Photobleach Characterization of Theranostic Quantum Dots

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Introduction

Quantum dots can generally be defined as semiconductor nanocrystals and must have certain properties. Among these properties are; the quantum dots' radius should be smaller than the Bohr radius of the material they are used in, due to quantum size and confinement effects. In addition, quantum dots have the ability to emit fluorescent light and resist photobleaching, with the emission property depending on the quantum dot's radius. This is because the radii of quantum dots directly affect quantum confinement and size properties. The radii of quantum dots can be adjusted depending on the synthesis method used, allowing for the tuning of both absorption and emission spectra. The tunability of the emission spectrum allows us to obtain different signals from quantum dots made from the same material but with different sizes, providing different color options. In the scope of this project, absorbance analyses of quantum dots obtained from the Quantag company were conducted to determine at which wavelengths the quantum dots should be excited. Then, all the quantum dots were observed to be excited every three months within a six-month period at the wavelengths determined, using a fluorescent microscope. Images of quantum dots were captured using 10x, 20x, 40x, and 63x objectives during each observation. It was determined how much the fluorescence intensity decreased through image processing of these images. Using the data obtained from the images, hypothesis testing was performed to calculate how long it takes for quantum dots to undergo photobleaching.

Method

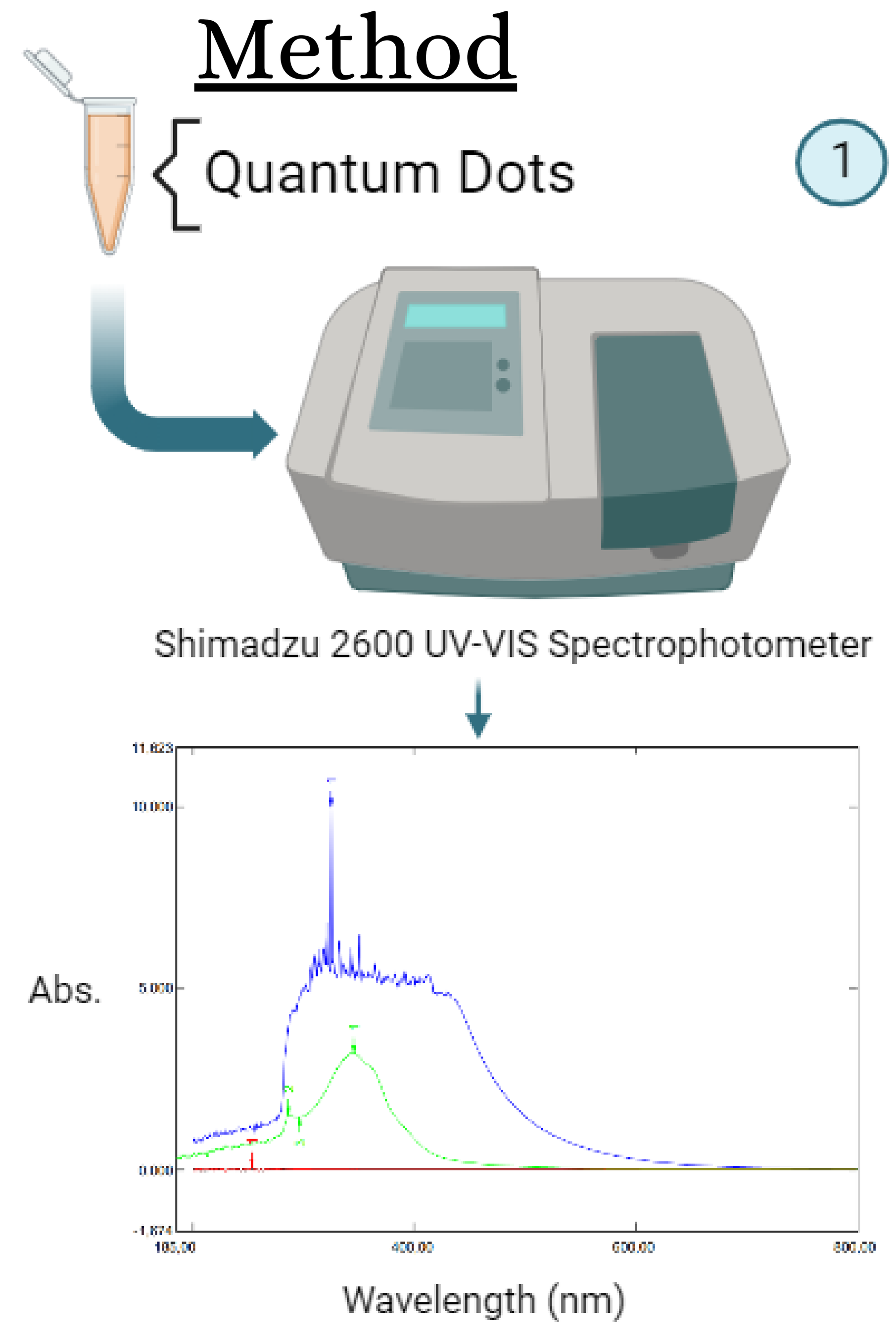

Figure 1: After getting the quantum dots, their absorption spectra were evaluated to see if their absorption spectrum matched up with the datasheet.

