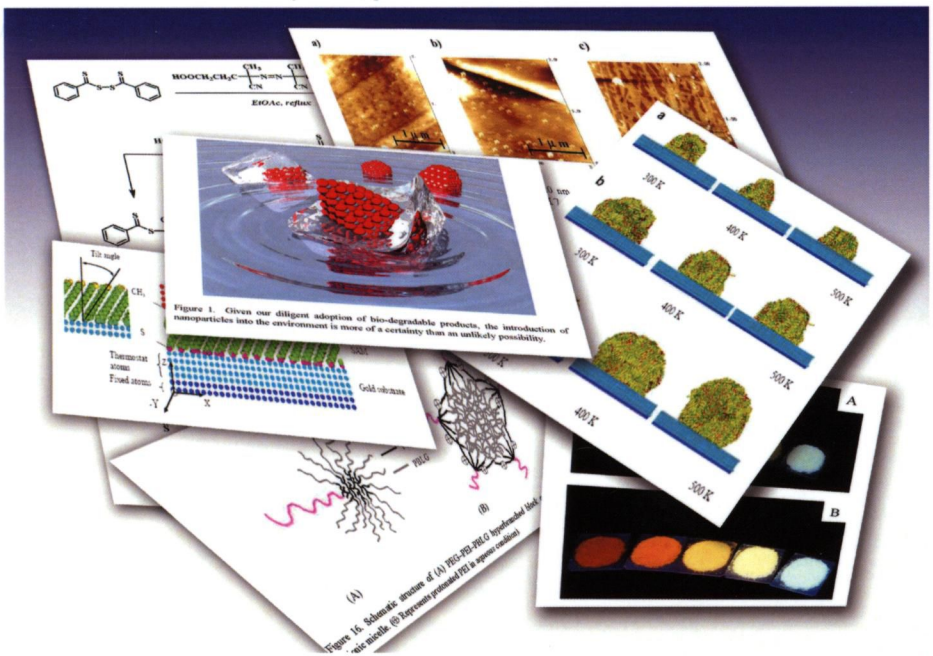
ADVANCES IN NANOTECHNOLOGY

Volume 21



Zacharie Bartul
Jérôme Trenor
Editors

NOVA

ADVANCES IN NANOTECHNOLOGY

Volume 21

Contributors

Zacharie Bartul
Jérôme Trenor
Editors

nova
science publishers
www.novapublishers.com

ISBN 978-1-53613-202-1

ADVANCES IN NANOTECHNOLOGY

VOLUME 21

ZACHARIE BARTUL
AND
JÉRÔME TRENOR
EDITORS

NOTICE TO THE READER

Library of Congress Cataloging-in-Publication Data

ISBN: 978-1-53613-202-1
ISSN: 2159-1490

Published by Nova Science Publishers, Inc. † New York

ADVANCES IN NANOTECHNOLOGY

VOLUME 21

ADVANCES IN NANOTECHNOLOGY

Additional books in this series can be found on Nova's website under the Series tab.

Additional e-books in this series can be found on Nova's website under the eBooks tab.

PREFACE

In this compilation, the authors discuss a synergistic enhancement of electron and thermal conductivities of epoxy-based composites (CMs) with different hybrid fillers. Their investigation shows an increase of the thermal conductivity as compared to CMs with a single carbon filler. This increase is more pronounced for GNPs/BN fillers. However, the role of an interface thermal resistance is still dominant in the determination of the thermal conductivity of investigated epoxy composites. A subsequent chapter aims to present an overview of noteworthy functionalised materials that have been produced in recent years, in order to act as a guide for the future design of more efficient adsorbent materials. The authors also provide a review which could pave the way for the potential use of nanotechnology in the treatment of skin diseases. The potential implication of the nanotechnology-based cosmeceuticals could be significant and is warranted to be evaluated in long-term *in vivo* and clinical studies. Next, a transparent and flexible crystalline polymer nanohybrid was fabricated, containing well-dispersed magnetic nanoparticles with organic chain-modified surfaces. The partially fluorinated copolymer matrix used is composed of switchboard-type lamellae. These become transparent owing to the creation of high-density amorphous regions on drawing the corresponding film at just below the polymer melting point. Lastly, the book investigates double-diffusive convection in unsteady nanofluid flow

over a moving surface in a porous medium in the presence of a chemical reaction and subject to thermal radiation. This study includes the effects of Brownian motion and thermophoresis.

