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Recent advances in interface microscopic characterization of carbon fiber-reinforced polymer composites

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Carbon fiber reinforced polymer composites (CFRPs) have excellent properties, e.g., low density, high-temperature resistance, high specific modulus, and high specific strength, and are widely used in aerospace and civil industries. CFRP comprises carbon fiber, polymer matrix, and the interface between them. The microstructure, chemical composition, bonding mode, and interfacial bonding strength of the CFRPs interface greatly influence the mechanical properties and failure behavior of CFRPs. Accordingly, the deep, systematic and nuanced characterization of the microstructure and properties of the interfaces is one of the critical problems in the research field of CFRPs. In this paper, various microscopic characterization methods of CFRPs interface micromorphology, microstructure, chemical composition and mechanical properties developed in recent years are reviewed. For example, scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), X-ray photoelectron spectroscopy (XPS), Raman spectroscopy (Raman), nanoindentation and other advanced analytical characterization techniques, as well as the application of newly developed microscopic in situ mechanical testing methods in the interface characterization of CFRPs. The prospect and trend of interface microscopic characterization technology of CFRPs have also been prospected.

KEYWORDS

carbon fiber reinforced polymer composites (CFRPs), composites, interface, microscopic characterization, micromorphology, microstructure, chemical composition, mechanical property

1 Introduction

Carbon fiber reinforced polymer composites (CFRPs) are composite materials with carbon fiber (CF) as reinforcement and polymer as the matrix, accounting for more than 90% of the total CF composites market share. Unlike polymer composites that use traditional fibers, such as glass fibers or aramid fibers, CFRPs offer excellent performance in terms of light weight and high strength. CFRPs are not only lightweight, but also have higher strength and higher hardness per unit weight than glass fiber polymer composites. According to the source of the precursor, CFs can be divided into polyacrylonitrile (PAN)-based CFs, pitch-based CFs, and viscose-based CFs (Zhang et al., 2021a). The polymer matrix is usually classified into two types, thermosetting resins and thermoplastic resins. Commonly used thermosetting resins include epoxy, bismaleimide, polyimide and phenolic resins. Commonly used thermoplastic resins are polyethylene, nylon, polytetrafluoroethylene and polyetheretherketone. CFRPs have high specific strength and modulus, low density, low coefficient of thermal expansion, corrosion and abrasion resistance, fatigue resistance, good electrical conductivity, good electromagnetic

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Polymer and Fiber Science Raymond E. Fornes, Richard D. Gilbert, 1992 The result of a symposium held in Raleigh NC March 1990 In Honor of the Retirement of Richard Dean Gilbert from North Carolina State University and in Celebration of the Twentieth Graduating Class of the Fiber and Polymer Science Program Twenty seven chapters by leaders in the field cover the most recent advances in fiber science Chapters discuss the environmental effects biomedical applications mechanistic considerations and latex blends For polymer scientists in the field of textiles Annotation copyrighted by Book News Inc Portland OR Proceedings of Recent Advances in Polymers and Composites., 2000 Proceedings of the Symposium Macro 2000 held at Kanpur on 1 2 December 2000 *Recent Advances in Smart Self-Healing Polymers and Composites* Guoqiang Li, Xiaming Feng, 2022-06-08 There have been many new developments since the first edition of this book was published back in 2015 These can be summarized as follows integration of multiple properties into self healing polymer materials such as the shape memory effect and flame retardancy beyond self healing and the development of recyclable thermoset polymers and the application of self healing polymers in both 3D and 4D printing Recent Advances in Smart Self healing Polymers and Composites Second Edition provides a comprehensive introduction to the fascinating field of smart self healing polymers and composites All chapters are brought fully up to date with the addition of six brand new contributions on the characterization of self healing polymers light triggered self healing additive manufacturing multifunctional thermoset polymers with self healing ability and recyclable thermoset polymers and 4D printing It is written for a large readership including not only R D researchers from diverse backgrounds such as chemistry materials science aerospace physics and biological science but also for graduate student working on self healing technologies as well as their newly developed applications Features new chapters on characterization of self healing polymers light triggered self healing additive manufacturing multifunctional thermoset polymers with self healing ability recyclable thermoset polymers and 4D printing All chapters have been significantly updated from the previous edition Provides a grounding in all key areas of research to bring people up to speed with the latest developments **Recent Advances in Smart Manufacturing and Materials** Rajeev Agrawal, Jinesh Kumar Jain, Vinod Singh Yadav, Vijaya Kumar Manupati, Leonilde Varela, 2021-07-22 This book presents select proceedings of the International Conference on Evolution in Manufacturing ICEM 2020 and examines a range of areas including internet of things for cyber manufacturing data analytics for manufacturing systems and processes and materials The topics covered include modeling simulation and decision making in cyber physical systems for supporting engineering and production management innovative approach in materials development biomaterial applications and advancement in manufacturing and material technologies The book also discusses sustainability in manufacturing and supply chain management including circular economy The book will be a valuable reference for beginners researchers and professionals interested in smart manufacturing in engineering production management and materials technology Recent