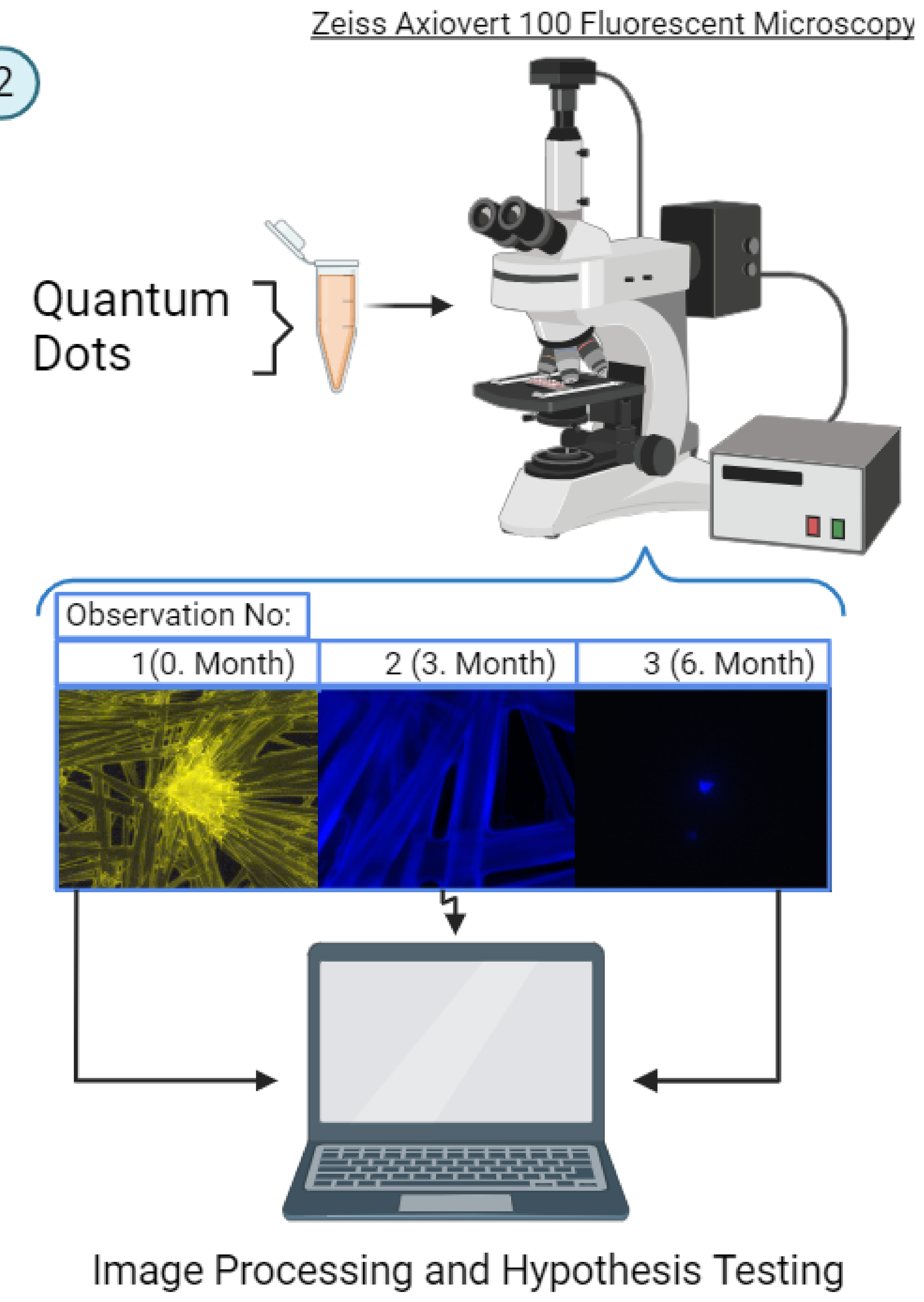

Figure 2: Quantum dots were excited with the wavelength found in the first part of the method in every observation. The observations occurred every three months over the course of six months. Their 10x, 20x, 40x and 63x images were taken in each observation.

Findings

After examining the fluorescent microscope images obtained during the observations, it was observed that some samples had undergone degradation. For this reason, the imagehash algorithm was used to determine which image from the previous observation corresponded to the degraded samples, and the images with the lowest error rates were compared to each other. As a result of the comparison, data regarding the percentage decrease or increase in fluorescent radiation intensity was obtained.

