PREFACE

Over the past forty years the field of Biomaterials Science and Engineering has grown from a small research area of no more than twenty researchers worldwide, to a robust discipline that has become a cornerstone of the field of Biomedical Engineering. During this time period, the field of biomaterials has found a welcome home in academic chemical engineering departments and in companies working with artificial organs, medical devices, and pharmaceutical formulations. The contributions of chemical engineers to the definition and the growth of the field have been important and at times seminal. It was therefore only natural for us to edit a volume that would highlight some of the major contributions of the chemical engineering world to biomaterials science and engineering.

In the mid 1960s biomaterials science was still at its infancy. The development of biomaterials was an evolving process. As Robert Langer of MIT and I indicated in a recent article (AIChE Journal, 49, 2990 (2003)), many biomaterials in clinical use were not originally designed as such but were off-the-shelf materials that clinicians found useful in solving a problem. Thus, dialysis tubing was originally made of cellulose acetate, a commodity plastic. The polymers initially used in vascular grafts, such as Dacron, were derived from textiles. The materials used for artificial hearts were originally based on commercial-grade polyurethanes. These materials allowed serious medical problems to be addressed. Yet, they also introduced complications. Dialysis tubing would activate platelets and the complement system. Dacron-based vascular grafts could only be used if their diameter exceeded about 6 mm. Otherwise occlusion could occur because of biological reactions at the blood–material and tissue–material interfaces. Blood–materials interactions could also lead to clot formation in an artificial heart, with the subsequent possibility of stroke and other complications.

In the last few years, novel synthetic techniques have been used to impart desirable chemical, physical, and biological properties to biomaterials. Materials have been synthesized either directly, so that desirable chain segments or functional groups are built into the material, or indirectly, by chemical modification of existing structures to add desirable segments or functional groups. It is possible to produce polymers containing specific hydrophilic or hydrophobic entities, biodegradable repeating units, or multifunctional structures that can become points for three-dimensional expansion of networks. Another synthetic approach involves genetic engineering for the preparation of artificial proteins of uniform structure. This enables the synthesis of periodic polypeptides that form well-defined lamellar crystals, polypeptides containing non-natural amino acids, and monodisperse helical rods. Important issues to be addressed include immunogenicity and purification from contaminants during large-scale production. If techniques were developed to produce polymers with the use of non-amide backbones, the versatility of this approach would be extended.

In this volume, we have collected a series of important critical articles on the present and future of biomaterials science as viewed by some of the leading chemical engineers of the field. It was not our intention to cover all aspects of biomaterials science but rather to unify certain synthetic, structural, and biological topics, and to point out the significant contributions of chemical engineers to the field. It is not a coincidence that this book is part of the well-known series of *Advances in Chemical Engineering*.

As I was commissioning the various chapters included in this volume, I wanted to highlight the main directions of this field: (i) novel methods of synthesis; (ii) advanced design; (iii) advanced characterization methods; (iv) better understanding of biomaterials/tissue interactions; and (v) a wealth of applications. Concerning this last point, it must be noted that just 25 years ago, the term biomaterials referred to materials in contact with the body but was restricted to materials for artificial organs and extracorporeal devices. The "explosion" of the fields of drug delivery and tissue engineering has led to new function and applications of biomaterials. The use of biomaterials in nanoscale technology requires added appreciation for the importance of chemical engineering principles in biomaterials science and engineering.

After a masterful introduction of the field and its new directions by Michael Sefton of the University of Toronto, Kristi Anseth of the University of Colorado offers a critical analysis of cell–materials interaction problems with emphasis on the nature of cell adhesions, adhesion ligands, and surface chemistry.

Surya Mallapragada of Iowa State University addresses questions related to the use of biomaterials in tissue engineering and nerve regeneration, while Anthony Lowman of Drexel University offers a detailed structural analysis of biological hydrogels used in biomaterials and drug delivery applications. Antonios Mikos of Rice University offers a critical review of biomaterials for gene therapy, whereas Balaji Narasimhan of Iowa State University pursues the question of biodegradability in materials, especially those used as drug delivery carriers.

As you read this book, I hope you will appreciate the infinite possibilities of biomaterials science in solving important medical problems.

If this book can influence young engineers and scientists to pursue a career in biomaterials science and engineering, it will have made a lasting impact. I want to thank Michael Sefton for coming to this project with an open mind and adding his advice as a co-editor and author of the first chapter. And I am indebted to the two early chemical engineering giants of the field, Edward Merrill of MIT and Alan Hoffman of the University of Washington, for having taken the first giant leaps in the tortuous road that is "biomaterials".

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