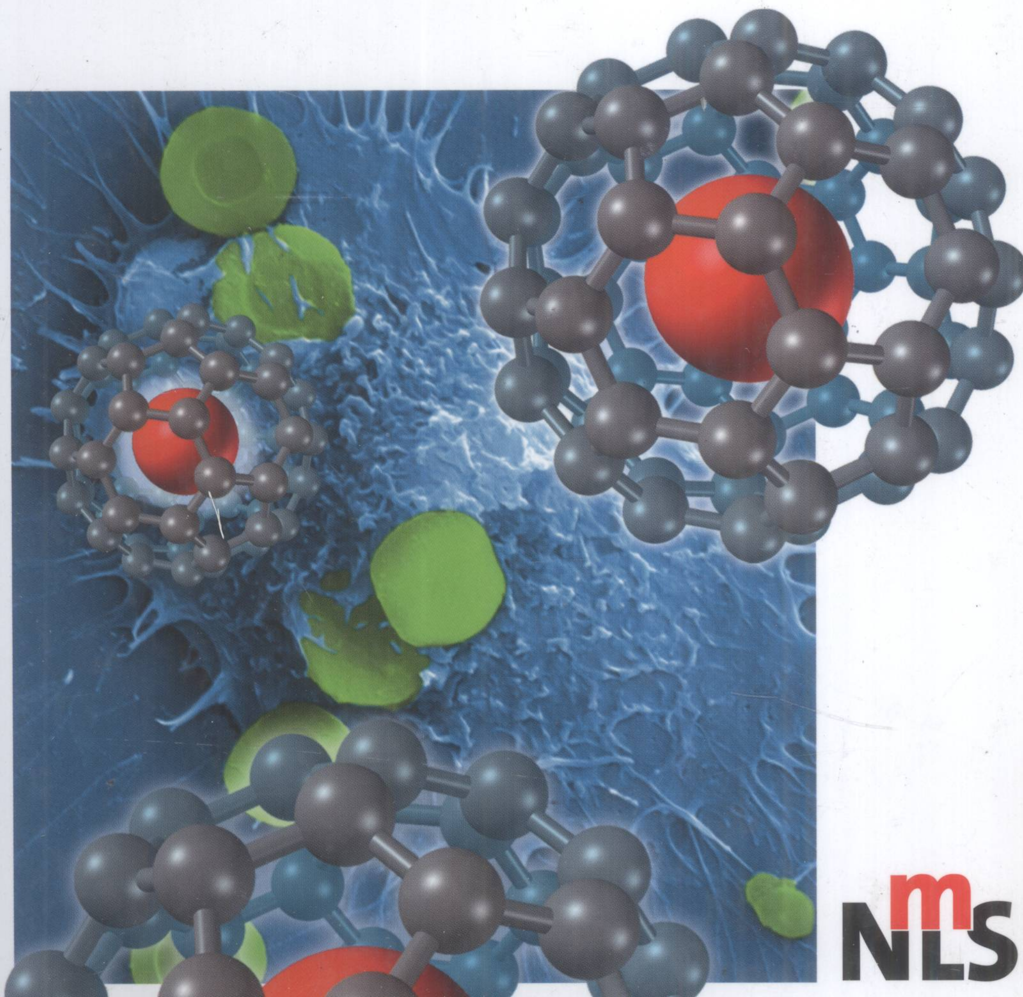
Nanomaterials for the Life Sciences

Edited by Challa Kumar

WILEY-VCH

Metallic Nanomaterials



NLS

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Further Reading

Kumar, C. S. S. R. (Ed.)

Nanotechnologies for the Life Sciences (NtLS)

10 Volume Set

2007

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Kumar, C. S. S. R. (Ed.)

Nanomaterials for the Life Sciences (NmLS)

