Preface

The journey of a polymer from raw material to functional product is one of transformation for both literal and conceptual. In the reactor, long macromolecular chains are born; in the processing line, they are given shape and purpose; and through modification, they are endowed with properties that transcend their native capabilities.

The field of polymer science and engineering has matured tremendously since the first synthetic polymers emerged over a century ago. What began as a quest to replicate natural materials has evolved into a sophisticated discipline capable of designing molecules and materials with unprecedented precision. Yet, as our ability to create complex polymeric structures has grown, so too has the need to understand how these materials behave under the conditions of manufacturing and how their performance can be enhanced through purposeful modification.

This *Polymer Processing and Modification* is founded on a simple premise: that processing and modification are not merely downstream activities that follow polymerization, but rather integral components of the materials design process. The thermal-mechanical history imparted during processing fundamentally determines the final microstructure and therefore the properties of a polymeric product. Similarly, the modification strategies we adopted (the introduction of fillers) has created a feasible opportunity to tailor materials for specific applications.

The intended audience for this work is broad, reflecting the interdisciplinary nature of the subject. Advanced undergraduate and graduate students in polymer science, materials engineering, and chemical engineering will find here a structured introduction to the principles that govern polymer processing and the techniques available for property modification. For researchers and industry practitioners, we hope this volume serves as a valuable reference that bridges fundamental understanding with practical application.

This book mainly focuses on the process design, modification strategies, and influencing factors of polymer materials during the molding and processing stages (such as extrusion, micro-injection molding, and spinning). In addition, a distinguishing feature of this book is its emphasis on the relationships between processing conditions, morphology development, and final properties. Too often, these connections are treated in isolation. Here, we have made them central to the narrative, illustrating how stretching and shear fields influence orientation, how thermal histories determine crystallinity, and how interfacial phenomena govern the performance of multiphase systems. The book presents detailed case studies on isotactic polypropylene (iPP) and polyvinylidene fluoride (PVDF), demonstrating how processing parameters can be manipulated to achieve enhanced mechanical and functional properties. Chapters 1-5 focus on extrusion processing of polymers, with particular emphasis on melt-stretching techniques. Through systematic investigations of iPP films prepared under various stretching ratios, we elucidate the relationships between processing conditions, crystalline structure development, and resulting mechanical properties. The role of β-nucleating agents in modifying crystal morphology and enhancing toughness is explored in depth, revealing the complex interplay between flow fields and nucleation agents. Chapters 6-7 examine micro-injection molding, a critical technology for producing miniaturized polymer components. The introduction of an overflow vice-cavity design demonstrates how stronger shear fields can be imposed to generate highly oriented shish-kebab structures, leading to remarkably enhanced tensile properties. The effects of nucleating agents and carbon nanotubes on crystallization behavior and mechanical performance are systematically investigated. Chapters 8-9 address fiber processing technologies, including melt-spinning and electrospinning. The simultaneous enhancement of strength and toughness in β-nucleated iPP fibers is achieved through careful control of take-up velocity. Additionally, electrospun PVDF/PAN membranes are developed for dual applications as pressure sensors and battery separators, showcasing the versatility of polymer processing in creating multifunctional materials.

A work of this scope and depth is never the product of solitary effort. The

intellectual journey that culminated in this volume has been shaped, guided, and enriched by numerous individuals whose contributions deserve far more than this brief acknowledgment. Foremost among them is Professor Zheng Guoqiang from Zhengzhou University, to whom I owe an incalculable debt of gratitude. This book's conception, logical framework, structural design, and refinement through multiple drafts have all benefited immeasurably from Professor Zheng's profound insights and rigorous guidance. His unwavering commitment to scientific excellence, his ability to discern the essential from the merely interesting, and his patience in nurturing young researchers have left an indelible mark not only on this work but on my entire approach to scientific inquiry. The countless hours of discussion, the careful reading of each manuscript chapter, and the incisive critiques that always pointed toward deeper understanding, which represent gifts that cannot be adequately acknowledged in words. In addition, we are grateful to our colleagues and students, whose questions and insights have shaped our understanding over the years. We acknowledge the financial support from the National Natural Science Foundation of China (52403061), Natural Science Foundation of Henan Province (242300420371), and other funding agencies that made this research possible. Finally, we acknowledge the broader community of polymer scientists and engineers upon whose work this volume is built.

We invite readers to approach this text not as a final authority, but as a starting point for exploration. The field of polymer processing and modification continues to evolve, driven by new materials, new applications, and new societal imperatives. May this book serve as a useful companion on that journey of discovery.

Zhongzhu Liu

March 2026