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Stretchable phosphorescent polymers by multiphase engineering

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Stretchable phosphorescence materials potentially enable applications in diverse advanced fields in wearable electronics. However, achieving room-temperature phosphorescence materials simultaneously featuring long-lived emission and good stretchability is challenging because it is hard to balance the rigidity and flexibility in the same polymer. Here we present a multiphase engineering for obtaining stretchable phosphorescent materials by combining stiffness and softness simultaneously in well-designed block copolymers. Due to the microphase separation, copolymers demonstrate an intrinsic stretchability of 712%, maintaining an ultralong phosphorescence lifetime of up to 981.11 ms. This multiphase engineering is generally applicable to a series of binary and ternary initiator systems with color-tunable phosphorescence in the visible range. Moreover, these copolymers enable multi-level volumetric data encryption and stretchable afterglow display. This work provides a fundamental understanding of the nanostructures and material properties for designing stretchable materials and extends the potential of phosphorescence polymers.

Stretchable and flexible materials are highly desirable for developing flexible electronics[1–4]. Wherein stretchable luminescent materials as vital components can provide emission sources and intrinsic flexibility to the optoelectronic displays for versatile applications in soft robots, intelligent sensing/detection, on-skin displays, and wireless communication (Fig. 1a)[5–8]. To date, most of the reported stretchable emitters are based on fluorescent polymers that only harness singlet excitons and suffer from short lifetimes[9–11]. Rare stretchable phosphorescent materials for advanced applications have been developed. Room-temperature phosphorescence (RTP) materials, featuring long emission lifetimes, tunable excited state properties, and high exciton utilization, have recently received increasing attention[12–16]. To obtain organic RTP materials, tremendous efforts have been devoted to promoting the intersystem crossing (ISC) process by incorporating heavy atoms, heteroatoms, and aromatic carbonyls into phosphors[17–20], and restraining the non-radiative decay of triplet excitons by building a rigid environment[21,22]. Given the intrinsic merits of polymers in good processability, lightweight, and flexibility, polymer-based RTP materials become attractive alternatives to small molecules for expanding applications in stretchable photoelectronics[23–25]. Conventionally, RTP polymers can be obtained by chemically conjugating phosphors onto a polymer backbone via polymerization[26–28], or doping chromophores into rigid polymer hosts[29–31]. These homopolymers with rich hydrogen bonds and rigid microenvironments could suppress the non-radiative decay of phosphors for efficient RTP. However, the small free volume and high glass transition temperature (T_g) limit the movement and rearrangement of polymer chains, resulting in poor mechanical deformations. Generally, stretchable polymers require a low T_g to meet the fast segmental dynamics at room temperature, which will cause intensive non-radiative deactivation and weaken RTP performance.

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Multiphase Polymers

Chang Han

Multiphase Polymers:

Multiphase Polymers L. A. Utracki,1989 **Structure and Properties of Multiphase Polymeric Materials** Takeo Araki,Mitsuhiro Shibayama,Qui Tran-Cong,1998-03-03 Offers an overview of recent advances in multiphase polymeric materials ranging from theoretical aspects of polymer miscibility and phase separation kinetics to bulk surface and interface properties in polymeric materials This work considers the possibility of a nondestructive methodology to investigative multiphase polymers based mainly on a scattering technique that is sensitive to changes in the phase behaviour of multicomponent polymer systems *Crystallization in Multiphase Polymer Systems* Sabu Thomas,Mohammed Arif P.,E. Bhoje Gowd,Nandakumar Kalarikkal,2017-09-15 Crystallization in Multiphase Polymer Systems is the first book that explains in depth the crystallization behavior of multiphase polymer systems Polymeric structures are more complex in nature than other material structures due to their significant structural disorder Most of the polymers used today are semicrystalline and the subject of crystallization is still one of the major issues relating to the performance of semicrystalline polymers in the modern polymer industry The study of the crystallization processes crystalline morphologies and other phase transitions is of great significance for the understanding the structure property relationships of these systems Crystallization in block copolymers miscible blends immiscible blends and polymer composites and nanocomposites is thoroughly discussed and represents the core coverage of this book The book critically analyzes the kinetics of nucleation and growth process of the crystalline phases in multi component polymer systems in different length scales from macro to nanoscale Various experimental techniques used for the characterization of polymer crystallization process are discussed Written by experts in the field of polymer crystallization this book is a unique source and enables professionals and students to understand crystallization behavior in multiphase polymer systems such as block copolymers polymer blends composites and nanocomposites Covers crystallization of multiphase polymer systems including copolymers blends and nanocomposites Features comprehensive detailed information about the basic research practical applications and new developments for these polymeric materials Analyzes the kinetics of nucleation and growth process of the crystalline phases in multi component polymer systems in different length scales from macro to nanoscale **Multiphase Polymers : Blends and Ionomers /** ,1989 **Polymer Microscopy** Linda Sawyer,David T. Grubb,Gregory F. Meyers,2008-12-24 Polymer Microscopy Third Edition is a comprehensive and practical guide to the study of the microstructure of polymers and is the result of the authors many years of academic and industrial experience To address the needs of students and professionals from a variety of backgrounds introductory chapters deal with the basic concepts of both polymer morphology and processing and microscopy and imaging theory The core of the book is more applied with many examples of specimen preparation and image interpretation leading to materials characterization Microscopy is applied to the characterization of a wide range of polymer systems including fibers films engineering resins and plastics composites nanocomposites polymer blends emulsions and