Chapter 1 - This chapter is dedicated to a synergistic enhancement of electron and thermal conductivities of epoxy-based composites (CMs) with different hybrid fillers. It was shown that combination of carbon fillers with various morphology (1D carbon nanotubes — CNTs, carbon fibers — CFs, 2D graphite nanoplatelets — GNPs) influences a microstructure of composites and leads to a decrease of a percolation threshold and enhancement of an electrical conductivity due to more homogeneous filler dispersion in the epoxy matrix. The addition of the second dielectric filler (hexagonal boron nitride — BN or barium hexaferrite — BaM) into epoxy composites filled with nanocarbon (GNPs or CNTs) lead to a better interconnectivity among fillers in the epoxy matrix, hence, increase of electrical and thermal conductivities. Moreover, the utilizing of the magnetic filler allows preparation of CMs with oriented (or aligned) filler distribution that leads to the anisotropy of physical properties.

The results of a numerical modeling of the percolation threshold for CMs with hybrid 1D/2D carbon fillers allowed to establish the relationship between a value of the percolation threshold and size, aspect ratio and mixing ratio of different nanofillers.

The electric resistance analysis of the authors' experimental samples under various uniaxial strains and hydrostatic pressures has shown that the change of the filler orientation and an interparticle distance in CMs are responsible for significant changes in a value and temperature dependence of the electrical conductivity of epoxy CMs.

The investigations of AC conductivity (up to 10 MHz) of epoxy CMs have shown that tunneling mechanism of the electrical conductivity is prevailing for the CMs with a filler content near the percolation threshold, while for the CMs with a high filler content electric transport is mainly realized via direct contacts between carbon nanoparticles.

The results obtained for the thermal conductivity of epoxy composites with single and hybrid filler have shown no indication of the rapid increase for CMs with a filler content higher than the corresponded percolation

threshold. These results suggest that a considerable thermal contact resistance might also exist at interfiller contacts. It was found that, compared to carbon nanotubes, GNP particles are the most efficient fillers for an enhancement of the thermal conductivity. This can be explained by a larger surface area and effective interaction of the fillers with the epoxy matrix which results in the formation of a better conductive network. The model of an effective thermal conductivity for carbon-polymer composites based on a mixture model has been proposed. This model takes into account the morphology of a carbon filler, the thermal conductivity of constituents, the thermal contact resistance between filler particles (including interface thermal resistance) and their spatial orientation in a composite. The authors' investigations of epoxy composites with hybrid fillers have shown the increase of the thermal conductivity as compared to CMs with a single carbon filler. This increase is more pronounced for GNPs/BN fillers. However, the role of an interface thermal resistance is still dominant in the determination of the thermal conductivity of investigated epoxy composites.

Chapter 2 - Adsorption as a means of pollutant removal from water is a well-established technique. As a reflection of the variety of different types of problematic pollutants that can be found in wastewater, so too exists a variety of adsorbent materials that have been used to target them. The modification of adsorbents via manipulation of both the morphology of the particles as well as tailoring of the surface chemistry has resulted in materials able to target specific pollutants with varying degrees of success. This chapter aims to present an overview of noteworthy functionalised materials that have been produced in recent years, in order to act as a guide for the future design of more efficient adsorbent materials.

Chapter 3 - Nanotechnology principles represent one of the most promising technologies and have been identified as a new industrial revolution. It provides therapeutic, diagnostic, and preventive applications in dermatology. Nanomaterials are being applied in sunscreens and cosmetics products to improve the properties attained by the particles at the nano level such as solubility, transparency, and color. However, prolonged use of nanotechnology in cosmeceuticals has initiated public health

concern about the possible penetration and absorption of nanoparticles through the skin. Therefore, this review was performed to highlight the emerging role of this nanotechnology in the treatment of skin diseases and cancer as well as the safety aspects of nanotechnology-based cosmeceuticals. Taken together, this review could pave the way for the potential use of nanotechnology in the treatment of skin diseases. The potential implication of the nanotechnology-based cosmeceuticals could be significant and is warranted to be evaluated in long-term *in vivo* and clinical studies.

Chapter 4 - A transparent and flexible crystalline polymer nanohybrid was fabricated, containing well-dispersed magnetic nanoparticles with organic chain-modified surfaces. The partially fluorinated copolymer matrix used is composed of switchboard-type lamellae. These become transparent owing to the creation of high-density amorphous regions on drawing the corresponding film at just below the polymer melting point. Although the creation of oleo- and hydrophobic fluorinated polymer/ organo-modified magnetic nanoparticle nanohybrids is generally difficult, formation *via* melt compounding was confirmed using wide-angle X-ray diffraction and thermal analysis. On organo-modification of the hydroxyl-terminated magnetic nanoparticle surface with long-chain fatty acids, the resulting improvement in wettability aids the dispersion of the particles and hence maintains transparency. Nano-dispersion of the organo-filler was considered to result from surface modification-induced improvement of particle miscibility and melt compounding. These nanohybrids have enhanced thermal degradation temperatures and mechanical properties, derived from the nucleation effect caused by the adsorption of the terminal polymer chains onto the organic modifier.

