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Amperometric glucose sensor based on nickel nanoparticle/chitosan and multiwall carbon nanotube on modified graphite electrode

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Abstract:

A novel Ni (Nickel)/CS(chitosan)/CNT(carbon nanotube) network nanocomposite was constructed on graphite electrode for glucose detection . Firstly, multi-walled carbon nanotubes were purified and characterized by Fourier transform infrared (FT-IR) spectroscopy, scanning electron microscopy (SEM). The modified electrode with the Ni/CS/CNTs showed excellent electrocatalytical response to the oxidation, which was studied by cyclic voltammetry (CV). The synthesized biosensor exhibited rapid response, low detection limit, broad linear range, good reproducibility and stability.

Introduction:

Many studies about providing suitable coating on the electrodes have been investigated. Electron transfer chemical and electrocatalysis properties is very important for them. Exact determination of glucose concentration is necessary for treatment of diabet and food industry [1].

Chitosan include excellent biocompatibility, biodegradability, nontoxicity, high mechanical strength, good adhesion and cheapness properties, therefore it has been used as an immobilization matrix. Although it has poor electrical conductivity, but it usually has been combined with carbon nanotubes, redox mediator and metal nanoparticles. Carbon nanotubes have been used in various sensors due to unique properties such as high electronical and mechanical stability.

Modified electrodes by various metal (gold, platinum) metal oxide (tungsten oxide, nickel oxide), metal decorated carbon nanotubes and metallic complexes that uniformly dispersed in insoluble organic film (cabolt phethalocyamine), have been recognized [2].

Nickel hydroxide severely adsorbs some organic substance, such as chitosan, and has high electrocatalytical properties. Therefore it has been used for preparation of modified electrodes [3].

In this work, a film of Ni/CS/CNTs network was prepared for oxidation of glucose. The electrochemical properties of this biosensor were investigated. This biosensor exhibited rapid response, low detection limit and broad linear range [2-5].

Materials:

In this study we used chitosan were purchased from Sigma-Aldrich. Multi walled Carbon Nanotubes (MWCNTs) were purchased from Arkema. Acetic acid, nickel hydroxide, sodium hydroxide, d-glucose were obtained from Merck company. All solutions were prepared with doubly distilled water.

Apparatus:

A three-electrode system including Ni/CS/CNTs electrode as the working electrode, a Pt wire as the counter electrode and an Ag/AgCl as the reference electrode was used in electrochemical measurement .The microstructure was observed by using a scanning electron microscope (SEM) (TESCAN, VEGA, Czech Republic. Electrochemical characterizations were carried out by an electrochemical workstation (SAMA, 500 electro analyzer, Iran). FTIR spectra were recorded on a shimadzu S8400 Fourier transform infrared spectrometer.

Method:

0.1g chitosan was dissolved in 10 ml acetic acid (1%) to obtain soluble chitosan (1%). The chitosan solution was left at room temperature. The resulting was filtered carefully because of the dust. MWCNTs were functionalized with HNO_3.After that, functionalized MWCNTs were dispersed in 5 ml of the above solution and were solubilized by sonication for 20 min. The nickel hydroxide powder was mixed and was stirred uniformly for 24 h until complete dissolution. Finally, the resulting solution was ready for cover on the electrode. The biosensors prepared, was stored at 4 °

Results and discussion:

Fig. 1 shows the FTIR spectra of the MWCNT-COOH (a) and CS-MWCNT (b). The sharp absorbance at 1712.67 cm^{-1} shows C=O stretching of –COOH in the spectra of MWCNT-COOH. The strong absorbance at 1634.45 cm^{-1} indicates the –COOH of MWCNT were reacted with the –NH2 of CS and turned into –NHCO- in the spectra of CS-MWCNT [6].

