

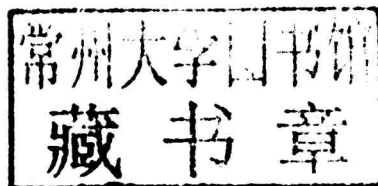
Edited by
Karthikeyan Subramani
Waqar Ahmed
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NANOBIOMATERIALS IN CLINICAL DENTISTRY

Micro & Nano Technologies Series

Nanobiomaterials in Clinical Dentistry

Edited by
Karthikeyan Subramani
Waqar Ahmed
James K. Hartsfield, Jr.



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Nanobiomaterials in Clinical Dentistry

Every good and perfect gift is from above, coming down from The Almighty.

Thanks be to God for his blessings and this wonderful life!

I would like to dedicate this book to my parents for making me who I am today. This is a special moment to remember and thank all my teachers, research mentors, and professors who have been the guiding light throughout my career. A very special thanks to Prof. G. Thomas Kluemper, Prof. Sarandeep Huja, and Prof. James K. Hartsfield Jr. for being a source of immense motivation and moral support.

Karthikeyan Subramani

I would like to dedicate this book to my father, Muhammed Mukhtar, and mother, Shamim Anwar, for their unconditional love and guidance, and to my family—Rihana, Aisha, Imran, Omar, Usman, and Adam—who have provided an environment of fun and happiness for my work to flourish. Thank you to the most beautiful little girl in the whole wide world, my granddaughter Zoya, for coming into my life and lighting it up with joy and happiness.

Waqar Ahmed

I would like to dedicate this book to my parents Jim and Shirley, to my loving wife Karen, our son Kennedy of whom we are very proud, and our grandson Clayton. Special thanks to all my teachers, faculty, students, and patients, from whom I continue to learn.

James K. Hartsfield Jr.

Foreword by Professor C.N.R. Rao

I am glad to write a foreword for this book which, for the first time, focuses on clinical applications of nanotechnology and nanobiomaterials in dentistry.

At a fundamental level, nanotechnology helps to manipulate individual atoms and molecules to produce novel structures with unique properties or improved properties. It involves the production and applications of physical, chemical, and biological systems and materials at a size scale ranging 1–100 nm. Even though nanotechnology was first introduced over half a century ago, its progress has been slow, but in the last decade, nanotechnology has caught the imagination of scientists and the general public. Nanotechnology offers us the ability to design materials with totally new desirable characteristics. Nanotechnology can be approached in two ways: “top-down” and “bottom-up” approaches. The “top-down” approach has resulted in remarkable breakthroughs. This approach has been responsible for the rapid development of the semiconductor industry. Future impact of this approach will depend on how quickly we reach the limits in lithographic technologies. Much progress has been made in integrating nanostructured materials into larger systems. The “bottom-up” approach refers to the construction of macromolecular structures from atoms or molecules that self-assemble to form macroscopic structures. The “bottom-up” approach represents “molecular nanotechnology.” The field of nanotechnology is diverse, involving the need for a good understanding of biology, chemistry, physics, and mathematics. Extensive research is being carried out worldwide to understand the advantages and scientific limitations of nanotechnology and its applications to a wide range of disciplines from materials science and biomedical research to space research.

Much has been written on the fundamental aspects of nanotechnology. This book is refreshing because it deals with recent studies and techniques used in nanotechnology to produce newer biomaterials for practical applications in clinical dentistry. Even though progress in the application of nanotechnology in biological systems and medicine has been much slower, it is evident that the “bottom-up” approach is potentially far more as we develop the ability to control and manipulate atoms and molecules more precisely. Nature uses the bottom-up approach and builds diverse structures in biological systems. The complexity and functionality of these structures is truly amazing. If we can control in fine detail the way in which these structures can be produced in the same way as nature does, remarkable and rapid advances can be made in the field of medicine and dentistry.