Chapter 5 – The authors investigate double-diffusive convection in unsteady nanofluid flow over a moving surface in a porous medium in the presence of a chemical reaction and subject to thermal radiation. This study includes the effects of Brownian motion and thermophoresis. The nanofluid particle volume fraction at the boundary surface is passively controlled suggesting that the nanoparticle flux at the boundary surface vanishes. The authors used the spectral relaxation method as the preferred

method of solution for the differential equations that describe this fluid flow model. The numerical results are discussed and demonstrated graphically and in tabular forms for the velocity, temperature, concentration, and nanoparticle concentration; as well as the skin friction coefficient, heat and mass transfer rate. A comparative study between previously published and the present results for some limiting cases shows an excellent agreement between the results.

CONTENTS

In: Advances in Nanotechnology. Volume 21 ISBN: 978-1-53613-202-1
Editors: Z. Bartul and J. Trenor

Chapter 1

ELECTRICAL AND THERMAL CONDUCTIVITY OF EPOXY NANOCOMPOSITES WITH HYBRID FILLERS

Ludmila Vovchenko*, Ludmila Matzui, Yulia Perets, Igor Sagalianov and Olena Yakovenko
Taras Shevchenko National University of Kyiv, Kyiv, Ukraine

ABSTRACT

This chapter is dedicated to a synergistic enhancement of electron and thermal conductivities of epoxy-based composites (CMs) with different hybrid fillers. It was shown that combination of carbon fillers with various morphology (1D carbon nanotubes — CNTs, carbon fibers — CFs, 2D graphite nanoplatelets — GNPs) influences a microstructure of composites and leads to a decrease of a percolation threshold and enhancement of an electrical conductivity due to more homogeneous filler dispersion in the epoxy matrix. The addition of the second dielectric filler (hexagonal boron nitride — BN or barium hexaferrite — BaM) into epoxy composites filled with nanocarbon (GNPs or CNTs) lead to a

* Corresponding Author Email: vovch@univ.kiev.ua.

better interconnectivity among fillers in the epoxy matrix, hence, increase of electrical and thermal conductivities. Moreover, the utilizing of the magnetic filler allows preparation of CMs with oriented (or aligned) filler distribution that leads to the anisotropy of physical properties.

The results of a numerical modeling of the percolation threshold for CMs with hybrid 1D/2D carbon fillers allowed to establish the relationship between a value of the percolation threshold and size, aspect ratio and mixing ratio of different nanofillers.

The electric resistance analysis of our experimental samples under various uniaxial strains and hydrostatic pressures has shown that the change of the filler orientation and an interparticle distance in CMs are responsible for significant changes in a value and temperature dependence of the electrical conductivity of epoxy CMs.

The investigations of AC conductivity (up to 10 MHz) of epoxy CMs have shown that tunneling mechanism of the electrical conductivity is prevailing for the CMs with a filler content near the percolation threshold, while for the CMs with a high filler content electric transport is mainly realized via direct contacts between carbon nanoparticles.

The results obtained for the thermal conductivity of epoxy composites with single and hybrid filler have shown no indication of the rapid increase for CMs with a filler content higher than the corresponded percolation threshold. These results suggest that a considerable thermal contact resistance might also exist at interfiller contacts. It was found that, compared to carbon nanotubes, GNP particles are the most efficient fillers for an enhancement of the thermal conductivity. This can be explained by a larger surface area and effective interaction of the fillers with the epoxy matrix which results in the formation of a better conductive network. The model of an effective thermal conductivity for carbon-polymer composites based on a mixture model has been proposed. This model takes into account the morphology of a carbon filler, the thermal conductivity of constituents, the thermal contact resistance between filler particles (including interface thermal resistance) and their spatial orientation in a composite. Our investigations of epoxy composites with hybrid fillers have shown the increase of the thermal conductivity as compared to CMs with a single carbon filler. This increase is more pronounced for GNPs/BN fillers. However, the role of an interface thermal resistance is still dominant in the determination of the thermal conductivity of investigated epoxy composites.

Keywords: nanocarbon fillers, nanocomposite, hybrid filler, electrical conductivity, thermal conductivity