NANO- AND BIOCOMPOSITES

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Preface

Advanced polymer–based nanocomposite materials have gained in popularity for a wide range of engineering applications, with improvement of virtually all types of products and commercialization of products that exploit their unique mechanical, thermal, and electrical properties. However, these properties present new challenges in understanding, predicting, and managing potential adverse effects, such as toxicity and the impact of exposure on human lives and the environment. Thus, widespread applications of nanomaterials have enormous potential to both positively and negatively affect humans and the environment. The federal budget emphasizes these implications, and it is expected that the total annual budget for various sectors from the National Nanotechnology Initiatives will increase substantially in coming years.

In the past few years of research, biological applications of nanostructural resins have been conducted in *in vitro* and *in vivo* environments. The evaluation involved how the resins can bond for biocompatibility to bone for repair after breaking, to teeth for filling, to various types of tissues for wound healing, and so on. Natural and synthetic polymeric materials have been found to be suitable for tissue engineering applications. For an example, silk (like cocoon or spider) fiber, and biodegradable polymer biocomposites have been used for tissue engineering (scaffolding) for bone repair. Many researchers have also demonstrated the use of nanostructural materials as reinforcements, such as nano-apatite, nanoclay, and nanofibers (polymer-based or carbon nanotubes) to enhance the mechanical properties and thermal stability of biocompatible polymers for artificial joints and scaffolding. Tissue engineering is one such aspect that utilizes both engineering and life science disciplines to either maintain existing tissue structures or enable tissue growth. Furthermore, tissue-engineered organs can be used in testing procedures, reducing or eliminating the need for animal subjects. Nano-biotechnology is an interdisciplinary field resulting from the interfaces between biotechnology, materials science, and nanotechnology.

This book includes works from different aspects of nanomaterial and biomaterial technologies to contribute to the advanced materials and biomedical industries. In fact, nano- and biotechnology are the two foremost research areas that govern the majority of research in the science and engineering fields.

Included in this book are 12 chapters organized into two main sections: "Nanostructured Polymer Composites" and "Nano-Bio Composites." All contributing authors have been working in these fields for many years. The works addressed in this book will give important guidelines and new insights for readers and will stimulate investigation of anticipated research.

In the first section, a basic understanding of nanomaterial and nanocomposite research will be provided, to give fundamental knowledge on how these nanostructured fillers strengthen polymer-based materials. The second section will emphasize the use of nanostructured fillers and natural fiber to reinforce biodegradable and biocompatible polymers to form new types of biomedical and bioengineered composites for biomedical applications. The last chapter will focus on the toxicity impact of using nanostructured materials, which is an important topic that most researchers have ignored in their research in the past years.

Here I would like to give my sincere thanks to all contributors to this book, as the time and effort involved to make such a comprehensive work as this is enormous. The great help given by the publisher, CRC Press/Taylor & Francis Group, is also important to bring the book finally to the market. We believe that this book will give many researchers, scientists, and academics important information in the fields of nanomaterials, biomaterials, and the up-and-coming topic—nano-biomaterials research.

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Editors

Alan K.T. Lau, Ph.D., received his bachelor and master degrees of Engineering in Aerospace Engineering from the Royal Melbourne Institute of Technology (RMIT) University, Australia, in 1996 and 1997, respectively. Within this period, he also worked at General Aviation Maintenance Pty. Ltd. Australia and the Corporative Research Centre for Advanced Composite Structure (CRC-ACS) in Australia, designing a repair scheme and an advanced manufacturing process for composite structures. He then received his Ph.D. at The Hong Kong Polytechnic University in 2001. Thereafter, he was appointed Assistant Professor and then promoted to Associate Professor in 2002 and 2005, respectively. Currently, he is also an Adjunct Professor at the University of New Orleans (Louisiana), Lanzhou University (China), Ocean University of China (China), and the University of Southern Queensland (Centre of Excellence in Engineered Fiber Composites, Australia).

Based on his outstanding research performance in the fields of advanced composites, FRP for infrastructure applications, smart materials and structures, and nanomaterials, he has received numerous awards, including: Best Paper Awards on Materials (1998); Sir Edward Youde Memorial Fellowship Award (2000); Young Scientist Award (2002); Young Engineer of the Year Award (2004); Faculty Outstanding Award for Research and Scholarly Activities (2005); Award for Outstanding Research in Nanocomposites for Space Applications (2006); Chemical Physics Letters, Most Cited Paper 2003–2007 Award (2007), and the President Award in Teaching (2008). In 2007, due to his significant contribution to the field of science and engineering, he was elected as a member of the European Academy of Sciences, with the citation "for profound contributions to materials science and fundamental developments in the field of composite materials." He is also the winner of the Ernest L. Boyer International Award for Excellence in Teaching, Learning, and Technology in the 20th International Conference on College Teaching and Learning, United States (2009).

