Physica E 41 (2009) 609–616

Contents lists available at ScienceDirect

Physica E

journal homepage: www.elsevier.com/locate/physe

Characterization of a benzoic acid modified glassy carbon electrode expressed quantitatively by new statistical parameters

Raoul R. Nigmatullin [a], Dumitru Baleanu [b,c,*], Erdal Dinç [d], Ali Osman Solak [e]

[a] Theoretical Physics Department, Kazan State University, Kazan 420008, Tatarstan, Russia
[b] Department of Mathematics and Computer Science, Faculty of Arts and Sciences, Çankaya University, Balgat 06530, Ankara, Turkey
[c] Institute of Space Sciences, P.O. Box, MG-23, R 76900, Magurele-Bucharest, Romania
[d] Department of Analytical Chemistry, Faculty of Pharmacy, Ankara University, 06100 Tandoğan, Ankara, Turkey
[e] Department of Chemistry, Faculty of Science, Ankara University, 06100 Tandoğan, Ankara, Turkey

ARTICLE INFO

Article history:
Received 10 September 2008
Received in revised form
12 October 2008
Accepted 14 October 2008
Available online 18 November 2008

PACS:
68.37.−d

Keywords:
Nanosurface
Surfaces and interfaces
Glassy carbon electrode
Statistics of the fractional moments

ABSTRACT

The main aim of this study is to characterize the nanosurface of the benzoic acid modified glassy carbon (GC) electrode by using a new statistical approach. In this study, the electrode surfaces were modified by cyclic voltametry in the potential range of +0.4 and −0.8 V at a scan rate 200 mV s^{-1} for four cycles versus Ag/Ag^{+} electrode in acetonitrile containing 0.1 M tetrabutylammonium tetraflouroborate (TBATFB). FT-IR spectra of the surface modifier molecules in both solid (GC and nanofilm (GC–benzoic acid)) forms were recorded in the spectral range 600–4000 cm^{-1}. The FT-IR spectra of *p*-aminobenzoic acid were obtained by using KBr pellets. The above FT-IR spectra of both GC and its nanofilm with benzoic acid were processed by new statistical approach to reach optimal smoothing trend for the characterization of the modified electrode surface consisting of the nanofilm of GC–benzoic acid. In the frame of new statistical approach all measured spectra have been 'read' in terms of a set of universal statistical parameters.

1. Introduction and the formulation of the basic problem

During the past years, chemically modified electrodes, especially glassy carbon (GC) electrodes, have received increased attention due to their potential use in analytical and different technological applications. The covalent modification of GC electrodes using aryl diazonium salts was firstly developed by Pinson's group [1]. It is a well-known fact that aryl diazonium salts are reduced with a one-electron mechanism on the carbon surfaces. This reduction causes the formation of nanofilms by the covalent bonds of aryl groups with carbon atoms on the electrode surface. A very interesting behavior of the modified electrodes is the current–voltage responses of the monolayer surfaces, such as rectification, negative differential resistance, conductance switching and various electron transfer mechanisms [2]. Solak et al. reported the conductance-switching behavior of several organic nanofilms on carbon surfaces and also in another study they concluded that in the presence of a negative voltage applied between a graphitic conductor and a metallic top contact, a monolayer of nitroazobenzene, nitrobiphenyl, or biphenyl 'switched' from a high-resistance state to one with a factor of 10 or more lower resistance [3,4].

Characterization of modified GC surfaces can be performed by various spectroscopic methods such as X-ray photoelectron spectroscopy (XPS), electron spin resonance (ESR) and especially infrared (IR) spectroscopy. IR spectroscopy has the advantage of providing structural information about the monolayer at the GC electrode surface. Therefore, this very powerful technique is generally used to acquire the surface spectra of the modified GC electrode characterization.

One of the main problems of the modified electrode studies is the structural characterization of nanofilms based on the formation of the covalent bonds between aryl groups and carbon atoms on the electrode surface. As mentioned above, IR spectroscopy has been frequently used for the characterization analysis of the original GC electrode and modified GC electrode surfaces. The noise elimination coming from IR spectroscopic instrumentation is another problem of IR spectral characterization of the nanosurface of the modified GC electrode with *p*-aminobenzoic acid (PABA). One way of elimination of these drawbacks is the application of new statistical signal processing approaches to the original IR spectra for the chemometric characterization of nanosurface of the modified electrode. Besides this experimental problem that is solved in this paper and related to studying of the

* Corresponding author at: Department of Mathematics and Computer Science, Faculty of Arts and Sciences, Çankaya University, Balgat 06530, Ankara, Turkey. Fax: +90 312 2868962.
E-mail address: dumitru@cankaya.edu.tr (D. Baleanu).

1386-9477/$ - see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.physe.2008.10.015