Designing a Capacitive Immunosensor for Detection of Hepatitis B Surface Antigen

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***Abstract*: A capacitive immunosensor for monitoring capacitance changes due to hepatitis B surface antigen (HBsAg) was designed. There are three factors affecting capacitive biosensors: surface area, distance between the capacitor electrodes and dielectric constant of the material between the electrodes. Our results indicate that the presence of HBsAg mostly affects the surface area of the capacitors and causes an increase in the capacitance. This method is simple, fast, low-cost, and the experiments were devoted to improvement of its accuracy and limit of detection. The results were achieved by developing a sandwich type immunoassay capacitor by using gold nanoparticles as amplifiers. The experiments were also conducted on accuracy enhancement by monitoring each step of the immunochemical reactions in real-time with new advanced optical methods and by using different designs of electrodes and magnetic nanoparticles.**

Keywords: Capacitive immunosensor; Label-free biosensor; Gold nanoparticle; Magnetic particle; Hepatitis B surface antigen.

I. Introduction

Hepatitis B virus (HBV) is one of the most important causes of liver disease, and it can induce chronic or acute hepatitis. So far, nine HBV serotypes have been discovered. Hepatitis B surface antigen (HBsAg) is the first virological marker that appears in the blood circulation. In addition to virions, it also can be found in filamentous or spherical surface antigen particles. It is generally accepted that the presence of the HBsAg in blood could be a sign for the diagnosis of HBV infection even at the virus incubation period.

Although different methods such as ELISA, chemiluminescence, amperometry and voltammetry have been used for HBV detection, developing early diagnosis methods is requested. Therefore, in the present research, we planned to design an immunosensor that features high accuracy, low cost, simplicity and fast detection rate. During developing such immunosensor, designing different types of nanoparticles of various sizes and materials would be very useful to improve its analytical parameters. It is expected that by applying such nanoparticles in the capacitive immunosensor it would be possible to achieve higher sensitivity.

II. Results and Discussion

Insulation of the electrode surface is an important step in the capacitive biosensor assay. The degree of insulation increased after modification of the electrode surface with alkanethiols and proteins [1]. Forming the insulating self-assembled monolayer (SAM) on a gold electrode makes a stable capacitance and blocks any faradaic processes. Therefore, the capacitance is set to the highest level. Two planar gold electrodes can act as two plates of the capacitor, and the buffer between them can act as a connector between the capacitors. By forming each layer on the gold electrodes, a new capacitor is formed with a different dielectric coefficient, thickness and surface area.

Immobilization of the primary antibody (Ab_1) onto the SAM realizes a capacitive biosensor for specific detection of its antigen (Ag). Interaction of Ag to the Ab_1 changes the surface area and, consequently, changes in capacitance. Finally, addition to the capacitor of a secondary antibody (Ab_2) conjugated to a properly designed nanoparticle again significantly increases thickness of the dielectric layer and, thus, causes the capacitance decrease [2]. This method is simple, fast and low cost but its sensitivity and the detection limit are to be improved. To enhance the sensitivity, the capacitive sensors were integrated with microcoils implemented with a monolithic micro-manipulation and biosensing array [3]. Also, by applying short potential pulses and then recording the current, further optimization was realized [4]. The stability was significantly improved via introducing the current pulses and recording the potential responses. The reagents selection was done by measuring the kinetic parameters of reactions with advanced optical label-free biosensors [5]. This led to the development of the ultra-sensitive immunosensor.

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