

D. L. Kaplan (Ed.)

Biopolymers from Renewable Resources

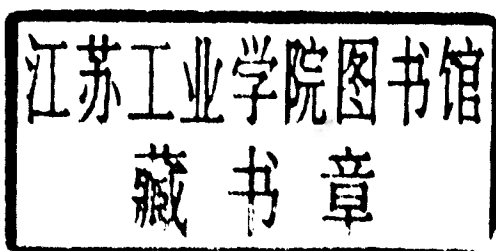


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Biopolymers from Renewable Resources

With 118 Figures



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Dr. David L. Kaplan
Department of Chemical Engineering
Biotechnology Center
Tufts University
4 Colby Street
Medford, MA 02155
USA

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Preface

Biopolymers from Renewable Resources is a compilation of information on the diverse and useful polymers derived from agricultural, animal, and microbial sources. The volume provides insight into the diversity of polymers obtained directly from, or derived from, renewable resources. The beneficial aspects of utilizing polymers from renewable resources, when considering synthesis, processing, disposal, biodegradability, and overall material life-cycle issues, suggests that this will continue to be an important and growing area of interest. The individual chapters provide information on synthesis, processing and properties for a variety of polyamides, polysaccharides, polyesters and polyphenols. The reader will have a single volume that provides a resource from which to gain initial insights into this diverse field and from which key references and contacts can be drawn. Aspects of biology, biotechnology, polymer synthesis, polymer processing and engineering, mechanical properties and biophysics are addressed to varying degrees for the specific biopolymers. The volume can be used as a reference book or as a teaching text.

At the more practical level, the range of important materials derived from renewable resources is both extensive and impressive. Gels, additives, fibers, coatings and films are generated from a variety of the biopolymers reviewed in this volume. These polymers are used in commodity materials in our everyday lives, as well as in specialty products. Aside from describing some of the more established products derived from biopolymers, this volume also presents some of the new directions in research and development that are being pursued for biopolymers. Some of these new directions are driven by biotechnology, novel chemistries, and enzymatic processing. These new options are extending the utilization of traditional biopolymers into new value-added products. This volume highlights some of these new applications, such as for biodegradable polymers, while also providing insights into the current level of understanding of the synthesis and processing of these polymers to achieve these new applications.

The study and utilization of polymers from renewable resources is an ancient science. Examples include the development of processes to make paper and the evolution of sericulture for the production of silk fibers thousands of years ago. These ancient arts are rapidly evolving in new directions. This new evolution is due to renewed interest in biopolymers because of the availability of new research tools to help elucidate structure-function relationships. These insights are being obtained at the molecular level as well as at higher orders of complexity. This new level of understanding has resulted in the establishment of new opportunities for the use of biopolymers from renewable resources. An improved understanding of

biological synthesis and processing methods, and the growing importance of “green chemistries” in industry due to environmental concerns and regulations, are helping to drive this new level of interest. The explosion of new analytical techniques, new understanding of molecular-level structure-function relationships, insights into mesophase formation in biological systems, and the development of a plethora of biotechnology tools are driving this renewed interest in biopolymers. The ability to generate biopolymers with tight control of structural features leads to the manipulation of functional properties. In addition, the need to develop more environmentally compatible processes suggests a strong and important future for these materials. Importantly, once the useful life of these polymers is completed, they can be recycled back into natural geochemical cycles due to their inherent biodegradability and environmental biocompatibility.

The volume also highlights the growing interface between biology and materials science. This interdisciplinary endeavor has been referred to as biomimetics, bioengineering, biomolecular materials, bioinspired materials, and biomaterials. In general, these concepts are based on the use of the biology for inspiration, blueprints, or building blocks from which materials scientists can develop new concepts in materials science. The primary reason for this interest derives from the level of structural control demonstrated by biological systems, including molecular size, stereochemistry and regioselectivity in building biopolymers. This level of structural control, in turn, drives self-assembly and organization at higher levels of complexity. Thus, biopolymers from renewable resources can be used directly as new materials, while also serving as guides for future designs of synthetic materials that capture the key features of the natural polymers. The biological world is constantly yielding new insights, new inspiration, and new blueprints into novel approaches for the design, synthesis and processing of materials. Whether dealing with intracellular synthesis and processing, or extracellular self-assembly and self-directed hierarchical organization to complex macroscopic materials, there is a wealth of information to be tapped into and utilized in the broader community of materials science.

I wish to thank the authors for their contributions and my many collaborators over the years on the subject of biopolymer engineering. A special thanks is due to Carmela Bailey, U.S. Department of Agriculture, for her unyielding help in helping to make this volume possible.

