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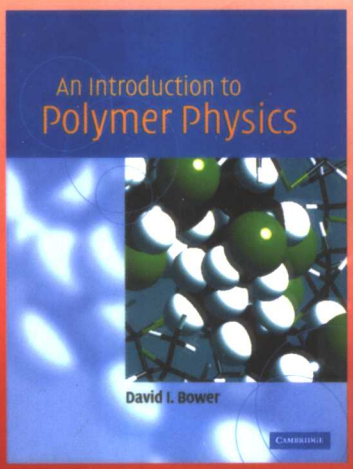
AN INTRODUCTION TO POLYMER PHYSICS

高分子物理导论

（英文影印版）

David I. Bower



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David I. Bower

Formerly at the University of Leeds

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前　言

随着中国社会主义现代化建设进入新的阶段，以高质量的高等教育培养千百万专门人才，迎接新世纪的挑战，是实现“科教兴国”战略的基础工程，也是完成“十五”计划各项奋斗目标的重要保证。为切实加强高等学校本科教学并提高教学质量，教育部于2001年专门下发文件提出12条意见，对高等学校教学工作从认识、管理、教师队伍到教学方法和教学手段等给予指导。文件强调，按照“教育要面向现代化、面向世界、面向未来”的要求，为适应经济全球化和科技国际化的挑战，本科教育要创造条件使用英语等外语进行公共课和专业课教学。

在文件精神指导下，全国普通高等学校尤其是重点高校中兴起了使用国外教材开展教学活动的潮流。如生物技术与工程、环境科学与工程、材料科学与工程及作为其学科基础理论重要组成部分的化学技术和化学工程技术又是这股潮流中最为活跃的领域之一。在教育部“化工类专业人才培养方案及教学内容体系改革的研究与实践”项目组及“化工类专业创新人才培养模式、教学内容、教学方法和教学技术改革的研究与实践”项目组和“全国本科化学工程与工艺专业教学指导委员会”的指导和支持下，化学工业出版社及时启动了引进国外名校名著的教材工程。

出版社组织编辑人员多次赴国外学习考察，通过国外出版研究机构对国外著名的高等学校进行调查研究，搜集了一大批国际知名院校的现用教材选题。他们还联络国内重点高校的专家学者组建了“国外名校名著评价委员会”，对国外和国内高等本科教学进行比较研究，对教材内容质量进行审查评议，然后决定是否引进。他们与国外许多著名的出版机构建立了联系，有的还建立了长期合作关系，以掌握世界范围内优秀教材的出版动态。

以其化学化工专业领域的优势资源为基础，化学工业出版社的教材引进主要涉及化学、化学工程与工艺、环境科学与工程、生物技术与工程、材料科学与工程、制药工程等专业，对过程装备与控制工程、自动化等传统专业教材的引进也在规划之中。

他们在影印、翻译出版国外教材的过程中，注意学习国外教材出版的经验，提高编辑素质，密切编读联系，整合课程体系，更新教材内容，科学设计版面，提高印装质量，更好地为教育服务。

在化工版“国外名校名著”系列教材即将问世之际，我们不仅感谢化学工业出版社为高等教育所做的努力，更应赞赏他们严谨认真的工作作风。

中国科学院院士，天津大学教授

余国琮

2002年8月

An Introduction to Polymer Physics

No previous knowledge of polymers is assumed in this book which provides a general introduction to the physics of solid polymers.

The book covers a wide range of topics within the field of polymer physics, beginning with a brief history of the development of synthetic polymers and an overview of the methods of polymerisation and processing. In the following chapter, David Bower describes important experimental techniques used in the study of polymers. The main part of the book, however, is devoted to the structure and properties of solid polymers, including blends, copolymers and liquid-crystal polymers.

With an approach appropriate for advanced undergraduate and graduate students of physics, materials science and chemistry, the book includes many worked examples and problems with solutions. It will provide a firm foundation for the study of the physics of solid polymers.

DAVID BOWER received his D.Phil. from the University of Oxford in 1964. In 1990 he became a reader in the Department of Physics at the University of Leeds, retiring from this position in 1995. He was a founder member of the management committee of the IRC in Polymer Science and Technology (Universities of Leeds, Durham and Bradford), and co-authored *The Vibrational Spectroscopy of Polymers* with W. F. Maddams (CUP, 1989). His contribution to the primary literature has included work on polymers, solid-state physics and magnetism.

Preface

There are already a fairly large number of textbooks on various aspects of polymers and, more specifically, on polymer physics, so why another? While presenting a short series of undergraduate lectures on polymer physics at the University of Leeds over a number of years I found it difficult to recommend a suitable textbook. There were books that had chapters appropriate to some of the topics being covered, but it was difficult to find suitable material at the right level for others. In fact most of the textbooks available both then and now seem to me more suitable for postgraduate students than for undergraduates. This book is definitely for undergraduates, though some students will still find parts of it quite demanding.

