NEAR INFRARED SENSORS BASED ON SINGLE WALLED CARBON NANOTUBES: ENGINEERING APPLICATIONS OF ONE DIMENSIONAL EXCITONS

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Molecular detection using near-infrared light between 0.9 and 1.3 eV has important environmental and biomedical applications because of greater light penetration into scattering media and reduced auto-fluorescent background from biological contaminants. Single Walled Carbon Nanotubes (SWNT) have a tunable band-gap fluorescence in the near infrared that we have demonstrated to be sensitive to changes in their local dielectric function but remain stable to permanent photobleaching. We report the synthesis and demonstration of several types of solution-phase, near-infrared sensors by functionalizing carbon nanotubes with ligands designed to modulate the fluorescence in response to selective molecular binding. This presentation will review the development of the current quasi-one-dimensional excitonic view of carbon nanotube photo-physics and describe a series of model sensor architectures developed in our laboratory. By adsorbing glucose oxidase and ferricyanide ions to the surface of carbon nanotubes, a flux-based b-D-glucose sensor can be created. Reaction of glucose at the enzyme ultimately injects charge into the nanotube and modulates the fluorescence via two distinct mechanisms of signal transduction-fluorescence quenching and charge transfer. We also demonstrate a separate and parallel optical detection modality via specific DNA sequences including single nucleotide polymorphism on the surface of solution suspended single-walled carbon nanotubes. Hybridization of a 24-mer oligonucleotide sequence with its complement produces a hypsochromic shift of 2 meV, with a detection sensitivity of 6 nM. In another system, the transition of DNA secondary structure from the native B to the Z conformation is shown to modulate the dielectric environment of the single walled carbon nanotube (SWNT) around which it is adsorbed. The results demonstrate new opportunities for nanoparticle optical sensors that operate in strongly absorbing media of relevance to medicine, biology and environmental remediation.