Seeing Double: A Bifurcated Cable's Guide to Fluorescence Detection

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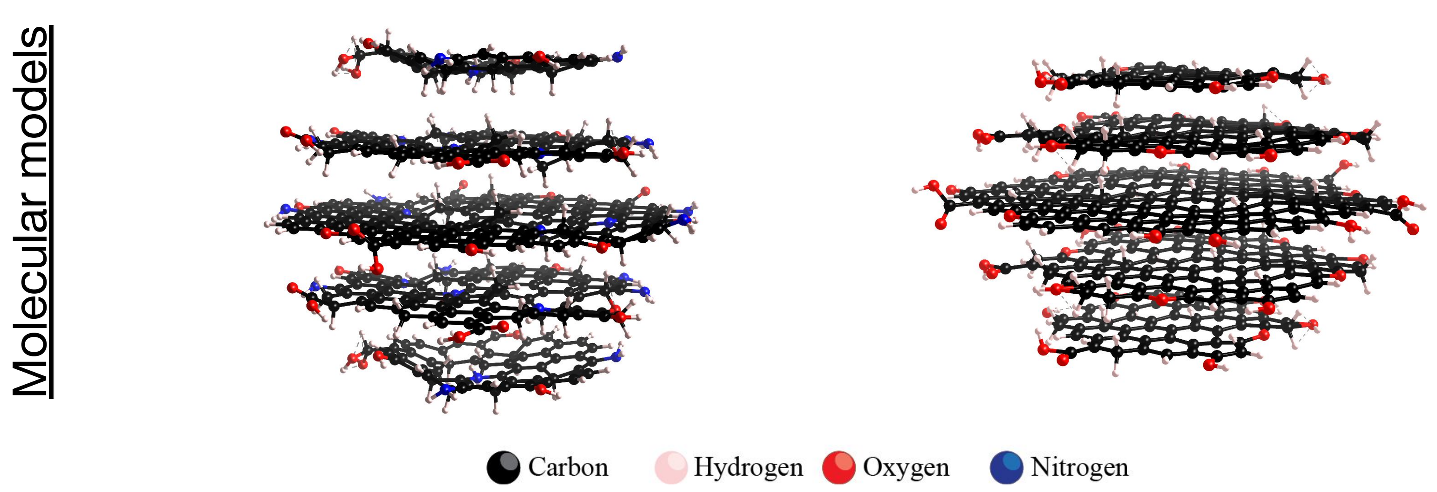
Abstract

Graphene quantum dots (GQDs) have emerged as a promising platform for drug delivery and bioimaging due to their nanoscale size, water solubility, biocompatibility, and fluorescence properties. When functionalized, they enable both therapeutic delivery and real-time tracking in biological systems. This study focuses on the engineering of an optical system designed to cost effectively perform ex vivo spectra collection of GQDs. We utilized a bifurcated fiber optic cable connected to a laser and spectrometer, enabling simultaneous excitation and signal collection through a single optical path. Because excitation and collection occurred at the same angle rather than the conventional 90-degree configuration, a high optical density 840 nm long pass emission filter is utilized to optimize signal collection and minimize scattering. The system's cheap and easy to build design offers a streamlined method for studying nanomaterial-based therapeutics, providing a foundation for future advancements in biomedical imaging.

Introduction



GQDs and Their Importance in Cancer Therapeutics

- **Unique optoelectronic properties and strong fluorescence enable high-resolution imaging of biological structures**
- **Emission in the near-infrared (NIR) range allows for deeper tissue penetration and reduced background interference**
- **Excellent biocompatibility and low toxicity make them safe for use in biological systems**
- **Stable fluorescence under prolonged excitation supports real-time, long-term imaging**
- **Small size and surface tunability allow for targeted imaging and labeling of specific cells or tissues**

