Quantification of Hydrogen Peroxide using Single Walled Carbon Nanotube Based Optical Sensors

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Hydrogen peroxide (H_2O_2), a reactive oxygen species (ROS), plays a vital role in cellular processes, including regulation of protein metabolism, redox signaling, inflammation, apoptosis, and cell proliferation. Understanding changes in H_2O_2 concentrations at a sub-cellular level could lead to improved disease detection/identification and optimization of drug treatments in the presence of increased or decreased levels of ROS. Many H_2O_2 detection methods face challenges such as low sensitivity, complex operational procedures, extended processing times, lack of spatial/temporal detection, and elevated expenses, which restrict their broad utilization. Optical sensors based on single-walled carbon nanotubes (SWNT) have shown the potential to provide high-quality spatial and temporal information regarding a wide range of cellular signaling molecules, including H_2O_2. Herein, we detect and quantify H_2O_2 based on changes in SWNT fluorescence intensity, the first step towards quantifying intracellular and extracellular H_2O_2 concentrations at the sub-cellular level. The SWNT-based H_2O_2 sensors are prepared by wrapping SWNT with single-stranded DNA, specifically (GT)15. To determine SWNT's response to H_2O_2, various concentrations of H_2O_2 were recorded in intervals for 60 minutes using a custom-built hyperspectral microscope. The fluorescence quenching of the sensor was used to create a calibration curve. It was observed that the quenching was rapid for 35 minutes, after which it began to slow down, eventually reaching a plateau at 60 minutes. Hence, we have the calibration curves for both time points with R^2 values of 0.969 and 0.991 respectively for 35 and 60 minutes. The calibration curve provides a linear positive regression relationship between H_2O_2 concentration and percent quenching of SWNT fluorescence. Hence, the concentration of H_2O_2 was successfully quantified through the utilization of the SWNT sensors. This ability to quantify H_2O_2 will allow for investigation into H_2O_2 concentrations in bodily fluids, which could help in early disease detection and improved treatments.

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