Abstract

The present thesis entitled *"Bio/molecular information processing of the fascinating world of nanostructures: from micro- to "smart" electrodes"* is a survey of the scientific activity developed after the public defences of the PhD thesis in December 1997. It is based on the results published in almost 20 ISI journals in the area of electroanalysis, applied electrochemistry and materials science. The impact of the published results is demonstrated by the 122 citations (without the self-citations, see scopus database).

The research activities carried out and summarized in this thesis represent an implementation at national level of international major research topics that are included in research agenda worldwide. A part of these researches are performed during post-doctoral studies at University "Tor Vergata" and University "La Sapienza" in Rome or at University of Alcala de Henares (Spain) proving the ability of the candidate to establish relationships and to work and to integrate herself in a research team. In this period of time, the theoretical approaches and the research results have been strongly interrelated, and how presented at the beginning of each chapter, the research activities were financially supported (research grants) and oriented intensely for obtaining applicative results which answer to the requirements of the current industrial market.

In order to provide an overview of the quality, the quantity and the level of the research activity, the present habilitation thesis is organized as follows:

Part I: original contributions

Part II: evolution and development of professional, scientific and academic career.

Part III: references (125 titles including 22 papers having the candidate as author)

Part IA is divided in 4 chapters. The *Chapter 1* is an introduction including the most important theoretical principles and the state of arts in the fileds used in the research activity. The Chapters 2-4 include the presentation of the scientific results and the original contributions concerning the preparation and characterisation by electrochemical techniques of electrode materials based on trilacunary Keggin type polyoxometalates, hemin and other categories (bioglass, iron-based carbon aerogel, Bi doped xerogels, Pt or Ru nanoparticles etc.).

Thus, *Chapter 2* is dedicated to the description of the results published in 4 ISI papers. The electrochemical investigation of a new trilacunary Keggin type polyoxometalate was studied in solution at graphite electrode (G//PFe_3Mo_9) or immobilised on different ways using conducting polymer (*e.g.*, G/PFe_3Mo_9-poly(1,2-DAB)) or non-conducting polymer (*e.g.*, G/PFe_3Mo_9-poly(1,8-DAN)) or self-assembled multilayer structures (*e.g.*, Au/MPS/B/PFe_3Mo_9). The obtained structures were used for H_2O_2 detection. When GOx was deposited as the outermost layer on the modified electrode, a new bioelectrode (*i.e.*, G/PFe_3Mo_9-poly(1,8-DAN)/GOx or Au/MPS/B/PFe_3Mo_9/B/GOx) for glucose amperometric detection was obtained. The analytical parameters of the different *supramolecular architectures*, were in accordance with other studied electrodes presented in literature, as reported in the own mentioned paper.

The *Chapter 3* is dedicated to the description of the results obtained during the construction of architectures containing iron (III) protoporphyrin (IX) which were the subject for 6 ISI papers. The electrochemical behaviour of hemin was studied in solution (G//Hm) or after immobilisation as G/Hm by adsorption method, G/poly-Hm by electropolymerisation, Au/L-Cys/Hm by self-assembling method on Au electrode, G/SWCNT-Hm/Nafion and G/SWCNT-My/Nafion by drop-coating method. For their investigation, different electrochemical techniques as linear voltammetry, cyclic voltammetry, square wave voltammetry were used and different electrochemical parameters were estimated (*e.g.*, redox reaction identification, influence of scan rate, influence of frequency, influence of pH, electrocatalytic behaviour). To the best of our knowledge, we have reported for the first time a simple and reproducible way to prepare an electrode modified with Hm, using either the electropolymerisation of Hm on graphite electrode (G/polyHm) or its adsorption on L-Cyst film, by self-assembling on the surface of Au electrode (Au/L-Cys/Hm). The obtained modified electrodes were investigated for H_2O_2 or NO_2^- detections. Also, the G/My-SWCNT/Nafion modified electrode (My contains heme (Fe^{2+}) which is the reduced form of hemin) is a new, sensitive, robust and stable sensor, showing alternative and great potential for the analytical determination of nitrite by square-wave voltammetry (detection range and lower detection limit consistent with those from literature). The sensor was applied to nitrite detection in real meat products samples and the results were comparable with those obtained with the recommend standard Griess spectrophotometric assay.

The *Chapter 4* is describing different modified electrodes using great varieties of materials which were the object of 9 ISI published papers. Thus a bioglass (a stable hydroxyapatite-like material) immobilised in chitosan give rise to a biocompatible polymer/inorganic composites which was studied by electrochemical impedance spectroscopy. The Fe-doped aerogel was included in a carbon paste matrix and testes for H_2O_2 reduction. Another Bi-impregnated carbon xerogel also incorporated in a carbon paste matrix was used for heavy metal (*e.g.*, Pb^{2+} and Cd^{2+}) detection separately or simultaneously. Nanoparticles of Ru and Pt were immobilised in carbon paste or in chitosan polymeric matrix and used for H_2O_2 or epinephrine detection, respectively. A CuO film obtained by continuously cyclic the potential of a Cu electrode was the transducer for a Gox based amperometric biosensor for glucose detection having good analytical and kinetical parameters.

Part IB contains the Curriculum vitae and the lists of publications (papers, international/national communications), grants, and other activities developed during the academic career of the candidate.

The habilitation thesis concludes with *Part II* which describes the objectives, the steps and directions of the future research activity for an evolution and development of the both *scientific research* and *academic career* in the filed of chemical engineering of materials investigated by using electrochemical techniques and electrochemical sensors.

The main objectives of the *scientific research* activities are the following:

(i) The investigation of new materials (*e.g.*, metallic nanoparticles, new in/organic substances synthesised in our faculty) as sensing nonconventional materials for developing sensors useful for detection analytes having biological or environmental protection importance;
(ii) Developing nano/self-assembling films having anticorrosive protection or biocompatible properties;
(iii) Developing materials for the electrochemically detection of drugs.

The objectives, related to the *academic career* development at the Faculty of chemistry and chemical engineering from "Babes Bolyai" University in the direction of knowledge transfer and industrial inter/national cooperation, are the following:

a) Intensifying the research activities and the ability to provide consulting in preparation technique of electrode materials;
b) Including the most interesting and recent results of the research activity as examples in the lectures, in view to attract more students for research activity and to develop their creative abilities;
c) Increasing the research team by attracting new members who are motivated to continue their doctoral studies in the field of chemical engineering of material;
d) Intensifying the collaboration relations with national and international partners in research projects;
e) Intensifying the valorisation of the research results in the scientific community and in the industrial filed.

The habilitation thesis highlights the continued and constant ability of the candidate to conduct research at a significant scientific level, the skill in teaching at academic level and the ability to initiate and coordinate national (and international) research projects.

Instead of conclusions, considering the progress and evolution of the of the research trajectory of candidate at national and international level, the receiving of the habilitation title and the increasing of the research team with PhD students under the competent supervision of the candidate could considerably improve the visibility of the scientific coherent and interdisciplinary research results with a clearer and more nuanced understanding of the approaches in the field of chemical engineering of material investigated by electrochemical techniques.