



# Biosensing of glucose in flow injection analysis system based on glucose oxidase-quantum dot modified pencil graphite electrode

Özlem Sağlam<sup>a</sup>, Bayram Kızılkaya<sup>b</sup>, Hüseyin Uysal<sup>c</sup>, Yusuf Dilgin<sup>a,\*</sup>

<sup>a</sup> Çanakkale Onsekiz Mart University, Faculty of Art and Science, Department of Chemistry, Çanakkale, Turkey

<sup>b</sup> Çanakkale Onsekiz Mart University, Faculty of Marine Sciences and Technology, Çanakkale, Turkey

<sup>c</sup> Çanakkale Onsekiz Mart University, Faculty of Art and Science, Department of Molecular Biology and Genetics, Çanakkale, Turkey

## ARTICLE INFO

### Article history:

Received 24 April 2015

Received in revised form

15 September 2015

Accepted 20 September 2015

Available online 25 September 2015

### Keywords:

Glucose oxidase

Quantum dots

Glucose biosensor

Flow injection analysis

Pencil graphite electrode

## ABSTRACT

A novel amperometric glucose biosensor was proposed in flow injection analysis (FIA) system using glucose oxidase (GOD) and Quantum dot (ZnS–CdS) modified Pencil Graphite Electrode (PGE). After ZnS–CdS film was electrochemically deposited onto PGE surface, GOD was immobilized on the surface of ZnS–CdS/PGE through crosslinking with chitosan (CT). A pair of well-defined reversible redox peak of GOD was observed at GOD/CT/ZnS–CdS/PGE based on enzyme electrode by direct electron transfer between the protein and electrode. Further, obtained GOD/CT/ZnS–CdS/PGE offers a disposable, low cost, selective and sensitive electrochemical biosensing of glucose in FIA system based on the decrease of the electrocatalytic response of the reduced form of GOD to dissolved oxygen. Under optimum conditions (flow rate, 1.3 mL min<sup>−1</sup>; transmission tubing length, 10 cm; injection volume, 100 µL; and constant applied potential, −500 mV vs. Ag/AgCl), the proposed method displayed a linear response to glucose in the range of 0.01–1.0 mM with detection limit of 3.0 µM. The results obtained from this study would provide the basis for further development of the biosensing using PGE based FIA systems.

© 2015 Elsevier B.V. All rights reserved.

## 1. Introduction

Nanomaterials have received great attention due to their unique chemical, physical and electronic properties that provide their broad applications in many areas such as catalysis, electrochemical and photoelectrochemical sensing and biosensing, electronics and photonics [1–3]. The unique properties of these materials have also been effectively exploited in the immobilization of biomolecules, the catalysis of electrochemical reactions, the enhancement of electron transfer between electrode and substrate, labeling of biomolecules and acting as a reactant [1,2]. Facilitation of the direct electron transfer between the redox center of the enzyme and the electrode is one of the most important features of nanomaterials therefore mainly used in the construction of the third generation biosensors. Many kinds of nanomaterials such as metal nanoparticles, carbon nanotubes, graphene, metal oxide nanoparticles, semiconductor nanoparticles and hybrid nanoparticles have been widely used in direct electrochemistry of proteins, catalytic activity of many biomolecules and also construction of electrochemical sensors and biosensors [1,2]. Among them, recently, semiconductor quantum dots (QDs) such as CdS,

CdTe, CdSe, ZnS etc. have received considerable interest in the fields of electrochemical and especially photoelectrochemical biosensors due to their interesting optical and electronic properties [2,3]. One of the important applications of QDs is the construction of glucose oxidase (GOD) based electrochemical and especially photoelectrochemical glucose biosensors [3–14]. The QDs enhance the electron transfer reactivity of GOD due to direct electron transfer capability [3–9]. However, hybrid or core-shell QDs such as CdS–ZnS, CdSe–CdS or hybrid nanomaterial such as carbon nanotube-QDs, graphene-QDs etc. have been preferred instead of using only QDs or nanomaterials in the electrochemical studies [10–14]. The core-shell QDs or hybrid nanomaterials exhibit better charge separation than a single QD or nanomaterial based systems. The core-shell QDs and hybrid materials are ideal candidates for sensing and biosensing applications due to higher quantum yield, increased photostability in photoelectrochemical reactions, extremely large surface-to-atom ratio and good sensitivity to surface ligands [8,15,16]. Therefore, CdS–ZnS modified pencil graphite electrode (PGE) was preferred in this study.

