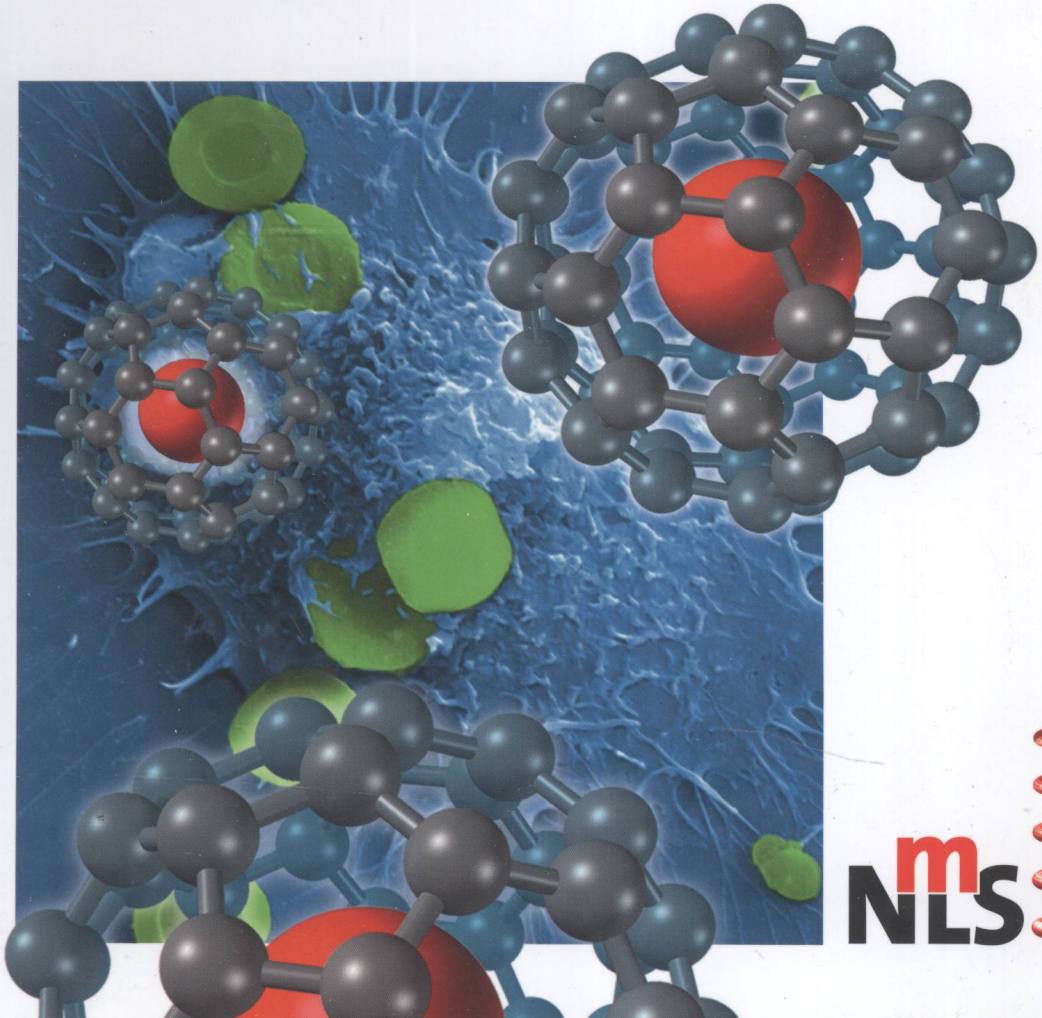
Nanomaterials for the Life Sciences

Edited by Challa Kumar

WILEY-VCH

Magnetic Nanomaterials



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Nanomaterials for the Life Sciences
Volume 4

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WILEY-VCH Verlag GmbH & Co. KGaA

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Library of Congress Card No.: applied for

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at <http://dnb.d-nb.de>.

