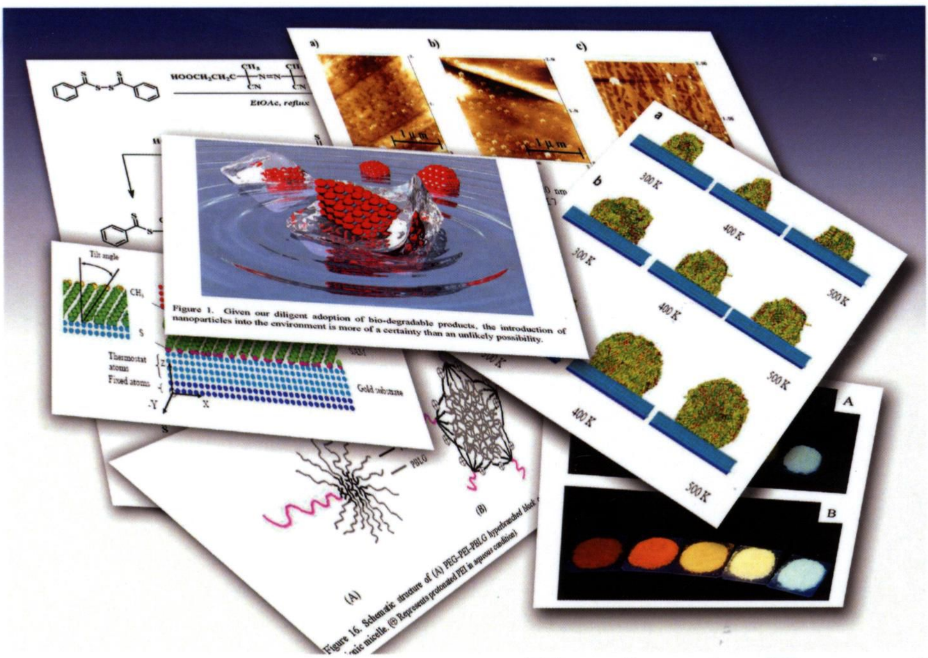
ADVANCES IN NANOTECHNOLOGY

Volume 19



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PREFACE

This book gathers and presents data on nanotechnology. Major obstacles, drawbacks and challenges were analyzed, and optimum solutions were provided / recommended for each individual nanomaterial in Chapter One, which also covers some technical analysis and sustainable uses of these materials in different industries. Chapter Two summarizes recent advances in the fabrication, characterization, properties, and applications of CB nanoparticles in various industries. The (simultaneous) twin polymerization using diverse main-group and transition metal compounds as twin monomers, and additives like metal carboxylates or tin alkoxides to produce metal and metal oxide nanoparticle- as well as tin alloy-decorated porous carbon and silica hybrid materials is reported in Chapter Three. Several nanocomposites and products available in the market were studied in detail in Chapter Four to understand the Eol concepts of these materials and structures used for numerous product developments. Chapter Five summarizes recent advances in the fabrication of nanoparticles, especially carbon nanoparticles (CNPs) and their inherent failure mechanism under various external loading conditions. Chapter Six utilizes thermal performance-illumination experiment with intelligent dimensional analysis to study the green-energy device characteristics in high power heating sources, in order to reach the green recycling of energy efficiency and depict how to prepare the process of thermo-electric nanofluid and fill it into pipe to form a TEP device. Chapter Seven presents a summary of the fabrication of soft nanostructure by molecular self-assembly of synthetic peptides. The structural-parametric model, the solution of the wave equation of the electroelastic actuator and the calculation their transfer functions are presented in Chapter Eight.

Chapter 1 - Carbon nanoparticles, including carbon nanotubes (CNTs), carbon blacks, graphene carbon, nanofibers (CNFs) and buckyballs (fullerene) are of great interest worldwide for many industrial applications because of their excellent mechanical, electrical, thermal and optical properties. The major industrial applications of the carbon nanoparticles are rubber and tire toughening in nanocomposite forms, coating, corrosion protections, batteries, sensors, laser printer ink, charging and discharging, heat sink, solar energy and storage, electronics, and so on. A number of physical, and chemical techniques have been developed and used for the fabrications of carbon nanoparticulates in various size, shape and morphologies for different industrial applications and scientific investigations. In this book chapter, a number of carbon nanoparticulates, such as CNTs, carbon blacks and graphene were investigated in terms of manufacturing, stabilization, and industrial applications. Major obstacles, drawbacks and challenges were analyzed, and optimum solutions were provided / recommended for each individual nanomaterial. This book chapter also covers some technical analysis and sustainable uses of these materials in different industries. This will be very useful for the beginners, workers, students, engineers, scientists, and legislators working in the field.

