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Glucose biosensor based on glucose oxidase and gold nanoparticles of different sizes covered by polypyrrole layer

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ABSTRACT

Different glucose biosensors based on glucose oxidase (GOx) immobilised on bare carbon rod electrode (CR) modified with gold nanoparticles (Au-NPs) of (i) 3.5 nm (GOx/3.5Au-NPs/CR), (ii) 6 nm (GOx/6Au-NPs/CR) and (iii) 13 nm (GOx/13Au-NPs/CR) were investigated and compared with biosensors based on GOx immobilised on bare CR (GOx/CR). Enzymatic polymerisation of pyrrole was applied to increase linear detection range of biosensors. The influence of the formed polypyrrole layer on sensitivity and Michaelis–Menten kinetics of designed electrochemical biosensors was investigated. The linear glucose detection interval for GOx/CR and GOx/Au-NPs/CR electrodes was dependent on the duration of polymerisation.

1. Introduction

Nanotechnology has recently become one of the most exciting forefront fields offering technological advantages suitable for analytical chemistry [1–4]. In some cases a combination of nanomaterials and nanotechnological approaches resolves challenging bioanalytical problems, including specificity, stability and sensitivity [5,6]. Several reviews have recently appeared demonstrating the advantages of different nanomaterials and polymers in the design of electrochemical biosensors and immunosensors [2–4,7–10]. Au-NPs have been used as electron-transfer mediators and electric wires for enhancing the electron-transfer rate between the active centre of enzymes and electrodes [11]. The practical advantage of Au-NPs is that their size and surface morphology can be controlled experimentally adjusting the preparation conditions [12]. It was shown that Au-NPs increase the efficiency of enzyme immobilisation [13,14]. To exploit this unique property many electrochemical biosensors based on gold nanoparticles were designed and applied for biochemical, clinical and environment needs, including cancer diagnostics, detection of infectious microorganisms, sensing of vitamins, amino acids, sugars, and pesticides [2,3,5,6,15,16].

Electrically conducting materials based on π–π conjugated polymers are often used as electrocatalysts or immobilisation matrix for biomolecules. Conjugated polymers provide effective immobilisation patterning for biomolecules on different substrates [17]. Moreover in some cases π–π conjugated polymers facilitate electron transfer from enzymes to electronically conductive electrodes [18,19]. Most promising electrically conducting polymers (e.g., polyaniline, polypyrrole (Ppy)) are chemically stabile on different substrates [20]. Increased interest in synthesis of chiral conducting polymers has recently been observed due to their potential application such as electrochemical asymmetric synthesis. Electrochemical properties of polymers (e.g., Ppy) strongly depend on their red-ox states, and overoxidation level, which occurs at positive potentials and leads to de-doping of anionic molecules followed by lowering of polymer conductivity [18,19].

Conducting polymers are easily synthesised by electrochemical [3,21–24], chemical [25,26] and enzymatic [27] oxidative polymerisation techniques [18,19]. Insoluble, stable in ambient conditions Ppy films usually are prepared electrochemically by the oxidation of commercially available pyrrole monomers [24,28]. On the other hand, electrochemical polymerisation methods have a limitation: it is difficult to prepare a large amount of Ppy. In contrast, chemical polymerisation is suitable for large-scale production of conjugated polymers [29,30]. Chemical polymerisation occurs by oxidation of pyrrole monomers and formed oligomers to the cation-radicals, which recombine and form polymeric structure of polypyrrole [18,31]. During chemical polymerisation of pyrrole using $HAuCl_4$

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