The potential of GQDs has opened up new possibilities for applications in electronics, photonics, and biomedical sciences.

Method

In this experiment, a 0.1 M solution of citric acid monohydrate was prepared, and the concentration of KCl was adjusted to five different levels: 0.15 M, 0.25 M, 0.3 M, 0.35 M, and 0.45 M. Deionized (DI) water served as the solvent, and the total solution volume was maintained at 30 milliliters. The mixture was stirred thoroughly to ensure a uniform and homogeneous solution.



After preparing the solution for each condition, the pre-made EE-pencil rod electrodes were immersed in the solution and connected to a DC power supply. Initially, a potential of 4 volts was applied for one hour, after which the voltage was increased to 10 volts for an additional four hours. Once the process was complete, the resulting solution was filtered and transferred into vials for further analysis.



Result

KCl Conc.	Absorption Band Edge (eV)				
	0.15M	0.25M	0.30M	0.35M	0.45M
Temperature (°C)					
RT	3.32	3.41	3.30	3.56	3.32
50°	3.35	3.27	3.17	3.23	3.21
80°	3.14	3.33	3.13	3.17	3.13

Table 1. Show result of absorption band edge calculated from UV-Vis spectroscopy data for each condition

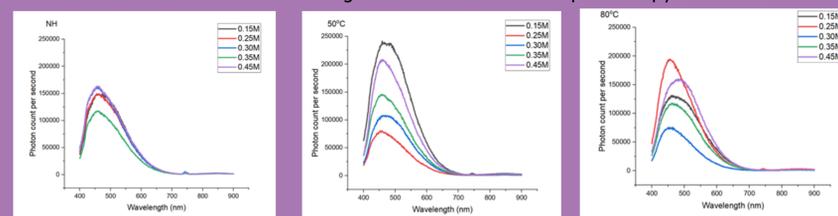


Figure 1-3. Photon count per second from sample for each condition using Photoluminescence Spectrometer

KCl Conc.	Emitted Wavelength (nm)				
	0.15M	0.25M	0.30M	0.35M	0.45M
Temperature (°C)					
RT	457	462	455	456	462
50°	459	458	470	460	462
80°	463	455	463	462	486

Table 2. Photon emitted wavelength from sample for each condition using Photoluminescence Spectrometer

KCl Conc.	Particle Size (nm)				
	0.15M	0.25M	0.30M	0.35M	0.45M
Temperature (°C)					
RT	210	220	290	250	310
50°	250	140	500	600	600
80°	180	200	300	800	1800

Table 3. Hydrodynamic size of particle for each condition using Dynamic Light Scattering analysis method

Conclusion

Graphene Quantum Dots (GQDs) were synthesized using an electrochemical method with KCl and citric acid as precursors. UV-Vis spectroscopy and Tauc plot analysis showed an energy bandgap of 3.2–3.4 eV, with slight variations due to temperature effects on graphene size. Photoluminescence (PL) analysis indicated that photon emission changes with synthesis temperature and KCl concentration, following a non-uniform trend. Dynamic Light Scattering (DLS) results showed that higher temperatures increase the hydrodynamic size of GQDs, especially at KCl concentrations of 0.35 M and 0.45 M, suggesting a stronger temperature effect at higher KCl levels.