The selection of the electrode material is very important in the construction of the electrochemical biosensor since the type of the electrode generally determines the selectivity, sensitivity, stability and the cost of the biosensor. When compared with the other carbon based electrodes, PGEs have the same advantages such as the high electrochemical reactivity, commercial availability, good

\* Corresponding author.

E-mail address: [ydilgin@yahoo.com](mailto:ydilgin@yahoo.com) (Y. Dilgin).

mechanical rigidity, disposability, lower cost and the ease of modification [17–27]. In addition, it was reported that the pencil lead electrodes offer a renewable surface which is simpler and faster than polishing procedures, in common with the solid electrodes, provide useful and reproducible results for the individual surfaces [17]. Thus PGEs have been extensively used in various electroanalytical studies [17–27].

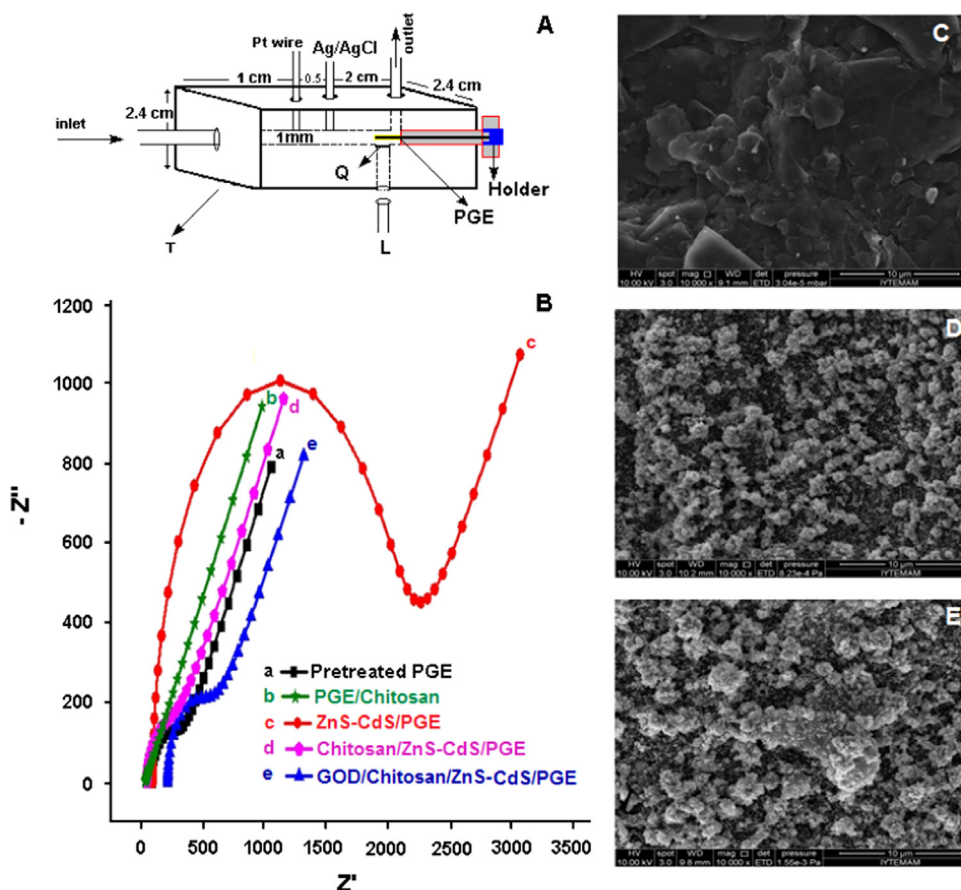
A useful approach for the construction of electrochemical sensors and biosensors is using of Flow Injection Analysis (FIA) in electrochemical techniques [28,29]. FIA has some advantages for routine analytical determinations, such as low sample consumption, short analysis time based on a transient signal measurement in a flow-through detector, and using online method for difficult operations of separation and chemical conversion of analyses into detectable species. The GOD immobilization onto various modified electrodes have been proposed in FIA in order to enhance the accuracy, reproducibility, stability and response rates in the analysis [30–35]. However, according to our search of the literature, electrochemical biosensing of glucose using FIA system depending on GOD immobilized onto quantum dot modified PGE has not been reported. This study shows a combination of QDs, PGE and FIA for biosensing of glucose which offers some advantages such as (i) a disposable, practical, easy-to-use and low cost biosensing due to the useful properties of PGE, (ii) fast and economic analysis (FIA exhibits fast analysis and lower cost because of lower consumption of reactant) and (iii) Efficient immobilization of GOD, good selectivity and sensitivity due to the unique functions of QDs.