Typesetting SNP Best-set Typesetter Ltd., Hong Kong
Printing Strauss GmbH, Mörlenbach
Binding Litges & Dopf GmbH, Heppenheim
Cover Design Grafik-Design Schulz, Fußgönheim

Printed in the Federal Republic of Germany
Printed on acid-free paper

ISBN: 978-3-527-32154-4

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Further Reading

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

Nanotechnologies for the Life Sciences (NtLS)

10 Volume Set

2007

ISBN: 978-3-527-31301-3

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

Nanostructured Oxides

2009

ISBN: 978-3-527-32152-0

Vol. 3

Mixed Metal Nanomaterials

2009

ISBN: 978-3-527-32153-7

Vol. 4

Magnetic Nanomaterials

2009

ISBN: 978-3-527-32154-4

Vol. 5

Nanostructured Thin Films and Surfaces

2010

ISBN: 978-3-527-32155-1

Preface

For a moment consider the bigger picture. Earth is a giant magnet in comparison with magnetic nanomaterials. However, in the gigantic universe earth could be relatively as tiny as a nanoparticle! Having a right perspective is extremely important not only in science but also in life in general. This message comes out more clearly in a recent cartoon movie, ***Horton Hears A Who***. This movie is entertaining, philosophical and scientific to the core and I would strongly recommend watching it. I truly believe that science and philosophy are entwined and a dose of entertainment makes it a potent combination! With this perspective in mind, I am extremely pleased to present to you, the fourth volume entitled, **Magnetic Nanomaterials for Life Sciences** within the ten volume NmLS series. Thanks to excellent contributors and punctual Wiley-VCH publishing team, this book has turned out to be the only one of its kind bringing synergy between magnetic nanomaterials and life science applications. With four sections, totaling sixteen chapters, covering life science applications ranging from bio-sensing, diagnosis, therapy, tissue engineering and environment in combination with synthesis and biofunctionalization of a whole range of magnetic nanomaterials, I have no doubt that this book would provide a strong foundation for nano researchers with background in chemistry, physics, materials, biology and medicine.

The book starts with a chapter on **Nanomaterials-Based Magnetic Relaxation Switch Biosensors**. This contribution comes from Dr. Tom Lowery, T2 Biosystems; a start-up company developing next-generation medical diagnostic platform. This chapter is a testimony to the fact that magnetic nanomaterials are moving closer to commercial applications. Magnetic relaxation switches (MRSw) technology, described in detail in this chapter, is poised to bring in new approach to solution-based biosensing with potential impact in medical diagnostics, personalized medicine, environmental sensing, and homeland security Moving to the second chapter, Prof. Robert Wilson from Liverpool University, UK, provides an authoritative presentation on multiplexed detection-the detection of multiple analyte (target) molecules in the same undivided volume (aliquot) of sample at the same time. Such an approach is anticipated to yield close to one thousand resolvable codes without losing any sensitivity in each. Continuing on the same theme of biosensing, the third chapter describes concepts and applications in magnetophoretic biosensing. Authored by Je-Kyun Park and team from KAIST, Daejeon, South

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ISBN: 978-3-527-32154-4

Korea, the chapter covers examples ranging from device fabrication and biosensing to magnetic separation. This section on application of magnetic nanomaterials in biosensing concludes with a chapter on **Magnetic Nanomaterials as MRI Contrast Agents** by Prof. Iouri Gounko and Dermot F. Brougham of Trinity College, Dublin. As magnetic nanomaterials are gaining prominence as MRI contrast agents, this chapter is extremely important as it presents an overview of magnetic nanocomposite materials, their biofunctionalization followed by current and potential clinical MRI imaging uses, including cell labeling and molecular imaging.

In the second section, the emphasis is on application of magnetic nanomaterials on diagnosis & therapy. Prof. Kim from George Washington University, USA, brings out in the fifth chapter technological developments in magnetic nanoparticle-based platforms for *in vitro* molecular diagnostics. In the sixth chapter, latest developments in utilization of magnetic nanoparticle for cancer diagnosis and therapy are reviewed. In this review, Dr. Natarajan and his team from Stanford University School of Medicine, Stanford, USA describes applications in the areas relevant to cancer such as MRI, multimodal imaging (MRI, Optical, and Radioactive), chemo drug delivery, targeted delivery, and hyperthermia. The final chapter in this section, **Core-Shell Magnetic Nanomaterials in Medical Diagnosis and Therapy,** is a contribution from the laboratories of Prof. Chun Li, The University of Texas M. D. Anderson Cancer Center, Houston, USA. This chapter provides a broad view on synthesis of magnetic nanomaterials and their potential applications in magnetic resonance imaging (MRI), hyperthermia-based treatment, and drug delivery.