Advances in Textile Composites Christophe Binetruy, François Boussu, 2010 *Advances in Natural Fibre Composites* Raul Figueiro, Sohel Rana, 2017-10-24 This book presents selected high quality research papers submitted to ICNF 2017 the 3rd International Conference on Natural Fibers which was held in Braga Portugal on 21-23 June 2017 It discusses the latest research and developments in the field and covers a wide range of topics related to various aspects of natural fiber composites such as production and processing of raw materials surface modification and functionalization advanced fibrous structures for composites nano fibers experimental characterization modeling and analysis design and product development applications market potential and environmental impacts The book presents the latest research work addressing different approaches and techniques to improve processing performance functionalities and cost effectiveness of natural fibers composites in order to increase their applications in different industrial sectors such as automobiles transportation construction and sport

Fundamentals and Recent Advances in Nanocomposites Based on Polymers and Nanocellulose Md Rezaur Rahman, 2021-10-05 Fundamentals and Recent Advances in Nanocomposites Based on Polymers and Nanocellulose brings together the latest research in cellulose based nanocomposites covering fundamentals processing properties performance applications and the state of the art The book begins by explaining the fundamentals of cellulose and cellulose based nanocomposites including sources extraction types classification linkages model structure model compounds and characterization techniques The second part of the book covers the incorporation of cellulose fillers to improve the properties or characteristics of nanocomposites organized by composite category including in aerogels thermoplastic composites thermoset composites bioplastic composites carbon nanofibers rubber composites carbon fibers and foaming materials Throughout these chapters there is an emphasis on the latest innovations and application potential Finally applications are explored in more detail notably focusing on the utilization of nanocellulose in biodegradable composites for biomedical applications along with other important industrial application areas This book is of great interest to researchers scientists and advanced students working with bio based materials and across polymer science nanomaterials composite materials plastics engineering chemical engineering materials science and engineering as well as R D professionals engineers and industrialists interested in the development of bio based materials for advanced applications or material commercialization Presents the fundamentals of cellulose based nanocomposites including sources extraction types classification linkages structure compounds and characterization Discusses and analyzes the most suitable fabrication methods and processing techniques for cellulose as a reinforcement in a range of composites Opens the door to a range of cutting edge applications and considers key aspects such as cost lifecycle and biodegradability

Recent Advances in Plasticizers Mohammad Luqman, 2012-03-21 Plasticizers are used to increase the process ability flexibility and durability of the material and of course to reduce the cost in many cases This edition covers introduction and applications of various types of plasticizers including those based on non toxic and highly effective pyrrolidones and a new source of Collagen based bio

plasticizers that can be obtained from discarded materials from a natural source Jumbo Squid *Dosidicus gigas* It covers the application of plasticizers in plastic ion selective electrode electrochemical sensor transdermal drug delivery system pharmaceutical and environmental sectors This book can be used as an important reference by graduate students and researchers scientists engineers and industrialists in polymer electrochemical pharmaceutical and environmental industries

Recent Advances in Polymer Chemical Physics Dunsan C Prevorsek, 1998-09-16 The Institute of Chemical Physics of the Russian Academy of Sciences has become one of the world's premiere centers for studies of polymeric materials in use during processing and in harsh environments The Institute's focus is on commercially available materials and their modifications to improve performance through advanced theoretical analysis and implementation of experimental results Selected papers from the Institute have been incorporated into five sections Stabilization and Degradation Biochemistry Photochemistry Rheology and Flame Retardancy and should provide invaluable background to producers of polymeric materials

Fiber-Reinforced Polymer Composites Madhu Puttegowda, Sanjay M. R, Suchart Siengchin, 2025-06-27 Fiber Reinforced Polymer Composites Materials and Manufacturing systematically explores the essential concepts and latest advancements in fiber reinforced polymer composites This comprehensive book begins with an introduction to composite materials progressing to detailed discussions on reinforcements polymers and innovative manufacturing techniques It addresses characterization of these composites environmental considerations design and analysis joining and repair and their durability and performance Each chapter contributes to a deeper understanding from basic principles to sophisticated real world applications It is a valuable reference for researchers material scientists engineers polymer chemists and manufacturers invested in sustainable polymer composite materials Covers fundamental concepts and recent advances in the synthesis processing functionalization characterization and applications of fiber reinforced polymer composites Includes the latest developments in novel manufacturing methods across various industries Contains case studies of real world applications including selection fabrication and design as well as sustainable production practices and disposal Provides environmental and ecological aspects regulations standards recycling and lifecycle assessment Discusses commercialization economical and societal aspects and future prospects