D.L. Kaplan

Medford, USA, January 1998

Contributors

Argyropoulos, D. S.

Paprican and Department of Chemistry, McGill University,
Pulp and Paper Research Centre, 3420 University Street, Montreal,
Quebec H3A 2A7, Canada, FAX: 514-398-8254

Backhaus, R. A.

Department of Botany, Box 871601, Arizona State University, Tempe,
AZ 85287-1601, USA, FAX: 602-965-6899, E-mail: ATRAB@ACVAX.INRE.ASU.EDU

Blanton, M. D.

Department of Polymer Science, University of Southern Mississippi, Box 10076,
Hattiesburg, MS 39406-0076, USA, FAX: 601-266-5880,
E-mail: mblanton@whale.st.usm.edu

Butler, M. M.

Science and Technology Directorate, U.S. Army Natick RD&E Center,
Kansas St. Natick, MA 01760-5020; Center for Advanced Biotechnology,
Boston University, Boston, MA 02215, USA, FAX: 508-233-5521

Day, D. F.

Audubon Sugar Institute, Louisiana Agricultural Experiment Station,
Louisiana State University, Baton Rouge, LA 70803-7305, USA, FAX: 504-388-2708,
E-mail: ddayi@unix1.sncc.lsu.edu

Gilbert, R. D.

Department of Wood and Paper Science, North Carolina State University,
Box 8005, Raleigh, NC 27695, USA, FAX: 919-515-6302,
E-mail: GILBERT@cfr.ncsu.edu

Gross, R. A.

Department of Chemistry, University of Massachusetts Lowell,
One University Avenue, Lowell, MA 01854, USA, FAX: 508-934-3037,
E-mail: grossr@woods.uml.edu

Hartmann, M. H.

Cargill Inc., EcoPLA Div., 2301 Crosby Rd., Wayzata MN 55391, USA,
FAX: 612-742-5638, E-mail: mark.hartmann@cdpoy.com

Hocking, P. J.
NOVA Research and Technology Corporation, 2928-16 Street N.E., Calgary,
Alberta T2E 7K7, Canada

Hudson, S. M.
Fiber and Polymer Science Program, Box 8301, North Carolina State University,
Raleigh, NC 27695-8301, USA, FAX: 919-515-6532, E-mail: shudson@tx.ncsu.edu

Jane, J.
Department of Food Science & Human Nutrition,
Center for Crops Utilization Research, Iowa State University, Ames,
IA 50011-1061, USA

Johnson, L. A.
Department of Food Science & Human Nutrition,
Center for Crops Utilization Research, Iowa State University, Ames,
IA 50011-1061, USA

Kadla, J. F.
Department of Wood and Paper Science, North Carolina State University,
Box 8005, Raleigh, NC 27695, USA

Kaplan, D. L.
Department of Chemical Engineering, Biotechnology Center, Tufts University,
4 Colby Street, Medford, MA 02155, USA, FAX: 508-233-5521,
E-mail: dkaplan@natick-emh.2.army.mil

Ly, Y. T.-P.
Department of Food Science & Human Nutrition,
Center for Crops Utilization Research, Iowa State University, Ames,
IA 50011-1061, USA, FAX: 515-294-8181, E-mail: Lyy@iastate.edu

Marchessault, R. H.
Department of Chemistry, McGill University, 3420 University, Montreal,
Quebec H3A 2A7, Canada, FAX: 514-398-7249, E-mail: CH21@musica.mcgill.ca

McGrath, K. P.
Corporate New Business and Technology, Kimberly-Clark Corporation,
1400 Holcomb Bridge Road, Roswell, GA 30076-2199, USA

Menachem, S. B.
Paprican and Department of Chemistry, McGill University,
Pulp and Paper Research Centre, 3420 University Street, Montreal,
Quebec H3A 2A7, Canada

Mendon, S.
Department of Polymer Science, University of Southern Mississippi,
Box 10076, Hattiesburg, MS 39406-0076, USA, FAX: 601-266-5880,
E-mail: smendon@ocean.st.usm.edu

Roland, C. M.

Chemistry Division, Code 6120, Naval Research Laboratory, Washington,
DC 20375-5342, USA

Ron E. Z.

Department of Molecular Microbiology & Biotechnology,
George S. Faculty of Life Sciences, Tel Aviv University, Ramat Aviv, Israel 69978,
FAX: 00972-3-641-41 38, E-mail: eliora@post.tau.ac.il

Rosenberg, E.