In writing any book it is, of course, necessary to be selective. The criteria for inclusion of material in an undergraduate text are, I believe, its importance within the overall field covered, its generally non-controversial nature and, as already indicated, its difficulty. All of these are somewhat subjective, because assessing the importance of material tends to be tainted by the author's own interests and opinions. I have simply tried to cover the field of solid polymers widely in a book of reasonable length, but some topics that others would have included are inevitably omitted. As for material being non-controversial, I have given only rather brief mentions of ideas and theoretical models that have not gained general acceptance or regarding which there is still much debate. Students must, of course, understand that all of science involves uncertainties and judgements, but such matters are better left mainly for discussion in seminars or to be set as short research tasks or essays; inclusion of too much doubt in a textbook only confuses.

Difficulty is particularly subjective, so one must judge partly from one's own experiences with students and partly from comments of colleagues who read the text. There is, however, no place in the modern undergraduate text for long, very complicated, particularly mathematically complicated, discussions of difficult topics. Nevertheless, these topics cannot be avoided altogether if they are important either practically or for the general development of the subject, so an appropriate simplified treatment must be given. Comments from readers have ranged from 'too

difficult' to 'too easy' for various parts of the text as it now stands, with a large part 'about right'. This seems to me a good mix, offering both comfort and challenge, and I have not, therefore, aimed at greater homogeneity.

It is my experience that students are put off by unfamiliar symbols or symbols with a large number of superscripts or subscripts, so I have attempted where possible to use standard symbols for all quantities. This means that, because the book covers a wide range of areas of physics, the same symbols sometimes have different meanings in different places. I have therefore, for instance, used θ to stand for a wide range of different angles in different parts of the book and only used subscripts on it where absolutely necessary for clarity. Within a given chapter I have, however, tried to avoid using the same symbol to mean different things, but where this was unavoidable without excess complication I have drawn attention to the fact.

It is sometimes said that an author has simply compiled his book by taking the best bits out of a number of other books. I have certainly *used* what I consider to be some of the best or most relevant bits from many more specialised books, in the sense that these books have often provided me with general guidance as to what is important in a particular area in which my experience is limited and have also provided many specific examples of properties or behaviour; it is clearly not sensible to use poor examples because somebody else has used the best ones! I hope, however, that my choice of material, the way that I have reworked it and added explanatory material, and the way that I have cross-referenced different areas of the text has allowed me to construct a coherent whole, spanning a wider range of topics at a simpler level than that of many of the books that I have consulted and made use of. I therefore hope that this book will provide a useful introduction to them.

Chapters 7 and 8 and parts of chapter 11, in particular, have been influenced strongly by the two more-advanced textbooks on the mechanical properties of solid polymers by Professor I. M. Ward, and the section of chapter 12 on liquid-crystal polymers has drawn heavily on the more-advanced textbook by Professors A. Donald and A. H. Windle. These books are referred to in the sections on further reading in those chapters and I wish to acknowledge my debt to them, as to all the books referred to there and in the corresponding sections of other chapters.

In addition, I should like to thank the following for reading various sections of the book and providing critical comments in writing and sometimes also in discussion: Professors D. Bloor, G. R. Davies, W. J. Feast, T. C. B. McLeish and I. M. Ward and Drs P. Barham, R. A. Duckett, P. G. Klein and D. J. Read. In addition, Drs P. Hine and A.

P. Unwin read the whole book between them and checked the solutions to all the examples and problems. Without the efforts of all these people many obscurities and errors would not have been removed. For any that remain and for sometimes not taking the advice offered, I am, of course, responsible.

Dr W. F. Maddams, my co-author for an earlier book, *The Vibrational Spectroscopy of Polymers* (CUP 1989), kindly permitted me to use or adapt materials from that book, for which I thank him. I have spent considerable time trying to track down the copyright holders and originators of the other figures and tables not drawn or compiled by me and I am grateful to those who have given permission to use or adapt material. If I have inadvertently not given due credit for any material used I apologise. I have generally requested permission to use material from only one of a set of co-authors and I hope that I shall be excused for using material without their explicit permission by those authors that I have not contacted and authors that I have not been able to trace. Brief acknowledgements are given in the figure captions and fuller versions are listed on p. xv. This list may provide useful additional references to supplement the books cited in the further reading sections of each chapter. I am grateful to The University of Leeds for permission to use or adapt some past examination questions as problems.

Finally, I should like to thank my wife for her support during the writing of this book.

D. I. B., Leeds, November 2001

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