Bio- and Bioinspired Nanomaterials

With a Foreword by João F. Mano
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Foreword

Without being aware, mankind has been in contact with nanomaterials for a long time. For example, a bright blue pigment invented and used 5000 years ago in Egypt, or the fourth century Lycurgus Cup, the magnificent Roman glass cage cup made of a dichroic glass showing different colors depending on which angle light is shown through, provide today clues how to develop new nanomaterials that could be used in almost any field. In particular, with the latest developments in nanoscience and nanotechnology, biology and medicine have been making revolutionary progress that will provide in the future new diagnosis and therapeutic solutions. The editors of this book were able to collect valuable contributions from top-level scientists that illustrate representative examples of how bionanomaterials could lead to new devices or structures with unique properties. This fresh, exciting, and multidisciplinary field has been bridging principles and tools from physics, chemistry, or engineering to produce such novel elements at all dimensional ranges, including nanoparticles (0D), nanofibers (1D), thin-coating or nanostructured surfaces (2D), or 3D nano-organized materials (hybrid systems, nanocomposites, nano/meso-porous structures, and so on). Bionanomaterials are able to interact peculiarly with biological systems, permitting the accomplishment of tasks that could not be possible with higher-scale materials; well-established examples are nanoparticles for imaging with improved sensitivity, to be used as sensors or to deliver drugs to specific parts of the body.

The authors clearly realized the importance of using modern bioinspired concepts to develop tailored materials for a growing range of technological applications. Along with over 3.8 billion years of evolution, Nature has introduced highly effective biological mechanisms to produce surfaces and materials with exclusive or exceptional features. Biomimetic strategies rely first on the discovery of the structural or physicochemical reasons behind the manifestation of such characteristics, followed by the design and production of synthetic counterparts that could reproduce a similar effect. The second section of this book provides striking examples of bioinspired materials, including surfaces with extreme wettability properties, functional materials with improved adhesion (especially in wet environments), and structural and functional systems based on the complex and hierarchical organization of natural composites. These lessons from Nature are explored in the last section of the book, where bioinspired materials are
specifically proposed for biomedical applications, showing their potential for future applications in drug delivery, theragnosis, and regenerative medicine.

This editorial project provides the latest scientific and technological developments in the fields of bionanomaterials and biological inspired nanomaterials, which will be of value to academic and industrial researchers – the accumulated knowledge, together with the potential applicability of such systems, will have a tremendous impact across a range of different fields, including in the biomedical arena. Young research workers will also have in the contents of this book an indispensable support that could guide them in choosing to begin, or to continue, working in this stimulating area of research, which encompasses a wide range of disciplines, including chemistry, physics, materials science and engineering, biology, and medicine.

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Preface

Throughout history, far-reaching technical advances have changed established paradigms. Nowadays, nanotechnology is emerging as the latest revolutionary development that is expected to profoundly affect how novel materials, capable of delivering solutions that are cost-efficient, environmentally safe, and affording improved technical performance, are designed and manufactured.

Nanotechnology deals with the manipulation and fabrication of objects or structures at, and below, the nanometric scale, with the ultimate goal of developing new materials for specific technological niches. Because the physical and chemical properties of nanomaterials differ from those of bulk materials, they belong by themselves as a unique class. Although nanoscience started off as an academic research field in the mid-1980s, there are already plenty of examples of commercial applications of nanotechnology in the marketplace. Nanomaterials can be found as key components in healthcare, electronics, cosmetics, textiles, information technology, and environmental protection industries. Not surprisingly, the increasing interest they have attracted has translated into a sharp increase in both public and private funding in nanoscience and nanotechnology-related research.

In particular, the size-specific properties of nanomaterials make them a superior alternative to traditional materials in biology and medicine, and specifically for the fabrication of novel biomaterials, in such areas as cancer diagnosis and therapy, implantable devices, drug delivery systems, gene vectors, and tissue engineering, all of which are reviewed in this book. Overall, understanding and controlling the action mechanisms of the nanodevices targeting key biological processes stand out as foremost scientific challenges.

Alongside purely synthetic approaches, Nature itself offers different models and strategies at the nanoscale that can be mimicked with success. Indeed, the study of nanostructures found in many different animals, plants, and other biological systems has shown us ways to develop new materials for energy production, superhydrophobics, adhesives, biosensors, and materials with improved physical and chemical resistance. As far as future technological applications are concerned, these bioinspired nanomaterials are already showing great potential.
This book includes some of the most recent breakthrough research in both bio- and bioinspired nanomaterials. In this respect, it is intended as a navigation guide through some innovative and elegant contributions from a wide group of researchers of high standing in their respective fields, aimed at an advanced and specialist readership community, and relevant in general to readers in research, academia, or private companies focused on high added value contributions.
Part I
Bionanomaterials