Synthesis and Characterization of Polymer–Nanoclay Conductive Nanocomposites

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ABSTRACT: Polymer–clay nanocomposites based on poly(3,4-ethylenedioxythiophene)/polystyrene sulfonate (PEDOT) : PSS and nanoclay montmorillonite were synthesized and characterized. The doping of PEDOT with polystyrene sulfonate made it water dispersible (PEDOT–PSS). Sodium dodecyl benzene sulfonate (SDBS) and ionic liquid were used to increase the interlayer spacing and the conductivity of the nanocomposites, respectively. The nanocomposite was characterized by various techniques, such as X-ray diffraction (XRD), TEM, surface resistivity, and thermogravimetric measurement analysis. Interlayer spacing increased as a result of the addition of SDBS, and this was confirmed by the 2θ shift observed via XRD analysis. The surface morphology of the conductive coated clay was examined by TEM analysis. Good electrical surface conductivity, interlayer spacing, and polymer coating were observed for the material prepared using the surfactant and conductive ionic liquid. © 2009 Wiley Periodicals, Inc. J Appl Polym Sci 116: 314–319, 2010

Key words: conductive clay; nanocomposites; surfactant; morphology; conductive ionic liquid

INTRODUCTION

In recent years, there has been increased focus on polymer/clay nanocomposites to develop structural materials with enhanced mechanical, thermal, and gas barrier properties as well as new hybrid materials providing functional properties such as electrical conductivity.[1–3]

Electrically conductive polymer–clay nanocomposites are of great interest as they may be applied as electro-active components in different electrochemical devices, such as solid state batteries, fuel cells, or electrochemical sensors.[3–11] As the properties of the materials are directly related to the morphology of these systems, the dispersion of the clay inorganic phase plays an important role.[12,13]

Clay minerals find almost innumerable applications, and the diversity of uses is still increasing. The reason for this is the large variety of clays and clay minerals and the facilities with which these materials are modified. Swelling behavior, adsorption properties, colloidal and rheological phenomena can be optimized and adjusted for the intended application. Clay minerals normally occur as crystals of colloid size, in which parallel silicate layers about 7–14 Å thick are stacked. These layers are negatively charged because of ionic substitutions at various sites within their structures, and as a result exchangeable cations are adsorbed on their surfaces. Clay minerals and clays are more and more involved in materials studies and are parent materials of organic–inorganic composites.

Two materials, montmorillonite (MMT) and poly(3,4-ethylenedioxythiophene) (PEDOT) are the primary components of the nanocomposites used in this study. MMT is hydrated alumina-silicate clay composed of units made up of two silica tetrahedral sheets with a central alumina octahedral sheet. PEDOT was first synthesized by Heywang and Jonas.[14] It is now considered an excellent conjugated conducting polymer when positively doped because of its relatively high conductivity, thermal stability and the fact that it is more environmental friendly than other conjugated polymers.[14–17] The main problem with PEDOT is its poor solubility, which makes the processing of this material very difficult, and represents the major barrier to its commercial applications.[18] A good aqueous dispersion of PEDOT can be obtained by using dopant poly(styrene sulfonate) sold under the trade name of Baytron P®. As the dispersion of the clay is important in determining the subsequent hybrid materials preparation, it is essential to improve the interaction between the clay and the polymer matrix to produce a useful polymer

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Polymer Nanocomposites Synthesis Characterization And Modeling

Rajesh Kumar Verma,Shivi Kesarwani,Jinyang Xu,J. Paulo Davim

Polymer Nanocomposites Synthesis Characterization And Modeling:

Polymer Nanocomposites Ramanan Krishnamoorti,2002-01-17 Polymer Nanocomposites Synthesis Characterization and Modeling examines the unique chemical and physical aspects associated with polymer based nanocomposite materials The volume discusses the latest fundamental and applied research in the field of polymer nanocomposites as well as future directions for the development of high performance materials *Polymer Nanocomposites* Joseph H. Koo,2010-05-10 Understand the principles applications and limitations of a cutting edge material Based on the author s 26 years of experience in the field of Nanotechnology this reference offers researchers and materials scientists a complete reference to the physical concepts techniques applications and principles underlying one of the most researched materials Keeps you abreast of the latest trends developments and commercial applications **Polymer Nanocomposites** Aravind Dasari,Zhong-Zhen Yu,Yiu-Wing Mai,2016-06-28 This highlights ongoing research efforts on different aspects of polymer nanocomposites and explores their potentials to exhibit multi functional properties In this context it addresses both fundamental and advanced concepts while delineating the parameters and mechanisms responsible for these potentials Aspects considered include embrittlement toughness wear scratch behaviour thermal stability and flame retardancy barrier electrical and thermal conductivity and optical and magnetic properties Further the book was written as a coherent unit rather than a collection of chapters on different topics As such the results analyses and discussions presented herein provide a guide for the development of a new class of multi functional nanocomposites Offering an invaluable resource for materials researchers and postgraduate students in the polymer composites field they will also greatly benefit materials *Modeling and Simulation in Polymers* Purushottam D. Gujrati,Arkady I. Leonov,2010-03-30 Filling a gap in the literature and all set to become the standard in this field this monograph begins with a look at computational viscoelastic fluid mechanics and studies of turbulent flows of dilute polymer solutions It then goes on discuss simulations of nanocomposites polymerization kinetics computational approaches for polymers and modeling polyelectrolytes Further sections deal with tire optimization irreversible phenomena in polymers the hydrodynamics of artificial and bacterial flagella as well as modeling and simulation in liquid crystals The result is invaluable reading for polymer and theoretical chemists chemists in industry materials scientists and plastics technologists **Polymer Composites** Klaus Friedrich,Stoyko Fakirov,Zhong Zhang,2005-12-06 The use of polymer composites in various engineering applications has become state of the art This multi author volume provides a useful summary of updated knowledge on polymer composites in general practically integrating experimental studies theoretical analyses and computational modeling at different scales i e from nano to macroscale Detailed consideration is given to four major areas structure and properties of polymer nanocomposites characterization and modeling processing and application of macrocomposites and mechanical performance of macrocomposites The idea to organize this volume arose from a very impressive workshop The First International Workshop on Polymers and Composites at IVW Kaiserslautern

Invited Humboldt Fellows and Distinguished Scientists which was held on May 22 24 2003 at the University of Kaiserslautern Germany The contributing authors were invited to incorporate updated knowledge and developments into their individual chapters within a year after the workshop which finally led to these excellent contributions The success of this workshop was mainly sponsored by the German Alexander von Humboldt Foundation through a Sofia Kovalevskaja Award Program financed by the Federal Ministry for Education and Research within the Investment in the Future Program of the German Government In 2001 the Humboldt Foundation launched this new award program in order to offer outstanding young researchers throughout the world an opportunity to establish their own work groups and to develop innovative research concepts virtually in Germany One of the editors Z *Experimental Characterization, Predictive Mechanical and Thermal Modeling of Nanostructures and Their Polymer Composites* Francesco Marotti De Sciarra,Pietro Russo,2018-03-23 Experimental Characterization Predictive Mechanical and Thermal Modeling of Nanostructures and Their Polymer Composite focuses on the recent observations and predictions regarding the size dependent mechanical properties material properties and processing issues of carbon nanotubes CNTs and other nanostructured materials The book takes various approaches including dedicated characterization methods theoretical approaches and computer simulations providing a detailed examination of the fundamental mechanisms governing the deviations of the properties of CNTs and other nanostructured materials The book explores their applications in materials science mechanics engineering chemistry and physics due to their unique and appealing properties The use of such materials is however still largely limited due to the difficulty in tuning their properties and morphological and structural features Presents a thorough discussion on how to effectively model the properties of carbon nanotubes and their polymer nanocomposites Includes a size dependent analysis of properties and multiscale modeling Outlines the fundamentals and procedures of computational modeling as it is applied to carbon nanotubes and other nanomaterials **Spectroscopy of Polymer Nanocomposites** Sabu Thomas,Didier Rouxel,Deepalekshmi Ponnamma,2016-02-16 Spectroscopy of Polymer Nanocomposites covers all aspects of the spectroscopic characterization of polymer nanocomposites More than 25 spectroscopy characterization techniques almost all used in materials science are treated in the book with discussion of their potentialities and limitations By comparing the techniques with each other and presenting the techniques together with their specific application areas the book provides scientists and engineers the information needed for solving specific problems and choosing the right technique for analyzing the material structure From this the dispersion structure of fillers property relations and filler polymer interactions can be determined and ultimately the right materials can be chosen for the right applications Besides the techniques and structure property relations aspects covered include phase segregation of filler particles filler agglomeration and deagglomeration filler dispersion filler polymer interactions surfaces and interfaces The book also examines recent developments as well as unresolved issues and new challenges in the characterization of surfaces and interfaces in polymer nanocomposites This

