



Electrochemical fabrication of conducting polymer/multi-walled carbon nanotube composite films for electrocatalytic oxidation in fuel cell

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Abstract

Recent studies have shown that carbon nanotubes can be dissolved in conductive polymers via formation of donor– acceptor complex. In this work, we have prepared Poly o-aminophenol/multi-walled carbon nanotubes (POAP/ MWNT) composite by electropolymerisation of aminophenol containing well-dissolved MWNTs. NiO particles were electrodeposited on the composite films subsequently. The primary focus of these studies is to compare the glucose oxidation activity on the Ni/ MWNT/POAP and Ni/POAP electrode.

Keywords: Conducting polymer, Fuel cell, Modified electrode, Electrocatalysis, Nickel

Introduction

The direct glucose fuel cell (DMFC) has attracted a great interest as power sources for many advantages, such as high energy density of glucose, low negative impact on the environment and ease of maintenance [1]. To improve the performance of DMFC, considerable efforts have been devoted to the studying of electrode materials. Platinum has been recognized as the most powerful electrocatalyst among noble metals for glucose electrooxidation. Today, to reduce the amount of platinum required and improve the electrooxidation efficiency, the design of catalyst supports has attracted great interesting. The support material also influences catalytic activity. Conducting polymers have been widely used as porous catalyst supports for electrooxidation of glucose [2]. Among these conducting polymers, poly o-aminophenol has many advantages over other conducting polymers due to its relatively facile process ability, high electrical conductivity and environmental stability. Carbon nanotubes are unique nanostructured materials with remarkable physical and mechanical properties [3]. These properties have inspired interest in using CNTs as the nano-fillers in polymer composite systems to obtain composite structural materials with enhanced electrical, mechanical and optical characteristics.



Experimental

MWNTs were produced via the chemical vapor deposition method. *o*-aminophenol was purified by distillation under reduced pressure and stored under nitrogen atmosphere at 4 °C. All other reagents were of analytical grade and were used as received. All the solutions were prepared with twice distilled water. 0.8 g MWNTs were added to 25 ml *o*-aminophenol and the mixture was heated at reflux for 3 h in the dark. Dissolution of MWNTs in *ortho* aminophenol can be observed by color change of the solution with continuous heating. After has been cooled to room temperature and settled for 24 h, small quantities of unresolved MWNTs were precipitated from MWNT- *o*-aminophenol solution.

Electrochemical experiments were performed on AUTOLAB system with micro III in a three electrodes system. A glassy carbon (geometric surface area = 0.1 cm²) was used as substrate-working electrode. Another platinum sheet and a saturated calomel electrode (SCE) were used as counter and reference electrode, respectively. The POAP/MWNT composite films were electrodeposited on the GC substrate-working electrode by using the pulse voltammetry technique. NiO particles were electrodeposited on the presynthesized MWNT/POAP composite film from 0.5 M NaOH solution.

Results

Ni/POAP/MWNT composite films modified GC electrode prepared by galvanostatic deposition were examined for their redox process and electrocatalytic activities towards the oxidation of glucose in alkaline solutions. The methods of cyclic voltammetry (CV), Chronoamperometry (CA). The cyclic voltammogram of Ni/POAP/MWNT demonstrates the formation of α/β crystallographic forms of the nickel oxyhydroxide under prolonged repetitive potential cycling in alkaline solution. In CV studies, in the presence of glucose Ni/POAP/MWNT modified electrode shows a significantly higher response for glucose oxidation. The peak current of the oxidation of nickel hydroxide increase is followed by a decrease in the corresponding cathodic current in presence of glucose. The anodic peak currents show linear dependency with the square root of scan rate. This behavior is the characteristic of a diffusion controlled process. Under the CA regime the reaction followed a Cottrellian behavior and the diffusion coefficient of glucose was found to be 4.6×10^{-6} cm² s⁻¹. A mechanism based on the electro-chemical generation of Ni³⁺ active sites and their subsequent consumptions by glucose have been discussed and the corresponding rate law under the control of charge transfer has been developed and kinetic parameters have been derived.

References

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