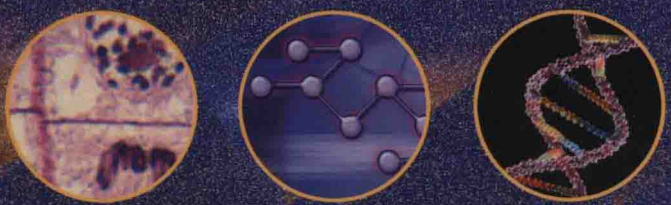
INTRODUCTION TO POLYMER CHEMISTRY

A Biobased Approach



Judit E. Puskas

INTRODUCTION TO POLYMER CHEMISTRY

A Biobased Approach

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Foreword

WHILE it is a difficult undertaking to conceive and create a course for new students in polymer science, and even more so to provide a suitable textbook for the course, Professor Puskas' "Introduction to Polymer Chemistry: a Biobased Approach" admirably accomplishes these objectives. The text is almost entirely biology based. She presents living organisms with which we share our world in terms of the fundamentals of synthetic polymer science, and harmonizes the macro-, micro- and nano-worlds with polymeric materials and molecules essential for life. The focus is on the relationship between biologically essential nature-produced polymers (proteins, nucleic acids, sugars, terpenes, etc.) and their architecture, composition, and synthesis. Every chapter contains excellent illustrations, incorporates interesting case histories, practices and experiments, and includes self-examination questions to challenge the student (instructive answers provided). Chapters end with useful references that invite further study.

In my opinion, Professor Puskas has succeeded in what she set out to accomplish: to introduce polymer chemistry, particularly polymer synthesis science, to biology-oriented students. Further, this book provides new insights of great value to everyone entering the field of polymers. Such a volume could be assembled only by an excellent scientist-educator at the height of her abilities.

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Akron, Ohio, USA

Preface

BEFORE polyester, there was silk. Before Kevlar, there was collagen. Before plastic water bottles, there were natural polymers. Polymers are not a recent phenomenon, as Nature has been putting atoms together for eons and humans have taken advantage of the unique properties of polymers even before understanding their chemical composition and syntheses. Polymeric fibers and resins from plants and animals have been an integral part of human life since the first civilization. In this text, students are challenged to start seeing polymers within the context of organisms and to learn how macromolecules are not just convenient new materials but indispensible for life.

This book connects modern synthetic polymer chemistry to its roots by exploring the chemistry of natural polymers and self-assembled macromolecular structures. Throughout the chapters, students are given the fundamentals of organic chemistry including intermolecular forces, functional groups and key reactions, and the basic concepts of polymer chemistry. They are presented with real-life examples and challenging exercises, which require them to apply the concepts they have learned.

The book is designed and authored by Professor Judit E. Puskas. The first draft was prepared with the help of graduate students enrolled in the world-renowned polymer science program at The University of Akron, in consultation with a local chemistry high-school teacher. The second draft was developed in the framework of a vertically integrated special course, with a high-school student, a high-school teacher, and an undergraduate and graduate student. The final draft was integrated by the author and her graduate students, with editorial help from Emily Q. Rosenthal-Kim.

Introduction to Polymer Chemistry: A Biobased Approach is an educational resource for Advanced Placement secondary students and university undergraduates and graduate students. The book fills a void in the literature by linking natural polymer systems to modern synthetic systems, which are typically thought of as completely artificial and not natural. The book strives to introduce, educate and inspire a new generation of scientists and engineers to explore polymer science more deeply. We hope that understanding polymer science from the viewpoint of natural polymerization processes will encourage a new generation to create environmentally friendly and bioinspired synthetic materials. It is hoped the information contained within this unique introduction to polymer chemistry will move students to study polymer science at a more advanced level and look to nature to find novel polymer technologies through natural processes, in combination with synthetic chemistry.

To assist students and instructors this volume offers numerous suggested exercises, experiments and discussion questions at the end of each chapter. In addition, four further instructional resources are provided. The first is a syllabus (p. xiii) for organizing a one-semester course based on the present book's chapters. Next is an answer key (p. 299), which repeats the questions found at the end of each chapter and provides answers. Thirdly, Appendix A (p. 185) comprises an article listing polymer science terms and their definitions as approved and updated by the International Union of Pure and Applied Chemistry (IUPAC)'s Polymer Division.[1] A number of these IUPAC terms are also listed in the book's index, including such key concepts as chain polymerization. Finally, Appendix B contains detailed instructions and forms for carrying out and recording polymerase chain (PCR) analyses as described in the experiment section of Chapter 2.[2]

In the author's opinion, many polymer chemistry books targeted at an introductory-level audience fail to grasp the attention of the students. The books currently used in these classes place too much emphasis on commodity plastics and commercial products. Many students early in their academic careers are still deciding on their major. To them it needs to be made clear that polymer science is more than just rubber and plastic—that chemistry, including polymer chemistry, can be environmentally friendly. After all, the word "chemistry" itself stems from the Arabic term for *earth*.

[1]The article in Appendix A is reproduced with permission of the International Union of Pure and Applied Chemistry.

[2]Laboratory and PCR instructional exercises in Appendix B are reproduced with permission of the Bay Area Biotechnology Education Consortium.

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Course Structure: Syllabus and Schedule

This book is designed for a one-semester course that introduces polymer chemistry through polymers found in nature. It has been prepared as a unique introduction to the subject, one that connects natural polymer systems and synthetic systems by exploring the chemistry of natural polymers from plants and animals, as well as self-assembled macromolecular structures, ranging from proteins to DNA and other natural polymers. Individual chapters cover the basic concepts of polymer chemistry: building blocks, structure, elementary reactions and polymerization mechanisms. The following represents a suggested syllabus for a 15-week course based on the text. The course is highly interactive and requires active in-class and out-of-class participation (homework) from students. During "Student lectures" groups are expected to give Powerpoint presentations based on notes, the text itself and independent research. The book provides experiments and questions with answers, as well as extensive print and online references.

Suggested Structure/Schedule

Wk1	Ch1	Preface; course structuring; group assignment. General IUPAC nomenclature
Wk2	Ch1	Introduction—History; Chemical bonds; most important concepts in polymer science
Wk3	Ch1	Student lectures
Wk4	Ch2	Polynucleic acids
Wk5	Ch2	Student lectures
Wk6	Ch2	Experiments

Wk7 Ch3 Proteins
Wk8 Ch3 Student lectures; experiments
Wk9 Ch4 Terpenoids
Wk10 Ch4 Student lectures; experiments
Wk11 Ch5 Carbohydrates
Wk12 Ch5 Student lectures; experiment
Wk13 Ch6 Lignins; experiments
Wk14 Ch7 Self-assembly; experiments; wrap up.
Wk15 Final exam

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