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Electrochemical Nanobiosensors for Cancer Diagnosis

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Editorial

Cancer is one of the most leading cause of death worldwide and can take over 200 diverse forms, including lung, prostate, breast, cervical, ovarian, hematologic, colon cancer, and leukemia. It has been found that environmental factors (eg, alcohol, radiation, smoke, and carcinogenic chemical compounds) as well as genetic factors (eg, autoimmune dysfunction and hereditary mutations) are linked with an increased threat in the development and progression of cancer [1]. In addition microorganisms are also reported to be associated with some types of cancer (eg, stomach cancer and cervical cancer etc) [2]. In view of such an important medical condition, several methods have already been discovered to diagnose cancer and many more methods are in the process of development [3]. Conventional clinical approaches to detect cancers are based on biopsy followed by histopathology [4], biomarkers using protein levels or nucleic acid content and its expression in the cancer suspects [5]. Biopsy is the most widely used technique, however, it is an invasive technique and cannot always be used. Furthermore, it cannot be applied when cancer biomarkers are present in an extremely low concentrations in the body fluids and in malignant tissues. Thus, the development of highly sensitive and new techniques of cancer diagnosis is extremely interesting and significant in medical science. Due to high interest in interdisciplinary research in the last decade several nanobiosensors based on spectrophotometric or optical methods, fluorescence immunoassay, chemiluminescence analysis, electrochemistry, radioimmunoassay, capillary electrophoresis and chromatographic analysis have been developed to detect cancer biomarkers (proteomic and genetic markers) and cells [6,7]. The major issues in cancer diagnosis are sensitivity and to develop a miniaturized platforms that can be used as point-of-care medical device and can be applied in the remote areas. The development of electrochemical nanobiosensors composed of nanomaterials and biological receptors (antibody, aptamer, peptide etc) are likely the most encouraging approach to solve the problems related to sensitivity, rapidity, selectivity, and low cost [8-12]. This approach is expected to be very effective for cancer diagnosis due to the combination of conventional bioassay (antibody, aptamer, peptide etc) coupled with nanomaterials and electrochemical measurement. Another advantage of the electrochemical biosensor include its ability to be miniaturized as an onsite medical device, low cost, small, and handy size [13-17]. These features of electrochemical nanobiosensors may serve as a smart alternative to support fast cancer diagnosis, thereby designing better therapeutic strategies which will be extremely helpful in decreasing patient stress.

Usually, an electrochemical nanobiosensor is developed for either cancer biomarkers detection such as; embryonic antigen biomarkers, carbohydrate antigens biomarkers, enzyme and isozyme biomarkers, protein biomarkers, hormone biomarkers etc. or for the direct detection of whole cancer cells. The real implication of all these studies are to develop at first a sensor prototype and then translate it into a genuine and real biomedical device for cancer suspects and patients. A recent electrochemical nanobiosensor for breast cancer diagnosis has been developed in Yoon-Bo Shim laboratory, Pusan National University, South Korea, where in a single prototype human epidermal growth factor receptor 2 (HER2) protein and HER2-overexpressing breast cancer cells have been detected by an electrochemical nanobiosensor directly in body fluids [16]. The sensor probe was fabricated by covalently immobilizing anti-HER2 onto a nanoconducting film and the signal was obtained by a novel bioconjugate composed of hydrazine–gold nanoparticle–aptamer, where the hydrazine acted as an electrocatalyst and aptamer worked as a reporter molecule. The developed sensor was capable of differentiating between HER2-positive breast cancer cells and HER2-negative cells. This method exhibited an excellent diagnosis method for the ultrasensitive detection of SK-BR-3 breast cancer cells in real samples. The interesting feature of this method is that, it is a generic method and can be applied for any type of cancer biomarkers and cells simply by changing the detector and reporter probe. In another study, a voltammeric and impidimetric detection of microRNA-21 and mir-21 from cell lysates was investigated for the detection of breast cancer cell line and hepatoma cell line [18]. The developed biosensor showed detection limit of 2.09 μg/mL and was successfully applied in real sample analysis. Apart of cancer diagnosis based on singly analyte detection, multiplex detection strategies have also been attempted by various research groups. In this regard, an electrochemical detector has been integrated with the microfluidic system for the simultaneous detection of cancer protein markers. For instance, Fragoso et al., reported an integrated microfluidic system for the electrochemical detection of breast cancer markers directly in patient serum samples [19]. The results obtained in this particular case were in excellent correlation with the conventionally used ELISA method indicating the promise of microfluidic integrated electrochemical sensor for multiplex detection of cancer biomarkers. In another work Chikkaveeraiah et al., reported a microfluidic electrochemical immunoassay system for simultaneous detection of prostate specific antigen (PSA) and interleukin-6 (IL-6) using a molded polydimethylsiloxane channel interfaced with a pump and test sample injector [20]. Using off-line recognition of target compounds by enzyme-labeled superparamagnetic particle-antibody bioconjugates and capture antibodies attached to an eight-electrode measuring chip. The developed system was very efficient and was able to detect the cancer biomarkers with the detection limit in picogram/mL. The biomedical application of these markers were demonstrated by using serum samples. Apart of these few examples several studies have been conducted to develop electrochemical nanobiosensors for highly sensitive cancer diagnosis.

Through the studies mentioned above clearly indicate that electrochemical nanobiosensors could be very effective diagnostic tool for cancer diagnosis and can be applied for clinical purposes and especially if it can be realized for high-throughput and onsite detection. Future study should be directed towards designing new simple electrochemical sensor platforms with high sensitivity and selectivity.

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