Emerging Technologies in Polymer Processing

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Abstract

Resting on the foundation of fundamental concepts, polymer processing has undergone phenomenal progress, beginning from the basic operations of mixing and molding, and evolving into advanced manufacturing techniques, such as 4D printing and nanocellular foaming. The use of cutting-edge technologies, such as computational modeling, have revolutionized even conventional processing techniques. Existing processing techniques have been modified, and new methods have been developed to meet application-specific requirements. The book “Emerging Technologies in Polymer Processing” is carefully structured to provide readers with a comprehensive understanding of the dynamic field of polymer processing innovation, covering a wide range of topics. This pioneering work is organized into several chapters, each meticulously crafted to look into specific facets of emerging technologies, their implications, and their applications within the polymer industry. The introductory chapter (Chapter 1) serves as the gateway to this exploration, setting the stage by delineating the evolution of polymer processing techniques. It offers a historical overview of traditional methods while elucidating the pressing need for innovation in response to evolving industry demands. Moreover, it candidly addresses the challenges inherent in conventional polymer processing techniques, laying the groundwork for the subsequent discussion on emerging technologies. Chapter 2 extensively reviews the role of rheology in the processability of polymeric materials: An in-depth understanding of the rheological characteristics of polymeric materials can help select the right materials and/or grades and processing conditions to achieve superior processability in various emerging processing operations. In Chapter 3, we emphasize the fundamentals of the conventional injection molding of polymeric materials with process control technologies, critical drivers of the market and restraints on them, recent trends, factors influencing precision, and advances in precision injection molding, including process control and material aspects. Chapter 4 provides a broad perspective on the manufacturing processes, the history of additive manufacturing, its economic feasibility, market and technology trends, and fundamentals of the different additive manufacturing processes. In Chapter 5, the fundamental principles governing electrospinning and the influence of solution properties, electric fields, and other processing parameters on nanofibers’ morphology are discussed. Chapter 6 complements Chapter 5, providing a thorough description of the various other processing methods used to prepare polymer fibers, as well as the most recent advancements in these processing methods. It also lists some of the benefits and drawbacks of each production process. Chapter 7 provides a comprehensive overview of the use of ultrasound in various polymer processing operations, highlighting its significant benefits. By shedding light on these advantages, the chapter aims to equip readers with a deeper understanding of the potential of ultrasound in polymer processing, fostering a sense of awareness and informed decision-making. In Chapter 8, we provide an overview of the fundamentals of plasma treatment technology and the use of plasma treatment in the surface modification of polymeric materials. Chapter 9 begins with a brief introduction to polymer foams and foam manufacturing techniques. After discussing the thermal insulation property of polymer foams, it then offers insight into recent advances in the development of nanocellular foams of superior properties, with a special focus on thermal insulation and mechanical properties.