The chapter eight, **Use of Magnetic Particles in Tissue Engineering**, is the only chapter in the third section on application of magnetic nanoparticles in tissue engineering. Professor Jon Dobson from Keele University, UK and University of Florida, Gainesville, Florida, USA presents most recent literature discussing tissue engineering applications with special emphasis on mechanotransduction and gene therapy approaches to tissue engineering using magnetic particles. Similarly the next section on environmental applications also has only one chapter covering synthesis, functionalization, and application of engineered magnetic nanoparticles in separation and detection of a wide variety of analytes from complex environmental and biological matrices. The chapter is a contribution from Dr. Marvin G. Warner and his team from Pacific Northwest National Laboratory, Richland, USA.

The final section, **Synthesis, Bio-functionalization and Characterization**, is the most important one in the book. For a life scientist who is not familiar with magnetic nanomaterials, it is great to find all the pertinent information about these materials in one book. This section has seven chapters covering all the important types of magnetic nanomaterials. The section begins with chapter 10 entitled **Magnetic Core-Polymer Shell Nanoparticles: Synthesis and Biomedical Applications** and is written by Prof. Koon Gee Neoh and his team from National University of Singapore, Singapore. As the title goes, this chapter discusses synthetic routes to magnetic core-polymer shell nanoparticles, with emphasis on the tailoring of the polymer shell to confer the nanoparticles with desired properties for biomedical applications. Next chapter, chapter 11, delineates fundamentals of magnetosomes

and their potential in biomedical applications centering on futuristic healthcare solutions. Contributed by Dr. Sarah S. Staniland, The University of Leeds, UK, this chapter provides the reader information on this new class of magnetic nanomaterials and how to exploit their properties for targeted drug delivery and hyperthermic treatments.

The next three chapters in the final section highlight anisotropic magnetic materials. The chapter 12, **Approaches to Synthesis and Characterization of Spherical and Anisotropic Metal Oxide Magnetic Nanomaterials,** is from Prof. Lorenza Suber's laboratories in Institute of Matter Structure-CNR, Rome, Italy. She has done a remarkable job in capturing the interplay between magnetic properties and chemical composition, structure and morphology in both spherical as well as anisotropic magnetic nanostructured iron oxides. The chapter 13 is by Prof. Charles M. Lukehart and his team from Vanderbilt University, Nashville, U.S.A. This chapter provides an overview of the latest developments in chemical synthesis of spherical and anisotropic transition metal alloy magnetic nanoparticles with an emphasis on how synthesis conditions impact magnetic nanoparticle's shape and composition. **Approaches to Bio-functionalization of Spherical & Anisotropic Iron Oxide Nanomaterials** is the title of the 14th chapter penned by Prof. Mary Beth Williams, The Pennsylvania State University, USA. In this chapter the most recent and important contributions to the chemical and biological functionalization of magnetic nanomaterials have been presented.

Among the characterization tools for magnetic nanomaterials, magnetic force microscopy (MFM) is one of the most important ones. Thanks to Prof. Gunjun Agarwal of Ohio State University, USA, the penultimate chapter in the book introduces the reader to fundamental concepts in MFM, and its application for characterization of magnetic nanoparticles (MNPs). The final and the 16th chapter is from the laboratories of Dr. Piramanayagam, Data Storage Institute, Singapore. In this chapter the authors provide a discussion on the magnetic properties and synthesis of cobalt-based nanoparticles. While toxicity issues have so far limited the application of cobalt-based nanomaterials in life sciences, efforts are currently underway to fine tune their structures in order to make them more biocompatible.

With sixteen authoritative chapters covering almost all the aspects of application of magnetic nanomaterials in life sciences, this close to 700 pages book is the first of its kind on this topic. I have no doubt that it will be extremely helpful for a broad spectrum of readers ranging from students, teachers, practitioners and followers of nanotechnologies.

Thank you for reading!

6th April 2009

Challa S.S.R.Kumar

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ISBN: 978-3-527-32154-4

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ISBN: 978-3-527-32154-4