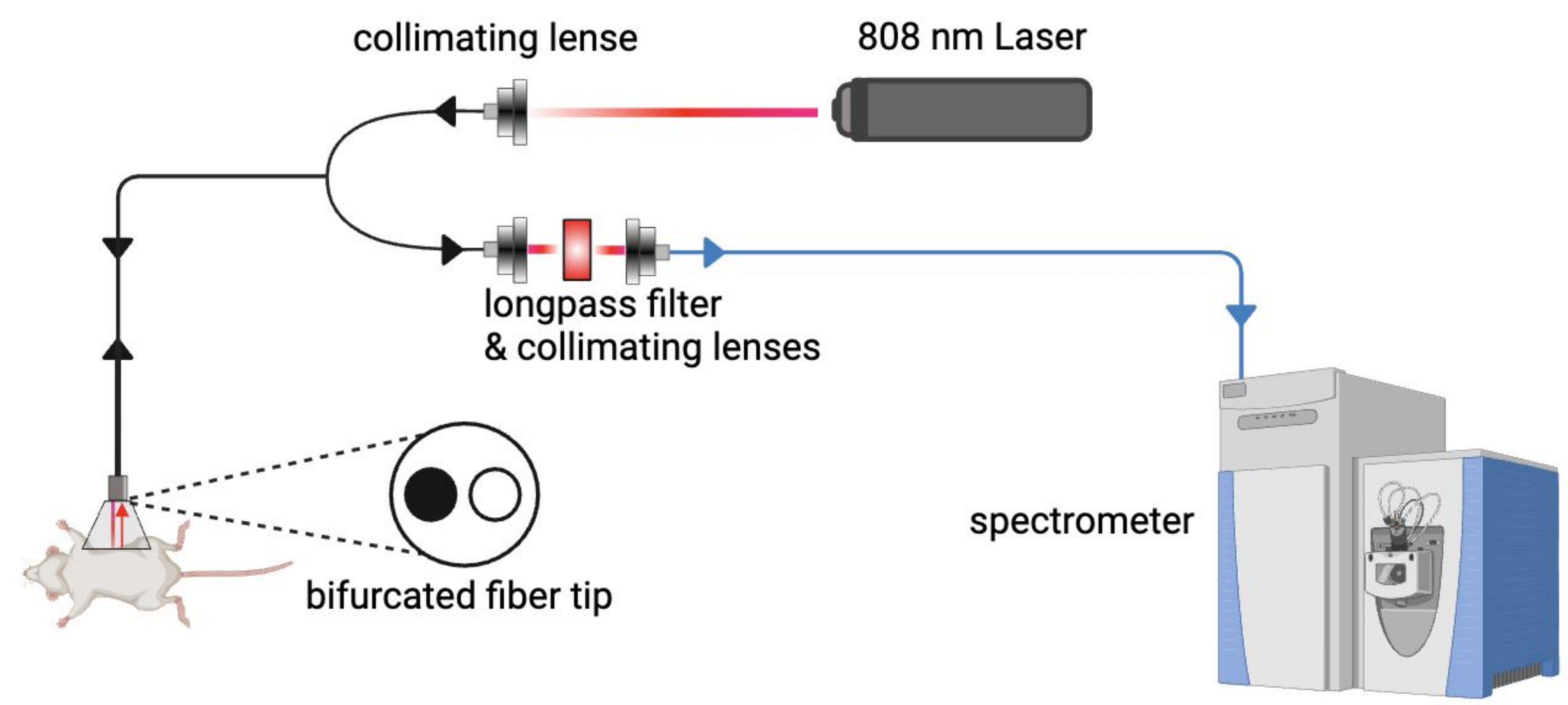
Limitations of Modern in vivo and ex vivo imaging techniques

- **High Cost: Advanced systems like confocal microscopes and spectrometers are expensive and often out of reach for smaller labs.**
- **Lack of Portability: Most systems are large and fixed, limiting flexibility for different research environments.**
- **Specialized Operation: Equipment often requires trained personnel, which can be a barrier in academic settings.**
- **Limited Customization: Commercial systems may not allow easy modifications for specific experimental needs.**