## 2. Experimental

### 2.1. Materials and apparatus

Glucose oxidase (GOD, from *Aspergillus niger*, E.C. 1.1.3.4) was purchased from Sigma. All other chemicals such as  $\text{CdCl}_2$ ,  $\text{ZnCl}_2$ ,  $\text{Na}_2\text{S}_2\text{O}_3$ , glucose, chitosan,  $\text{Na}_2\text{EDTA}$ , mercapto acetic acid (MAA),  $\text{KCl}$ ,  $\text{H}_3\text{PO}_4$ ,  $\text{NaH}_2\text{PO}_4$ ,  $\text{Na}_2\text{HPO}_4$ ,  $\text{CH}_3\text{OOH}$ , etc. were commercially available as analytical reagent. All the solutions were prepared with ultrapure water from Elga Option Q7B water purification system ( $18.2 \text{ M}\Omega \text{ cm}$ )

All electrochemical experiments were carried out using an Autolab PGSTAT 128N Potentiostat/Galvanostat equipped with a FRA2 frequency response analyzer. A traditional three-electrode system was used with a platinum wire as the counter electrode, an  $\text{Ag}/\text{AgCl}/\text{KCl}_{(\text{sat.})}$  as the reference electrode, and a PGE as the working electrode [18–21]. A pencil lead with a diameter of 0.5 mm (Ultra-Polymer, 2B) and a total length of 60 mm (Tombow, Japan), and a mechanical pencil Model T 0.5 (Rotring, Germany), which was used as the holder for the pencil lead, were purchased from a local bookstore. Electrical contact to the lead was obtained by wrapping a metallic wire to the metallic part of the holder. For each measurement, a total of 10 mm of lead (area is about  $15.9 \text{ mm}^2$ ) was immersed into the solution. Cyclic voltammograms and electrochemical impedance curves were recorded in a static cell while amperometric experiments were performed in a FIA system. A new home-made flow cell for only PGEs, which was constructed for photoelectrocatalytic studies from TEFLON, was used (Fig. 1A). Deepness of pencil lead in this flow cell was arranged as 10 mm. The pH values of the solutions were adjusted using a HI 221 Hanna pH-meter with a combined glass electrode



**Fig. 1.** (A) A home-made electrochemical flow cell for PGE (B) Electrochemical impedance spectra of modified electrodes in 0.1 M KCl containing 10.0 mM  $\text{K}_3[\text{Fe}(\text{CN})_6]/\text{K}_4[\text{Fe}(\text{CN})_6]$  and SEM images of (C) Pretreated PGE, (D) CdS/PGE and (E) ZnS–CdS/PGE.

Download English Version:

<https://daneshyari.com/en/article/1242761>

Download Persian Version:

<https://daneshyari.com/article/1242761>

[Daneshyari.com](https://daneshyari.com)