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Detection and quantification of heavy metals in water bodies by label-free optical biosensors

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The objective of this research is to develop a generic integrated biosensing platform for detection of heavy metal pollutants in aqueous solutions. Heavy metals are one of the most serious pollution problems of our time, which threatens global sustainability as being non-biodegradable. Increasing industrial activity and the use of metallic constituents of pesticides leads to the accumulation of heavy metals in the food chain. Long-term exposure to these highly toxic pollutants may result in severe physiological and neurological damage and may even cause cancer. Consequently, growing environmental awareness has resulted in strict regulations for reducing heavy metals presence in the environment. Thus, we have designed and fabricated a simple optical biosensing platform based on Porous Silicon (PSi) nanostructures that allows for real-time monitoring of heavy metal pollutants in aqueous solutions by enzymatic activity inhibition. An oxidized PSi optical nanostructure, a Fabry-Pérot thin film is synthesized and is used as the optical transducer element. First, we show a general detection assay by immobilizing Horseradish Peroxidase (HRP) within the oxidized PSi nanostructure and monitor its catalytic activity in real-time by reflective interferometric Fourier transform spectroscopy. Optical studies reveal high specificity and sensitivity of the HRP-immobilized PSi towards three metal ions (Ag^{+}>Pb^{2+}>Cu^{2+}), with a detection limit range of 50-110 ppb. Next, we demonstrate the concept of specific detection of Cu^{2+} ions (as a model heavy metal) by immobilizing Laccase, a multi-copper oxidase, within the oxidized PSi. The resulting biosensor allows for specific detection and quantification of copper ions in real water samples by monitoring the Laccase relative activity. The optical biosensing results are found to be in excellent agreement with those obtained by the gold standard analytical technique (ICP-AES) for all water samples. The main advantage of the presented biosensing concept is the ability to detect heavy metal ions at environmentally relevant concentrations using a simple and portable experimental setup, while the specific biosensor design can be tailored by varying the enzyme type.

Biography

Giorgi Shtenberg has obtained his PhD in Biotechnology and Food Engineering, Technion-Israel Institute of Technology, Israel (2014). He has multidisciplinary expertise in nanomaterials, semiconductors, microfluidics, photonics and biological interfaces for biomedical and environmental monitoring applications. He is currently a Research Scientist and the Head of Biosensors and Nanoengineering Laboratory at the Institute of Agriculture Engineering, ARO-Volcani Center. His lab focuses on the development of novel biosensors/bioassays that will transform from a laboratory-based research into a real on-site lab-on-chip platform for addressing problems in the fields of agriculture, animal diagnostics, food safety and environmental monitoring and detection.

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