Dr. Lau has published more than 190 scientific and engineering articles, and his publications have been cited in over 1000 instances since 2002. Three of his articles have placed in the Thomson Reuters Top 1% Most Cited Paper in Its Field in 2007 and 2008 according to *Essential Science Indicators*. Dr. Lau has successfully converted his research findings into real-life practical tools, and as a result, has been granted eight patents. Currently, he is serving on more than 40 local and international professional bodies as chairman, committee member, editor, and key officer to promote the engineering profession to the public. In 2007, Dr. Lau was elected as Fellow of Engineers Australia (FIEAust) and Institution of Mechanical Engineers (FIMechE); Chair of the Institution of Engineering Designers (IED) (United Kingdom), Hong

Kong Chapter; President of Engineers Australia, Hong Kong Chapter; and Vice Chair of the American Society of Mechanical Engineers, Hong Kong Section. He is also the Chairman of the 1st International Conference on Multifunctional Materials and Structures.

Farzana Hussain has been involved with scientific endeavors of composite materials, focusing on man-made fibrous polymeric composites, nanocomposite and biocomposite materials since 2000. Her current focus is to process, model, and characterize biocomposite materials at Oregon State University. In 2006, Hussain performed biopolymer research designing microfabrication for biomedical application at ONAMI (Oregon Nanoscience and Micro-Nanotechnology Institute). Prior to her work at ONAMI, she was a technical project lead for aerospace polymer nanocomposite materials research at the Aerospace Manufacturing Technology Centre, Institute for Aerospace Research, National Research Council (NRC), Canada. At NRC, Hussain was also involved in product designing, evaluation of different processing and manufacturing techniques, and mechanical behaviors of advanced composite aircraft structures using liquid composite molding techniques.

Hussain has authored numerous journal articles, technical and conference papers, book chapters, and a comprehensive review on polymer composite and nanocomposite materials. She is the invited reviewer of the *Journal of Composite Materials*, *Composite Science and Technology* and the *Journal of Advanced Materials*. In addition, her comprehensive review based on polymer nanocomposites placed the most-read rankings article in 2006, 2007, 2008, and 2009 in the *Journal of Composite Materials*. She is an active member of the Society of Women Engineers (SWE) and American Institute for Aeronautics and Astronautics (AIAA). Her contribution to the book is dedicated to her parents and her husband.

Khalid Lafdi, Ph.D., is a professor at the University of Dayton (UD) and carbon group leader at University of Dayton Research Institute (UDRI), Ohio. From 1994 to 2000, Dr. Lafdi worked at the Center for Advanced Friction Studies (CAFS), Southern Illinois University at Carbondale (SIUC). He is a carbon specialist with expertise in the fields of carbon processing, physical properties, and structural characterizations at all scale levels. From 1987 to 1991, he completed his habilitation (physics) and Ph.D. (Chemical Engineering) under the supervision of Dr. Agnes Oberlin with a focus on carbon science and technology of carbons from macro- to nanometric nanoscales.

In January 1994, Dr. Lafdi was invited to stimulate carbon materials research at Southern Illinois University and to develop various applications including the development of new electrode supercapacitors, nanostructural materials, nanocomposites, carbon–carbon composites, and aircraft friction materials. He joined the University of Dayton as a UDRI scientist and professor (Mechanical Engineering and Aerospace Department) in July 2001, to help with the nano research activity. He was involved in building the nano research vision at the University of Dayton. In 2004, he was responsible for establishing the Nanoscale Engineering, Science, and Technology (NEST) facility at UD. Also in 2007, Dr. Lafdi established a new Carbon Research Laboratory (CRL) at UDRI. CRL is directly involved in the processing, characterization, and modeling of various aspects of carbon hybrid research. In the last four years, he had a state-of-the-art thermal and energy management laboratory built. Dr. Lafdi has established a manufacturing transition facility located at the National Composite Center (Kettering, Ohio) to facilitate the nano-artifacts scale-up processes and technology transfer.

At this time, Dr. Lafdi has more than 140 articles and chapters published in refereed journals and four patents. He has gained valuable experience in developing new ideas and collaborations to develop a world-class carbon research program on material hybrids from fundamental understanding to manufacturing.

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