Department of Molecular Microbiology & Biotechnology,
George S. Faculty of Life Sciences, Tel Aviv University, Ramat Aviv, Israel 69978,
FAX: 00972-3-642-93 77, E-mail: euegene@post.tau.ac.il

Santangelo, P. G.

Chemistry Division, Code 6120, Naval Research Laboratory, Washington,
DC 20375-5342, USA, FAX: 202-767-0594

Shogren, R. L.

Plant Polymer Research Unit, National Center for Agricultural Utilization Research,
Agricultural Research Service, U.S. Department of Agriculture,
1815 N. University St, Peoria, IL 61604, USA, FAX: 309-681-6686

Smith, C.

Fiber and Polymer Science Program, Box 8301, North Carolina State University,
Raleigh, NC 27695-8301, USA

Subramanian, R.

Department of Polymer Science, University of Southern Mississippi, Box 10076,
Hattiesburg, MS 39406-0076, USA, FAX: 601-266-5880,
E-mail: sramesh@ocean.st.usm.edu

Thames, S. F.

Department of Polymer Science, University of Southern Mississippi, Box 10037,
Hattiesburg, MS 39406-0037, USA, FAX: 601-266-5880,
E-mail: sfthames@whale.st.usm.edu

Yu, H.

University of Southern Mississippi, Department of Polymer Science, Box 10076,
Hattiesburg, MS 39406-0076, USA, FAX: 601-266-5880,
E-mail: hyu@whale.st.usm.edu

Abbreviations

ASTM	American Society for Testing and Materials
CDNA	Complementary Deoxyribonucleic Acid
CMO	Chinese melon oil
CO	castor oil
Da	Daltons
DCO	dehydrated castor oil
DLO	dehydrated lesquerella oil
DNA	Deoxyribonucleic Acid
DSC	differential scanning calorimeter
ECH	epichlorohydrin
ECHLO	epichlorohydrin lesquerella oil
ECHLO-10	epichlorohydrin lesquerella oil with 10 units
ECHLO-2	epichlorohydrin lesquerella oil with 2 units
ECHLO-5	epichlorohydrin lesquerella oil with 5 units
ESA	eleostearic acid
HDI	hexane diisocyanate
HPLC	high performance liquid chromatographic
IPDI	isophorone diisocyanate
IPTG	β -Isopropylthiogalactoside
LO	lesquerella oil
MDI	diphenylmethane diisocyanate
Mefp	<i>Mytilis edulis</i> foot protein
mRNA	Messenger Ribonucleic Acid
NCA	N-carboxyanhydride
P _R , P _L	Phage lambda right and left promoters
PVC	polyvinylchloride
RNA	Ribonucleic Acid
TDI	toluene diisocyanate
TO	tung oil
tRNA	Transfer Ribonucleic Acid
T _i	Inverse transition temperature
UV	ultraviolet
VOC	volatile organic content

Contents

CHAPTER 1	
Introduction to Biopolymers from Renewable Resources	
D.L. Kaplan	1
1.1 Introduction	1
1.1.1 Natural Functions	1
1.1.2 Benefits	1
1.1.3 Limitations	2
1.1.4 Interface Between Biology and Materials Science	2
1.2 Polysaccharides	3
1.2.1 Polysaccharides (Plant, Algal)	3
1.2.2 Polysaccharides (Animal)	10
1.2.3 Polysaccharides (Fungal)	11
1.2.4 Polysaccharides (Bacterial)	12
1.3 Proteins	16
1.4 Polyesters	20
1.5 Lipids/Surfactants	22
1.6 Specialty Polymers	23
1.7 Conclusions	25
1.8 References	26
CHAPTER 2	
Starch: Properties and Materials Applications	
R.L. Shogrun	30
2.1 Introduction	30
2.2 Sources of Starch	30
2.3 Structure and Composition	31
2.4 Methods of Isolation and Characterization	33
2.5 Properties	34
2.6 Chemically Modified Starches	35
2.7 Processing Methods	36
2.8 Properties of Processed Starch	37
2.9 Applications	40
2.9.1 Food	40
2.9.2 Paper	41
2.9.3 Textiles, Adhesives, and Other Uses	41

