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Congress Abstract

An Optical Biosensor for Label-Free Detection of Soluble Biomarker: Toward Minimally Invasive Breast Cancer Monitoring

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ABSTRACT

Tumor cells release biomarkers such as CD44 into the bloodstream, offering opportunities for minimally invasive monitoring of tumor progression. However, conventional analytical methods often suffer from insufficient sensitivity and a limited dynamic range, which hinders reliable detection of such biomarkers in complex biological fluids. Optical fiber biosensors are particularly attractive alternatives, offering high sensitivity, low cost, chemical inertness, and diverse surface functionalization strategies, making them well suited for detecting clinically relevant circulating tumor biomarkers that require sensitive, quantitative analysis. CD44, a cell adhesion glycoprotein whose soluble form (solCD44) is elevated in several cancers including breast cancer (BC), was selected as a model biomarker for this study owing to its well-established diagnostic relevance.

Here, we report the development of a graphene oxide-coated fiber-optic biosensor based on a semi-distributed interferometric sensing platform for the highly sensitive detection of solCD44. A total of 46 sensors were fabricated and characterized for their sensitivity to refractive index changes in the surrounding medium. The sensor surface was subsequently functionalized with anti-CD44 antibodies, and successful biofunctionalization together with antibody specificity was confirmed using several complementary techniques, including atomic force microscopy (AFM) and ELISA.

The optimized biosensor exhibited a wide dynamic detection range, spanning attomolar concentrations up to 100 nM, with a limit of detection (LOD) as low as 175 aM in spiked serum. Specificity was confirmed by comparison with non-functionalized sensors and healthy control samples. To validate its practical clinical applicability, the biosensor was further tested in human serum samples from breast cancer patients, showing significantly higher signal in cancer patients than in healthy controls. Successful detection of solCD44 in urine additionally demonstrated the biosensor's compatibility with multiple biological matrices. Together, these findings establish this fiber-optic biosensor as a promising platform for highly sensitive, label-free, and minimally invasive detection of cancer biomarkers, with strong potential for clinical translation and point-of-care diagnostic systems.

Keywords: Soluble CD44; Breast Cancer; Clinical Samples; Serum; Urine; Optical Fiber Biosensor; Semi-Distributed Interferometry