

Preface

Nanomaterials and nanotechnologies are part of the most attractive areas of scientific research and commercial interest because they offer new opportunities for improving human life. Nanomaterials are materials with morphological features on the nano-range, which usually are defined as smaller than one-tenth of a micrometer in at least one direction, with special properties that stem from their nanoscale dimensions.

A common characteristic of all nano-size materials, regardless of their chemical composition and method of preparation, is the extremely large ratio of surface area to volume. The natural tendency to reduce this free surface is the driving force for agglomeration of nanoparticles into larger formations.

Nanomaterials are not new—they have been used for many centuries, but it is only in recent decades that their unique properties were demonstrated at the nano-scale, where quantum effects are possible. A revolutionary discovery in nanoscience was the preparation of carbon nanotubes. It turned out that this all-carbon material is the ideal material—it has the highest heat conductivity, electrical conductivity, mechanical properties, etc.—and thus attracted the attention of researchers from various fields, including polymer science and technology. For example, with tensile moduli in the terapascal range and lengths exceeding $10\text{ }\mu\text{m}$ of carbon nanotubes, simple composite models predict order-of-magnitude enhancement in modulus at loadings less than 1 %. For this reason, a decade ago, it was believed that the most common polymer composites comprising about 30 % glass fibers will be replaced by the nanocomposites having only 2–5 % nano-size filler as reinforcement! Unfortunately, this has proved to be elusive.

The case of nanocomposites is one example of polymer nanotechnology, in which the polymer remains in a bulk state. Completely different is the situation when the polymer itself has to be converted into nano-size material, as, for example, in electrospinning. This technique exists since the beginning of the last century and nowadays it is used in hundreds of labs worldwide because of its elegance, economic setup, and the fascinating electron microscopic images of the nanofibers obtained, which can be seen in some 2000 papers published per year.

It is important to mention a terminological peculiarity related with nanomaterials. In the literature, the terms “nanomaterials”, “nano-structured materials” (and even “nano-size materials”) are considered synonymous and used interchangeably, which is hardly correct. A good example in this respect, are the polymer materials, whose structural elements (lamellae, microfibrils, etc.) are nano-sized. Their common characteristic feature is the fact that they are **interconnected** via *tie molecules* and cannot be isolated as separate particles. In contrast, the nanomaterials, or even better, the nano-size materials are of the same sizes but they represent **individual**, not interconnected particles.

In addition to electrospinning, bulk polymers can be converted into nano-size materials by the recently developed concept of micro- or nanofibrillar composites starting from polymer blends. Nano-size polymers can also be obtained directly during synthesis. In the pharmaceutical industry, nano-size polymers are prepared using their solution. Many more applications also exist.

Because of the variety of potential applications (including the industrial and military ones), governments have invested billions of dollars in nanotechnology research. Through its National Nanotechnology Initiative, the USA has invested 3.7 billion dollars. The European Union has invested 1.2 billion, and Japan 750 million dollars.

This book represents an attempt to collect all available techniques used for converting the bulk polymers into nano-sized materials, as well as to discuss the properties of these materials and the potential for their applications. The chapters are prepared by leading worldwide specialists working in the respective areas.

Finally, the editor would like to thank all the contributors for their valuable contributions to this book as well as for being patient during the compilation work. Thanks are also extended to the Centre for Advanced Composite Materials of the Auckland University, Auckland, where this project was realized, as well as to the Ministry of Science and Innovations, New Zealand, for their financial support.

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