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Metallic nanoparticles biosensors: A colorful platform for detecting biomolecular interactions

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Nobel metal nanoparticles (NPs) such as gold and silver, in the same size domain (<100 nm) as the biomolecules, are well suited for biosensing applications due to their unique optical properties arising from the localized surface plasmon resonance. We have developed three nanoplasmonic sensing to interrogate estrogen receptor (ER)-DNA interactions- an important transcriptional activity related to breast cancer biology. These assays exploit the interparticle distance-dependent plasmonic coupling and/or plasmon-induced fluorescent quenching as sensing elements. The first assay uses the citrate-anions capped AuNPs to probe the sequence-specific binding interactions of ER to various DNA sequences and to determine their binding stoichiometry without using labels, tedious sample preparation, and sophisticated instrumentation. This assay was further designed to couple with the aggregation-induced emission luminogen to allow dual optical signal (i.e., colorimetric and fluorescent) detection in a single experiment. The second assay was founded on the de-novo design of segmented ER-response DNA element onto two sets of metal NPs conjugates with complementary short sticky ends, where ER serves as a stabilizer to retard the particle aggregation induced by base-pairing and charge screening. This protein binding-stabilization strategy is generic and reduces the risk of getting false positive results. The third assay was designed based on the concept of traditional DNA footprinting using DNase with the combinatorial use of DNA-modified AuNPs to enable fast colorimetric detection without hazardous radioactive-labeling and tedious assessment of cleavage pattern. This versatile AuNPs-based enzymatic assay can be used to monitor nucleases activity, screen nucleases inhibitor, detect DNA-binding proteins and determine DNA sequence specificity in a fast, sensitive and convenient way.

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Design and optimization of SansEC resonant sensors for electromagnetic sensing of biological systems

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This work explores a novel approach towards the detection of electrical and chemical activity originating from biological nerve tissue using a wireless interface based on NASA SansEC (without Electrical Connections) Sensing Technology. The concept takes advantage of the unique ability of a resonant spiral to characterize an electromagnetic signature response for material media in proximity to such sensors. During the propagation of action potentials in living axons and neural pathways, there is an emergence of a magnetic-field component that can couple with the electromagnetic field of an appropriately tuned SansEC sensor. This coupling produces an observable change to the sensor's response within its fundamental or harmonic resonance spectra. To demonstrate feasibility of this proposal, system design experimentation was conducted on a non-biological assembly consisting of a transmission-line submerged in an aqueous-solution simulating a nerve surrounded by interstitial fluid. An arbitrary function generator provided the action potential stimulus while a SansEC sensor was placed in the proximity of but external to the assemblage. Interrogation was accomplished using a near-field loop antenna connected to a network analyzer. The presence of the fluid was detectable by a measurable frequency shift of the sensor resonance. Chemical changes in the fluid using common ionic concentrations of Na^+, K^+, and Cl^- were similarly detectable as smaller frequency shifts. Results also demonstrate that detectable coupling of simulated nerve impulses and electrical activity is possible. This research lays a foundation towards the realization of practical sensing systems utilizing SansEC sensor technology for detecting and quantifying electrochemical activity in living organisms.

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