handpicked selection of topics and the combined expertise of contributors from industry academia government and private research organizations across the globe make this survey an outstanding reference source for anyone involved in the field of polymer nanocomposites in academia or industry Provides comprehensive coverage of spectroscopy techniques for analyzing polymer nanocomposites Enables researchers and engineers to choose the right technique and make better materials decisions in research and a range of industries Presents the fundamentals information on structure property relations and all other aspects relevant for understanding spectroscopic analyses of nanoreinforced polymers and their applications

Optimization of Polymer Nanocomposite Properties Vikas Mittal,2009-12-09 A one stop resource for researchers and developers alike this book covers a plethora of nanocomposite properties and their enhancement mechanisms With contributors from industry as well as academia each chapter elucidates in detail the mechanisms to achieve a certain functionality of the polymer nanocomposite such as improved biodegradability increased chemical resistance and tribological performance Special emphasis is laid on the interdependence of the factors that affect the nanocomposite properties such that readers obtain the information necessary to synthesize the polymer materials according to the requirements of their respective applications Advances in Polymer Processing S Thomas,Weimin Yang,2009-05-30 Processing techniques are critical to the performance of polymer products which are used in a wide range of industries Advances in polymer processing From macro to nano scales reviews the latest advances in polymer processing techniques and materials Part one reviews the fundamentals of polymer processing with chapters on rheology materials and polymer extrusion Part two then discusses advances in moulding technology with chapters on such topics as compression rotational and blow moulding of polymers Chapters in Part three review alternative processing technologies such as calendaring and coating foam processing and radiation processing of polymers Part four discusses micro and nano technologies with coverage of themes such as processing of macro micro and nanocomposites and processing of carbon nanotubes The final section of the book addresses post processing technologies with chapters on online monitoring and computer modelling as well as joining machining finishing and decorating of polymers With is distinguished editors and team of international contributors Advances in polymer processing From macro to nano scales is an invaluable reference for engineers and academics concerned with polymer processing Reviews the latest advances in polymer processing techniques and materials analysing new challenges and opportunities Discusses the fundamentals of polymer processing considering the compounding and mixing of polymers as well as extrusion Assesses alternative processing technologies including calendaring and coating and thermoforming of polymers **Polymer Science: A Comprehensive Reference** ,2012-12-05 The progress in polymer science is revealed in the chapters of Polymer Science A Comprehensive Reference Ten Volume Set In Volume 1 this is reflected in the improved understanding of the properties of polymers in solution in bulk and in confined situations such as in thin films Volume 2 addresses new characterization techniques such as high resolution optical microscopy scanning probe microscopy and other

procedures for surface and interface characterization Volume 3 presents the great progress achieved in precise synthetic polymerization techniques for vinyl monomers to control macromolecular architecture the development of metallocene and post metallocene catalysis for olefin polymerization new ionic polymerization procedures and atom transfer radical polymerization nitroxide mediated polymerization and reversible addition fragmentation chain transfer systems as the most often used controlled living radical polymerization methods Volume 4 is devoted to kinetics mechanisms and applications of ring opening polymerization of heterocyclic monomers and cycloolefins ROMP as well as to various less common polymerization techniques Polycondensation and non chain polymerizations including dendrimer synthesis and various click procedures are covered in Volume 5 Volume 6 focuses on several aspects of controlled macromolecular architectures and soft nano objects including hybrids and bioconjugates Many of the achievements would have not been possible without new characterization techniques like AFM that allowed direct imaging of single molecules and nano objects with a precision available only recently An entirely new aspect in polymer science is based on the combination of bottom up methods such as polymer synthesis and molecularly programmed self assembly with top down structuring such as lithography and surface templating as presented in Volume 7 It encompasses polymer and nanoparticle assembly in bulk and under confined conditions or influenced by an external field including thin films inorganic organic hybrids or nanofibers Volume 8 expands these concepts focusing on applications in advanced technologies e g in electronic industry and centers on combination with top down approach and functional properties like conductivity Another type of functionality that is of rapidly increasing importance in polymer science is introduced in volume 9 It deals with various aspects of polymers in biology and medicine including the response of living cells and tissue to the contact with biofunctional particles and surfaces The last volume is devoted to the scope and potential provided by environmentally benign and green polymers as well as energy related polymers They discuss new technologies needed for a sustainable economy in our world of limited resources Provides broad and in depth coverage of all aspects of polymer science from synthesis polymerization properties and characterization methods and techniques to nanostructures sustainability and energy and biomedical uses of polymers Provides a definitive source for those entering or researching in this area by integrating the multidisciplinary aspects of the science into one unique up to date reference work Electronic version has complete cross referencing and multi media components Volume editors are world experts in their field including a Nobel Prize winner **Polymer Morphology** Qipeng Guo,2016-03-29 With a focus on structure property relationships this book describes how polymer morphology affects properties and how scientists can modify them The book covers structure development theory simulation and processing and discusses a broad range of techniques and methods Provides an up to date comprehensive introduction to the principles and practices of polymer morphology Illustrates major structure types such as semicrystalline morphology surface induced polymer crystallization phase separation self assembly deformation and surface topography Covers a variety of polymers such as

