Columbia Technology Ventures

Sensing device for DNA or RNA molecule binding events

Technology #m06-049

"Name of the lead innovator: Colin Nuckolls, PhD.

Carbon nanotubes used to detect DNA or RNA molecule binding events: Common biosensors and diagnostic platforms that involve the binding of probe with target molecules, such as microarrays and PCR, ELISAs, are powerful tools that can be used for the detection of bacteria, virus, tumors, or genetic variation. However, these technologies are expensive and time consuming. Several days usually elapse between initial sample collection and the generation of results. Furthermore, these platforms have limited specificity and resolution making false positive results an issue. The current invention provides for a system where single nucleotide or peptide binding event can be detected in real time.

DNA or RNA molecule binding events detected using carbon nanotubes and probe molecules: The invention is a nanostructured electronic device in which the binding event of a target molecule to a probe molecule results in electrical changes that can be directly monitored. It consists of a single walled carbon nanotube with a narrow gap allowing for the placement of a probe molecule that acts as a conductive bridge. This configuration allows the device to monitor electrical conductivity changes that result when the probe molecule binds with a target molecule. The inventors have developed a novel method to reproducibly create robust covalent bonds between the molecular bridge and the nanotube. A variety of different types of macromolecules can be used as the molecular bridge, including DNA oligonucleotides, aptamers, antibodies, and peptides. Experiments have been performed where a single nucleotide change in a single DNA strand (SNP) was detected indicating that well-matched and mismatched bonding events between two DNA stands could be monitored within seconds.

Applications: • The chemistry of DNA and RNA hybridization can be exploited to screen genetic variations including Single Nucleotide Polymorphisms (SNPs) • Detection of antibody or antigen in a sample • Utilization as biosensor containing aptamers, DNA, or protein probes • Point-of-Care diagnostics or In-the-Field forensics • Microbial detection, including bacteria and viruses • Analysis of biomarker expression • Immunoassays and screens that do not require secondary antibodies or conjugates • Detection of explosives • Device can be sensitive to photoswitching

Advantages: • The use of single stranded DNA as a conductive bridge offers a direct and very sensitive way to detect small changes in DNA hybridization • Label-free, real-time detection of target molecule possible • No chromogenic or fluorgenic substrate is required to detect binding of target • The electrical conductive properties of the device are dominated by probe-target binding events, not the nanotube. This is due the quality of the electrical contacts between probe molecule and nanotube electrodes • The device behavior is not sensitive to conductive nature of the nanotube, be it metallic or semiconducting • Linkages between molecule and electrodes are robust and tolerate broad changes in the environment • A variety of molecules can be used as a molecular bridge • Devices can be sensitive to pH and ionic changes • Inexpensive, quick, label-free, real-time DNA or protein based diagnostics allows for Point-of-Care personalized medicine
References: (1) X. Guo, et al, Covalently Bridging Gaps in Single-Walled Carbon Nanotubes with Conducting Molecules; (2) X.Guo, et al, Conductivity of a single DNA duplex bridging a carbon nanotube gap

Inventors

Colin Nuckolls