Chapter 2 - Nanoparticles have received significant attention from the scientific community because of their exceptionally large surface-area-to-volume ratios along with their extraordinary properties, in comparison to bulk materials of the same kind. These materials have unique thermal, optical, electrical, mechanical, electronic, and biological properties, which make them suitable candidates for many applications with significantly improved performance. Carbon black (CB) is a powdered form of elemental carbon that is produced by the partial combustion or thermal decomposition of solid, liquid, or gaseous hydrocarbons under a controlled environment. Its physical appearance is a spherical-shaped, finely divided pellet or powder form of amorphous carbon that has a high surface-area-to-volume ratio. It's primarily used as a reinforcing agent in vehicle parts and rubbery automotive products (e.g., tires, tubes, tread, belts, hoses, miscellaneous) and non-automotive industrial applications (e.g., molded items, laser printing, and extruded products), which are employed in many countries, and consume approximately 90% of CB production. The remaining 10% of CB is divided among other special applications that include everyday products, such as coatings, plastics, lithium ion batteries, vehicles for large hydrogen storage, chemical sensors, super capacitors, and ultra-violet protection. Carbon black is mass-produced by controlled vapor-phase pyrolysis and the incomplete combustion of gaseous or liquid hydrocarbons. This book chapter summarizes recent advances in the fabrication, characterization, properties, and applications of CB nanoparticles in various industries. The new plasma technology for the production of superior quality CB has been studied extensively and compared with other techniques.

Chapter 3 - The (simultaneous) twin polymerization using diverse main-group and transition metal compounds as twin monomers, and additives like metal carboxylates or tin alkoxides to produce metal and metal oxide nanoparticle- as well as tin alloy-decorated porous carbon and silica hybrid materials is reported. In addition, the encapsulation of metal and metal oxide nanoparticles within hollow carbon shells by using the twin polymerization approach is discussed. Current trends in this field of chemistry are presented as well.

Chapter 4 - Nanocomposites and other nanotechnology products are of great interest worldwide because of the superior physical, chemical, physicochemical and biological properties of these new classes of materials. However, the environmental and health impacts of nanocomposites and nanostructured materials require major analysis prior to the industrial applications and consumer product developments. The early life cycle studies of the nanocomposites are very important to determine their environmental and health effects during the manufacturing, transportation and usage stages. Investigating and understanding the end-of-life (Eol) stage of nanocomposites can be critical because of the significant effects and benefits on the environment and health that can arise at this stage. The properties of nanocomposites can be adjusted depending on the selected inclusions, geometry, concentrations, types and processing parameters for different industrial applications, such as aircraft, energy, medical, automotive, computer, defense, and others. In this study, several nanocomposites and products available in the market were studied in detail to understand the Eol concepts of these materials and structures used for numerous product developments. Among the many nanomaterials, nanocomposites are used more, so the authors focused on those nanomaterials and their Eol concepts. In addition to these, some other nanomaterials and products were also analyzed briefly in terms of their economic, health and environmental aspects. Because nanocomposites and devices are rare and highly expensive, sustainability of these nanomaterials and devices were examined in terms of recycling and reusing purposes to save our natural resources, health and environment. Throughout the studies, a number of different scientific sources (e.g., journal articles, technical reports, books and book chapters, magazines, and government and company web pages) were used to complete the nanocomposites list in the market. The Eol stages of these nanocomposites were investigated to **assess** sustainable life cycles options for the future consumptions in the same or different industries.

Chapter 5 - Nanoparticles have received significant attention in many scientific communities due to their exceptionally large surface area-to-volume ratios along with extraordinary properties, compared to their bulk counterparts. These materials have unique thermal, optical, electrical, mechanical, electronic, and biological properties, which make them suitable candidates for many engineering applications with significantly improved product performance. Different types of nanoparticles have been produced from a range of materials, such as polymers, metals and alloys, ceramics, semiconductors, and carbon with different geometries, including spherical nano-particles, nanotubes, nanowires, nanofibers, nanocomposites, and nanofilms. In order to design small-scale nanodevices, understanding the fundamental failure mechanisms of these nanomaterials is of great importance for new product development. The fracture and failure behavior of nanomaterials is not well defined because of many factors influencing deformation and fracture processes. Few articles in the literature have reported on the underlying fracture mechanism of nanomaterials. This book chapter summarizes recent advances in the fabrication of nanoparticles, especially carbon nanoparticles (CNPs) and their inherent failure mechanism under various external loading conditions.

Chapter 6 - Thermo-electric nanofluids that contain nanoparticles dispersed in a continuous liquid phase are expected to exhibit superior thermal and electric characteristics composed ThermoElectric pipe (TEP), which is a two-phase flow heat transfer device with high heat transfer efficiency applied in saving-green energy region. This chapter utilizes thermal performance-illumination experiment with intelligent dimensional analysis to study the green-energy device characteristics in high power heating sources, in order to reach the green recycling of energy efficiency and depict how to prepare the process of thermo-electric nanofluid and fill it into pipe to form a TEP device. A TEP with thermo-electric nanofluid device design effectively to reduce the temperature and transform raw heat capacity into electric energy of Personal Computer (PC), Note Book (NB), and Server including central processing unit (CPU) and graphic processing unit (GPU), and LED lighting lamp of smaller area and higher power.