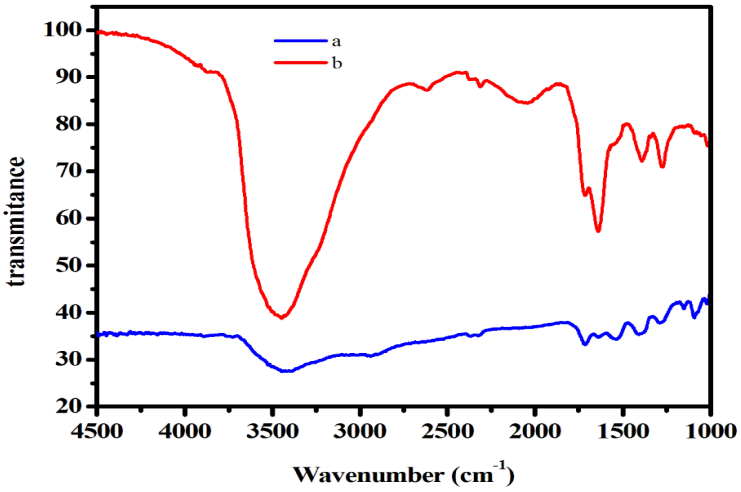

Fig. 1. FTIR spectra of the MWCNT-COOH (a) and CS-MWCNT (b)

Fig. 2 Shows SEM of the modified electrode with Ni/CS/CNTs films. The surface of Ni/CS/CNTs electrode was coarse and rough. As a result, the effective surface was increased and white grain Ni nanoparticles, with a size of 20 nm, were entrapped among carbon nanotube ropes.

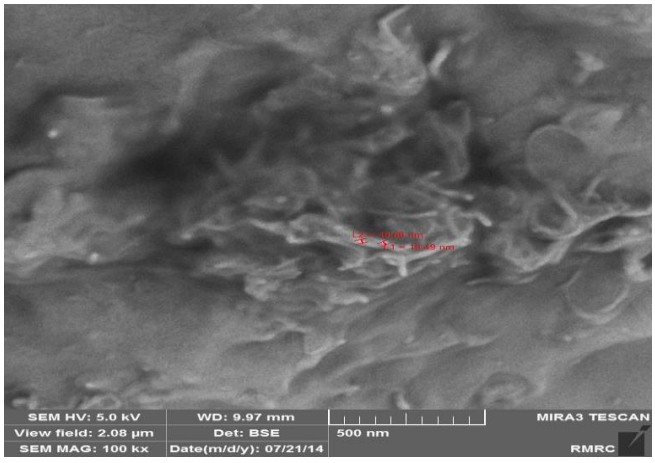

Fig. 2. SEM the modified electrode with Ni/CS/CNTs films

Fig. 3 shows CVs of Ni/CS/CNTs nanocomposite film electrode in NaOH 0.1M at different scan rates. It is considerable that peak current is dependent on the scan rate. The peak current of oxidation and reduction increased linearly with increase of scan rates from 20 to 100 mV s^{-1}. This results suggests that the electron transfer process of Ni/CS/CNTs nanocomposite film on the graphite electrode surface is a surface rein process [7].

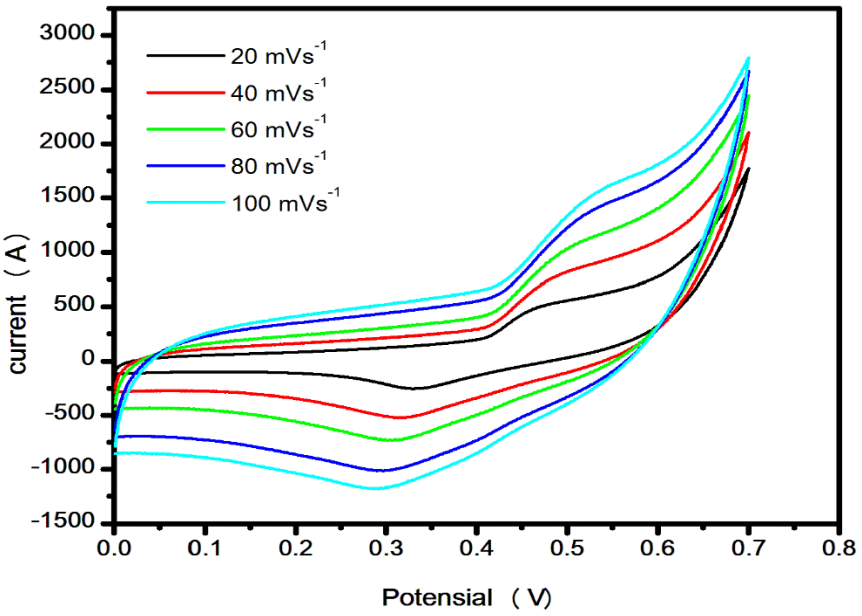

Fig3: cyclic voltammetry of of Ni/CS/CNTs nanocomposite film electrode in NaOH 0.1M at different scan rates

Fig. 4 shows that the peak currents in Ni/CS/CNTs electrode depend on concentration of glucose. It can be seen that at first peak, current increases linearly with increasing of glucose concentration. More molecules to reach the electrode surface with increasing of glucose concentration due to diffusion phenomena. The resulting, concentration of glucose is rate determining for glucose electrooxidation [8].