In recent years, there has been an explosive growth in the application of nanotechnology in medicine and dentistry. New drug delivery systems based on nanocarriers are being developed for treating diseases such as cancer, asthma, and diabetes. These developments are likely to accelerate in the future. The development of numerous new products may have a considerable economic impact.

There is intense research activity in the nanotechnology in dentistry with numerous publications appearing. Last year Subramani and Ahmed put together the first comprehensive text, *Emerging Nanotechnologies in Dentistry*. This was useful and timely for both experts and novices. However, developments in the applications of dentistry have been so rapid that they decided to work on this text along with Professor Hartsfield.

This book brings together recognized experts from across the globe to focus on clinical applications of nanobiomaterials in a comprehensive way with 24 chapters. The authors come from a number of countries including the United States, United Kingdom, Australia, Canada, Israel, Mexico, Germany, Brazil, Jordan, China, Taiwan, Korea, Japan, Oman, Hong Kong, Czech Republic, and Iran and represent many laboratories in both academia and industry which are in the forefront of the subject. Since no single person can be an expert in this vast field of nanotechnology, this book provides information that enables everyone to learn something valuable and interesting. It is written in a way that both experts and novices can benefit.

This comprehensive book will be a valuable addition as a textbook in university libraries and laboratories and as a reference source for members of the scientific, industrial, and clinical community.

The editors, Subramani, Ahmed, and Hartsfield, should be congratulated for bringing the experts together to produce a timely, useful, and comprehensive text on nanobiomaterials in clinical dentistry. I hope that readers will enjoy the book and find it useful.

Professor C.N.R. Rao

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Foreword by Professor Peixuan Guo

I am pleased to be writing a foreword for this book as nanotechnology is one of the most exciting and dynamic fields to emerge over the last century. Considerable investment, effort, and time have been spent on fundamental research and new applications of nanotechnology. New insights have emerged from scientists from multiple disciplines working together. Newer applications have been developed that have had a major impact in several industries such as semiconductors, aerospace, automotive, biomedical field, and cosmetics. Recently research and development has intensified in the field of medical nanotechnology where it is being used for drug delivery systems, medical implants, and dental and pharmaceutical products. Major diseases such as cancer, diabetes, and asthma are already being treated using nanotechnology for targeted controlled drug delivery systems. The “bottom-up” approach used by nature is being exploited and once we can precisely control the behavior of atoms and molecules, we will be able to make a staggering array of new products for a far wider range of applications.

Nanotechnology has been commonly defined as the manipulation and control of materials at the atomic and molecular level at a scale between 10 and 100 nm. This is an interesting scale because at this level the properties of materials are being defined and interesting phenomena occur. Japanese researchers are looking at it from a commercial perspective much more than the West. They define nanotechnology as a technology that will produce quantum leaps in producing new products and generating a great deal of wealth and contributing to a global economy. China is investing huge resources and efforts into nanotechnology, and it is widely agreed that this field is expected to have a massive impact on commercial applications in the near future.

It appears that Nobel laureate Richard P. Feynman's vision of nanotechnology outlined in his classic science lecture “There is Plenty of Room at the Bottom” in 1959 is finally being realized. He envisioned nanorobots and nanomachines that can do amazing things inside the body being built atom by atom. He predicted new materials having properties never seen before being created. This was years before the revolutionary “microchip” was developed. You can see how this has impacted our society by walking into any electronics store anywhere in the world or by almost everyone carrying mobile phones, computers and laptops, and the whole range of electronic equipment in homes and in cars. Nanoelectronics is huge commercially.

The academic importance of nanotechnology has been realised and acknowledged by several scientists winning Nobel prizes after Feynman for their work on nanotechnology notably Robert F. Curl Jr., Sir Harold W. Kroto, and Richard E. Smalley for the discovery of C_{60} in 1996 and much more recently in Physics 2010 to Andre Geim and Konstantin Novoselov for groundbreaking experiments regarding the two-dimensional material graphene.

