# Nanobioelectrochemistry

From Implantable Biosensors to Green Power Generation

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# Preface

Nanobioelectrochemistry covers the modern aspects of bioelectrochemistry, nanoscience, and materials science. The combination of nanostructured materials and biological molecules enable the development of biodevices capable of detecting specific substances. Furthermore, by using the bioelectrochemistry approach, the interaction between bio-system and nanostructured materials can be studied at molecular level, where several mechanisms of molecular behavior are elucidated from redox reactions. The combination of biological molecules and novel nanomaterials components is of great importance in the processes of developing new nanoscale devices for future biological, medical, and electronic applications. This book describes some of the different electrochemical techniques that can be used to study new strategies for patterning electrode surfaces with biomolecules and biomimetic systems. Also, it focuses on how nanomaterials can be used in combination with biological catalysts in fuel cells for the green power generation. By bringing together these different aspects of nanobioelectrochemistry, this book provides a valuable source of information for many students and scientists.

## Chapters from Implantable Biosensors to Green Power Generation

This book provides a comprehensive compilation of seven chapters, with important contributions of several authors. Chapter 1 reviews the recent research in using nanoparticle labels and multiplexed detection in protein immunosensors. This chapter summarizes recent progress in development of ultrasensitive electrochemical devices to measure cancer biomarker proteins, with emphasis on the use of nanoparticles and nanostructured sensors aimed for use in clinical cancer diagnostics. Based on recent strategies focused on nanomaterials for electrochemical biosensors development, Chap. 2 discusses the development of new methodologies for biomolecules immobilization; including the utilization of several biological molecules such as enzymes, nucleotides, antigens, DNA, amino-acids, and many others for biosensing. The utilization of these biological molecules in conjunction with nanostructured materials opens the possibility to develop several types of biosensors such as nanostructured and miniaturized devices and implantable biosensors for real-time monitoring. Also, nanomaterials, such as carbon nanotubes, seem to be the most appropriate electrical host matrix in biofuel cells due to their bio-compability, high conductivity, high specific surface, and ability to electrically connect many redox enzymes. The latter, is the focus of Chap. 3, which also shows that biofuel cells attract more and more attention as green and non-polluting energy source for, in general, mobile and implantable devices. Within this research topic discussed in this chapter, nanostructured materials prevail due to their higher efficiency, energy yields, and the possibility to construct miniaturized devices. This can also lead to development and applicability of implantable devices, when biosensing has benefitted enormously from the development of field-effect transistor (FET) sensor platforms, not only due to the design of specific FET architectures, but also because nanotechnological materials and techniques may be used to obtain gate platforms with tailored surfaces and functionalities. This topic is presented in Chap. 4, in which is shown the crucial points for improving the efficiency of biomolecules immobilization, leading to higher protein loadings, and as a consequence, better sensitivity and lower limit of detection. Another advantage is the number of possible architectures leading to distinct devices including ion-sensitive field-effect transistor (ISFET), electrolyte-insulator-semiconductor (EIS), light-addressable potentiometric sensor, extended-gate field-effect transistor (EGFET), and separative extended-gate field-effect transistor (SEGFET), each of which exhibits advantages for specific applications. Also, Chap. 5 show how the supramolecular chemistry strategy is used to map electrochemical phenomena at the nanoscale of low-dimensional highly organized hybrid structures containing several building blocks such as metallic nanoparticles, carbon nanotubes, metallic phthalocyanine, biopolymers, enzymes, and synthetic polymers. The principles of supramolecular chemistry as constitutional dynamic character of the reactions, functional recognition, and self-organization are explored from interaction between biomolecules and several supramolecular architectures in order to modulate the physicochemical properties that arise at molecular level. The developed platforms with high control of these electrochemical properties become interesting devices for sensor and biosensor applications. Chapter 6 illustrates recent developments on surface characterization of DNA and enzyme-based sensors to complement information obtained by electrochemical and impedance techniques. This chapter also shows how AFM imaging is used to characterize different procedures for immobilizing nanoscale double-stranded DNA surface films on carbon electrodes, in which a critical issue is the sensor material and the degree of surface coverage. In this regard, another important technique is the Electrochemical-Surface Plasmon Resonance (ESPR). The combination of SPR and electrochemical methods has become a powerful technique for simultaneous observation of optical and electrochemical properties at substrate/electrolyte interfaces, as shown in the Chap. 7. The fundamental aspects of the electric potential effects on surface plasmons are introduced and the use and applications of this combined electrochemical and optical technique are discussed.