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Aptamer-enhanced ultrasensitive electrochemical detection of HER-2 in breast cancer diagnosis using ZnO tetrapod-K_4PTC nanohybrids

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Breast cancer continues to be a severe global health issue, emphasizing the critical need for accurate and timely detection and screening of large numbers of patients. This ailment places an enormous strain on healthcare resources and poses severe mortality risks for women globally if not addressed promptly. Conventional diagnostic techniques face obstacles such as expensive apparatus, intricate procedures, and long duration in stratification. Therefore, the development of point-of-care (PoC) devices that enable early detection of breast cancer is of utmost importance. This research article focuses on the development of an electrochemical based aptasensor for the detection of Human Epidermal Growth Factor Receptor 2 (HER-2) using the novel nanohybrid substrate material, which consists of a 3D Zinc Oxide Tetrapods (ZnOT) and Potassium Perylene Tetra Carboxylate (K_4PTC). The analytical performance of the bio-nanoelectrode for detecting HER-2 was assessed using Square Wave Voltammetry (SWV) analysis. The developed nano-biosensor exhibited linear response in the range from 1 fg/mL – 10 µg/mL, and the overall limit of detection and sensitivity of the developed sensor is observed around 0.58 fg/mL and 2.08 µA/fg/mL/mm^2, respectively. The shelf life of the sensor substrate is above one month in normal storage conditions. This study offers a base for the development of an efficient and sensitive breast cancer biomarker sensing platform, which has the potential to be implemented at a low cost for society and perform screening testing for breast cancer management in rural areas.

Keywords Breast cancer, HER-2, Electrochemical biosensor, ZnOT-K_4PTC nanohybrids, Affordable healthcare, Early detection

Breast cancer is the most common category of cancer and the second leading root of mortality among the female populace. An estimated 2.1 to 2.3 million women worldwide are affected by it annually[1]. There were 1 million deaths globally, it is projected that the number of breast cancer cases is projected to increase by many times 2025 [2]. HER-2 is a common biomarker for breast cancer. It is overexpressed in 20–30% of breast cancer cells and has emerged as an essential biomarker for guiding therapeutic decisions in breast cancer patients[3,4]. Therefore, timely and accurate detection of breast cancer, especially in cases containing HER-2 overexpression, is crucial for adopting efficient therapeutic strategies.

Primary screening is important for valuable treatment of breast cancer which may result in improved survival rates. Several methods, such as mammography, sonography, thermography, positron emission tomography (PET), molecular breast imaging, magnetic resonance imaging (MRI, biopsy, and computed tomography (CT) scans, are utilized for breast cancer screening[5–7]. Traditional methods for HER-2 detections contain enzyme-linked immunosorbent assays, radioimmunoassays, electrochemical immunoassays, and colorimetric

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