

Preface

Nanotechnology involves the manipulation of matter on atomic and molecular scales. This technology combines nanosized materials in order to create entirely new products ranging from computers to micromachines and includes even the quantum level operation of materials. The structural control of materials on the nanometer scale can lead to the realization of new material characteristics that are totally different from those realized by conventional methods, and it is expected to result in technological innovations in a variety of materials including metals, semiconductors, ceramics, and organic materials.

The application of nanotechnology in advanced and high-tech medical care is known as nanomedicine. It covers a wide range of scientific and technological fields ranging from fundamental aspects related to the creation of new materials to actual applications in clinical medicine. The term nanomedicine was first mentioned in literature in 1990 by Drexler. The National Nanotechnology Initiative in the USA (2000) listed improved healthcare as one of the implications of nanotechnology, and the European Technology Platform “Nanomedicine” started in 2005. In this decade, more than 300 review articles have been published on nanomedicine. At present, nanomedicine is advocated to have the following promising applications: (1) the development of medication using nanosized devices including nanospheres, nanomicelles, nanocapsules, and nanofibers, (2) nano-order regulation of the interface between materials and cells/tissues, and (3) nanoimaging, which includes single-molecule imaging, using optical systems in particular, as well as whole body imaging at a very high resolution.

Nanosized objects perform various functions in the biomedical field. In the human body, nanosized particulate substances behave very differently from larger particles. In 1986, Maeda et al. found that the stained albumin, having a size of several nanometers, naturally accumulates in the region of cancerous tissues, which is now well known as the enhanced permeability and retention (EPR) effect. Many studies in the field of nanoparticles are based on this finding. Another application of nanoparticles is the delivery system using various polyplexes that are composed of carrier molecules and plasmid DNA or nucleic acid drugs such as antisenses and siRNA. In addition, nanofibers are mainly used for biodegradable scaffolds in tissue

engineering because of their good cell adhesion properties. The second area is the nanoscale regulation of the interface between materials and cells/tissues. Recently, regulation of the microenvironment for stem cells, referred to as stem cell niches, has attracted much attention. The elasticity of matrices, nanopatterning of cellular adhesion machinery, and mobility of the interfaces are known to be very important “cues” for cell functions. The third area is nanoimaging. Quantum dots, which are strong tools for in vivo imaging, are promising and useful inorganic fluorophores, and they are one of the most important nanomaterials. Other modalities in molecular imaging, such as magnetic resonance imaging using super-paramagnetic iron oxide and microcomputed tomography, have also improved significantly.

Polymers and polymeric materials are important organic materials and have played a very important role in the research and development of nanomedicines. The polymeric materials that are useful in this field can be classified by their chemical nature as follows: (1) water-soluble (compatible) synthetic polymers, (2) polyelectrolytes and polyion complexes, (3) natural polymers, and (4) biodegradable synthetic polymers. On the other hand, higher-order structures and morphology of the used materials such as nanowires, particles, vesicles, capsules, shells, gels, cages, skeletons, and film membranes can also be considered as key issues. For instance, tissue engineering requires two- or three-dimensional structures that are made from biodegradable polymers, and the synthesis of nanoparticles requires the self-assembling nature of polymers or pre-polymers.

Several review articles focusing on the contribution of polymeric materials to nanomedicine have been published. This volume of “Polymers in Nanomedicine” in the series *Advances in Polymer Science* will be one of the pioneering review books dedicated to the study of polymer science for medical nanotechnology.

In this book, we consider the importance of the chemical nature of polymeric materials and target the three major themes leading to their actual application in nanomedicines. With regard to polymeric delivery systems, specific nucleic acids and vaccine–antigen delivery systems are reviewed. Furthermore, general drug delivery systems using biodegradable synthetic polymers and poly(ethylene glycol)-modified drugs are discussed. The understanding and control of biological responses against artificial materials are important for the development of medical devices and tissue engineering therapies. The control of cell adhesion, modification of cell surfaces, and the development of biopolymer scaffolds are reviewed in the context of tissue engineering. The last and the most important area addressed in this book concerns imaging and therapeutic modalities.

The editors believe that incorporating contributions that cover topics ranging from molecular design to tissue architecture into one book will prove to be helpful and promote research in this rapidly developing area. We would like to thank all the contributing authors and colleagues assigned to work with us during the editing process.

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