셀룰로오스-산화주석 나노복합재로 된 바이오센서
Biosensor made with cellulose-Tin oxide nanocomposite

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1. Introduction

Urea is widely distributed in nature and its analysis is necessary in food chemistry and environmental monitoring [1]. Typical concentration of urea in serum is 15- 40 mg/dl (3- 7 mM) and in blood is 10- 50 mg/dl, while patients suffering form renal insufficiency, urea concentration in serum varies from 180 to 480 mg/dl (30 to 80 mM) and at the level above 180 mg/dl, the hemodialysis is required. However, too high concentration in the blood can cause damage to organs of body. Apart from this, urea also destabilizes biological macromolecules, altering their structure and function [2, 3]. Also due to rise in food adulteration, there is a growing demand for low cost, highly sensitive, real time urea biosensor by food industry. The use of cellulose, the most abundant naturally available polymer on the earth as a urea sensor potentially fulfills all these characteristics.

2. Experiments

A wet regenerated cellulose film was prepared by adopting the literature [4]. Deionized (DI) water in polypropylene bottle capped with cover having hole and kept at 90 °C. SnF_2 was added and dissolved in DI water at 90 °C (5mM) [5]. The wet regenerated cellulose film was then immersed in the solution maintained at 90 °C for 24 h with stirring. During this process SnO_2 was deposited and grown continuously on the cellulose surface. SnO_2 coated cellulose film was than washed with running water and dried in ambient conditions. The deposition and growth of SnO_2 over cellulose substrate was characterized by SEM (Hitachi S4300).

Enzyme activity of urease immobilized cellulose-SnO_2 hybrid nanocomposite was determined by measuring its electrical property using a computer interfaced semiconductor parameter analyzer (HP 4145B). For this measurement, a cell was constructed which consists of gold wire as one electrode and urease immobilized cellulose- SnO_2 hybrid nanocomposite film as another electrode. The slope ($\Delta I/\Delta V$) of current vs. potential (I-V) curve was used as a measure of enzyme activity. The sensitivity of the sensor defined as

$$Sensitivit\ y = \frac{\left(\frac{\Delta I}{\Delta V}\right)_x - \left(\frac{\Delta I}{\Delta V}\right)_0}{\left(\frac{\Delta I}{\Delta V}\right)_0}$$

Where $(\Delta I/\Delta V)_0$ is the slope of the I-V curve at '0' mM urea and $(\Delta I/\Delta V)x$ is at 'x' mM urea.

3. Results and Discussion

Figure 1 shows the compared surface SEM images of the cellulose before and after SnO_2 deposition. Pristine cellulose possesses a very smooth surface, while SnO_2 coated cellulose possesses many tin oxide particles grew all over the surface. The tin oxide particles grew uniformly all over the surface and they connected each other to form a continuous layer on the cellulose film.

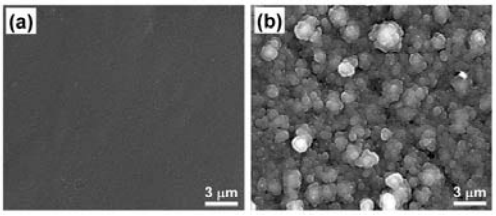

Fig. 1 Compared surface SEM images of cellulose (a) before and (b) after SnO_2 deposition.

Urease was immobilized into cellulose- SnO_2 hybrid nanocomposite by physical absorption method. Samples were dipped in the pH buffer and urease solution for 16 h at room temperature.

We studied the sensing behavior of the cellulose-SnO_2 hybrid nanocomposite sensor in a wide range of urea concentration from 0.5 ~ 100 mM. Increasing enzyme activity is observed with increase of the urea concentration Fig. 2. One can seen from figure that the sensitivity curves portray three regions; (i) highly sensitive region (up to 10 mM), (ii) linear region up to 42 mM and (iii) a saturation region above 50 mM. The first region appears to be the most sensitive region for urea detection. The developed sensor is useful at lower urea concentration, since the normal level of urea is below 10 mM. Second region indicates that the sensor can also be used to sense at higher urea concentration levels (upto 42 mM). The appearance of three regions indicates that the surface reactions are different at different concentrations [3].

4. Conclusions

The tin oxide-cellulose hybrid nanocomposite was developed as a biosensor for urea detection. Increasing enzyme activity was observed with increasing urea concentration. Experimental results suggested that the proposed biosensor under study is suitable for urea detection at low concentration.

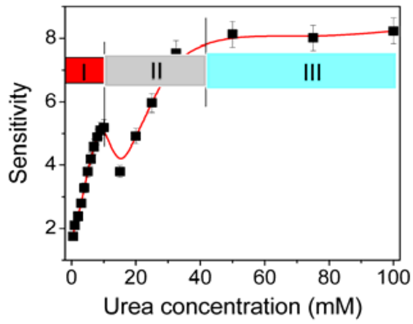

Fig. 2 Sensitivity of sensor showing influence of urea concentration on enzyme activity of cellulose-SnO_2 hybrid nanocomposite urea biosensor

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