liquid crystalline polymers Light microscopy atomic force microscopy and scanning and transmission electron microscopy techniques are all considered as are emerging techniques such as compositional mapping in which microscopy is combined with spectroscopy This extensively updated and revised Third Edition closes with a problem solving guide which gives a systematic framework for deciding on suitable approaches to the characterization of polymer microstructure Key Features Revised and updated this Third Edition remains the gold standard for information on the characterization of polymer microstructure Presents a wide variety of polymer systems and characterization techniques Covers the major advances in microscopy and polymers since the publication of the Second Edition in 1996 Describes new methods for use with the SPM and related to advances in cryo TEM as well as new polymer materials such as nanocomposites Includes both basic and applied topics making this book ideal as a professional reference and as a teaching text **Multiphase Flow in Polymer Processing** Chang Han,2012-12-02 Multiphase Flow in Polymer Processing focuses on dispersed and stratified multiphase flow in polymer processing This book explores the rheological behavior of multiphase or multicomponent polymeric systems as they are involved in various fabrication operations It also outlines the importance of the morphological states of multiphase polymeric systems to explain the systems rheological behavior in the fluid state and mechanical behavior in the solid state This monograph consists of eight chapters divided into two parts After discussing dispersed and stratified multiphase flow in polymer processing it introduces the reader to the fundamentals of rheology The following chapters focus on the rheological behavior of particulate filled polymeric systems and heterogeneous polymeric systems the phenomenon of droplet breakup in dispersed flow and gas charged polymeric systems The role of the discrete phase that is solid particles liquid droplets gas bubbles in determining the bulk rheological properties of the multiphase system is highlighted along with some representative polymer processing operations namely fiber spinning and injection molding of the multiphase or multicomponent polymeric systems Coextrusion in cylindrical rectangular and annular dies is also considered The final chapter is devoted to the phenomenon of interfacial instability in coextrusion This text will be a useful resource for chemists chemical engineers and those in the polymer processing industry *Multiphase Polymer Systems* Andreea Irina Barzic,Silvia Ioan,2016-09-19 Phase morphology in multicomponent polymer based systems represents the main physical characteristic that allows for control of the material design and implicitly the development of new plastics Emphasizing properties of these promising new materials in both solution and solid phase this book describes the preparation processing properties and practical implications of advanced multiphase systems from macro to nanoscales It covers a wide range of systems including copolymers polymer blends polymer composites gels interpenetrating polymers and layered polymer metal structures describing aspects of polymer science engineering and technology The book analyzes experimental and theoretical aspects regarding the thermal and electrical transport phenomena and magnetic properties of crucial importance in advanced technologies It reviews the most recent advances concerning morphological rheological interfacial physical fire