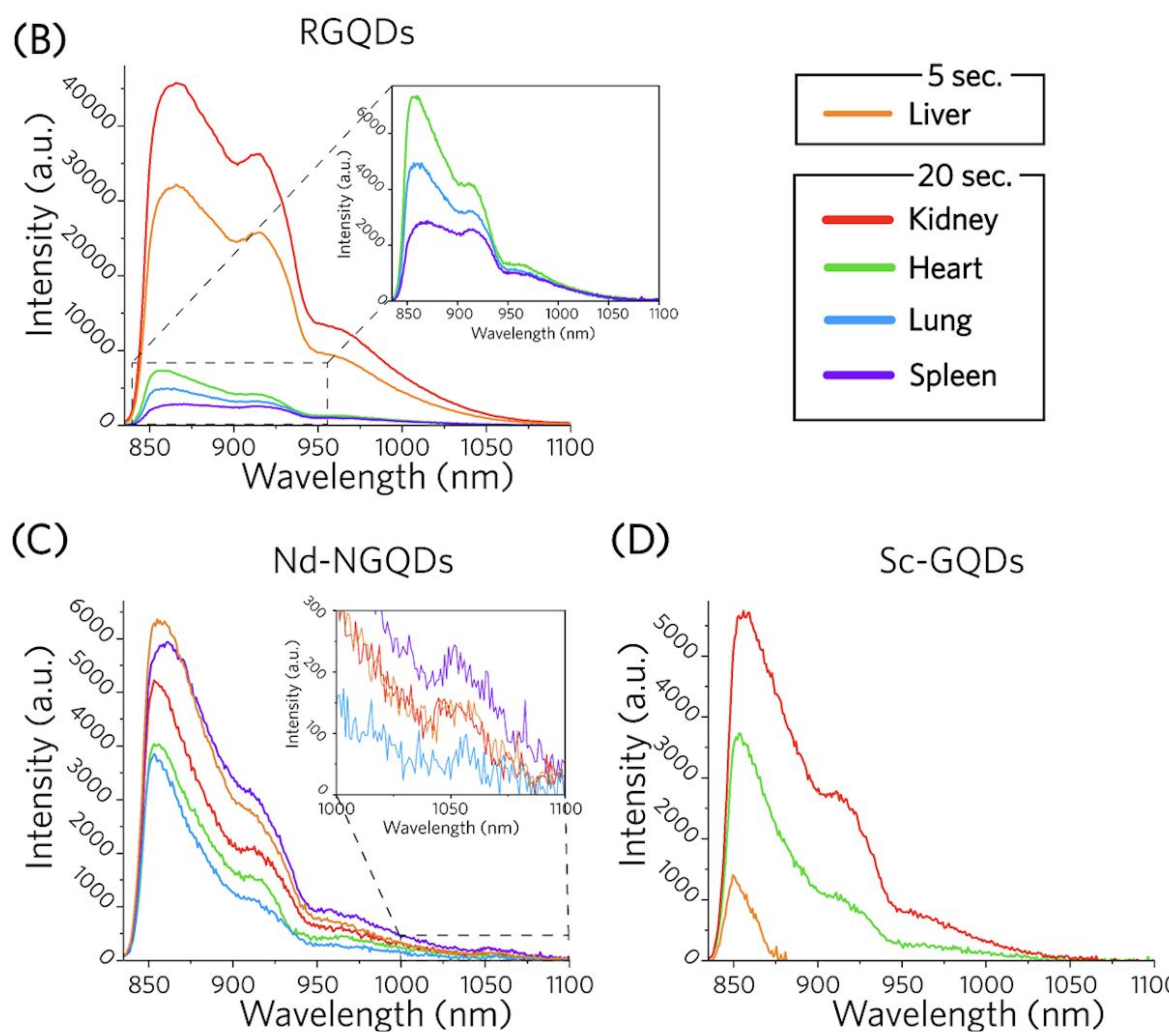
Our Solution

- **Cost-Effective Design: Avoids the use of expensive components like integrating spheres or high-end imaging systems**
- **Compact and Portable: Built with minimal, lightweight components for flexibility in different lab environments**
- **Simplified Alignment: Uses a bifurcated fiber optic cable for single-path excitation and collection, reducing complexity**
- **Minimal Training Required: Easy-to-use system suitable for student and research lab environments without specialized skills**
- **Customizable and Modular: Can be adapted for different wavelengths, filters, or nanomaterials with minimal changes**

Setup



Spectra Collected ex vivo



References

1. Gupta, A., Das, S., Singh, A., Sahoo, D. K., Maiti, T. K. (2023). Graphene Quantum Dots for Bioimaging and Biosensing Applications. Nanomaterials, 13(5), 805. https://doi.org/10.3390/nano13050805