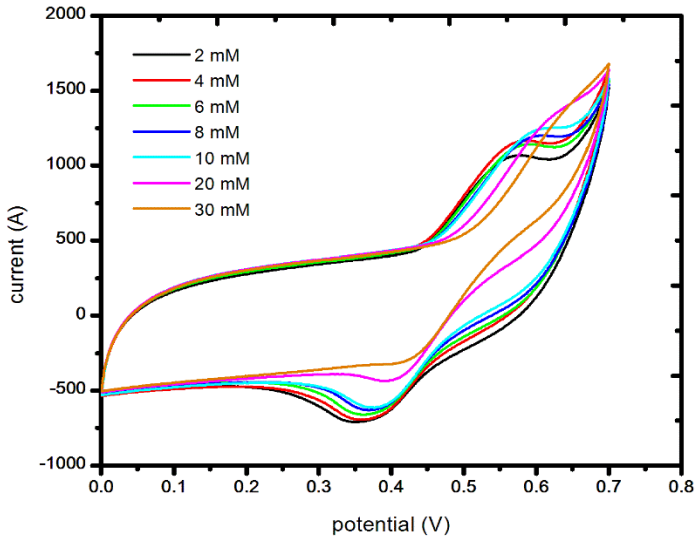

Fig 4.peak currents in Ni/CS/CNTs electrode depend on concentration of glucose

Conclusions:

A novel Ni/CS/CNTs was prepared and an electrode made of this film was used in the electrocatalytic glucose oxidation. This biosensor exhibited better electrocatalytic properties such as increased electroactive surface area, high sensitivity, low detection limit, good reproducibility and stability.

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References:

[1] Z. Wu, W. Feng, Y. Feng, Q. Liu, Xinhua Xu, T. Sekino,A. Fujii, M. Ozaki."Preparation and characterization of chitosan-grafted multiwalled carbon nanotubes and their electrochemical properties" Carbon 45, 1212–1218, 2007.

[2] L. Luo, Q. Li, Y. Xu, Y. Ding, X. Wang, D. Deng, Y. Xu "Amperometric glucose biosensor based on $NiFe_2O_4$ nanoparticles and chitosan", Sensors and Actuators B 145, 293–298, 2010.

[3] Y. Du, X. Luo, J. Xu, H. Chen, "A simple method to fabricate a chitosan-gold nanoparticles film and its application in glucose biosensor", Bio electrochemistry 70, 342–347, 2007.
[4] L. Yang, H. Xiong, X. Zhang, Sh. Wang, "A novel tyrosinase biosensor based on chitosan-carbon-coated nickel", nanocomposite film Bio electrochemistry 84, 44–48, 2012.
[5] M. Mathew, N. Sandhyarani, "A highly sensitive electrochemical glucose sensor structuring withnickel hydroxide and enzyme glucose oxidase", Electrochemical Acta, 108, 274– 280, 2013.
[6] A. Ciszewski, I. Stepniak, "Nanoparticles of Ni(OH)2embedded in chitosan membrane as electrocatalyst for non-enzymatic oxidation of glucose", Electrochimica Acta 111, 185– 191, 2013.
[7] T. Vural, F. Kuralay, C. Bayram, S. Abaci, E. B. Denkbas, "Preparation and physical/electrochemical characterization of carbon nanotube–chitosan modified pencil graphite electrode", Applied Surface Science 257, 622–627, 2010.
[8] J. Lin, Ch. He, Y. Zhao, Sh. Zhang, "One-step unipolar pulse electrodeposition of nickel hexacyanoferrate/chitosan/carbon nanotubes film and its application in hydrogen peroxide sensor", Sensors and Actuators B 137, 768–773, 2009.

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