resistant thermophysical and biomedical properties of multiphase polymer systems Concomitantly the book deals with basic investigation techniques that are sensitive in elucidating the features of each phase It also discusses the latest research trends that offer new solutions for advanced bio and nanotechnologies Introduces an overview of recent studies in the area of multiphase polymer systems their micro and nanostructural evolutions in advanced technologies and provides future outlooks new challenges and opportunities Discusses multicomponent structures that offer enhanced physical mechanical thermal electrical magnetic and optical properties adapted to current requirements of modern technologies Covers a wide range of materials such as composites blends alloys gels and interpenetrating polymer networks Presents new strategies for controlling the micro and nanomorphology and the mechanical properties of multiphase polymeric materials Describes different applications of multiphase polymeric materials in various fields including automotive aeronautics and space industry displays and medicine **Multiphase Polymers** Stuart L. Cooper,1979 Good No Highlights No Markup all pages are intact Slight Shelfwear may have the corners slightly dented may have slight color changes slightly damaged spine Multiphase Flow in Polymer Processing Chang Dae Han,1981 **Polymer Blends and Composites in Multiphase Systems** Chang Dae Han,1984 **Micro- and Nanostructured Multiphase Polymer Blend Systems** Charef Harrats,Sabu Thomas,Gabriel Groeninckx,2005-09-29 Micro and Nanostructured Multiphase Polymer Blend Systems Phase Morphology and Interfaces focuses on the formation of phase morphology in polymer blends and copolymers and considers various types of blends including thermosets thermoplastics thermoplastic vulcanizates and structured copolymers The book carefully debates the processing **Multiphase Polymer- Based Materials** Charef Harrats,2009-03-24 During the past 10 years a large variety of new multiphase polymer based materials have been studied from a morphological point of view Simultaneously huge progress has been achieved in microscopy These circumstances underline the need for a reference that delineates the differences of various types of nanostructures in multiphase polymer based Multiphase Polymers. Based on a Symposium Sponsored by the Division of Polymer Chemistry at the 175.meeting of the American Chemical Society, ACS, Anaheim,Calif. 1978 American Chemical Society. Division of Polymer Chemistry,Stuart L. Cooper,American Chemical Society. Meeting,G.M. Estes,ACS,1979 *Polymer Microscopy* Linda C. Sawyer,2012-12-06 Modern materials include a vast array of polymers and plastics which are found in applications such as housing appliances clothing and household textiles and automotive and aerospace industries Thus research scientists engineers and materials science graduate students need to be aware of the methods and techniques required to understand the structure property relations of polymer materials This book will review the field of the microscopy of polymers There is a vast literature which describes the research results obtained by study of polymer materials using microscopy and other complementary analytical techniques and such studies are best left to journals on specific topics The major objective of this text is to provide the basic microscopy techniques and specimen preparation methods applicable to polymers The book will attempt to provide enough detail so that the methods described

can be applied and also to reference appropriate publications for the investigator interested in more detail The selection of two authors for this text came from the desire for a comprehen sive review of polymer microscopy with emphasis on methods and techniques rather than on research results The synergism provided by two authors with widely varied backgrounds was thought to be important one author LCS has an industrial focus and a background in chemistry whilst the other DTG has an academic environment and offers a background in polymer physics **Multicomponent Polymeric Materials** Jin Kuk Kim,Sabu Thomas,Prosenjit Saha,2016-08-26 The book offers an in depth review of the materials design and manufacturing processes employed in the development of multi component or multiphase polymer material systems This field has seen rapid growth in both academic and industrial research as multiphase materials are increasingly replacing traditional single component materials in commercial applications Many obstacles can be overcome by processing and using multiphase materials in automobile construction aerospace food processing and other chemical industry applications The comprehensive description of the processing characterization and application of multiphase materials presented in this book offers a world of new ideas and potential technological advantages for academics researchers students and industrial manufacturers from diverse fields including rubber engineering polymer chemistry materials processing and chemical science From the commercial point of view it will be of great value to those involved in processing optimizing and manufacturing new materials for novel end use applications The book takes a detailed approach to the description of process parameters process optimization mold design and other core manufacturing information Details of injection extrusion and compression molding processes have been provided based on the most recent advances in the field Over two comprehensive sections the book covers the entire field of multiphase polymer materials from a detailed description of material design and processing to the cutting edge applications of such multiphase materials It provides both precise guidelines and general concepts for the present and future leaders in academic and industrial sectors *Rheo-Physics of Multiphase Polymer Systems* Kai Sondergaard,J. Lyngaae-Jorgensen,1995-06-02 FROM THE PREFACE Almost all polymeric systems are subjected to a flow field at least once along the route between preparation and application There is also an increased interest in predictive models on phase behavior and suitable techniques for characterizing the structure of these systems when subjected to flow Multiphase polymeric systems are particularly susceptible to flow which may cause orientation of species morphological changes and phase transitions All these events may in turn affect the end product properties such as permeability electrical conductivity and mechanical properties In processing escalating needs have evolved for optimization and development of novel and more uniform product properties and increased productivity In order to arrive at an understanding of processing polymeric systems under elastic flow conditions it is convenient to analyze the basic physical mechanisms under conditions that enable development of predictive models in conjunction with controlled experimentation In recent years the science of rheo physics has evolved and now involves both advanced theories and experimental techniques Rheo physics means the

rheological morphological and thermodynamic behavior of structured polymer systems during flow In this monograph the rheo optical techniques are emphasized The book gives an introduction to rheo physics including fundamentals of theories and a representative selection of applications of rheo optical techniques for analyzing multiphase systems The chapters contain both practical advice for the new experimenter as well as review material for the experienced scientist