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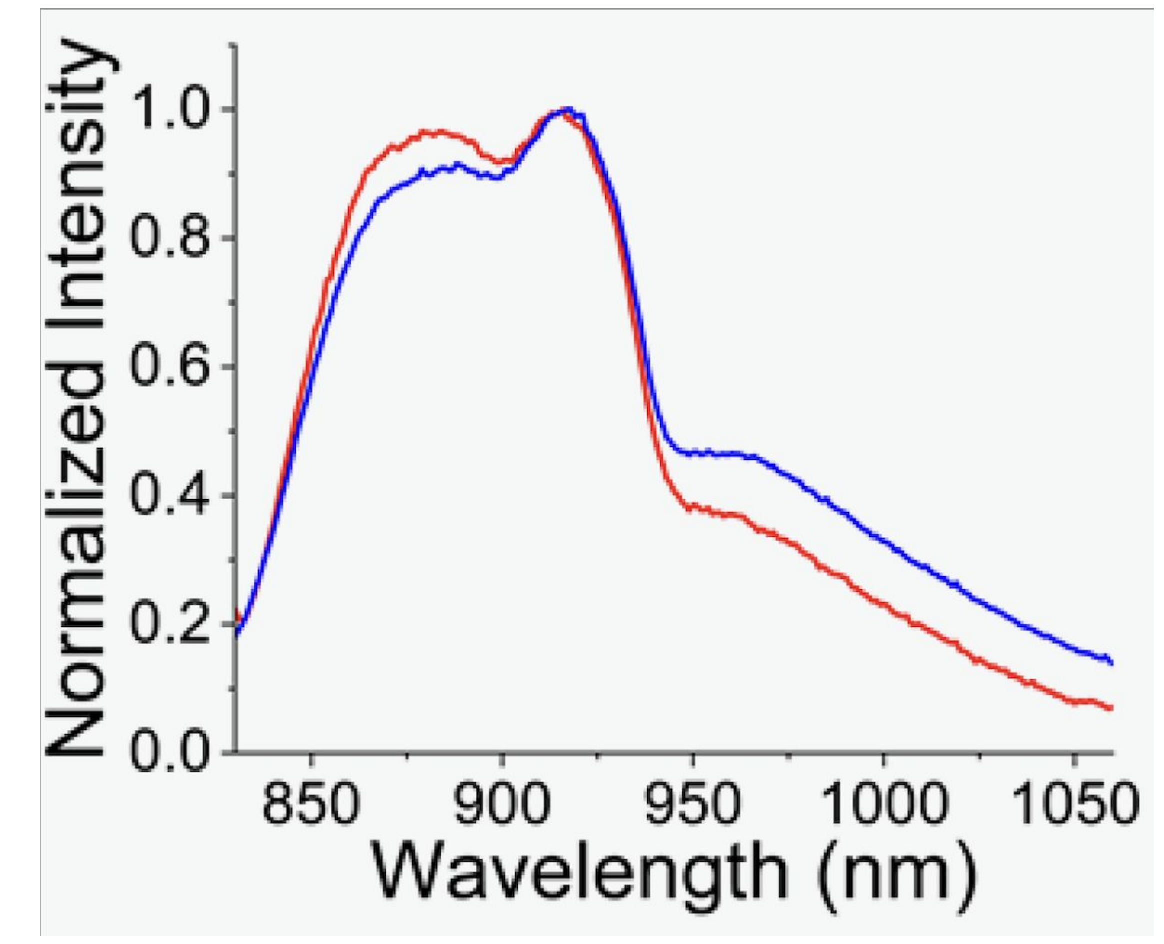
GQD Spectra



3D Printed Cone

Conclusion

Our results demonstrate the successful development of a cost-effective optical system for ex vivo spectra collection of graphene quantum dots. By carefully selecting affordable components and avoiding expensive optical elements—such as integrating spheres or beam splitters—we were able to significantly reduce the overall setup cost without sacrificing performance. The most critical aspect of our design was the use of a bifurcated fiber optic cable, which enabled both excitation and signal collection through a single path. This streamlined approach not only simplified alignment but also enhanced signal quality, making our setup a practical and accessible tool for nanomaterial research.

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Graphene quantum dots are tiny, glowing particles being studied for use in medicine, like delivering drugs and helping doctors see inside the body. Our project created a simple and low-cost tool to help scientists study these particles using light. We built a system that shines a laser on the dots and collects their glow using just one cable. We also used a special filter to make the signal clearer. This setup makes it easier and cheaper to study these tiny tools, which could lead to more accessible ways to treat and detect diseases.