Polymer Physics

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Polymer Physics

A Molecular Approach

Springer

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Foreword

There are many excellent books on polymer physics. It therefore requires some courage to write a new book on this subject. However, for the success of a book, the courage of the author is less important than the novelty of the approach that the book follows and, most importantly, it is crucial that this approach addresses an existing need.

Polymer Physics: A Molecular Approach that Professor Wenbing Hu has written aims to bring some of the key concepts of modern polymer physics to a readership that is not familiar with this field. For this target audience, the present book will provide the first, and in some cases, the only introduction to a very wide and active field of research. In writing a book for this readership, Professor Hu had to make choices. Systematically, he has decided to focus on underlying physical concepts rather than on detailed mathematical descriptions, and he has tried to highlight the links between the subject matter of the book and the (many) application areas. In addition, as the title says, the book uses a "molecular" picture to explain concepts and phenomena. This approach has proven to be very successful for the original (Chinese) edition of this book and it is therefore fortunate that the publishers have decided to publish an English translation.

I should add that, on some topics, Professor Hu's book goes well beyond existing textbooks—this is, in particular, true of Professor Hu's own field of research: polymer crystallization, demixing, and the interplay of the two. To my knowledge, this is the first book that presents some of the new developments in this area of research at a level accessible to undergraduate students. Hence, the book may be of interest to a wider community than its original target readership.

Cambridge
March 2012

Daan Frenkel

Preface to the English Edition

Polymer physics covers all the physical aspects of macromolecular substances. If we introduced the subject according to the current classifications of structures and properties of polymers, the textbook would become thicker and thicker with the fast expansion of our knowledge, and would look like an encyclopedia. Such a textbook cannot meet the current demand for a more concise introduction within a time-limited schedule of university courses on polymer-related subjects. In fact, the published textbooks on polymer physics normally selected the content according to the author's personal taste or to the specific training subjects. On the other hand, nowadays on the Internet, fragmental concepts of polymer physics are available. However, the students still need the course training on the intrinsic correlations among meaningful physical concepts of polymers as well as the useful theoretical tools for a fundamental analysis. On the basis of the above challenges, this book is intended to provide a concise entrance-level introduction on polymer physics. It tries to avoid the complicated mathematic treatments of modern theories, the trivial experimental techniques, the details of practical industrial processing, and the wide applications of polymers. Rather, the attention is only focused on three basic aspects of comprehensive principles of polymer physics, including molecular structures, molecular motions, and phase transitions, in order to elaborate the basic statistical thermodynamics and kinetics (the mean-field theory and the scaling analysis) as well as their state-of-the-art applications. The book may help readers to establish several key molecular-level pictures of polymer physics. The book targets senior undergraduate students, graduate students, teachers, and researchers, who are studying and working in the extensive fields of physical sciences, life sciences, materials sciences, and engineering sciences relevant to physical aspects of polymers. Through a systematic study, the readers are expected to grasp the basic concepts of polymer physics as well as the theoretical tools for a fundamental analysis of macromolecules.

The current English edition was basically translated from its recent Chinese version (Science Publisher in Beijing, 2011), with minor expansion on the historical aspects of some fundamental ideas and their original references. After the introductory chapter, the book has been split into three parts: chain structures, chain

motions, and chain assembly. The first part introduces the relationships between chemical structures of polymers and their physical behaviors, the Gaussian statistics of ideal-chain conformation, the derivation of the equation of state for ideal rubbers, as well as the scaling analysis of some non-ideal-chain conformations (polymer solutions, polyelectrolyte, stretching, and spatial confinement). The second part introduces the scaling analysis of chain dynamics, the relaxation behaviors of polymer deformation, and the viscoelastic behaviors of polymer flows. The third part introduces polymer assembly via phase transitions, which includes the statistical thermodynamics of polymer solutions (Flory-Huggins mean-field lattice theory and its developments), phase separation (its thermodynamics and kinetics; in addition, microphase separation of block copolymers), and polymer crystallization (thermodynamics, kinetics, and morphologies). The book ends with an extended reading material on the interplay of phase separation and crystallization in polymer-based multi-component systems. Each chapter is complemented at the end with several question sets to highlight some basic ideas.

The delivery of this English edition was decided in a nice conversation with Dr. Stephen Soehnlen, the Springer editor. Prof. Daan Frenkel offered a perfect foreword. Prof. Yifu Ding and Dr. Ran Ni made a thorough proofreading over the original text, and Prof. An-Chang Shi and Dr. Jamie Hobbs made separate proofreading on the first and second chapters. With their great help, the present book became more readable as a textbook!

The content of this book is limited by the author's academic background as well as by the pedagogic style of a textbook. It could not completely cover all the important academic ideas in the related fields or all the original references in the historical aspects. The author is mainly reponsible for any mistakes in the text. Friendly suggestions and comments are always most welcome!

Nanjing Wenbing Hu
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