International Journal of Biological Macromolecules 108 (2018) 69–80

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

journal homepage: www.elsevier.com/locate/ijbiomac

Aptamer based assay of plated-derived grow factor in unprocessed human plasma sample and MCF-7 breast cancer cell lysates using gold nanoparticle supported α-cyclodextrin

Mohammad Hasanzadeh[a,*], Nasrin Razmi[b], Ahad Mokhtarzadeh[c], Nasrin Shadjou[d,e], Soltanali Mahboob[f]

[a] Drug Applied Research Center, TabrizUniversity of Medical Sciences, Tabriz 51664, Iran
[b] Pharmaceutical Analysis Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[c] Immunology Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[d] Department of Nanochemistry, Nano Technology Research Center, Urmia University, Urmia 57154, Iran
[e] Department of Nano Technology, Faculty of Science, Urmia University, Urmia 57154, Iran
[f] Department of Biochemistry, Higher Education Institute of Rab-Rashid, Tabriz, Iran

ARTICLE INFO

Article history:
Received 19 September 2017
Received in revised form
22 November 2017
Accepted 23 November 2017
Available online 24 November 2017

Keywords:
Protein biomarker
Aptamersensor
Growth factor
Cancer
Gold nanostructure
Electrochemistry

ABSTRACT

Platelet-derived growth factor (PDGF), a protein biomarker, is directly involved in many cell transformation processes, such as tumor growth and progression. Elevation platelet-derived growth factor (PDGF-BB) concentration in plasma could indicate the accelerating growth of metastatic breast tumors and angiogenesis. The development of an apta-assay for detection of PDGF-BB in is presented in this work. A highly specific DNA-aptamer, selected to PDGF-BB was immobilized onto a gold nanoparticles supported α-cyclodextrin and electrochemical measurements were performed in a solution containing the phosphate buffer solution with physiological pH. Variety of shapes of gold nanostructures with different sizes from zero-dimensional nanoparticles to spherical structures were prepared by one-step template (α-cyclodextrin)-assistant green electrodeposition method. Fully electrochemical methodology was used to prepare a new transducer on a gold surface which provided a high surface area to immobilize a high amount of the aptamer. The surface morphology of electrode was characterized by high-resolution field emission scanning electron microscope (FE-SEM) and energy dispersive spectroscopy (EDX). The prepared aptasensors represented different electrochemical activities toward the redox processes of PDGF-BB attributing to the size and shape of the gold nanoparticles. The aptasensor was employed for the detection of PDGF using square wave voltammetry (SWV) and Cyclic voltammetry (CV) techniques. Under optimized condition the calibration curve for PDGF-BB was linear in 0.52–1.52 nM with low limit of quantification of 0.52 nM. Also, under the optimized experimental conditions, the proposed aptasensor of $GNPs_{-cubic}$-α-CD-Apt-Au electrode exhibited excellent analytical performance for MCF-7 cells determination, ranging from 328 TO 593 cells mL^{-1} with low limit of quantification of 328 cells mL^{-1}. As a result, the electrochemical aptasensor was able to detect cancer-related targets in unprocessed human plasma samples.

1. Introduction

Platelet-derived growth factor (PDGF), a protein marker, is directly involved in many cell transformation processes, such as tumor growth and progression [1]. As a widely used biomarker for hepatic fibrosis [2], liver cancer [3], and gastrointestinal stromal tumors [4], PDGF has been implicated in the pathogenesis of angiogenesis in these tumor types. Thus, a rapid, sensitive, and accurate biomarker detection platform for PDGF quantification is of considerable importance for clinical diagnosis and related biomedical research. Up to now, different analytical techniques have been reported to detect PDGF, including ELISA assays [5], fluorescent spectrometry [6], and chemiluminescence immunoassay [7]. However, these techniques are labor-intensive, time-consuming and

* Corresponding author.
E-mail addresses: mhmmd.hasanzadeh@yahoo.com, hasanzadehm@tbzmed.ac.ir (M. Hasanzadeh).

