Natural Polymers

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Editor

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Preface

The word polymer is derived from the Greek word "poly" meaning many and "meros" which means parts. Hence polymer refers to molecules made up of many parts. More specifically, polymers are defined as molecules made up of repeated units of smaller molecules. Although recent decades has seen a boost in the polymers in various industries from pharmaceutical to construction to fashion industries where designer shoes and bags made from synthetic and natural polymers from both plants and animals have become commonplace, polymers have been in existence since the very existence of life. DNA, cellulose, cotton, and rubber are all polymers occurring in nature since the beginning of the ages. Processing of natural polymers has been taking place since the early humans who have long woven and dyed fibers of silk, wool, and carbohydrates from flax and cotton. Natural rubber (*Hevea brasiliensis*) has been used by the early South American civilization for waterproofing and elastic materials (Seymour and Carraher 1992). Today processing techniques of natural and synthetic polymers have become more advanced with broader applications from scaffold in tissue engineering (Chap. 5) to films for packaging (Chap. 7). An account of the development of synthetic polymers over the years exists in the literature (Seymour and Carraher 1992) showing the development of polymers from mainly natural polymers such as wool, cotton, flax, leather cellulose, and silk in the early 1800s to the development of vulcanized rubber in 1839. Later developments led to development of bakelite, cellulose acetate, and cellulose nitrate between 1907 and 1923. Later in the 1930s–1940s as understanding of polymers gradually developed, more polymers such as poly(methyl methacrylates), polyvinyl acetate, and polystyrene were developed. Polycarbonate, polypropylene, high-density polyethylene, flurocarbones, silicones, and polyurethanes and a host of other polymers were developed between 1940 and the late 1950s, where polymer saw a huge development. Later years saw development of more polymers such as Kevlar and development of more varied forms of pre-existing polymers to improve properties such as electrical conductivity. Today biopolymers such as Polylactic acid and chitosan have gained increasing attention in industries in applications such as 3D printing and tissue engineering.

Polymers have for centuries been an attractive alternative to metals due to the rather unique properties they possess. These properties include their tendency to

be biocompatible, relative lighter weight, and ease of chemical modification compared to metals. Natural polymers herein refer to polymers obtained from natural sources with minimal or no alteration to their chemical structure. This book looks at their extraction, purification, modification, and processing for various industrial applications. Although a large portion of the organic chemistry industry is dedicated to producing systemic polymers, natural polymers play a significant role in many industries ranging from biomedical, pharmaceutical, to construction industries. These are discussed in this book.

Chapter 1 discusses the classification of natural polymers within the scope of the book. Natural polymers are classified based on their sources in nature as polysaccharides, proteins, polynucleotides, polyisoprenes, and polyesters. The chapter goes further to give descriptions and examples of natural polymers which fall within these classifications.

Chapter 2 discusses the processing and characterization techniques that are applicable to natural polymers of industrial relevance. For each processing and characterization technique discussed, example case studies of natural polymers which the techniques apply to are provided. The chapter discusses some recent works that present innovative approaches to processing of natural polymer-based materials. This includes techniques for production of polymer composites. Electrospinning, extrusion, film casting, and spin coating are some of the processes discussed. Characterization methods presented are mainly methods such as TEM, XRD, and NMR with some example results of their applications to natural polymer-based materials for various applications.

In Chap. 3 methods for extraction, purification, and modification of some natural polymers of industrial relevance are discussed. These include acid and alkali methods of extraction of gelatin from various sources, extraction of starch, chitin, and chitosan among others. In doing so the structure of the polymers are also discussed as well as the structural modifications that they undergo in the process of extraction and modification.

Chapter 4 discusses some biomedical applications of natural polymers. This includes applications in scaffolds, wound healing, and repair of skin and bones. The chapter gives examples of cases where natural polymers either alone or blended with other materials are used in such applications. Gelatin, chitosan, and cellulose have shown wide application in this particular industry.

Chapter 5 discusses applications of natural polymer in the food industry. This chapter does not greatly focus on food packaging as application of natural polymers in packaging is discussed in a separate chapter. The chapter looks at application of natural polymer-based microparticles, gels, and emulsions in the food industry with some example case studies.

Chapter 6 looks at the recent applications of natural polymers used in packaging, with particular focus on various polymer blends. This chapter takes the approach of pointing out some of the challenges in the packaging industry and the role natural polymers play in this. Here food packaging, both edible and nonedible, as well as pharmaceutical packaging are discussed as they cover a significant portion of the packaging industry.

Chapter 7 discusses the application of natural polymers in engineering with a large part focusing on drilling engineering. The first part of the chapter describes the role of natural polymers in the nonrenewable energy industry (drilling fluids). In doing so the problems of drilling fluid loss during its circulation in oil field wells and its solution by using natural polymers are also discussed. The second part deals with the role of natural polymers in the renewable energy industry, particularly as biomass; this part reviews the types of renewable energy produced from biomass. The third part focuses on the role of natural polymers in wastewater treatment technology.

The application of natural polymers in the cosmetics industry is discussed in Chap. 8, mainly polysaccharides and proteins obtained from vegetable, animal, and biotechnology origins. The use of cellulose derivatives which are widely used for their physicochemical properties and cosmetic benefits are also discussed. The versatile role of natural polymers as stabilizers, modifiers, or other additives is discussed. Examples of cosmetic formulations in the cosmetic industries are presented. Natural polymers are sometimes alone, but more often in combination with synthetic polymers to broaden their applicability in hair care, skin care, or toothpaste products.

In Chap. 9 the application of natural polymers in the pharmaceutical industry is discussed. This chapter covers a broad area which includes transdermal drug delivery, oral, topical, nasal, and ocular drug delivery, among others. Natural polymers as hydrogels, crosslinked with other natural and synthetic polymers in their various pharmaceutical applications are discussed.

The environmental impacts of natural polymers are discussed in Chap. 10. The use of natural polymers in place of synthetic polymers or in combination with synthetic polymers poses some advantages as well as disadvantages. Consideration should be given to the overall impact on the environment during extraction, purification, modification, and processing of natural polymers for various applications. Case studies in the case of lignocellulose-based natural polymers are considered alongside others.

Chapter 11 covers the economic impact of natural polymers. The chapter in a couple of pages highlights some natural polymers of economic importance. The chapter then looks at the global impacts of natural polymer in various economies mainly UK, US, Brazil, and some African regions.

In Chap. 12 some future prospects of natural polymers in specific industries are discussed. This includes some novel developments which point to the possible direction of natural polymer applications and processing in the various industries in the future. The future economic prospects of natural polymers are also discussed in this chapter with reference to some reported economic reports. This leads to the final chapter which gives some concluding remarks for the book.

Reference

Seymour R, Carraher C (1992) Polymer chemistry: an introduction, 3rd edn. Marcel Dekker, Inc., New York

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