

Preface

During the last few decades, the use of polymeric materials has grown so that they form the most important class of materials if counted by volume and it can be regarded as certain that their growth rates will remain high in the future. While at the beginning of the era of polymers Chemistry was the predominant science, Engineering and Physics have become more and more requisite for the successful development of polymeric materials. Engineering, as the efficient production of materials of good quality and their highly sophisticated processing have developed into key factors of economic success; and Physics, as material properties have become decisive for specific applications and the continuing innovation and improvement of products. These requirements cannot be fulfilled without a fundamental knowledge of polymeric materials and a profound understanding of the relations between the molecular structure of polymers and their physical and processing properties.

These developments and the increasing number of joint uses of various materials in highly sophisticated technical products led to the foundation of special institutes devoted to materials science at some universities about 40 years ago. Besides classical materials like metals, glass, and ceramics, polymers became a central point of academic teaching and research. This book has its origin in lectures for students in the field of polymeric materials within the Department of Materials Science and Processing at the Friedrich-Alexander-University Erlangen-Nürnberg. Its main intention is to teach the basics about polymers necessary for everybody working with these materials. One part is based on the textbook “Polymermechanik,” which appeared in 1990, the other stems from more recent lectures.

The book follows two main guidelines. One is a quantitative description of the molecular structure, though this has sometimes had to be simplified due to its complex nature. The other presents relationships between molecular quantities and material properties, which cover the solid and the molten state. The temperature is the key external parameter according to which the mechanical behavior is comprehensively discussed. Nevertheless, this work has to be regarded neither as a complete text book on the mechanics of polymer materials nor on their rheology. Rather, it is meant to discuss these fields from a common viewpoint, which encompasses the transitions between the solid and molten states.

“Tools” are described insofar as they are believed to be necessary for a deeper understanding of the results presented. They comprise measuring devices as well as mathematical formalisms required for dealing with large deformations.

Much space is devoted to the linear theory of viscoelasticity as it is coherent in itself and allows quantitative insights into relations between properties and molecular structure. Theories covering the nonlinear viscoelastic regime which dominates processing are not yet in a state of development enabling quantitative descriptions of properties and processes with a generality comparable to the linear behavior. This has to be said, although many theories have been published since 1990, the year of the appearance of “Polymermechanik.” Nevertheless, an overview of constitutive equations based on various models is given and some of their predictions are compared with experimental findings.

In many parts of the book, results of investigations performed at the Institute of Polymer Materials are presented. They are examples of how research and established knowledge can become complementary parts of teaching. Regarding the references, long lists, which could easily be obtained today from various electronic bibliographies, have deliberately been avoided. Instead, a selection of original literature is cited, which opens the door to deeper information for those who are interested in more details.

The book is written from our experience of teaching the knowledge on polymeric materials, which we think to be useful for people interested and engaged in this class of materials. We hope it will be helpful for students to consolidate and broaden their knowledge, to researchers in the field of polymers at various institutions, and even to those working in industry, whenever they would like to get some fundamental questions answered, which arise from dealing with polymers.

As it is obvious from the reference lists, the originality and actuality of the results presented in this book are based, to a high degree, on the research of doctoral students under the guidance of the authors of this book. Particularly appreciated are the contributions from the theses of:

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