Nanotechnologies for the Life Sciences

Edited by Challa Kumar

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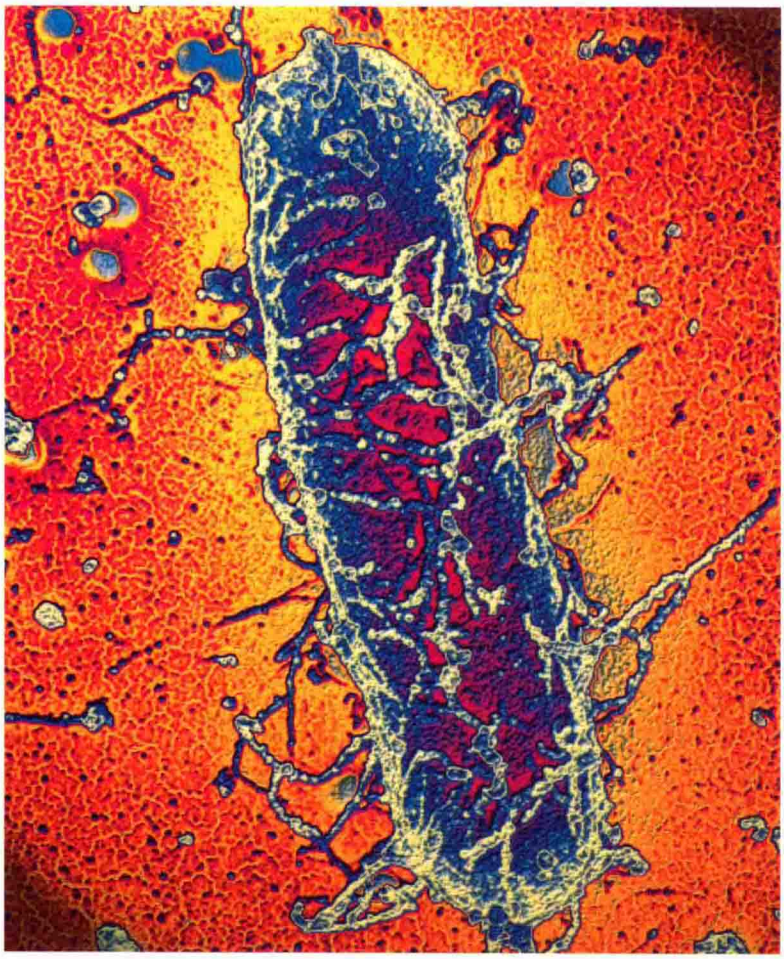
Biofunctionalization of Nanomaterials



NtLS

Nanotechnology of the Life Sciences
Volume 1

Biofunctionalization of Nanomaterials

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Preface

On behalf of a great team of nano researchers who have been part of this exciting project, I am pleased to introduce to the scientific community a comprehensive ten volume series on *Nanotechnologies for the Life Sciences* (*NtLS*), which is going to be a knowledge base of encyclopedic proportions for applications of nanotechnologies in biology, biotechnology and medicine. This is a unique series of books on an important facet of nanotechnology being presented by the nanotechnologists for the nanotechnologists. What you have in your hand is the first volume, *Biofunctionalization of Nanomaterials*, in this exciting series.

