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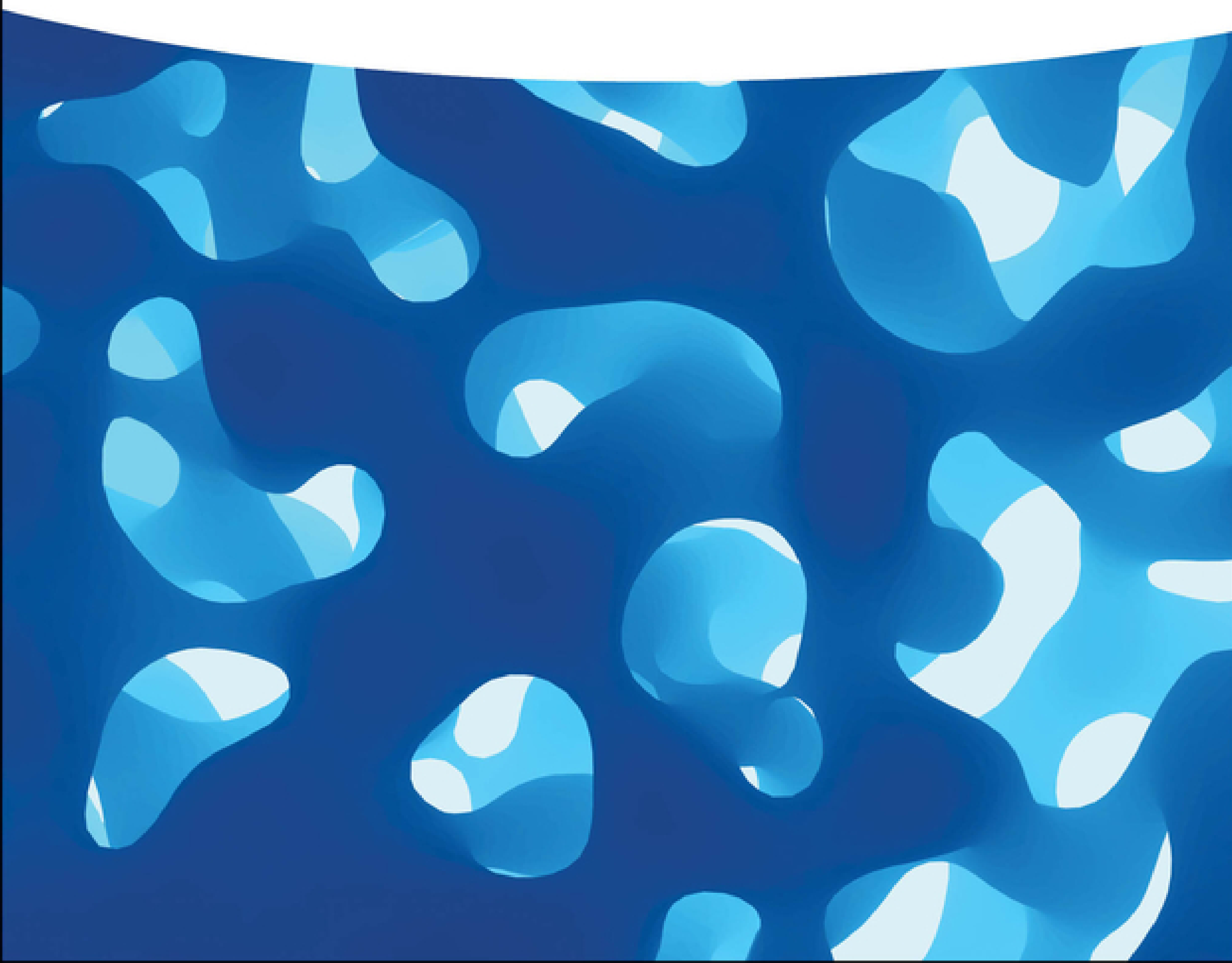