The research approach focuses on TEP device filled with thermo-electric nanofluid and develops the mathematical models to predict their thermal and electric performances respectively. The results show that the LED TEP system with thermo-electric nanofluids has more, and its junction temperature of LED can be reduced to increase the illumination and life. Moreover, it has high brightness and application in the green energy-saving lamps. The present correlations are in good agreement with the experimental results. Finally, the author would like to mention a few points as the contribution of this study. Modern electronic/LED systems have reached a dimensional complexity and power density which presents numerous cooling challenges and storage-power/saving-energy features. This work can serve as a reference for future researchers.

Chapter 7 - Nanostructure materials are highly important due to their potential application in chemistry, biology, medicine and material sciences. Even the designer material can be used as gene delivery and drug delivery vehicles. In this regard, peptides are very much interesting as novel building block for the design and fabrication of nano or microstructures, formulate peptide-drug complexes, and further control the complex size and shape for different applications. The non-covalent interactions like ionic, hydrogen bonding, hydrophobic, π-stacking and van der Waals interactions are necessary to determine the thermodynamically stable structure. All these interactions are individually weak (2–250 kJ mol^{-1}) than covalent bonds (100–400 kJ mol^{-1}), however when they present collectively in sufficient number, they are able to produce highly stable assemblies and the subtle balance of them can direct the shape, size and function of the final assembly. Co operative accumulation of these various non-covalent interactions in a small peptide can form oligomers, metaclusters, nanostructures and even toxic fibrillar aggregates. In this context, it is very important to understand the mechanism and control of building blocks assembly processes. There are different internal as well as external factors such as concentration, pH of the solution, ionic strength, solvent polarity, mechanical force, presence of denaturing agents, temperature, metal coordination, sonication that influence the assembly mechanism. The release of the encapsulated drugs also depends on various external stimuli. The recent advances and future scope in this area will be discussed briefly in this chapter.

Chapter 8 - The structural-parametric model, the solution of the wave equation of the electroelastic actuator and the calculation their transfer functions are presented in this chapter. The effects of the geometric and physical parameters of the electroelastic actuator and external loading on their dynamic characteristics are determined. For the calculation of the mechatronic systems for the nanometric movements with the electroelastic actuator the authors obtained the parametric structural schematic diagrams and the transfer functions of the piezoactuator. The static and dynamic characteristics of the piezoactuator are determined.

CONTENTS

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Chapter 1

MANUFACTURING, FUNCTIONALIZATION AND APPLICATIONS OF CARBON NANOPARTICLES

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ABSTRACT

Carbon nanoparticles, including carbon nanotubes (CNTs), carbon blacks, graphene carbon, nanofibers (CNFs) and buckyballs (fullerene) are of great interest worldwide for many industrial applications because of their excellent mechanical, electrical, thermal and optical properties. The major industrial applications of the carbon nanoparticles are rubber and tire toughening in nanocomposite forms, coating, corrosion protections, batteries, sensors, laser printer ink, charging and discharging, heat sink, solar energy and storage, electronics, and so on. A number of physical, and chemical techniques have been developed and used for the fabrications of carbon nanoparticulates in various size, shape and morphologies for different industrial applications and scientific

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investigations. In this book chapter, a number of carbon nanoparticulates, such as CNTs, carbon blacks and graphene were investigated in terms of manufacturing, stabilization, and industrial applications. Major obstacles, drawbacks and challenges were analyzed, and optimum solutions were provided / recommended for each individual nanomaterial. This book chapter also covers some technical analysis and sustainable uses of these materials in different industries. This will be very useful for the beginners, workers, students, engineers, scientists, and legislators working in the field.

Keywords: carbon nanoparticles, manufacturing, functionalizations, sustainability, applications

1. Introduction

1.1. Background

The general meaning of "nanocomposite" is a combination of two or more materials which are mixed together to improve their physical, thermal or electrical properties compared to each material individually. There are one or more discontinuous phases called "matrix" and a continued phase called "reinforcement" in a composite material. In nanocomposite, at least one of the components is in a nanosize ranging from 10^{-7} to 10^{-9} m. Matrix can be polymeric resin, ceramic, metal or other materials, and its mechanical performance is improved by adding the reinforcement [1]. The role of reinforcement is to add more mechanical performance to the composite, while the role of the matrix is to spread the load to the nanomaterials and protect them from external violence. The type of nanoparticle used in nanocomposite, depends on the application of the nanocomposite materials and the designer's limitations such as high mechanical properties, cost, corrosion resistance or good thermal stability. One of the most important microstructure feature of nanocomposites is to have a larger surface area to their volume [1]. Figure 1 shows three types of nanocomposites.