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Preliminary Study of Molecularly Imprinted Polymer-based Potentiometric Sensor for Glucose

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Abstract

Molecularly imprinted polymer (MIP) based on methacrylic acid (MAA) has been synthesized by bulk polymerization using glucose as template. Its potential application as electrode of potentiometric sensor for glucose has been studied. This study shows that potential responses of the MIP-based electrode depend on the concentration of glucose. For glucose concentration up to 7 mmol L^{-1}, the measured potential is within the range of 72.5 to 295.8 mV. The potential response is linearly correlated to glucose concentration within the range of 0.02 mmol L^{-1} to 5 mmol L^{-1} with sensitivity of about 43.7 ± 1.6 mV/mmol L^{-1}. As a comparison, potential response of Non Imprinted Polymer (NIP) electrode of has been measured. There is a significance difference between the two electrodes, where the NIP-based electrode shows far less sensitive potential response to glucose concentration compared to that of MIP-based electrode.

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1. Introduction

Molecular imprinted polymers (MIPs) are synthetic polymers with specific recognition sites obtained through polymerization of a functional monomer and a crosslinking agent in the presence of a specific molecule used as a template. After polymerization the template molecules are removed, leaving recognition sites that are capable of recognizing the target molecules that are identical to the previously template molecules used. The development and application of molecularly imprinted polymers (MIPs), with highly specific recognition ability for target molecules, have attracted significant attention. During recent years, the MIPs have been successfully applied to artificial antibodies [1,2], chromatography [3,4], solid phase extraction [5,6,7], and chemical sensors [8,9,10].

Recently, much attention has been paid to the development of electrochemical sensors based on MIPs [11,12,13,14,15]. The electrochemical sensors are basically categorized into four major groups depending on the measurement principles: i.e., potentiometric, amperometric, impedemetric, and conductometric sensors. Among them, the potentiometric sensors have attracted substantial interest for practical applications. Potentiometric detection based on MIP, as a simple method, offers several advantages such as ease of preparation and procedures, simple instrumentation, wide dynamic range, reasonable selectivity, and low cost.

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The MIPs-based potentiometric has been applied in the biological [16,17], environment [18,19], food and beverage analysis [14,20], and pharmaceutical [21,22,23]. But until now, there are only few reports on the MIPs-based potentiometric sensor which is applied to the determination of glucose. Wu (2016) had detected glucose with the MIP based-potentiometric sensor. The MIP for the recognition of glucose is synthesized by coelectropolymerizing the 3-hydroxyphenyl boronic acid and phenol. To the best of our knowledge, no potentiometric sensors have been developed for the detection of glucose based on the MAA-MIP. In this paper, potentiometric sensor for the determination of glucose containing MAA-based MIP as sensitive sensing elements is studied. We present a preliminary results potentiometric sensor with imprinted polymers which is fabricated on glass tube by means of methacrylic acid as the monomer and glucose as the template molecule to realize the sensitivity sensor of glucose.

2. The object of the study

This study is aimed to investigate the use of MAA-based MIP as active material of potentiometric sensor for glucose. To be used as sensor materials, it is expected that potential response of the MAA-based MIP has high sensitivity to glucose concentration.

3. Methods

3.1. Materials

Glucose, methacrylic acid (MAA), ethylene glycol dimethacrylate (EGDMA), benzoyl peroxide (BPO) were purchased from Sigma-Aldrich. Methanol, acetic acid, and chloroform were acquired Merck. All of the reagents were analytical grades and used as being supplied without any further purification.

3.2. Synthesis of molecularly imprinted polymers

The MAA-based MIP using glucose as template was synthesized by the bulk polymerization method. Simply, the powdered glucose (29.5 mg) and methacrylic acid (0.2 mL), EGDMA (0.62 mL), BPO (50 mg) were dissolved in 3.1 mL of chloroform. Thereafter, the mixture was then stirred for 20 min. Next, the mixture was uniformly dispersed with sonication for 40 min. The resulting mixture was then transferred into a glass dish of 6 mm diameter. The mixture was then cooled for 1 h in a refrigerator to remove oxygen prior starting the polymerization. The polymerization was carried out at 60°C for 21 h. The template was removed by washing the membrane successively in 0.3 mL acetonitrile for 1h, 0.2 ml of a methanol/acetic acid (1:1) for 1 h, then in 0.3 ml of methanol/aquabidest (1:1) and finally in 0.3 ml of methanol for 24 h. Recognition sites were formed after the template was removed. The scheme of glucose MIP formation can be found in Ref. [25]. The non-imprinted polymer (NIP) was synthesized by the similar procedure in the absence of template molecules.

3.3. Preparation of the potentiometric sensors

In order to create a potentiometric sensor, imprinted polymer as the working electrode was conditioned for 2 h by soaking in 5.0×10^{-3} mmol L^{-1} glucose solution, HCl 30 mmol L^{-1} (pH 1.2), and KCl. The reference electrode was an Ag/AgCl electrode while a copper wire was employed as counter electrode. All the potential measurements were carried out with the following cell assembly: Ag–AgCl|KCl|internal testing solution|salt bridge|MIP electrode|internal solution, 5.0×10^{-3} mmol L^{-1} glucose|Cu|. The cell potential was measured at different glucose concentration in the test solution in the range 0.02 mmol L^{-1} to 7 mmol L^{-1}. Metrohm 692 pH/mV-meter was used for potential measurements at 25.0 ± 1 ^{o}C.