homopolymers block copolymers polymer thin films polymer blends and polymer nanocomposites Discusses a broad range of advanced and novel techniques and methods like x ray diffraction thermal analysis and electron microscopy and their applications in the morphology of polymer materials Eco-friendly Polymer Nanocomposites Vijay Kumar Thakur,Manju Kumari Thakur,2015-07-20 This book contains precisely referenced chapters emphasizing environment friendly polymer nanocomposites with basic fundamentals practicality and alternatives to traditional nanocomposites through detailed reviews of different environmental friendly materials procured from different resources their synthesis and applications using alternative green approaches The book aims at explaining basics of eco friendly polymer nanocomposites from different natural resources and their chemistry along with practical applications which present a future direction in the biomedical pharmaceutical and automotive industry The book attempts to present emerging economic and environmentally friendly polymer nanocomposites that are free from side effects studied in the traditional nanocomposites This book is the outcome of contributions by many experts in the field from different disciplines with various backgrounds and expertises This book will appeal to researchers as well as students from different disciplines The content includes industrial applications and will fill the gap between the research works in laboratory to practical applications in related industries *Introduction to Nanoscale Science and Technology* Massimiliano Ventra,Stephane Evoy,James R. Heflin,2006-04-11 Nanoscale science and technology is a young promising field that encompasses a wide range of disciplines including physics chemistry biology electrical engineering chemical engineering and materials science With rapid advances in areas such as molecular electronics synthetic biomolecular motors DNA based self assembly and manipulation of individual atoms nanotechnology has captured the attention and imagination of researchers and the general public Introduction to Nanoscale Science and Technology provides a broad and thorough introduction that is aimed specifically at undergraduate seniors and early graduate students in all of the disciplines enumerated above It will also be of value to academic industrial and government researchers interested in a primer in the field The book consists of twenty three chapters arranged in seven sections All chapters have been written by experts from each respective field Exercises and general references are provided at the end of each chapter to encourage students to expand on the topics discussed in the book **Tribology of Polymeric Nanocomposites** Klaus Friedrich,Alois K. Schlarb,2011-08-30 The area of tribology deals with the design friction wear and lubrication of interacting surfaces in relative motion Polymer nanocomposite materials are increasingly common and offer remarkable improvements in the friction and wear properties of both bulk materials and coatings This book gives a comprehensive description of polymeric nanocomposites both as bulk materials and as thin surface coatings and their behavior and potential use in tribological applications It provides the preparation techniques friction and wear mechanisms properties of polymeric nanocomposites characterization evaluation and selection methodology It also provides various examples of application of polymeric nanocomposites Provides a complete reference from the preparation to the selection of

