Preface

The interaction of electrochemistry and nanotechnology has two sides, namely the applications of nanotechnology in electrochemistry, and vice versa. Although, as inferred by the title, this book deals with the former subject, the basic concept behind it was to unite the two sides of this newly born field, which we can then refer to as Electrochemical Nanotechnology. Due to vast range of topics in this field, there was a clear obligation to focus on only a part of the field, and hence this book is not considered to be an exhaustive resource on the subject, but rather to provide some important information on a variety of topics that will attract the attention of readers to current issues in the subject. In my opinion, such a united volume is indeed capable of providing a comprehensive perspective of the whole field. After undergoing rapid and growing specialization during the past few decades, now is the time for interdisciplinary studies and collaboration between the various fields. Today, the successful research groups are those which conduct studies that are significant and important not only for the people working within the field, but also for those working in other areas. Here, nanotechnology represents a vivid example, as the extreme success of this newborn field is due as much to the generality of its findings as to the interest of the research teams working in its various areas.

The reason why such emphasis is placed on Electrochemical Nanotechnology is due not only to the existence of so many interesting topics within the category, but also to its important concepts. Today, many research groups working in nanotechnology also have wider interests in electrochemistry, as electrochemical methods are typically low-cost and also highly effective for the preparation of nanostructures. This newfound attention is due largely to the methodology employed, which may also be used for fundamental studies. In fact, rather than electrochemistry being considered as a branch of chemistry, its footprints can be seen in a variety of fields for both methodological applications and fundamental studies. For example, when studying chaotic dynamics in chemical systems, electrochemical oscillators provide the best means of proposing general models, as both controllable parameters and system response form part of the electrochemical set-up. Indeed, this is also the case for nanotechnology.

The reason why I first came to the field of nanotechnology stemmed in fact from my studies in electrochemistry – it was not the “fame” of nanotechnology, because in
those days the subject was not famous! My first encounter with the subject occurred while studying electrochemical oscillations, when I noticed a classic theory that the distribution of potential is inhomogeneous across the electrode surface. So, I thought that it might be very interesting to identify a way in which the local currents on an electrode surface could be inspected. Subsequently, the invention of the scanning electrochemical microscope (SECM) paved the path to this goal. My second encounter occurred when I tried to use carbon nanotubes as the anode material of a lithium battery, and I had considered preparing separate sheets of graphene (not rolled as nanotubes), as solid-state diffusion within graphite interlayers occurred so slowly. Although neither of these topics has yet been fully addressed, these early calls for nanotechnology within the realms of electrochemistry were due to the essential role of nanoscale in electrochemical systems.

The SECM is commonly considered as a form of scanning probe microscopy (SPM), and is of major interest to electrochemists. In fact, opinion suggests SECM is an advanced form of SPM, as it provides the great opportunity to control not only (electro)chemical processes but also the common applications of SPM (here, I am not talking about the features of currently available commercial microscopes, but rather the concepts involved). Unfortunately, non-electrochemists are often afraid to use the SECM due to the existence of strange electrochemical processes that may affect their results. There is, therefore, a clear need for scientific collaboration, rather than simply ignoring these great opportunities. In the second case, as well as using electrolysis to prepare graphene sheets by simply cutting a graphite electrode layer-by-layer, the opportunity exists to examine these nanomaterials by using electrochemical methods, rather than by their applications. In this respect, recent advances in methods such as fast voltammetry have provided new opportunities in surface electrochemistry, mainly in the identification of nanostructures.

Richard Alkire has well described the journey of electrochemistry towards nanotechnology and summarized the contents of this book upon this connection. The present book deals with the area of Electrochemical Nanotechnology where nanomaterials are applied in electrochemical systems. Yury Gogotsi and Patrice Simon expressed the rapidly growing applications of nanotechnology in our everyday life as electrochemistry is an important part of such industries, and also the server need of nanotechnology in modern electrochemistry (e.g., electrochemical power sources). However, such mutual involvements are not vivid to both parties. In fact, the book’s contents describe the importance of nanostructured materials in electrochemical systems, and the value of electrochemical methods in the preparation of nanostructures.

At this point the reader may wonder why I so frequently place emphasis on Electrochemical Nanotechnology, when in fact the book does not comprehensively cover all aspects of the subject. The main mission of books such as this is to review certain “hot” topics within specified areas of research – something that review articles in scholarly journals often cannot do because they are published in a too-general or too-specialized medium. In this regard, electrochemical materials science is of particular interest due to a very broad readership since, within the electrochemical literature, most studies are associated with materials science, and numerous electrochemical studies are also reported in the materials science literature. Yet, according to
the similarities of the electrochemical processes (both in applications and synthesis), it is very useful for the different research groups to know similar systems. Consequently, in order to address so many different aspects of the subject under consideration, a variety of current topics that should be of interest to all readers are discussed.

Today, perhaps the main emphasis in the rapidly growing field of Electrochemical Nanotechnology is to identify a new way of thinking. However, whilst all fields of science have their own “jargon”, it is clearly more important to devise a consistent method of thinking rather than a unique terminology. Moreover, such concerted effort should lead to a united scientific community, which is essential for the advancement of any field of investigation. Within the realms of Electrochemical Nanotechnology, researchers of different training and thought methods are becoming increasingly involved, and this can surely only prove to be advantageous for the subject in the long term.

It is hoped that, although similar volumes have been produced in the past, this book will attract the attention of many research groups, who hopefully will unite in their studies of the general features of this new area. Undoubtedly, such a situation will not only result in a more comprehensive realization of the subject, but also lead to improved problem-solving capabilities in the field of Electrochemical Nanotechnology.

The realm of Electrochemical Nanotechnology in fact consists of a broad range of topics, hence leading researchers from various areas of study were involved in this book project. They address the most fascinating current issues and challenges that have presented themselves at the interface of electrochemistry and nanotechnology. Though coming from various different backgrounds in electrochemistry or materials science, the authors share a joint belief that the essential link between electrochemistry and nanotechnology has previously been missing, and must now be tackled.

It is my great pleasure and good fortune to have two invaluable forewords by three highly esteemed scientists. As a leading electrochemist, the fame of Richard Alkire is due to his considerable contributions to the fundamentals of electrochemistry, and in this capacity he has also contributed brilliantly to the fundamental aspects of Electrochemical Nanotechnology, in particular electrodeposition.

Yury Gogotsi is one of the leading scientists in nanomaterials, and has carried out groundbreaking work on numerous types of nanomaterials, especially carboneous ones. His collaboration with Patrice Simon is an example of the need for the combination of electrochemistry with nanotechnology, which cannot be emphasized often enough.

Last but not least, I would like to note my appreciation of the Wiley-VCH editors’ foresight in picking out this particular topic and their kind efforts which made the publication of this book possible. I wish to thank them for their essential roles.

I sincerely hope that the readers find the contents of this work useful for their scientific research.

January 2008

Ali Eftekhari