https://doi.org/10.1016/j.ijbiomac.2017.11.149
0141-8130/

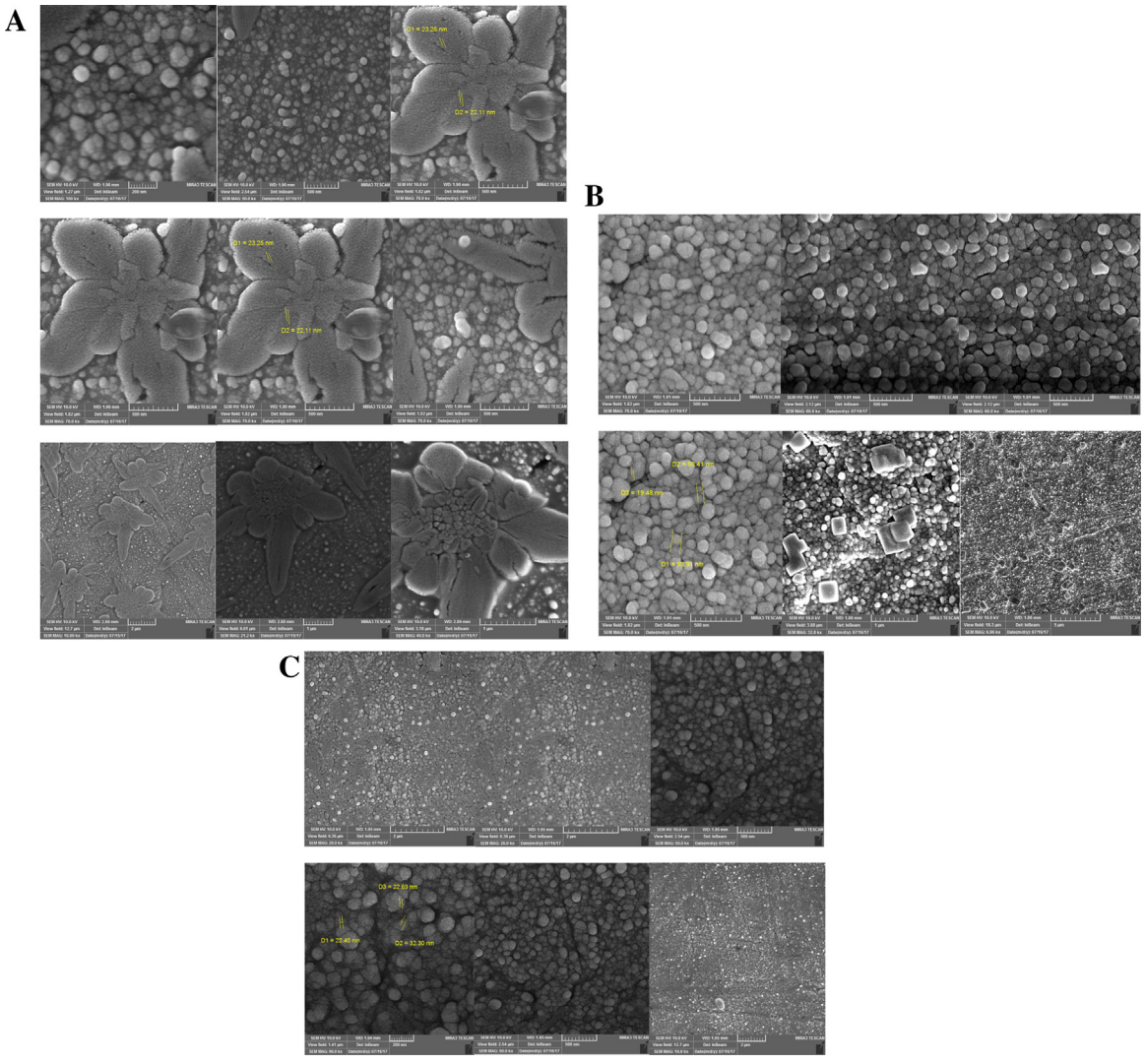

Fig. 1. FE-SEM images of the different modified layers of GNPs supported α-CD on the surface of Au electrode in various magnification: **A**) GNPs with petal shape prepared in E = −0.5 V *vs.* Ag/AgCl, **B)** GNPs with cubic shape prepared in E = −1.5 V *vs.* Ag/AgCl, **C)** GNPs with spherical shape prepared in E = −1.8 V *vs.* Ag/AgCl.

often require sophisticated instrumentations, which limit their use in general applications.

Recently, some of apata-assays have been proposed for detecting PDGF based on electrocatalysis [8], fluorescence [9], colorimetry [10], chemiluminescence [11], and electrochemiluminescence [12]. In the past few decades, electrochemical techniques have been receiving considerable interest for the detection of small biomolecules owing to their high sensitivity, rapid response, and low expense. For example, Deng and coworkers explored an enzyme-mediated direct electrochemistry for sensitive detection of PDGF. This proposed aptasensor shows a relatively low detection limit of 1.7 pM [13]. Among the existing aptasensors, electrochemical aptasensors based on the specificity of aptamer-target recognition have received particular attention because of their high sensitivity, low sample volume, short detection time, simple pretreatment procedure, inexpensive instrumentation, and automated detection. Different nanomaterials, including gold nanoparticles, carbon nanostructures, and quantum dots, have been used to modify detection signals to obtain highly sensitive electrochemical aptasensors [14–18]. However, many disadvantages, such as complicated procedures, high costs, and poor reproducibility and quantification, especially when complex samples are detected, have also been observed in the application of these nanomaterials. Thus, simple aptasensors for ultrasensitive and convenient detection of proteins remain an urgent need.

Electro-synthesis of nanostructured materials (such as gold nanostructures) is a potentially superior method due to advantages of having a high degree of controllability, being single-step process and easy control, having effective controllable of size and shape of the electrodeposits, being easy to anchor securely on the substrate, producing uniform and high pure deposits, being environmentally friend, and providing more opportunities for the design and fabrication of different aptasensors. On the other hand, biomolecules such as aptamers can provide chelating groups for the interaction with gold nanostructure and act as signal amplification agents; this approach to generate nanomaterials is somewhat similar to the bio-mineralization behavior of many organisms in nature.

Gold nanostructures owing to the unique physical and chemical properties are useful to fabricate transducers of sensors and biosensors [19]. Gold nanostructures are biocompatible and can be readily tuned by changing their size, morphology and surrounding chemical entity [20]. In addition, gold nanostructures can offer multifunctional surfaces with a wide range of organic or biological macromolecules for selective binding and provide an excellent platform to fabricate other metallic nanostructures [21–23]. One of these macromolecules are α-cyclodextrins.