The first volume has eleven chapters covering various aspects and techniques for functionalization of different nanomaterials with variety of biomolecules. The book begins with an exciting chapter by *Michael J. Murcia* and *Christoph A. Naumann* from the Indiana University-Purdue University, USA, which provides an overview of developments in *biofunctionalization and biocompatible coating of fluorescent nanoparticles*. There is an explosion of knowledge on carbon nanotubes, long, thin cylinders of carbon, discovered in 1991 by S. Iijima and the focus of their practical applications have been due to their unique physical properties such as optical, electrical, thermal, elastic behavior and so on. However, once it was demonstrated that it is possible to functionalize them with biomolecules, there has been a great interest amongst nanoresearchers to investigate their potential in life sciences. The University of California team of researchers from Riverside, USA, *Elena Bekyarova*, *Robert C. Haddon* and *Vladimir Parpura*, has done a remarkable job in capturing the up-to-date information in their chapter entitled *biofunctionalization of carbon nanotubes*. Metallic and metal oxide nanoparticles are well studied and their extraordinary physical and chemical properties make them useful in variety of applications. Not surprisingly, a great deal of research work was carried out to make them not only biocompatible, but also attach biological molecules in order to extend their applications into the life sciences. Four chapters have been dedicated to capture this information and the authors of these four chapters – 3, 4, 6 and 8 – have done a thorough job in comprehensively providing the information on biofunctionalization aspects of a wide variety of metallic/metal oxide nanoparticles. *Yong Guo* from the Southern Illinois University, Carbondale, USA, dealt with *biofunctionalization of magnetic nanoparticles*. *Ming Zheng* and *Xueying Huang* from DuPont Central Research and Development, USA, described some unique aspects

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of *biofunctionalization of gold nanoparticles*. *Grit Festag, Uwe Klenz, Thomas Henkel, Andrea Csllki* and *Wolfgang Fritzsche* from the Institute for Physical High Technology, Jena, Germany, in a very unique fashion reviewed several approaches towards *biofunctionalization of metallic nanoparticles* for biosensing. In addition to the completely chemical based approach for biofunctionalization, *Raphael Levy* and *Chris Doty* from the University of Liverpool, UK, provided a state-of-the-art review on the use of biomolecules themselves for stabilization of metallic nanomaterials in the chapter entitled *stabilization and biofunctionalization of metallic nanoparticles: the peptide route*.

In addition to metallic nanoparticles, polymeric nanoparticles have been widely investigated for their applications in life sciences primarily in the area of drug delivery. It is again very important for the polymeric nanoparticles to be either biocompatible or biofunctionalized in order to be suitable for life science applications. *Biofunctionalization of phospholipid polymeric nanoparticles* by *Junji Watanabe, Jongwon Park, Tornomi Ito, Madoku Takai*, and *Kazuhiko Ishihara* from the University of Tokyo, Japan, provides information, based on their own research experience, on phospholipid polymeric nanoparticles and their biofunctionalization. The chapter *magnetic core conducting polymer shell nanocomposites for DNA attachment und hybridization* contributed by *Jean-Paul Lellouche* of Bar-llan University, Israel, presents an interesting perspective towards biofunctionalization of magnetic core polymer shell nanomaterials. The researchers from the Northeastern University, Boston, USA, – *Sushama Kommareddy, Dinesh B. Shenoy* and *Mansoor M. Amiji* – brought out comprehensive information on *gelatin nanoparticles and their biofunctionalization*.

Amongst all the biomolecules, proteins are unique and their conjugation to nanomaterials provides a very broad base for life science researchers. The research group from Clemson University, USA, led by *Ya-Ping Sun* with *Mohammed J. Meziani* and *Yi Lin* brought out an excellent in-depth analysis of various conjugation approaches to bind proteins to variety of nanomaterials in their chapter entitled *conjugation of nanomaterials with proteins*. In this chapter, they provide an overview of current and emerging approaches in the coupling of metal and semiconductor nanostructures with proteins and their assemblies into different architectures followed by approaches to conjugation of carbon nanotubes with proteins and the mechanistic issues involved with nanotube-protein interactions. The chapter entitled *folate-linked lipid based nunoparticles for tumor-targeted gene therapy* by *Yoshiyuki Hattori* and *Yoshie Maitani*, Institute of Medicinal Chemistry, Japan, contains a review of literature on folate-linked liposomes and nanoparticles, and show the effectiveness of folate-linked lipid-based nanoparticles as a vector for DNA transfection and for suicide gene therapy to treat human nasopharyngeal and prostate tumors.