Book Series, 10 Volumes

Vol. 1

Metallic Nanomaterials

2009

ISBN: 978-3-527-32151-3

Vol. 2

Nonmagnetic Inorganic Nanomaterials

2009

ISBN: 978-3-527-32152-0

Vol. 3

Bimetallic and Metal Oxide Nanomaterials

2010

ISBN: 978-3-527-32153-7

Vol. 4

Polymeric Nanomaterials

2010

ISBN: 978-3-527-32154-4

Vol. 5

Semiconductor Nanomaterials

2010

ISBN: 978-3-527-32155-1

Preface

The global demand for nanomaterials is currently estimated to be around US$ 3.7 billion, driven mainly by nanoscale metals and oxides. Moreover, this demand is likely to grow further as they find more and more newer applications. With the increasing realization that nanoscale systems are very similar to biological systems – not only in terms of size but also in terms of multifunctionality – there is a constant communication between research groups and those industries fabricating nanomaterials and those specializing in biology, biotechnology, medicine, environmental sciences, agricultural and food science and in general life sciences. This communication is leading to a rapid convergence between nanomaterials and the life sciences, paving the way for the establishment of one of the most promising and exciting scientific fields of today – Nanotechnologies/Nanomaterials for the Life Sciences. With a vision to promote 'nano thinking' and to act as a catalyst in ensuring the rapid dissemination of knowledge in this field, I previously had an opportunity to present to the scientific community a 10-volume series on *Nanotechnologies for the Life Sciences* (NtLS). With over 4600 pages in 124 chapters, these 10 volumes represented the first major effort to cover the whole breadth and width of this highly dynamic and exciting field. However, as the NtLS series focused more on the influence of nanotechnologies on the life sciences, there remained an unfulfilled gap in the knowledge base that required a greater focus on materials properties and the implications for their application in the life sciences. So, thanks to yet another wonderful team of nanoresearchers, we are now in the process of filling this gap. On behalf of this new team, I am now pleased to introduce to the scientific community a comprehensive 10-volume series entitled *Nanomaterials for the Life Sciences* (NmLS). Whilst the NmLS series can be seen as continuation of the NtLS series, adding new information from the research findings of the past few years, it takes us a step higher in appreciating the interplay of nanomaterials and applications in life sciences. The NmLS series also takes us to newer heights in ensuring that the field of life sciences is changed for ever. The NmLS series will include 10 volumes covering a broad range of nanomaterials-metals, metal oxides and magnetic materials – all of which will impact on the life sciences.

Before discussing in detail the contents of the first volume, I would like to share with you some nuggets regarding the rest of the nine volumes. The second and third volumes in this series are already in print. The second volume,

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Nanostructured Oxides for Life Sciences, and the third volume, *Mixed Metal Nanomaterials for Life Sciences*, are the first of their kind ever to be published. The remainder of the volumes will cover the application of other types of nanomaterial, such as thin films, polymeric materials and quantum dots. Each of these volumes will contain more than 500 printed pages, and provide an in-depth source of information related to a particular type of nanomaterial. I am honored by the enthusiasm of the contributing authors and am very grateful to them for being part of this exciting project by contributing high-quality manuscripts, on time, while keeping in tune with the design and theme of each volume and the vision for the whole book series. Indeed, the only reason you have this book in your hand is due to their dedication, perseverance and commitment. The Center for Advanced Microstructures and Devices (CAMD), Baton Rouge, USA, continues to demonstrate its strong commitment to research in high-technology areas, and this is an example of its support. I am humbled to be working for such a great organization. However, a venture of this magnitude can only become a reality when timely support is provided from all sides, and I therefore appreciate the understanding of my family and the support from Wiley-VCH publishers. It has been a fantastic experience working with the team from Wiley – Dr. Martin Ottmar, Dr. Rainer Münz and Dr. Martin Preuss. Thank you Wiley-VCH!

I am now pleased to present to you the first volume, *Metallic Nanomaterials for the Life Sciences*. This covers different metallic nanomaterials, and more specifically gold, silver, copper, palladium and platinum nanomaterials, and their applications in the life sciences. The book is divided into three distinct parts. In Part One, the focus is on copper, silver and gold nanomaterials, both spherical as well as anisotropic. Part Two discusses palladium and platinum nanomaterials, while Part Three provides an overview of all different types of metallic nanomaterials and their applications in the life sciences.

Part One begins with a chapter entitled *Approaches to Synthesis and Characterization of Spherical and Anisotropic Copper Nanomaterials*, by Professor Nicola Cioffi and her team from the Università di Bari, Bari, Italy. In this chapter, the authors provide a 'bird's-eye view' of the main approaches for the synthesis and characterization of nanosized copper and structures, together with characterization data regarding their morphology, structure and surface chemical composition. While copper nanomaterials are just on the verge of being utilized in the field of life sciences, the second chapter by Chi-Chung Chou and his team from National Chung-Hsing University, Taichung, Taiwan, provides an overview of developments in the application of copper nanomaterials in medical diagnosis. This chapter, *Spherical and Anisotropic Copper Nanomaterials in Medical Diagnosis*, covers the application of copper nanomaterials as contrast agents for MRI or PET scanning and as biosensors for detecting early changes in biological metabolites/elements that carry significant implications in disease identification. Chapters 3 to 5 focus on silver nanomaterials, their synthesis and characterization and application in medical diagnosis, therapy and environment. Chapter 3, *Approaches to Synthesis and Characterization of Spherical and Anisotropic Silver Nanomaterials*, is contributed by Professor John Kelly and his team from Trinity College Dublin, Dublin, Ireland, while

