

STRUCTURE
AND PROPERTIES
OF POLYMERS

He Pingsheng



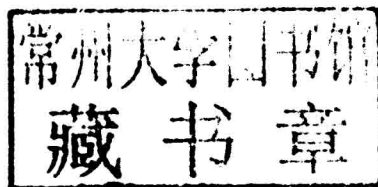
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Structure and Properties of Polymers

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Structure and Properties of Polymers

Preface

Since 1958, the Department of Polymer Chemistry and Physics has been built in the University of Science and Technology of China (USTC). The course of “Structure and Properties of Polymers” lectured by deceased Academician Prof. Qian Renyuan is being taught since 50 years. The textbook of “Structure and Properties of Polymers” based on the lecture notes and published by Science Press (the first edition in 1981) has been adopted as a standard textbook by several Universities in China. In recent ten years, the author has not only contributed in the development in Polymer Physics, but also carried intense teaching research, resulting in the new understanding of the existing system and its key points. The course has been welcomed unanimously by the students. Thus, the course has won “outstanding teaching research achievement award” at provincial and national level. The textbook is updated on his teaching research.

The Polymer Science consists of three parts: Polymer Chemistry, Polymer Physics and Polymer Processing. Polymer chemistry investigates how to synthesize the polymers through the polymerization of the monomers, including polymer processing, how to manufacture the polymer products from the raw polymers? Polymer Physics includes all kinds of physical contents related with the polymers.

As an undergraduate course “polymer physics” is hard to understand the task of “all kinds of physical contents”. The reasons are obvious. Firstly, the Polymer Physics has not reached the maturity as like that in other branches of physics. On the other hand the Polymer Physics belongs to the frame of chemistry and the students of Polymer Physics find it difficult to accept the deep knowledge on mathematics and physics. Polymer Physics deals with the structure and properties of polymers and their relationship, therefore “Structure and Properties of Polymer” has been introduced in this textbook. According to the molecular weight, a polymer may be divided into high polymer and low polymer, but the polymers used as materials are of high molecular weight. The low polymers are used as adhesives and high-energy propellants etc, therefore they are not included in the scope of this textbook.

The basic tasks of the course includes the structure and properties of polymers, opening the inherent relationships and basic laws between them, in order to provide the theoretical base for synthesis, processing, testing, selecting and exploitation of polymers. The author suggests that there are three levels in the relationship between structure and properties of polymers, i.e. “the relationship between chemical structure and material properties” connected through the molecular motion. The relationship between condensed state structure and product properties” connected through the product design, and “the relationship between electronic state structure and material functions” connected through the knowledge of condensed state physics. Due to the historical reason, the main contents are “the relationship between chemical structure and material properties”. It is necessary to establish the normal courses of “Rheology” and “Condensed State Physics” in order to understand the second “relationship between condensed state structure and product properties” and the third “relationship between electronic state structure and materials functions”. Although these are beyond the scope of the

present textbook, but the idea of three levels in the relationship between structure and properties of polymers has been kept in the mind by the author and has been included in the textbook.

It is worth to point out that Chinese polymer physicists have carried out an indepth and systematic research work from an international point of view on the internal action between polymer chains, especially between chain units, and all phases of polymer—polymer solution, amorphous, crystalline and liquid crystal polymers. A number of International pioneering research results have been made. Some new concepts have been proposed in the field of Polymer Physics and the school of polymer physics with Chinese characteristics. Chinese scientists have also created original electromagnetic vibration plasticating extrusion processing of polymers etc., which are presented in the textbook. Besides, new contents such as the macroscopic single crystal of polymer, possible two-dimensional rubber state etc are added in the textbook. Some new concepts such as different polymer crystals may be obtained by the “polymerization first, then crystallization” or “crystallization first, then polymerization”. WLF equation, a special temperature dependence obeyed by special molecular motion of polymers have been introduced.

The discussion and research results in many open-published textbooks and monographs are quoted during the writing. The author would like to extend his deepest gratitude to all of them. The author would also like to thank Prof. Zhu Pingping, Associate Prof. Yang Haiyang for their suggestions, Senior Engineer Li Chune for her printing and checking the manuscript. The contents of this textbook have been taught in the Department of Polymer Science and Engineering, USTC every year and in the Changchun Institute of Applied Chemistry, Chinese Academy of Sciences for 7 years. Several good suggestions have come from the students. A sincere thanks to them. Many textbooks and references on Polymer Physics have been listed in the appendix for readers for checking and further reading. In another appendix, more than 30 published papers about teaching research articles on polymer physics written by the author in recent years have been listed. They may be read by the reader as reference to share our experiences during the research.

Due to the limited capability of the author, some missing errors at inappropriate places are unavoidable, so the author welcomes readers and experts criticism, to point out and make corrections without sparing.

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Preface for English Edition

The “Polymer Physics” or “Structure and Properties of Polymers” has been recognized as a difficult course since the content is vast and needs higher mathematical foundation, especially for the students in chemistry. Consequently, a good textbook will be important for teaching the course. Based on teaching practices in the University of Science and Technology of China, and the Changchun Applied Chemistry Institute. Chinese Academy of Sciences during past several decades, has highlighted the “Structure and Properties of Polymers, Updated Edition” including relationship between structure and properties, deleting obsolete contents and adding the latest scientific and technological achievements, combined with author’s experiences during the research.

“Structure and Properties of Polymers, Updated Edition” was translated from its Chinese edition with a few corrections, which was originally written for the students in China. The appendices have been given up since the most referenced textbooks listed and teaching research articles are written in Chinese. Translation of the textbook into English is not an easy job. Fortunately, I have got a lot of help from my friends and former students during the translation. They are Prof. Zhu Pingping, Drs. Yang Haiyang, Zou Gang, Bao Suping, Jing Bangkun, Fang Kun, Chen Dazhu, who translated one complete chapter and parts of the other chapters, and Drs. Sheng Xia, Chen Xin, Ye Fan, Wu Xiaosong who modified the translated manuscript(s). I would also like to extend my special thanks to Prof Jim White for his useful suggestions.

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