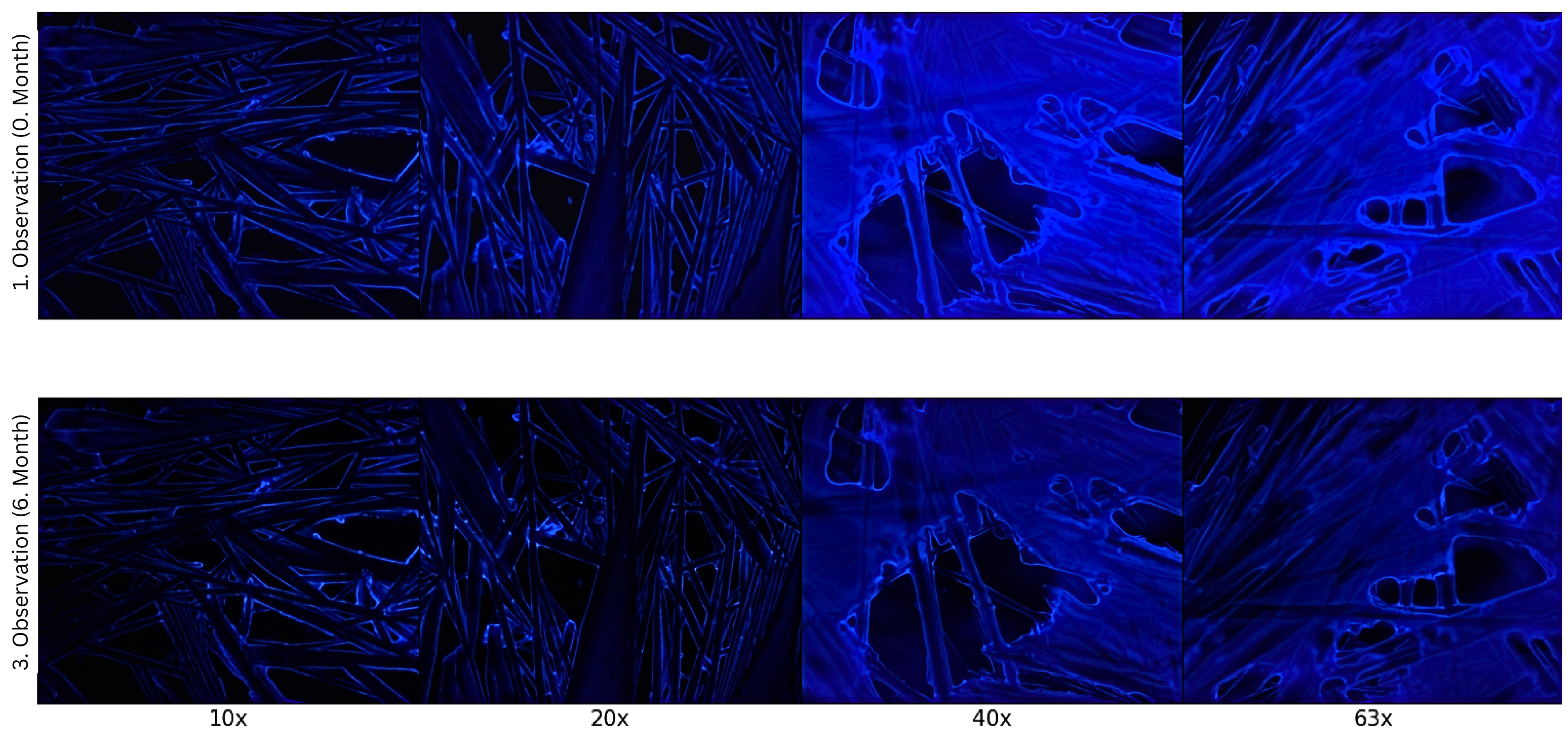

Figure 3: Images at 10x, 20x, 40x, and 63x magnification of graphene quantum dots at 80,000 ppm concentration for the first and third observations.

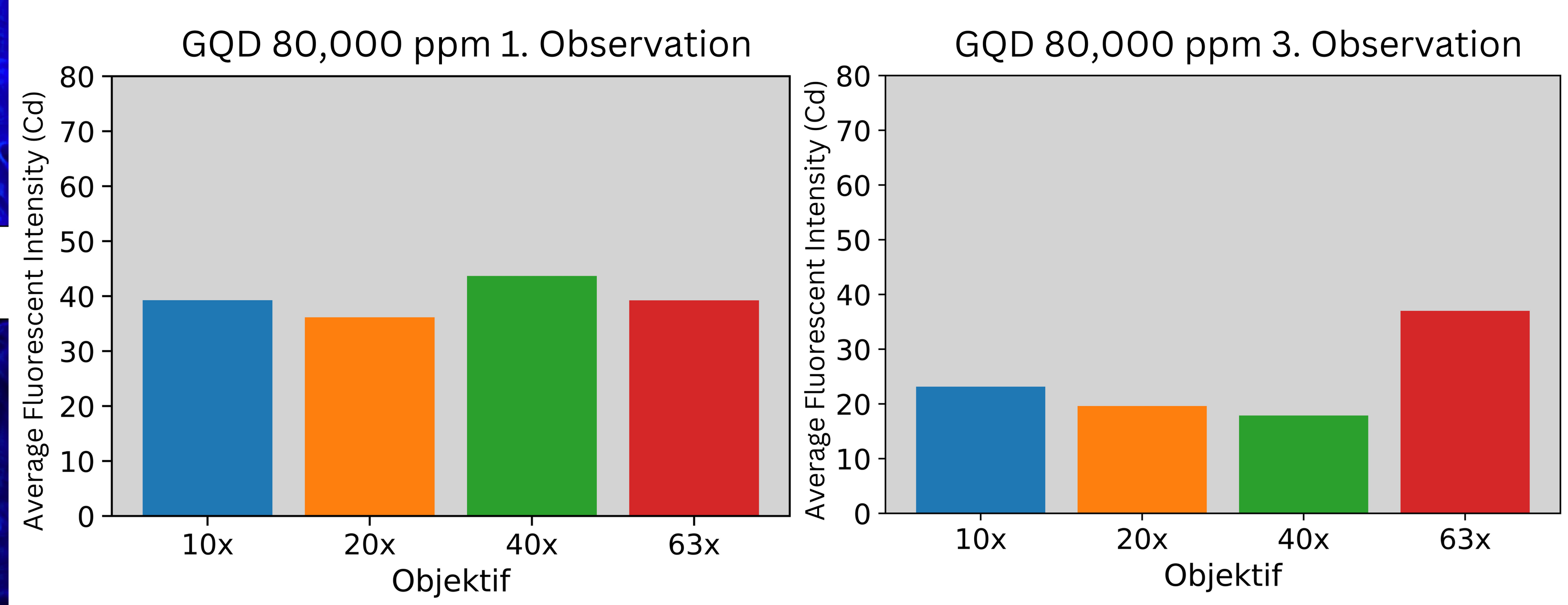

Figure 4: Average fluorescent intensity of images at 10x, 20x, 40x, and 63x magnification of graphene quantum dots at 80,000 ppm concentration.

Conclusion

When the first and third observations were compared, a noticeable decrease was observed in the images at 10x, 20x, and 40x magnifications, while a very slight decrease was observed in the 63x magnification image. The average fluorescent intensity data obtained from these images were subsequently used in the hypothesis test. As a result of the hypothesis test, it was determined that graphene quantum dots had undergone photobleaching within 6 months, and the average fluorescent intensity had decreased by 35.372%.

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