Basics of Polymers Muralisrinivasan Natamai Subramanian, 2015-12-30 Basics of Polymers Materials and Synthesis is a major investigative tool in the design and synthesis of polymers in the modern academic and industrial fields Materials and synthesis encompass a wide range of operations such as selection of monomers and polymerization techniques for the synthesis of materials under various operating conditions The design and synthesis of each process should therefore be based on specific features This book highlights the diversity of approaches used in understanding polymer synthesis This book is designed to be used as study materials for students professionals and professors that support their wide use on material and synthesis It emphasizes the value of each relevant synthesis method and polymerization type rather than complex mechanisms or the history of its development An area of

considerable interest in this book is polymer synthesis in terms of the relationship between the structure and function of monomers. This book is also directed toward postgraduate students and practicing engineers who wish to develop polymer synthesis. **Surface Modification and Coating of Fibers, Polymers, and Composites** Sanjay Mavinkere

Rangappa, Sathish Kumar Palaniappan, Ramesh Manickam, Rajeshkumar Lakshminarasimhan, Suchart Siengchin, 2024-11-25

Surface Modification and Coating of Fibers Polymers and Composites Techniques Properties and Applications outlines techniques concepts characterization and applications of surface modification for fibers polymers and coated fiber reinforced composites allowing for precision engineering of the mechanical and thermal properties electrical conductivity and chemical resistance of these materials. A broad range of fiber types are covered and the book highlights how surface modification enhances the durability and sustainability of them. The book starts with chapters that discuss surface modification techniques for a range of different fibers and composites including animal based mineral leaf based root based and more. The next section of the book covers surface coating techniques as well as morphology characterization and computational modeling of surface coated materials and the book concludes with a section that outlines the properties and applications of coated fiber composites. Outlines techniques concepts characterization and applications of surface modification of fibers polymers and coated fiber reinforced composites. Techniques provided allow for precision tailoring of the mechanical and thermal properties electrical conductivity and chemical resistance of natural and synthetic fibers. Highlights the sustainability features of surface modification of these materials. Covers a variety of fiber types including synthetic biofibers MXene and graphene based. **Polymer Modification** John Meister, 2000-07-25 Describes new modification methods and applications for natural synthetic thermoplastic and thermoset polymers that result from economic forces commercial processes and the latest research and development. Features chemical and physical technologies such as sulfonation alkylation acid base hydrolysis hydrogenation stress orienting anneal. **Advanced Fiber Spinning Technology** T. Nakajima, 1994-01-01 Translated from Japanese this book details some of the most interesting developments of the last few decades in the field of fibre manufacture. Many of these have been the result of intensive study in industry and research institutes in Japan the country at the forefront of research in fibre spinning technology. *Physico-chemical Aspects of Textile Coloration* Stephen M. Burkinshaw, 2016-02-08 The production of textile materials comprises a very large and complex global industry that utilises a diverse range of fibre types and creates a variety of textile products. As the great majority of such products are coloured predominantly using aqueous dyeing processes the coloration of textiles is a large scale global business in which complex procedures are used to apply different types of dye to the various types of textile material. The development of such dyeing processes is the result of substantial research activity undertaken over many decades into the physico chemical aspects of dye adsorption and the establishment of dyeing theory which seeks to describe the mechanism by which dyes interact with textile fibres. *Physico Chemical Aspects of Textile Coloration* provides a comprehensive treatment of the

physical chemistry involved in the dyeing of the major types of natural man made and synthetic fibres with the principal types of dye The book covers fundamental aspects of the physical and chemical structure of both fibres and dyes together with the structure and properties of water in relation to dyeing dyeing as an area of study as well as the terminology employed in dyeing technology and science contemporary views of intermolecular forces and the nature of the interactions that can occur between dyes and fibres at a molecular level fundamental principles involved in dyeing theory as represented by the thermodynamics and kinetics of dye sorption detailed accounts of the mechanism of dyeing that applies to cotton and other cellulosic fibres polyester polyamide wool polyacrylonitrile and silk fibres non aqueous dyeing as represented by the use of air organic solvents and supercritical CO₂ fluid as alternatives to water as application medium The up to date text is supported by a large number of tables figures and illustrations as well as footnotes and widespread use of references to published work The book is essential reading for students teachers researchers and professionals involved in textile coloration