Professor Kenneth Wong and his team from the University of Hong Kong, Hong Kong (Chapter 4) and Professor Ralph A. Tripp and colleagues from the University of Georgia, Athens, USA (Chapter 5) have done a remarkable job in capturing the up-to-date information in their chapters entitled *Spherical and Anisotropic Silver Nanomaterials in Medical Therapy* and *Spherical and Anisotropic Silver Nanomaterials in Medical Diagnosis*, respectively. Silver nanomaterials are well studied, and their extraordinary physical and chemical properties make them useful in medical therapy and diagnosis. In addition to these applications, Professor Il Je Yu from the Korea Environment & Merchandise Testing Institute, Incheon, Korea, and Bruce Kelman from Veritox, Redmond, USA, in Chapter 6–*Health and Environmental Impact of Silver Nanomaterials*–stress the importance of the impact of silver nanomaterials on human health and the environment. A combination of these three chapters on silver nanomaterials makes this volume a comprehensive source of information on these nanomaterials and their applications to the life sciences. The final two chapters of Part One are contributed by Professor Tai Hwan Ha and his team from the Korea Research Institute of Bioscience and Biotechnology, Daejeon, Republic of Korea, and by Professor Takuro Niidome and colleagues from Kyushu University, Fukuoka, Japan. In Chapter 7, *Approaches to Synthesis and Characterization of Spherical and Anisotropic Gold Nanomaterials*, Professor Ha rationalizes the current approaches for the syntheses of gold nanomaterials and the control of their size and shape. In Chapter 8, *Spherical and Anisotropic Gold Nanomaterials in Medical Therapy*, Professor Niidome reviews the current research trends in the use of gold nanomaterials, especially of gold nanospheres and gold nanorods, in diagnosis and therapy.

Part Two of the volume is dedicated to palladium and platinum nanomaterials, in Chapters 9 and 10, respectively. Chapter 9 is a contribution from the laboratories of Professor Sherine Obare, at The University of North Carolina at Charlotte, Charlotte, USA. In her chapter, *Approaches to Synthesis and Characterization of-Spherical & Anisotropic Palladium Nanomaterials*, Professor Obare describes the synthetic procedures to create spherical and anisotropic palladium nanostructures with controlled size and shape. Current applications of palladium nanoparticles in the life sciences are primarily in the area of environmental remediation and biosensing. Hence, Chapter 10 provides up-to-date information on *Approaches to the Synthesis and Characterization of Spherical and Anisotropic Platinum Nanomaterials*, with Professor Hong Yang and his team having done a commendable job in examining the basic principles for the shape control of platinum nanostructures. As examples of applications of platinum nanomaterials in life science are limited, the authors hope that the easy-to-read information provided on their synthesis will motivate life science researchers to begin exploring the use of these materials in life science applications.

The final part of this volume provides the reader with an overview of metallic nanomaterials, their characteristics and life science applications. Part Three begins with Chapter 11, on *Approaches to the Synthesis and Characterization of Spherical and Anisotropic Noble Metal Nanomaterials*, where Professor Ru-Shi Liu and his team discuss a number of useful parameters that can be tuned to control the formation of anisotropic noble metal nanomaterials in a solution-phase synthesis. The general modalities presented are also applicable to other types of metallic nanomaterial. In addition to wet chemical methods, there is a growing appreciation of biologically based synthetic methods. Thus, Chapter 12–aptly entitled *Biological and Biomaterials-Assisted Synthesis of Precious Metal Nanoparticles*–focuses on the biological formation of metallic nanoparticles. In this chapter, which is a contribution from the University of Texas at El Paso, USA, the authors–led by Professor Jorge L. Gardea-Torresdey–also highlight the differences between wet-chemical synthesis and biological synthesis of metallic nanomaterials. The authors of Chapter 13, led by Professor Adela Ben-Yakar, provide the reader with a comprehensive review of the current state of therapeutic nanobiophotonics using metallic nanomaterials. Their chapter, entitled *Spherical and Anisotropic Metal Nanomaterials in Laser-Based Cancer Therapy*, provides several examples of the clinical application of metallic nanoparticles, especially gold nanoparticles, and demonstrates the clear potential of plasmonic phototherapy to become a 'gold standard' among cancer treatments. The final chapter of Part Three highlights the unique applications of metallic nanomaterials in textiles. In addition, Professor Vigneswaran and the team from the Central Institute for Research on Cotton Technology, Mumbai, India, describe the functionalization of textiles with metal nanoparticles, the methods of application onto textile materials, and their evaluation. This chapter, *Application of Metallic Nanoparticles in Textiles*, describes the impact of nanotechnology on commercial textile industrials, together with their environmental concerns.

Finally as I conclude this preface, I recollect the preface that I wrote for the first volume in the NtLS series, in which I talked about the growing number of 'nano thinkers'. The NmLS series is a testimony to the fact that the followers of 'nano thinking'–the so-called 'nano thinkers'–are growing in number day by day, and their presence is now very strong in the field of the life sciences. I am very confident that the firm knowledge foundation provided with the availability of the NtLS and NmLS series will pave the way for many exciting discoveries in the field of life sciences.

Challa S.S.R. Kumar
25th September 2008

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