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Novel carbon-film-sputter-coated piezoelectric quartz crystals for electrochemical studies

Edilson M. Pinto[(1)*], Carla Gouveia-Caridade[(1)], David M. Soares[(2)], Christopher M.A. Brett[(1)]

(1) Departamento de Química, Faculdade de Ciências e Tecnologia, 3004-535 Coimbra, Portugal. e-mail: edilson.m.pinto@gmail.com
(2) Instituto de Física Gleb Wataghin, Unicamp, CP 6165 Campinas-SP, Brazil
* Corresponding author.

Abstract – Carbon film modified Au and Pt-coated quartz crystals, C/Au and C/Pt, have been prepared by sputtering and characterized electrochemically using the electrochemical quartz crystal nanobalance (EQCN). Voltammetric studies show that C/Au and C/Pt have a wider potential window than without carbon. The electroactive area was measured using model redox couples. The results obtained demonstrate the feasibility of the preparation and development of nanoscale thickness carbon film modified quartz crystals, with good long-term stability. Carbon/gold crystals should open up new opportunities for the investigation of electrode processes at carbon electrodes and for the application of electrochemical sensing associated with the EQCN.

Electrochemical quartz crystal nanobalance (EQCN) piezoelectric quartz crystals generally have metallic thin film coatings, such as gold or platinum, which are susceptible to formation of surface oxides or, under special conditions, can form complexes [1,2]. Such phenomena are a limiting factor in electrochemical studies, and other electrode materials are desirable, especially for the development of sensors and biosensors. Carbon in various forms has emerged as a promising electrode material for this purpose due to the wide accessible range of potential and other physical and mechanical properties [3].

The electrochemical properties of carbon films, of thickness between 200 and 500 nm, sputter-coated onto gold- and platinum-coated 6 MHz piezoelectric quartz crystal oscillators, as new electrode materials have been investigated. Comparative studies under the same experimental conditions were performed on bulk electrodes. Cyclic voltammetry carried out in 0.1 M KCl electrolyte solution with the model redox systems $Fe(CN)_6^{3-/4-}$ and $[Ru(NH_3)_6]^{3+/2+}$ showed that the electroactive area is 18% smaller for carbon-coated Au electrodes compared with bare Au electrodes, and the electrode kinetics are good compared to other carbon electrodes. Atomic force microscopy was used in order to examine the surface morphology of the films; the properties of the carbon films and the electrode-solution interface were studied by electrochemical impedance spectroscopy. The carbon coatings present long-term stability due to their good adherence to metal substrate films, which can be related to high sputtering energy applied permitting the “injection” of carbon atoms into the gold (or platinum) film, and carbon atom intercalation with gold (or platinum) atoms on the surfaces. [4].

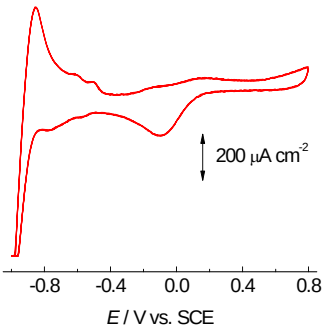

Figure 1: Cyclic voltammogram obtained with carbon coated gold quartz crystal electrode, in 0.1 M KCl at 25ºC; 5 scans at 20 mV s^{-1}

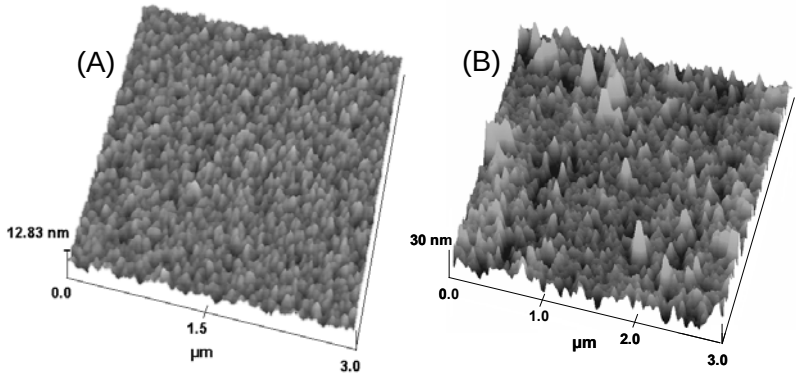

Figure 2: AFM topographical images of (A) Au crystal in (B) C/Au crystal in 3D.

References

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