2.9.4	Biodegradable Plastics	42
2.10	References	43

CHAPTER 3

Polysaccharides – Cellulose

R.D. Gilbert, J.F. Kadla	47
3.1 Introduction	47
3.2 Chemical Composition and Structure	47
3.3 Conformational Aspects	49
3.4 Hydrogen Bonding	49
3.5 Molecular Weight	51
3.6 Crystallinity	51
3.7 Cellulose Polymorphs	52
3.8 Cellulose I	55
3.8.1 Intra-Molecular Hydrogen Bonding	55
3.8.2 Crystal Structure of Cellulose I	56
3.8.3 Cellulose I _α and I _β	58
3.9 Cellulose II	61
3.9.1 Crystal Structure of Cellulose II	61
3.9.2 Hydrogen-Bonding	62
3.10 Fibrillar Structure	64
3.11 Synthetic Cellulose	65
3.12 Cellulosic Mesophases	66
3.12.1 Introduction	66
3.12.2 Liquid Crystal Solutions of Cellulose	69
3.12.3 Liquid Crystalline Cellulose Derivatives	72
3.12.4 Thermotropic Cellulose Derivatives	72
3.13 Chemical Modification	73
3.13.1 Introduction	73
3.13.2 Cellulose Esters	80
3.13.3 Cellulose Ethers	82
3.13.4 Cellulose Sulfate Esters	86
3.13.5 Reduction of Cellulose	87
3.13.6 Homogeneous Derivatization	87
3.13.7 Cellulose Graft Copolymers	88
3.14 Biotechnology Routes to Cellulose	89
3.15 References	90

CHAPTER 4

Polysaccharides: Chitin and Chitosan: Chemistry and Technology of Their Use As Structural Materials

S.M. Hudson, C. Smith	96
4.1 Introduction	96
4.2 Sources of Chitin and Chitosan	97

4.3	The Structure and Composition of Chitin and Chitosan	100
4.3.1	Structure	100
4.3.2	Polymorphs	102
4.4	Methods of Isolation and Characterization	104
4.4.1	Isolation of Chitin	104
4.4.2	Degree of <i>N</i> -Acetylation	106
4.4.3	Molecular Weight and Molecular Weight Distribution	107
4.5	Physical, Chemical, and Biological Properties of Chitin and Chitosan	107
4.5.1	Solution Properties	108
4.5.2	Biological Properties	108
4.6	Chemical Modifications of Chitin and Chitosan	109
4.7	Processing and Physical Forms of Materials Based on Chitin and Chitosan	110
4.7.1	Fibers	110
4.7.2	Films	112
4.7.3	Other Physical Forms	113
4.8	Products and Applications of Chitin and Chitosan	114
4.9	References	115

CHAPTER 5

Alginates

D.F. Day	119
5.1 Introduction	119
5.2 Sources of Biopolymer – Renewable Sources	120
5.2.1 Seaweed Alginates	120
5.2.2 Bacterial Alginates	121
5.3 Structure and Composition	124
5.3.1 Seaweed Alginates	124
5.3.2 Bacterial Alginates	126
5.4 Methods of Isolation, Purification, and Characterization	127
5.4.1 Seaweed Alginate	127
5.4.2 Bacterial Alginates	128
5.5 Physical, Chemical, and Biological Properties	130
5.5.1 Seaweed Alginate	130
5.5.2 Alginate Gels	132
5.6 Alginate As an Ion Exchanger	134
5.6.1 Seaweed Alginate	134
5.6.2 Bacterial Alginate	135
5.7 Chemical or Other Modifications	136
5.7.1 Seaweed Polymer	136
5.7.2 Bacterial Polymer	137
5.8 Processing of the Biopolymer	138
5.9 Production or Potential Applications	140
5.9.1 Seaweed Alginate	140

5.9.2	Bacterial Alginate	140
5.10	References	142

CHAPTER 6

Soy Protein As Biopolymer

Y. T.-P. Ly, L. A. Johnson, J. Jane	144
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6.1	Introduction	144
6.2	Production of Soy Protein	144
6.3	Structure and Composition of Soy Protein	150
6.4	Physicochemical Properties of Soy Protein	153
6.4.1	Water Binding Capacity	153
6.4.2	Water Holding Capacity	154
6.4.3	Swelling	155
6.4.4	Solubility	155
6.4.5	Viscosity	156
6.4.6	Gelation	157
6.5	Processing of Soy Protein for Plastics	158
6.5.1	Effect of Plasticizers	159
6.5.2	Effect of Temperature	164
6.6	Properties of Soy Protein Plastics	165
6.6.1	Native Soy Proteins	166
6.6.2	Acid Treatment	167
6.6.3	Cross-Linking	167
6.6.4	Acetylation	168
6.6.5	Esterification	168
6.6.6	Graft Copolymerization	171
6.6.7	Incorporation of Other Biopolymers	172
6.7	Industrial Applications of Soy Protein	172
6.7.1	Historical and Current Status	172
6.7.2	Soy Protein for Biodegradable Plastics	174
6.8	References	174

