ABSTRACT:

Nanoengineered Multiplexed Immunosensors for Point-of-Care Cancer Detection

Muhammad Omar Shaikh*
Sustainability Science and Management Program, Tunghai University, Taichung 407224, Taiwan.
* Correspondence Email: omar@thu.edu.tw; Tel.: +886-4-23590121 ext.39204

Early detection and monitoring of cancer remain critical global challenges, particularly due to the limited sensitivity, high false-positive rates, and lack of multiplexing capability in current point-of-care (POC) diagnostics. Here, we present a multiplexed electrochemical immunosensor platform for the simultaneous detection of clinically relevant cancer biomarkers in complex biological fluids. This platform is enabled by a novel multifunctional 3D nanocomposite coating comprising a porous bovine serum albumin (BSA) matrix integrated with highly conductive carbon nanotubes (CNTs). This nanoengineered interface facilitates oriented antibody immobilization, minimizes nonspecific adsorption, enhances analyte diffusion, and significantly improves electron transfer, resulting in high sensitivity and specificity. As a proof-of-concept for clinical translation, the platform was validated for bladder cancer biomarkers (APO-A1, VEGF, and IL-8), demonstrating wide dynamic ranges (0.1–1000 ng/mL) and ultralow limits of detection (22–44 pg/mL). The sensor exhibited excellent reproducibility (RSD = 2.2%), robust antifouling performance in complex urine samples, and strong stability over one month of storage. Implemented on a low-cost, disposable screen-printed platform, this approach enables rapid, non-invasive, and multiplexed biomarker profiling directly at the POC. These results highlight the potential of nanoengineered immunosensors to enable accessible, high-performance cancer diagnostics and accelerate real-world clinical translation.

Keywords: Electrochemical Biosensors; Multiplexed Immunosensor; Nanocomposite; Carbon Nanotubes (CNTs); Point-of-Care Diagnostics; Cancer Biomarkers