I am very grateful to all the authors who have shared my enthusiasm and vision by contributing high quality manuscripts, on time, keeping in tune with the original design and theme of not only this particular volume but also the whole series. You will not be having this book in your hand but for their dedication, perseverance and sacrifice. I am thankful to my employer, the Center for Advanced Micro-

structures and Devices (CAMD), and especially to my superior, Prof. Josef Hormes, Director of CAMD, who has been supporting me in all my creative ventures. Without this backing it would be impossible to make this venture of such magnitude a reality. No words can express the understanding of my wife, Suma, in allowing me to make my office a second home and bearing with my spending innumerable number of hours in front of the computer at home. My little daughter, Saakshi, has been the source of joy and inspiration in bringing forth my intellectual creativity. My families, friends and mentors are integral part of my existence and continue to shape my life and I am indebted to them. While it would be impossible to thank everyone individually in this preface, I must make a special mention of the support from Wiley VCH publishers in general and the publishing editor, Dr. Martin Ottmar, in particular, who has been working closely with me to ensure this project becomes a reality. I am grateful for this support.

I also would like to take this opportunity to provide few glimpses of the rest of the nine volumes in this series. As I write this preface, I am pleased to let you know that the second and the third volumes are in press and will be published shortly after volume one. The second volume, *Biological and Pharmaceutical Nanomaterials*, provides information on variety of nanomaterials from natural sources and also those that are particularly relevant from pharmaceutical stand point of view. As life scientists learn about nanotechnologies, they also need to be familiarized with tools and techniques for characterization and the third volume, *Nanosystem Characterization Tools in the Life Sciences*, brings forth the required information. The rest of the volumes in this series deal in general with sensing, controlled release, devices, engineering, biomimetic approaches that are relevant to life sciences. These volumes are currently under preparation and I hope to present them to you as soon as possible.

As I stop for moment and ponder at the amount of information that the dedicated team of scientists have been compiling for this ten volume series, I can't help but become philosophical. Scientific endeavors by their very nature, while providing answers to several questions, create more and more questions. If one examines the growth of various scientific disciplines one would realize that while we made tremendous progress in scientific achievements, we continue to be puzzled by several unanswered questions in addition to several more new ones popping up every day. In the words of one philosopher, "the measure of our intellectual maturity is our capacity to feel less and less satisfied with our answers to better problems." One could say that the progress in science is directly proportional to the number of unsolved problems. It is pertinent to remember what Einstein said once, "We can't solve problems by using the same kind of thinking we used when we created them." What we need as scientists is lateral thinking. In order for developing lateral thinking one needs to comprehend the existing knowledge and develop the ability to connect seemingly unconnected points in the web of knowledge.

Nanoscience and nanotechnology is beginning to gain respectable place in this web of knowledge that we scientists have been creating. This new scientific discipline is being touted as the greatest revolution in the history of mankind and is

anticipated to positively affect every facet of our existence. It is anticipated to improve quality of our life in leaps and bounds. However, Nanotechnology's greatest gift to mankind, in my view, is its ability to promote lateral thinking amongst not only scientists but all those who are associated with this new approach to problem solving. This is what I would like to call "nano vision or nano thinking". It is the ability to think small while thinking big and to connect small and big at the same time." The followers of "nano thinking", so called "nano thinkers", are growing day by day and their presence is beginning to be felt strongly in the field of life sciences. It is my endeavor to be a catalyst in inculcating this new thinking by providing a multi-pronged base of knowledge in nanotechnologies for the life sciences. The ten volume series *NtLS* is anticipated to be the solid foundation for all those who are interested in applying "nano thinking" in life sciences. I am leaving the book in your hands and take your leave sharing a quotation from one of the greatest thinkers from the United States of America, Oliver Wendell Holmes, who said "Man's mind, once stretched by a new idea, never regains its original dimensions." It is my hope that this book series will help in stretching the limits of thinking in all those who come in contact with it.

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