

# Preface

Research in electrochemical science and technology has brought tremendous achievements. Beyond the traditional applications in the electronics, energy devices, aerospace, and automotive areas, developments in electrochemistry are very important for practical biomedical applications. In particular, developments related to medical devices, implants, sensors, antimicrobially active material/materials, drug delivery systems etc., have significantly advanced in the past few decades.

The aim of this issue of *Modern Aspects of Electrochemistry* is to review the electrochemical aspects of the latest developments of various materials and/or methods used in biomedical and pharmaceutical applications. I must express my great thanks to Dr. Kenneth Howell of Springer for his continuous encouragement in collecting and editing these very valuable contributions from distinguished scientists in the field of electrochemical science and technology around the globe.

Ingrid Milošev in Chap. 1 analyses recent developments in antimicrobial coatings on titanium and titanium alloys. Titanium and titanium alloys are important biomedical materials since they exhibit excellent biocompatibility and very good mechanical properties. However, adhesion of bacteria and their colonization on titanium-based materials cause inflammatory process leading to the destruction of both soft and hard tissue around the implant. These problems require preventive measures in order to avoid or at least to reduce implant-related infection. For this purpose antimicrobial coatings are applied on the surface of titanium-based

implants. Several approaches have been proposed for this target and they are reviewed in this chapter. Of course, the electrochemical aspects are thoroughly discussed.

In Chap. 2, by Avramov-Ivić, Petrović, and Mijin, recent advances in electrochemical analysis of pharmaceuticals are discussed in detail. The application of the most commonly used voltammetric techniques combined with different chromatographic, spectrophotometric, and spectroscopic techniques in the analysis of the pharmaceuticals is reviewed. Pharmaceutically active compounds under consideration belong to chemotherapeutic agents (antibiotics), drugs affecting neurotransmission and enzymes as catalytic receptors, drugs affecting the cardiovascular system, drugs affecting the immune systems, and some other drugs. The new electroanalytical methods for qualitative and quantitative determination of standard substances are discussed in cases such as five macrolide antibiotics, amphetamines, carbamazepine, donepezil, amlodipine, nifedipine, clopidogrel, tamiflu, and oxaprozin. Some drugs are analyzed in human biological samples.

Chapter 3 by Ceré, Gomez Sanchez, and Ballarre describes anodization and sol gel coatings as surface modification to promote osseointegration in metallic prostheses. Orthopedic devices for permanent implants require short-term fixation and fast bone attachment and healing. Also they are required to have excellent mechanical properties in load bearing sites and to be corrosion resistant. This chapter reviews the surface modifications produced on orthopedic and dentistry metallic materials by anodization and by hybrid coatings by sol gel technique from an electrochemical point of view. Both of these processes promote corrosion resistance in physiological fluids and bioactivity.

In Chap. 4 by Mišković-Stanković novel nanostructured materials synthesized according to original electrochemical procedures are described and discussed. A constant increase in the number of microorganisms resistant to existing antibiotics has stimulated a revival in the clinical use of silver. Various products containing silver ions have been developed and utilized for treatments of infections in burns, open wounds, and chronic ulcers. Hydrogels are useful as wound dressings or soft tissue implants. Silver nanoparticles embedded in hydrogel matrices are attractive

for biomedical applications due to the possibility for the controlled release of Ag(I) ions resulting in antimicrobial activity. These gels are hydrophilic, biocompatible, biodegradable, easily processed into different shapes, and approved for medical use. Two electrochemical methods for material fabrication are described: (1) electrochemical synthesis of silver nanoparticles in the polymer solution under galvanostatic conditions, followed by electrostatic extrusion or freezing-thawing, and (2) electrochemical reduction of  $\text{Ag}^+$  ions into silver nanoparticles inside the polymer hydrogel, with the variation of applied voltage and implementation time. The nanocomposites produced by the suggested electrochemical methods are suitable for wound dressings, soft tissue implants, drug delivery devices, and carriers for cell cultivation. Silver alginates, silver-poly (*N*-vinyl-2-pyrrolidone), and silver-polyvinyl alcohol are examples of such materials discussed here. According to cytotoxicity, antimicrobial, in vitro bioactivity, and bioreactor tests, electrochemically produced materials for soft tissue implants are very promising candidates for future biomedical applications.

Chapter 5 by Mišković-Stanković describes biomaterials for hard tissue implants. The development of synthetic materials with acceptable mechanical properties and excellent biocompatibility is required for hard tissue implants. Hydroxyapatite (HAP) is very brittle, and for this reason, great attention has been focused on the development of composite coatings. Natural biodegradable polymer lignin (Lig) is considered a promising alternative for a new biocomposite coating. Application of graphene as a filler minimizes the brittleness of HAP and improves the mechanical properties of biocomposite coatings. However, bacterial infection of bone implants has resulted from rejection. This chapter explores the novel nanostructured biomaterials suitable for medical applications as hard tissue implants (hips, knees, ankle, shoulder, elbow joints), drug delivery devices, and dental restorations, implants, and orthodontics, synthesized according to electrochemical procedures. Lignin and graphene-based nanocomposite coatings doped with silver and deposited on titanium substrate using electrophoretic deposition method are explored in this chapter. Electrophoretic deposition produces thin films of controlled thickness and surface

morphology, by changing the electrochemical conditions. Coatings for hard tissue implants produced via electrochemical deposition are excellent candidates for future biomedical applications.

This new volume of *Modern Aspects of Electrochemistry* brings to scientists, engineers, and students new concepts and summarized results related to the application of electrochemical processes in the pharmaceutical and biomedical fields. I believe that the results presented in this issue of *Modern Aspects of Electrochemistry* will have significant influence for future practical applications.

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