polymeric nanocomposites Explains the theory through examples of real world applications More than 20 international tribology experts contribute to their area of expertise *Polymer Nanocomposites: Processing, Characterization, and Applications, Second Edition* Joseph H. Koo,2019-07-08 Publisher s Note Products purchased from Third Party sellers are not guaranteed by the publisher for quality authenticity or access to any online entitlements included with the product Up to date polymer nanocomposite principles practices and characteristics This fully updated guide helps engineers and scientists understand and use the special properties of cutting edge polymer nanocomposites Written by a recognized authority in the field Polymer Nanocomposites Processing Characterization and Applications Second Edition begins with an overview of key technologies and processes Each chapter then examines a different property structural mechanical thermal flammability ablation and electrical and explains relevant commercial and industrial applications Examples for a wide variety of usage include applications for spacecraft and defense vehicles medical and dental implants flame retardant and conductive polymers for additive manufacturing and fire resistant woven and nonwoven fabrics Coverage includes Nanotechnology and nanomaterials fundamentals Applications in an expansive range of industries and commercial sectors Processing of multifunctional polymer nanocomposites Structure and properties characterization Mechanical thermal flammability ablation electrical and tribological properties Opportunities trends and challenges in the field Advanced Composite Materials for Aerospace Engineering Sohel Rana,Raul Fangueiro,2016-04-26 Advanced Composite Materials for Aerospace Engineering Processing Properties and Applications predominately focuses on the use of advanced composite materials in aerospace engineering It discusses both the basic and advanced requirements of these materials for various applications in the aerospace sector and includes discussions on all the main types of commercial composites that are reviewed and compared to those of metals Various aspects including the type of fibre matrix structure properties modeling and testing are considered as well as mechanical and structural behavior along with recent developments There are several new types of composite materials that have huge potential for various applications in the aerospace sector including nanocomposites multiscale and auxetic composites and self sensing and self healing composites each of which is discussed in detail The book s main strength is its coverage of all aspects of the topics including materials design processing properties modeling and applications for both existing commercial composites and those currently under research or development Valuable case studies provide relevant examples of various product designs to enhance learning Contains contributions from leading experts in the field Provides a comprehensive resource on the use of advanced composite materials in the aerospace industry Discusses both existing commercial composite materials and those currently under research or development **Applied Nanoindentation in Advanced Materials** Atul Tiwari,Sridhar Natarajan,2017-08-30 Research in the area of nanoindentation has gained significant momentum in recent years but there are very few books currently available which can educate researchers on the application aspects of this technique in various areas of materials science Applied Nanoindentation in Advanced Materials

addresses this need and is a comprehensive self contained reference covering applied aspects of nanoindentation in advanced materials With contributions from leading researchers in the field this book is divided into three parts Part one covers innovations and analysis and parts two and three examine the application and evaluation of soft and ceramic like materials respectively Key features A one stop solution for scholars and researchers to learn applied aspects of nanoindentation Contains contributions from leading researchers in the field Includes the analysis of key properties that can be studied using the nanoindentation technique Covers recent innovations Includes worked examples Applied Nanoindentation in Advanced Materials is an ideal reference for researchers and practitioners working in the areas of nanotechnology and nanomechanics and is also a useful source of information for graduate students in mechanical and materials engineering and chemistry This book also contains a wealth of information for scientists and engineers interested in mathematical modelling and simulations related to nanoindentation testing and analysis **Handbook of Nanoscience, Engineering, and Technology** William A. Goddard III,Donald Brenner,Sergey Edward Lyshevski,Gerald J Iafrate,2007-05-03 The ability to study and manipulate matter at the nanoscale is the defining feature of 21st century science The first edition of the standard setting Handbook of Nanoscience Engineering and Technology saw the field through its infancy Reassembling the preeminent team of leading scientists and researchers from all areas of nanoscience and nanote

Polymer Nanocomposites Rajesh Kumar Verma,Shivi Kesarwani,Jinyang Xu,J. Paulo Davim,2023-09-11 Polymer Nanocomposites Fabrication to Applications offers readers an up to date interpretation of various polymeric nanocomposite materials and technologies via critical reviews It covers developments and advancements in various nanomaterials polymeric materials biopolymers and processes It initiates from nanomaterial synthesis fabrication and characterization to the manufacturing aspect and feasible product applications of polymer based nanocomposites The prime focus is on polymer matrix nanocomposites and their future trends in the engineering sector Features Explores synthesis characterization properties fabrication processing and applications of polymer nanocomposite materials Elaborates on polymer manufacturing phase challenges using various control methods and statistical tools and modules Includes machining and micro machining investigation on the polymer nanocomposites Discusses modeling simulation and optimization of process parameters during the machining processes and applications of additive manufacturing Comprehends the significance of nanomaterials functionalizing synthetic fibrous and biocompatible composites This book is aimed at researchers and graduate students in mechanical engineering materials science polymers composites and nanomaterials Clay-containing Polymeric Nanocomposites L. A. Utracki,2004 This is a very comprehensive book and represents the forefront of the technology of Clay Containing Polymeric Nanocomposites

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