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Screen-printed nanocomposite immunosensor for multiplexed detection of bladder cancer biomarkers at the point-of-care

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Bladder cancer (BC) is a major global health challenge, with early detection and monitoring heavily reliant on invasive cystoscopy due to the shortcomings of existing point-of-care (POC) diagnostic tools. Current POC tests suffer from qualitative outputs, high false-positive rates, and limited biomarker multiplexing capabilities, making them inadequate as standalone diagnostic solutions. Addressing these limitations, we present a multiplexed electrochemical immunosensor engineered for the simultaneous detection of key BC biomarkers—APO-A1, VEGF, and IL-8—in complex biological fluids such as urine. The immunosensor leverages a novel multifunctional 3D nanocomposite coating composed of a porous bovine serum albumin (BSA) matrix integrated with a network of highly conductive carbon nanotubes (CNTs). The BSA matrix enables oriented antibody immobilization, suppresses nonspecific adsorption, and facilitates unhindered analyte diffusion, while the CNTs enhance electron transfer and amplify signal outputs, ensuring high sensitivity and specificity in complex biological environments. The nanocomposite coating demonstrated remarkable stability, with minimal degradation in electrochemical performance after 1 month of incubation in 1% BSA, human serum, and human urine. Analytical validation confirmed simultaneous detection of APO-A1, VEGF, and IL-8 with broad dynamic ranges (0.1–1000 ng/mL) and exceptional limits of detection (22 pg/mL, 44 pg/mL, and 28 pg/mL, respectively). Moreover, the immunosensor exhibited excellent reproducibility (n = 5, RSD = 2.2%) and robust antifouling properties, ensuring reliable performance in the presence of urinary interferents such as FGFR3, NMP-22, and HSA. The low-cost and disposable screen-printed platform offers high feasibility for clinical translation, with sensitive and specific biomarker detection within clinically relevant ranges. These results highlight the transformative potential of this multiplexed immunosensor for non-invasive, early-stage BC diagnosis at the POC, providing a viable alternative to invasive cystoscopy.

Biography

Muhammad Omar Shaikh is Associate Professor of Sustainability Science and Management at Tunghai University, Taiwan, and Director of the Advanced NanoTech Laboratory (ANT Lab). He holds an MEng in Materials Science and Engineering from Imperial College London and a Ph.D. in Mechatronic Science and Engineering from Southern Taiwan University of Science and Technology. His interdisciplinary research integrates nanotechnology, electrochemistry, flexible electronics, and AIoT, with a focus on developing high-performance functional nanomaterials for applications in medical diagnostics, sustainable energy, and carbon-neutral technologies. He previously served as Chief Technology Officer at BiTAPE Logistics, a university spin-off that pioneered smart printed tape technology for real-time supply chain visibility and AI-enhanced logistics services.

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