CHAPTER 7

Protein-Based Materials

M. M. Butler, K. P. McGrath	177
---------------------------------------	-----

7.1	Introduction	177
7.2	Chemical Synthesis of Polypeptides	178
7.2.1	Polycondensation	178
7.2.2	Polymerization of <i>N</i> -Carboxyanhydrides	179
7.3	Biosynthetic Production of Polypeptides	180
7.3.1	Strategies in Genetic Design	180
7.3.2	Expression of Target Proteins	181
7.4	Useful Classes of Protein Materials	184
7.4.1	Fiber-Forming Proteins	184

7.4.2	Elastomeric Proteins	187
7.4.3	Adhesive Protein Materials	190
7.5	Opportunities and Limitations	192
7.6	References	192

CHAPTER 8

Bacterial γ -Poly(glutamic Acid)

R. A. Gross	195
8.1 Introduction and Background	195
8.2 Biological Role of γ -PGA Biosynthesis	196
8.3 Purification from Culture Broth	197
8.4 Analyses of γ -PGA by Nuclear Magnetic Resonance (NMR) and Gel Permeation Chromatography (GPC)	197
8.5 Fermentation Methods: Medium Formulations, Nutritional Requirements and Strain Degeneration	199
8.5.1 Metals and Nitrogen	199
8.5.2 γ -PGA Formation by <i>B. licheniformis</i> 9945 a on 'Medium E'	200
8.5.3 Other Production Strains, Media Requirements and Carbon Sources	203
8.5.4 Degeneracy to a Non- γ -PGA Producing Variant	204
8.6 Stereochemical Composition of γ -PGA	204
8.6.1 Differences As a Function of the Production Strain	204
8.6.2 Effects of Mn (II) and Other Divalent Metal Salts	205
8.7 Molecular Weight of γ -PGAs	207
8.8 Biochemical Pathways of γ -PGA Biosynthesis	209
8.9 γ -PGA Degrading Enzymes	212
8.10 Modification of γ -PGA	214
8.11 Physical Properties and Applications	215
8.12 References	217

CHAPTER 9

Polyhydroxyalkanoates

P. J. Hocking, R. H. Marchessault	220
9.1 Introduction	220
9.2 History	220
9.3 Biological Production	222
9.3.1 Biosynthesis of PHB and PHBV	222
9.3.2 Other Bacterial PHAs	224
9.3.3 Isolation	226
9.3.4 Commercial Production	227
9.4 Properties	228
9.4.1 Physical Properties	228
9.4.2 Crystal Structure	229
9.5 Degradation	232

9.5.1	Intracellular Biodegradation	232
9.5.2	Extracellular Biodegradation	234
9.5.3	Thermal Degradation	235
9.5.4	Hydrolytic Degradation	235
9.5.5	Environmental Degradation	236
9.6	Applications	237
9.7	Economics	240
9.8	Genetic Engineering	241
9.9	Synthetic PHAs and Blends	242
9.10	Conclusion	243
9.11	References	244

CHAPTER 10

Surfactants and Fatty Acids: Plant Oils

S. F. Thames, M. D. Blanton, S. Mendon, R. Subramenian, H. Yu	249
10.1 Chinese Melon Oil (CMO)	249
10.1.1 Introduction	249
10.1.2 Fatty Acid Composition	249
10.1.3 Characterization	250
10.1.4 Epoxidation	254
10.1.5 Chinese Melon Oil's Future Prospects	254
10.2 Crambe Oil	255
10.2.1 Introduction	255
10.2.2 Fatty Acid Composition and Properties	255
10.2.3 Derivatives of Crambe Oil	257
10.3 Lesquerella Oil	258
10.3.1 Introduction	258
10.3.2 Fatty Acid Compositions	259
10.3.3 Oil Properties	260
10.3.4 Significance of Lesquerella Oil Research	260
10.3.5 Dehydrated Lesquerella Oil (DLO)	261
10.3.6 Polyesters Derived from Lesquerella Oil	262
10.3.7 Lesquerella Oil Acrylates	263
10.3.8 Lesquerella Oil Alkoxyates	265
10.4 Soybean Oil	267
10.4.1 Introduction	267
10.4.2 Oil Composition and Properties	267
10.4.3 Polyesters	268
10.4.4 Urethane Polymers	268
10.4.5 Epoxidized Oil	269
10.4.6 Epoxy Oil	270
10.4.7 Copolymers	270
10.5 Tung Oil	270
10.5.1 Introduction	270
10.5.2 Composition and Properties	271