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Applications of nano particles in increasing sensor signals

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Abstract

Different types of elelectrochemical sensors were studied from the point of view of possibility to enhanced signal response by using gold nanoparticles and carbon nanotubes. The measurement was performed by using amperometry and cyclic voltamometry. For testing, gold and platinum porous or nonporous and graphite sensors were taken. All tested layers with nanoparticles, especially with carbon nanotubes, provided higher response comparing to layers without nanoparticles. Sensors from porous platinum gave the highest response.

Keywords: nanoparticles, sensor, cyclic voltametry, amperometry

Introduction

The aim of our research is to increase response of electrochemical sensors by using nanoparticles. Nanoparticles could cause increase of the working surface of the electrode and improve interactions between the redox active compounds, enzymes and the electrode. In our present experiment, we use different types of sensors with 4 working gold electrodes prepared by screen-printing technology. The sensors were modified by different combinations of peroxidase, albumin, glutaraldehyde and nanoparticles. The mixture was applied on a pure surface of electrode or by means of cystamine–based self–assambled monolayer. Evaluation of the activity of immobilized peroxidase was measured by amperometry and cyclic voltammetry (CV). CV was realized by comparing voltamograms in buffer and the presence of a redox probe (Skládal et al. 2010).

Materials and Methods

Glutaraldehyde (GA, 25% aq. solution), bovine serum albumin (BSA), cystamine, gold nanoparticles (5nm, 20 nm), Single-Walled Carbon Nanotube (SWCN) and hexaammineruthenium (III) chloride were obtained from Sigma. Potassium ferricyanide, potassium iodide, hydrogen peroxide were obtained from Penta. Phosphate buffer (50mM sodium phosphate, pH adjusted to 7.0), phosphate buffered saline (PBS, 50mM sodium phosphate pH 7.0 and 150mM sodium chloride), acetate buffer pH 4 (50mM sodium acetate, pH 4 with 150mM NaCl) were used for most experiments.

Amperometry measurements was realized by prototype four-channel potentiostat (1.25μA range, ±1V excitation potential) ImmunoSMART. This system combines the measuring part including four miniature peristaltic pumps, digital microcontroller and battery. Control computer with software ML-615x is connecting by serial RS232C link. The amperometric response was measured in 0.5mM H_2O_2 mixed with the zone of 1mM potassium iodide; the iodine produced by the peroxidase label was detected on the sensor at -50mV vs. the silver pseudo reference electrode.

Cyclic voltammetry was measurement by commercial device EmStat (Palm Instruments) with six current ranges from 1 nA to 100 uA full scale and with a minimum resolution of 1 pA. Electrochemical measurements were performed in three electrode cell, where a platinum wire was used as the auxiliary electrode and Ag/AgCl electrode as the reference electrode. Our sensors were used as working electrode. 2mM concentration of $K_3[Fe(CN)_6]$ and $Ru(NH_3)_6Cl_3$ in PBS and 1mM concentration H_2O_2 in acetate buffer pH 4 were used as the redox probes. Scan window was between -0.6 to 0.6 V or -0.8 to 0.4 V for H_2O_2, scan rate 50mV/s. For evaluation each of sensors the difference between baseline and measurements with redox probe was taken, while the potential values were -500mV or – 400mV for H_2O_2.

Results and Discussion

In Table 1, you can see that we changed type of working electrode, type and size nanoparticles during a imobilization procedure of plotting layers. The non specific binding sites were saturated by bovine serum albumin.

The results obtained by CV and amperometric measurement of sensors shown some increase in enzyme activity and porosity of the layers. Au nanoparticles provided increase of the current response,

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but not in all tested configurations. The use of carbon nanotubes seems to be promising configuration. Sensors with porous Pt layer give higher responses than the other plain-surface sensors.

Table 1: Configuration of individual sets

Set	*Working electrode*	*Nano-particles*	*Obtained response*	
			Amp (nA)	CV (nA)
A	Au	5nm, 20nm Au	870	750
B	Au	20nm Au	559	903
C	Au	5nm, CN	1250	1425
D	Pt – p,n; Au – p,n	–	1250	2295
E	Pt – p,n; Au – p,n	–	31,6	770
F	graphite, Au	5nm, 20nm Au	742	1702

P = porous, n = non–porous; CN = carbon nanotube; Amp. = amperometry

Conclusion

The highest response we got for combination with gold working electrode and carbon nanotubes and for platinum electrode without nanoparticles. The best sensors modifications are going to be used for detection of bacteria by using specific antibodies.

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References

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