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Contents

Preface

Polymers, natural or synthetic, have changed the lifestyle of each individual through their immense application in almost every field. The first polymer discovered (early nineteenth century) was completely natural and derived from "Rubber" plants. It was known to have been used by the indigenous people in South America for centuries. Then, in 1839, Charles Goodyear successfully vulcanized the rubber by cross-linking the polymeric chains that impart strength to it. The year 1907 marked a special achievement in producing the first synthetic polymer that was resistant to heat and electric current and used in various materials. It was named after the creator Leo Baekeland as "Bakelite." Since then, there have been a series of remarkable discoveries in this budding field: polyethylene (1930s), nylon (1930s), polyester and PET (1940s), polypropylene (1950s), high-density polyethylene (HDPE) (1950s), and polycarbonate (1950s), to name a few. Since the mid-twentieth century, a significant advancement in polymer science and engineering has occurred, leading to novel and improved polymeric materials and applications. Although these polymers are of great use to humankind, they also have an adverse impact on the environment as they are not biodegradable and have been persistent for centuries. In the late twentieth century, the discovery of biodegradable polymers revolutionizes polymeric research and science. In recent years, research has focused on creating advanced polymers with unique properties, such as conducting polymers for electronics, smart polymers, biodegradable polymers, biopolymers advanced polymer blends and composites, 3D printing, polymeric nanoparticles, and polymers for energy storage that respond to environmental changes. The deployment of organic polymers has surpassed the traditional applications and can be seen in advances in imaging technology such as bioimaging, oil absorption, tissue engineering, and self-healing nanometer coatings in automobile and domestic housing. The recent advancements in organic polymers are expanding the range of applications and addressing important challenges, including environmental sustainability and improved performance across various industries.

The inception of this book was based on numerous applications and a plethora of research advancements in this field. The add-on factor of biodegradability to polymers has motivated us to dive into the depth of the knowledge. With this view, we attempted to comprehend the subject matter for our audience, including students, researchers, academicians, and scientists. The editors Dr. Ramesh Oraon (Central University of Jharkhand), Dr. Pardeep Singh (Delhi University), Dr. Sanchayita Rajkhowa (Haflong Govt. College, Assam, India), Dr. Sangita Agarwal (RCC Institute of Information Technology, Kolkata), and Dr. R.P. Singh (Central Public Works Dept., New Delhi) were keen to publish a handy material on this burning topic with elaborate details starting from its history, development, applications, and future aspects.

Chapter 1 starts with a basic introduction and history of organic polymers. It also offers a comprehensive summary of the basis of polymerization methodologies for synthesizing organic polymers, with recent developments describing the various applications of such materials. Functionalization and characterization of organic polymers demonstrate that the generation of hydrogels and their rheological properties were significantly influenced by the alteration of carboxylates in high molecular mass heparin (HMWH) with various maleimide groups and with thiol-derivatization of PEG crosslinker. In Chapter 2, the progress of porous organic polymers (POPs) as a potential catalyst in various applications like water splitting, CO_2 capture, and degradation of organic pollutants, among others, along with the various synthetic processes of POP catalysts as well as their properties and potential applications, are broadly discussed. The subsequent chapters 3, 4, 10, 14 and 18 comprehensively understand organic polymers in photodetectors, energy storage and solar cells, agriculture, pharmaceuticals, drug delivery systems, etc. There is a great emphasis on green synthesis of organic polymers and their application in environmental remediation (Chapter 11). Another chapter (Chapter 22) provides information about the history, the current research scenario, and the future scope of organic polymer-based adhesives. Owing to their diverse functions and utility, there is a blossoming resurgence of modified polymers in science and technology. In this regard, the methods of polymeric surface modification and their applications, along with the prospects in the future, are also discussed (Chapter 5). A few chapters (Chapters 9, 13, 20, 21 and 24) discuss organic polymers' current and developing trends in various fields, while another includes the future roadmap of POPs (Chapters 19 and 23). Organic polymers are a fundamental part of modern society, and their diverse properties and applications make them a crucial area of scientific and industrial research. Advances in polymer science continue to drive innovation in various industries, from materials engineering to medicine.

Through this journey, we hope to provide our readers with a deeper understanding of organic polymers, their applications, and recent trends that navigate to the future. We aim to make the content accessible, engaging, and relevant.

We extend our heartfelt thanks to the authors, researchers, educators, and all the contributors who have contributed their expertise to this endeavor.

So, dear readers, as you turn the pages of this book, I invite you to embark on this adventure with an open heart and a curious mind. Let us delve into the past, uncover its aspects and applications, and emerge with a deeper appreciation for the incredible journey of the future.

Thank you for joining us on this exploration.

Dr. Ramesh Oraon
Dr. Pardeep Singh
Dr. Sanchayita Rajkhowa
Dr. Sangita Agarwal
Dr. Ravindra Pratap Singh

Acknowledgments

We sincerely thank and appreciate everyone who helped make this book possible. We recognize the arduous labor, devotion, and support of the authors who helped make this project a reality with great pleasure and humility. The authors' passion, creativity, and unwavering commitment to work have made this project an absolute joy to edit. Every page exhibited your talent as a writer, and we feel privileged to have contributed to realizing one's dream.

We express our appreciation to Wiley and the publishing staff for their significant help and direction during the editorial process. This book has really benefited from your experience, professionalism, and unceasing effort.

The quality of a book depends to a large extent on proper reviewing. We gratefully acknowledge the time and expertise devoted to reviewing the manuscripts by a large group of reviewers.

