

# Surface Modification of Nanoparticles for Targeted Drug Delivery

Yashwant V Pathak

Editor

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*To the loving memories of my parents and  
Param Pujaniya Dr. Keshav Baliram  
Hedgewar and Mananiya Madhukar Limaye  
who gave a proper direction; my wife Seema,  
who gave a positive meaning; and my son  
Sarvadaman who gave a golden lining to my  
life.*

# Foreword: Nanobiotechnology Convergence for Drug Delivery

Convergence of knowledge offers a new universe of discovery, innovation, and applications. Nanoscale science and engineering field has emerged at the confluence of many disciplines and now is converging with biotechnology, medicine, digital revolution, cognitive sciences, and artificial intelligence. “Converging technologies for improving human performance” ([http://www.wtec.org/ConvergingTechnologies/Report/NBIC\\_report.pdf](http://www.wtec.org/ConvergingTechnologies/Report/NBIC_report.pdf), 2003) and “Nanotechnology convergence with modern biology and medicine” (Current Opinion in Biotechnology, 2003) have been recognized as most challenging and promising domains in the field from the first years of National Nanotechnology Initiative ([www.nano.gov](http://www.nano.gov)). Now, in 2018, nanobiotechnology and nanomedicine are leading research areas of nanotechnology with large economic and societal implications worldwide.

Targeted drug delivery using nanoparticles has attracted a broad interest from the scientists as well as clinicians as an effective treatment with limited secondary effects. Surface of nanoparticles is key in the recognition of the target and efficient delivery of the drug. Nanoparticulate drug delivery systems are especially promising when using natural and synthetic polymers. Despite significant advances, there are still a lot of open questions and barriers in the safe and efficient implementation of such drug carriers.

The surface characteristics of the nanoparticles play an important role in developing efficient delivery systems, in many cases even more important than the nanoparticle core of itself. Nanoparticles for therapeutic applications should be biocompatible, nontoxic, and non-detective by immune systems and induce few side effects. Typically, the size of nanoparticles is defined between 1 and 100 nm, domain that may be extended as a function of the presence of nanoscale properties and phenomena. It was found that if the surface of the nanoparticles is modified by hydrophilic polymer or other means, the respective particles remain in the circulation for longer time and can avoid uptake by reticuloendothelial system. They finally can reach the site of action of specific target organs, tissues, or cells. Many scientists have found that the functionalized nanoparticles with specific ligands which have high affinity to the disease site can be used as site-specific or targeted drug delivery systems. The functional ligand attached to the surface of the nanoparticles can guide the drug

carrier to the desired site such as specific tumor in relation to cancer. The importance of surface modification of nanoparticles for better therapeutic efficacy has been demonstrated in increasing the particle interaction with the targeted tissues and has become a highly promising strategy.

The editor of this volume, Yashwant Pathak, has selected a diverse and representative collection of 25 contributions written by leading authors and scientists in the field of surface modification of nanoparticles. It covers understanding of the surface modification of nanoparticles and its use in the targeted drug delivery, as well as functionalization of lipid nanoparticles for site-specific drug delivery systems. Several chapters are focused on disease-specific targeting such cancer, lung cancer, intracellular infections, and surface modification of liposomes and brain targeting.

The volume presents a diverse collection of opinions and ideas expressed by leading scientists, engineers, medical researchers, and educators in the field. The contributions integrate various perspectives and underline the importance of nanobiomedical convergence. I encourage the readers to explore the interesting points of view, methods, and trends assembled in this well-documented collection of research works.

National Science Foundation, Alexandria, VA, USA

Mihail C. Roco

National Nanotechnology Initiative, Alexandria, VA, USA

# Preface

Nanotechnology is a very broad interdisciplinary area of science leading to vast areas of research and applications, thousands of new product development and improvement of existing products, and a significant intellectual property development and industrial activity. Nanoparticles are the end product of a wide range of chemical, physical, or magnetic interactions and biological processes leading to very small particles mostly in submicron range and with new definitions by FDA within the range of 1–100 nm.

Nanoparticles provide many advantages especially when used for medical applications. Particle size and surface characteristics can be easily changed to suit the requirements for the delivery of the drugs. The drug release can be controlled and localized and can be easily transported to the site of action. Drugs which are highly hydrophobic in nature can be modified to hydrophilic properties and hydrophilic drug can be made hydrophobic as per the needs and applications. Site-specific targeting can be achieved using appropriate antibodies and targeting ligands to the surface of the nanoparticles. Best part of the nanoparticle application is it can be used for a variety of routes of administration such as intravenous, nasal, oral, and transdermal and so on.

There are limitations in the applications of nano-materials because of their restricted interactions with different solvents and body constituents and compartments when delivered in the living body. Surface modification of nanoparticles can improve the interactive properties of the nano-materials to suit their applications in different scenario.

Surface properties of the nano-materials decide how it will interact with other materials as well as in body systems when delivered in vivo. The main purpose of surface modification of nanoparticles based on its application is to offer hydrophilic, hydrophobic, conductive, or anticorrosive properties to the nanoparticles for specific applications.

Another possibility is to develop multifunctional hybrid coating to the nanoparticles so that these can be used as targeted drug delivery systems. Functionalized nanoparticles have applications in many different areas including engineering, biomedical, nanomedicine, and so on.

Functionalization of nanoparticles also helps in stabilizing the nanoparticles and provides specific size and shape and receptor affinity. It can also prevent the aggregation of colloidal nanocrystals and create many sites on the nano-surface to attach necessary ligands to target the nanoparticles.

This book consists of several chapters addressing various aspects of surface modification of nanoparticles. Chapters 1–4 discuss about understanding the surface characteristics of nanoparticles, surface modification for targeted drug delivery, surface modification of PLGA nanoparticles, and functionalized lipid nanoparticles. Chapters 5–8 discuss various ways of surface modifications for cancer application of nanoparticles using appropriate techniques. Remaining chapters cover various aspects of nanoparticle surface modification for versatile application in targeting the drug to the site of action.

Overall, I expect that this book will be a very good reference source for academicians, industry experts, and more importantly the students of nanomedicine. This book can also be used as a resource for teaching the graduate classes where nanotechnology applications in medicine are discussed.

This book was an effort of many scientists and chapter authors who have submitted the quality work in record time so we could get the book out in very short time. My sincere thanks to all the authors who have contributed to this book.

The Springer group has always been supportive of new projects especially Ms. Carolyn Spenser who has been very appreciative of my efforts to come up with new ideas and book projects. Many people from Springer have worked very hard to make this project happen, and I have no words to express my feelings for their hard work to get the book out.

My university and our Dean Kevin Sneed of the College of Pharmacy, at the University of South Florida, and my colleagues here are very supportive of my adventures in book publishing.

Without the support of my family nothing can happen, as this work is in a way an encroachment on their time, but they have been always very considerate toward my academic activities.

I think we tried our level best to make this a very good resource, but inadvertently if any mistakes left unattended, kindly do inform me immediately so I will be able to update in the second edition.

Tampa, FL, USA

Yashwant V Pathak



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