Even though nanotechnology is already having a huge impact commercially, I feel that we have only scratched the surface and there is a vast array of new applications and products that will be exploiting this dynamic field. In the near future almost every product on the market will be making use of nanotechnology in one form or another. For example, research into nanotechnology in medicine and dentistry has exploded with a large number of research papers appearing from all over the

world. In 2012, Karthikeyan and Ahmed published the first comprehensive book on “Emerging nanotechnologies in dentistry.” The pace of activity in nanotechnology in dentistry is so rapid that this new book became necessary. It focuses on “Nanobiomaterials in clinical dentistry.” Karthikeyan, Ahmed, and Hartsfield have brought together a group of international experts from multiple backgrounds to explore a range of topics. This book contains 24 comprehensive chapters written in the unique style of the authors. This book will be useful to dental surgeons, specialists, engineers, scientists, physicists, chemists, biologists, materials scientists, and decision and policy makers at undergraduate, post graduate, and specialist levels. Since no one individual can be an expert in all aspects of nanotechnology and its applications, this book will be useful for anyone with an interest in the field. I hope that you find this book stimulating, enjoyable, and useful, and that it ignites further interest in this field.

Professor Peixuan Guo

*William Farish Endowed Chair in Nanobiotechnology, Director of Nanobiotechnology Center,
College of Pharmacy, University of Kentucky, Lexington, KY, USA*

Acknowledgments

There has been an explosion of activity in the last few years in the research and development of nanobiomaterials for clinical applications in dentistry. Once again, as with our first book, we have had the pleasure and privilege of working with world-class experts who wrote the high-quality chapters included in this book. We are grateful for their dedication and hard work in writing the chapters in a timely manner. We would like to extend our thanks and appreciation to the following authors for their valuable time and hard work: Abdelbary Elhissi, Seyed Shahabeddin Mirsasaani, Mehran Hemati, Ehsan Sadeghian Dehkord, Golnaz Talebian Yazdi, Danesh Arshadi Poshtiri, Mrinal Bhattacharya, Wook-Jin Seong, Shin-Woo Ha, M. Neale Weitzmann, George R. Beck Jr., Abdul Samad Khan, Maria Khan, Ihtesham Ur Rehman, Hockin H. K. Xu, Lei Cheng, Ke Zhang, Mary Anne S. Melo, Michael D. Weir, Joseph M. Antonucci, Nancy J. Lin, Sheng Lin-Gibson, Laurence C. Chow, Xuedong Zhou, M. Nassif, F. El Askary, M. Hannig, C. Hannig, D.B. Barbosa, D.R. Monteiro, A.S. Takamyia, E.R. Camargo, A.M. Agostinho, A.C.B. Delbem, J.P. Pessan, R.P. Allaker, Sarandeep Huja, G. Thomas Klumper, Lorri Morford, Tarek El-Bialy, Meir Redlich, Reshef Tenne, Ki Young Nam, Chul Jae Lee, Sandhra M. Carvalho, Agda A. R. Oliveira, Elke M. F. Lemos, Marivalda M. Pereira, Sandrine Lavenus, Julie Rozé, Guy Louarn, Pierre Layrolle, Kaifu Huo, Lingzhou Zhao, Paul K. Chu, Qing Cai, Reji T. Mathew, Xiaoping Yang, R. Dziak, K. Mohan, B. Almaghrabi, Y. Park, Shengbin Huang, Tingting Wu, Haiyang Yu, Sami Chogle, Bassam Kinaia, Harold Goodis, Chamindie Punyadeera, Paul D. Slowey, Elizabeth Piñón-Segundo, Néstor Mendoza-Muñoz, David Quintanar-Guerrero, Yashwant Pathak, and Charles Preuss.

We were fortunate to get Forewords for this book written by Prof. C. N. R. Rao and Prof. Peixuan Guo.

We are thankful to the entire team of Elsevier for bringing this book in its finest form and quality.

We hope that this book inspires our readers to explore more into the science of nanobiomaterials and their clinical application in dentistry and that they find this work useful.

Karthikeyan Subramani, Waqar Ahmed and James K. Hartsfield, Jr.

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