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Electrochemical detection of human epidermal growth factor receptor 2 using an aptamer on cobalt phthalocyanines – Cerium oxide nanoparticle conjugate

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ABSTRACT

The role of the biointerface design towards the development of an impedimetric biosensor for the electrochemical detection of human epidermal growth factor receptor 2 (HER2) is investigated. Two novel cobalt phthalocyanines: cobalt tetraphenyl acetic acid phthalocyanine and cobalt tetraphenyl propionic acid phthalocyanine are compared as signal amplifiers and immobilization platforms of the HB5 aptamer towards the electrochemical detection of HER2. In addition, the phthalocyanines are coupled with the metal based cerium oxide nanoparticles. The efficiency of each electrode modification step and the performance of the constructed aptasensors were assessed by impedance spectroscopy. The aptasensors showed very low limit of detection values (all less than 0.2 ng/mL) with high sensitivity and stability. Furthermore, the aptasensors showed very good performance even in human serum samples. Considering these results, the aptasensors demonstrate great potential for improved monitoring of human epidermal growth factor receptor 2 levels for the management of breast cancers.

1. Introduction

Critical to biosensors, irrespective of their application, is the biointerface consisting of a biologically derived recognition element integrated with an abiotic transducing platform [1]. The biorecognition elements are strategically immobilized on the abiotic platform, to interact with the analyte molecules to generate a signal. A successful connection of the biotic and abiotic components is essential to the development of a stable, sensitive, accurate, and ultimately marketable biosensor [2,3]. The choice of core material provides unique opportunities for tailoring biomolecule binding and activities that are application and platform specific [4,5]. Cerium oxide (CeO_2) nanoparticles have high mechanical strength, good optical properties and good thermal stability, and they have found applications in various fields including biomedicine and biosensing [6–10]. The utilization of CeO_2 nanoparticles in biosensing applications has drawn much attention due to many advantages such as high sensitivity, unique surface properties that alter adsorption properties, biocompatibility, affordability, and simplicity [9,11]. Literature demonstrates the use of cerium oxide nanoparticles for the detection of cholesterol [10], glucose [12], hydrogen peroxide [13], lactate [14] and aeromonas hydrophila DNA oligonucleotide sequence [15]. The use of cerium oxide nanoparticles as immobilization support for the HB5 aptamer on a glassy carbon electrode is demonstrated, for the electrochemical detection of the human epidermal growth factor receptor 2 (HER2). The HER2 is an established breast cancer biomarker, which is overexpressed in 20–30 % breast cancer [16]. CeO_2 NPs have been employed for HER2 detection [17]. The cerium oxide nanoparticles are coupled with novel cobalt based phthalocyanines. Metallophthalocyanines (MPcs) are well known electrocatalysts [18], for signal generation/amplification in the detection of numerous analytes when alone or in bio- and nanocomposite assemblies [18–20]. MPc derivatives have been linked to an aptamer for human epidermal growth factor receptor 2 (HER2) detection [21]. We have reported on the use of a cobalt phthalocyanine with graphene quantum dots and polypyrrole towards the detection of HER2 [22]. Two novel phthalocyanines: cobalt tetraphenoxy propionic acid (CoTPPc) and cobalt tetraphenoxy acetic acid (CoTAPc) phthalocyanines are coupled with cerium oxide nanoparticles as electrode modifiers for immobilization support and signal amplification towards the electrochemical detection of HER2. The phthalocyanine ring systems used in this work are known for Zn as a central metal [23,24], and Co is employed as a central metal for the first time in these ring systems. The two

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