A Ratiometric Sensor Using Single Chirality Near-Infrared Fluorescent Carbon Nanotubes: Application to in Vivo Monitoring

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The development of ratiometric fluorescent SWCNT sensors has been limited by a lack in techniques to obtain preparative scales of chirality-separated single walled carbon nanotubes (SWCNT). Recent advances in SWCNT separation and functionalization [1] have enabled the creation of a near-infrared ratiometric optical sensor. Herein, we use single chirality-separated SWCNT, independently functionalized to recognize either nitric oxide (NO), hydrogen peroxide (H$_2$O$_2$), or no analyte (remaining invariant), to create sensor responses from the ratio of distinct near-infrared emission peaks. This ratiometric approach provides a measure of analyte concentration which is invariant to the absolute intensity emitted from the sensors, and hence, more stable to external noise and detection geometry. We specifically demonstrate two distinct ratiometric sensors functionalized for specificity based on Corona Phase Molecular Recognition [2]. Each sensor is responsive either to H$_2$O$_2$, or to NO, via selective quenching of 1100 nm emission, with an invariant 1000 nm emission wavelength as the optical reference. To synthesize these ratiometric sensors from chirality-separated SWCNT, we introduce a method for rapid and efficient coating exchange of single chirality sodium dodecyl sulfate (SDS)-SWCNT. As a proof of concept, spatial and temporal patterns of the ratiometric sensor response to H$_2$O$_2$, and separately NO, were monitored in leaves of living plants in real time. This ratiometric optical sensing platform can enable the detection of trace analytes in complex environments such as strongly scattering media and biological tissues [3].