We thank our colleagues and contributors for their invaluable collaboration, insights, and constructive feedback. Your input has been indispensable in refining the manuscripts and ensuring their quality. We also want to acknowledge the contributions of the proofreaders, copyeditors, and designers who worked diligently to make this book visually appealing and error-free. Your attention to detail and dedication to perfection have been truly exceptional.

A special thanks goes to the friends and family who provided emotional support during the long hours and deadlines. Your encouragement and understanding were crucial in helping me see this project through to completion.

Last but not least, we express our appreciation to the readers who will soon embark on this literary journey. Your interest in our work motivates us to continue creating, and we hope you find this book as rewarding to read as it was to edit.

Without the combined efforts of every member of the team, this book would not have been possible. We are incredibly appreciative of the chance to work upon this project and we are looking forward to engaging in many more imaginative partnerships in the futures.

Dr. Ramesh Oraon
Dr. Pardeep Singh
Dr. Sanchayita Rajkhowa
Dr. Sangita Agarwal
Dr. Ravindra Pratap Singh

1

Organic Polymers: Past and the Present

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Fredy A. Madukkakuzhy[1], *Monjumoni Das*[2], *and Pallabi Borah*[1]

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1.1 Introduction and History of Polymers

The word polymer is derived from the Greek word "polumeros" where "Polus" means "many" and "meros" means "units." Henceforth polymers can be defined as the complex and giant molecules or "**macromolecules**" which are supposed to form by the combination of many small repeating molecules called monomers. Examples of some commercially important polymers and their practical applications have been highlighted in Table 1.1. The most practical distinguishing feature of polymer from its monomer is its huge difference in physical, chemical, and mechanical properties after the polymerization process occurs (Dorel 2008). For example, ethene is a gas but when they combine with each other via the polymerization process, a new class of compound, i.e., polyethene, is formed which differs from its monomer in terms of many physicochemical properties. Monomers being smaller have low molecular weight, while polymers being much larger have very high molecular weight. Compared to simple organic molecules, polymers aren't composed of identical molecules; hence, a polymer sample generally comprises chains of different lengths, which is why their molecular weight is always expressed as an average molecular weight. For instance, the HDPE (high-density polyethylene) molecules are all long-chain carbon chains, but the lengths generally vary by thousands of monomer units. Depending on the type of monomeric units, polymers may be of different types such as homopolymers where all the repeating units (RUs) are same and co-polymers which can be made up of two or more monomer species. For example, in case of homopolymers such as polythene the monomer unit is ethylene, in polyvinylchloride (PVC) the monomer unit is vinyl chloride. Important examples of co-polymers include polyethylene-vinyl acetate (PEVA), nitrile rubber, and acrylonitrile butadiene styrene (ABS) which are formed by the combination of more than one monomer.

Based on the type of backbone chain and composition, polymeric materials are classified into two types, viz. organic polymers and inorganic polymers

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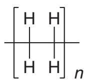
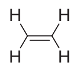
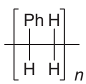
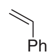
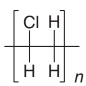
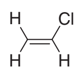
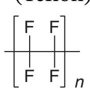
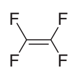
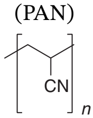
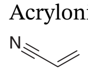
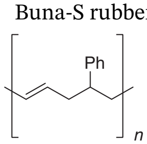
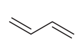
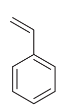
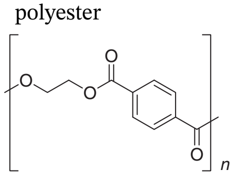
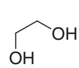
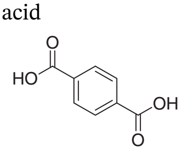
Table 1.1 Some commercially important polymers and their uses.

Name of polymer and structure	**Monomer**	**Practical applications**
Polythene 	Ethene 	Electrical insulators, packing of materials
Polystyrene 	Styrene 	As insulator, wrapping material, for construction of toys
Polyvinyl chloride 	Vinyl chloride 	In the manufacture of raincoats, handbags
Polytetrafluoroethylene (Teflon) 	Tetrafluoroethene 	As lubricant insulator in the manufacture of semiconductors, non-stick coating in kitchen cookware and medical devices
Polyacrylonitrile (PAN) 	Acrylonitrile 	In construction of synthetic fibers and wools
Styrene butadiene rubber (SBS) or Buna-S rubber 	1,3-Butadiene and styrene  and 	For making of automobile tires and footwear, etc.
Terylene (Dacron), polyester 	Ethylene glycol and terephthalic acid  and 	For making fibers, safety belts, plastic bottles, hard wear clothes like dresses