Multiphase Polylactide Blends Mohammadreza Nofar,2021-07-15 Multiphase Polylactide Blends Toward a Sustainable and Green Environment guides the reader through fundamentals science preparation and key areas of innovation in polylactide PLA blends Bio based polymers and notably PLA have not only gained increasing interest as a more sustainable alternative but also bring challenges in terms of mechanical rheological thermal and physical properties processability shapability and foamability The use of blends looks to address these with the development of new types of economically viable and environmentally friendly systems This is a valuable book for academic researchers scientists and graduate students across bio based polymers polymer science chemistry and materials science as well as engineers R D professionals and all those in industry with interest in PLA based blends biopolymers and sustainable materials and products More specifically the first three chapters of this book overview the fundamentals of thermoplastic polymers polymer blends and structure and properties of PLA These chapters could technically be used as a valuable textbook on the noted topics The rest of the chapters inclusively study the fundamentals investigations and achievements in PLA based blends with various types of polymers These include miscible blends of poly L lactide and poly D lactide binary immiscible miscible blends of PLA with other thermoplastics and elastomers PLA based ternary blends and blend nanocomposites as well as PLA based blend foams Overall this book provides a thorough and critical overview of the state of the art in PLA based blends including significant past and recent advances with the aim of supporting and shaping further research and industrial application of these materials for the development of a green and sustainable future Overviews the fundamentals of thermoplastic polymers polymer blends and the structure and properties of PLA Provides detailed coverage of the fundamentals and science of PLA blends including phase miscibility thermal and mechanical properties interface and rheological properties the use of compatibilizers and phase morphological analysis Offers a thorough critical overview of the state of the art in processing and development of PLA based blends addressing key challenges and future perspectives Covers the latest advances including PLA based ternary blends blend nanocomposites and PLA based blend microcellular foams *Multiphase Polymers : Blends and Ionomers* ,1989 **Multiscale Modeling of Multiphase Polymers** William Brantley Lawrimore,2016 Accurately simulating material systems in a virtual environment requires the synthesis and utilization of all relevant information regarding performance mechanisms for the material occurring over a range of length and time scales Multiscale modeling is the basis for the Integrated Computational Materials Engineering ICME Paradigm and is a powerful tool for accurate material simulations However while ICME has experienced adoption among those in the metals community it has not gained

traction in polymer research This thesis seeks establish a hierarchical multiscale modeling methodology for simulating polymers containing secondary phases The investigation laid out in the chapters below uses mesoscopic Finite Element Analysis FEA as a foundation to build a multiscale modeling methodology for polymer material systems At the mesoscale a Design of Experiments DOE parametric study utilizing FEA of polymers containing defects compared the relative impacts of a selection of parameters on damage growth and coalescence in polymers Of the parameters considered the applied stress state proved to be the most crucial parameter affecting damage growth and coalescence At the macroscale the significant influence of the applied stress state on damage growth and coalescence in polymers upscaled from the mesoscale motivated an expansion of the Bouvard Internal State Variable ISV Bouvard et al 2013 polymer model stress state sensitivity Deviatoric stress invariants were utilized to modify the Bouvard ISV model to account for asymmetry in polymer mechanical performance across different stress states tension compression torsion Lastly this work implements a hierarchical multiscale modeling methodology to examine parametric effects of heterogeneities on Polymer Clay Nanocomposite s PCNs mechanical performance under uncertainty A Virtual Composite Structure Generator VCSG built three dimensional periodic Representative Volume Elements RVEs coupled to the Bouvard ISV model and a Cohesive Zone Model CZM which featured a Traction Separation T S rule calibrated to results upscaled from Molecular Dynamics MD simulations A DOE parametric examination utilized the RVEs to determine the relative effects of a selection of parameters on the mechanical performance of PCNs DOE results determined that nanoclay particle orientation was the most influential parameter affecting PCN elastic modulus while intercalated interlamellar gallery strength had the greatest influence on PCN yield stress *Recent Advances in the Field of Crystallization and Fusion of Polymers* Jean-Pierre Mercier,R. Legras,1977

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