

Immunosensing prostate-specific antigen: Faradaic vs non-Faradaic electrochemical impedance spectroscopy analysis on interdigitated microelectrode device

Abstract

This work explores Electrochemical Impedance Spectroscopy (EIS) detection for a highly-sensitive quantification of prostate-specific antigen (PSA) in Faradaic (f-EIS) and non-Faradaic modes (nf-EIS). Immobilization of monoclonal antibody specific to PSA (anti-PSA) was performed using 1-ethyl-3-dimethylaminopropylcarbodiimide hydrochloride and N-hydroxysuccinimide crosslinking agents in order to conjugate carboxylic (-COOH) terminated group of 16-Mercaptoundecanoic acid with amine (-NH₃⁺) on anti-PSA epitope. This approach offers simple and efficient approach to form a strong, covalently bound thiol-gold (S-Au) for a reliable SAM layer formation. Studies on the topographic of pristine Au-IDE surface were performed by Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy techniques, meanwhile a 3-dimensional optical surface profiler, Atomic Force Microscopy and X-ray Photoelectron Spectroscopy techniques were used to validate the successful functionalization steps on the sensor transducer surface. Detection of PSA in f-EIS mode was carried out by measuring the response in charge transfer resistance (R_{ct}) and impedance change (Z), meanwhile in nf-EIS mode, the changes in device capacitance was monitored. In f-EIS mode, the sensor reveals a logarithmic detection of PSA in a range of 100 ng/ml down to 0.01 ng/ml in Phosphate Buffered Saline with a recorded sensitivity of 2.412 k Ω /log₁₀ ([PSA] ng/ml) and the limit of detection (LOD) down to 0.01 ng/ml. The nf-EIS detection mode yields a logarithmic detection range of 5000 ng/ml down to 0.5 ng/ml, with a sensitivity of 8.570 nF/log₁₀ ([PSA] ng/ml) and an LOD of 0.5 ng/ml. The developed bio-assay yields great device stability, specificity to PSA and repeatability of detection that would pave its way for the future development into portable lab-on-chip bio-sensing system.

Keybord

Biomarker; Capacitive biosensor; Electrochemical impedance spectroscopy; Gold interdigitated microelectrode; Impedimetric biosensor; Prostate-specific antigen