Handbook of Fiber Science and Technology Volume 2 Menachem Lewin, 1984-04-03 Continuing the outstanding coverage from Part A the authoritative information in Functional Finishes Part B makes your work with fibers and fabrics cost effective offers practical guidance in finishing techniques including flame retardancy water and oil repellency soil release electroconductivity and radiation and eases your continuing study of this expanding field with numerous current references with many original findings not previously cited As new advances widen the scope of this field each volume of Handbook of Fiber Science and Technology becomes an indispensable acquisition for researchers Textile fiber polymer organic physical and biological chemists textile finishers and chemical manufacturers R plastics and chemical engineers materials scientists and wood and paper technologists will find them essential references They are also superior sources of supplementary reading for graduate and advanced undergraduate courses in polymer fiber and textile chemistry and technology chemical processing of fibers chemical technology and engineering and polymer processing

Synthetic and Mineral Fibers, Their Composites and Applications Sanjay Mavinkere Rangappa, Vinod Ayyappan, Gaurav Manik, Suchart Siengchin, 2024-07-25 Synthetic and Mineral Fibers Their Composites and Applications reviews recent advances and technological developments in this important research field The book provides an up to date record of significant research findings and observations along with an update on current and future potential applications The book provides vital information on recent advancements modern processing technologies manufacturing and applications and summarizes lifecycle and performance parameters for these types of composites This book will be a valuable reference resource for academic and industrial researchers and materials scientists and engineers working in the development of polymer composite materials reinforced with synthetic and mineral fibers for applications in aerospace medical defense automotive and construction sectors Covers both synthetic and mineral fibers their composites and applications Highlights recent advances in mineral fiber reinforced polymer composites modern processing methods and functionalization Provides updates

on hybrid combination of both synthetic and mineral fiber composite technologies Features applications in aerospace medical defense and the construction industries *Wound Closure Biomaterials and Devices* Chih-Chang Chu,J. Anthony von Fraunhofer,Howard P. Greisler,2018-05-04 Virtually every wound whether surgical or traumatic needs to be closed to promote wound healing and prevent infection Increasingly sophisticated and effective materials for the crucial surgical treatment of wound closure are being developed continuously Keep up with the most recent research progress and future trends in this complex and rapidly changing field with *Wound Closure Biomaterial and Devices* This state of the art book provides detailed information and critical discussions on Electrospraying and Electrospinning in Drug Delivery Mulham Alfatama,Abid Mehmood Yousaf,Abd Almonem Doolaanea,Yasser Shahzad,2025-10-06 Electrospraying and electrospinning have emerged as powerful techniques for the fabrication of drug loaded nano and microstructures offering precise control over particle size morphology and drug release kinetics Electrospraying and Electrospinning in Drug Delivery provides a comprehensive overview of the principles and latest advancements methodologies and applications of electrospraying and electrospinning techniques in the field of drug delivery It encompasses a wide array of topics including but not limited to targeted drug delivery systems controlled release formulations stimuli responsive materials and biomedical applications Describes the most recent and successful applications of electrospraying electrospinning in drug delivery Covers fundamental principles instrumentation process parameters and optimization strategies Delves into the diverse range of materials employed in electrospraying and electrospinning such as polymers ceramics and metals highlighting their unique advantages and applications in drug delivery Explores the incorporation of functional additives such as nanoparticles and biomolecules to tailor the properties and performance of electrospun electrosprayed drug delivery platforms By compiling contributions from leading experts in the field this edited volume fosters interdisciplinary collaboration and inspires further research endeavors The book will serve as a valuable resource for researchers academicians and professionals interested in understanding and utilizing these innovative techniques for enhanced drug delivery systems **Advances in Filament Yarn Spinning of Textiles and Polymers** Dong Zhang,2014-02-15 *Advances in Filament Yarn Spinning of Textiles and Polymers* reviews the different types of spinning techniques for synthetic polymer based fibers and issues such as their effect on fiber properties including melt dry wet and gel spinning Synthetic polymer based fibers are used in a great variety of consumer and industrial textile applications ranging from clothing to home furnishings to surgical procedures This book explores how a wide array of spinning techniques can be applied in the textile industry Part one considers the fundamental structure and properties of fibers that determine their behavior during spinning The book then discusses developments in technologies for manufacturing synthetic polymer films to produce different fibers with specialized properties Part two focuses on spinning techniques including the benefits and limitations of melt spinning and the use of gel spinning to produce high strength and high elastic fibers These chapters focus specifically on developments in bi component bi constituent and

electro spinning in particular the fabrication of nanocomposite fibers The final chapters review integrated composite spinning of yarns and the principles of wet and dry spinning This collection is an important reference for a wide range of industrial textile technologists including spinners fabric and garment manufacturers and students of textile technology It is also of great interest for polymer scientists Reviews the different spinning techniques and issues such as their effect on fiber properties including melt dry wet and gel spinning Considers the fundamental structure and properties of fibers that determine their behavior during spinning Reviews integrated composite spinning of yarns and the principles of wet and dry spinning

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