

Contents

Preface.....	xiii
About the Editors.....	xiv
Contributors.....	xv

Chapter 1 Polysaccharide-Based Polymeric Gels: Structure, Properties, and Applications 1

Qazi Adfar, Raheela Akhter, Shokat Hussain, Mohammad Aslam, and Shrikant S Maktedar

1.1	Introduction.....	1
1.1.1	Polymeric Gels.....	2
1.1.2	Crosslinking Methods.....	4
1.2	Polysaccharide-Based Polymeric Gels.....	5
1.3	Structural Aspects.....	5
1.3.1	Cellulose.....	5
1.3.2	Starch.....	8
1.3.3	Chitin.....	9
1.3.4	Chitosan.....	12
1.3.5	Alginates.....	13
1.3.6	Carrageenans.....	16
1.3.7	Agarose.....	18
1.4	Properties.....	19
1.4.1	Mechanical Properties.....	19
1.4.2	Rheological Properties.....	22
1.4.3	Swelling Properties.....	23
1.4.4	Miscellaneous Properties.....	25
1.5	Applications.....	25
1.5.1	Biomedical Applications.....	25
1.5.2	Industrial Applications.....	29
1.5.3	Agricultural Applications.....	31
1.6	Conclusion.....	31
	Acknowledgments.....	32
	References.....	32

Chapter 2 Environmental Aspects, Recycling, and Sustainability of Polysaccharides 37

Liqaa Hamid and Irene Samy

2.1	Preface.....	37
2.2	Limitations, Challenges, and Opportunities.....	38
2.2.1	The Three Major Phenomena.....	39
2.3	Single-Use, Non-Biodegradable Plastics.....	39
2.4	Plastics Are Not Recycled.....	40
2.5	Human Behavior.....	40
2.6	Circular Economy for Plastic.....	40
2.7	Recycling vs. Upcycling.....	41
2.7.1	What Exactly Is Recycling?.....	41

2.7.2	And Upcycling?.....	42
2.8	Recyclability.....	42
2.9	From Biowaste Burden to Useful Bio-based Plastic.....	42
2.9.1	Bioplastics	43
2.9.2	Its Applications.....	44
2.10	Invest in New Possibilities.....	45
2.11	Conclusion and Way Forward.....	45
	Acknowledgments	45
	Notes/Thanks/Other Declarations	46
	References	46
Chapter 3	Synthetic Polysaccharides: Adored, Deplored and Ubiquitous.....	48
	<i>Rois Uddin Mahmud, Md. Raijul Islam, Md. Abdur Rouf, Md. Rubel Alam, Asif Mahmud Rayhan, and Md Enamul Hoque</i>	
3.1	Introduction	48
3.2	Synthesis and Exploration of Polysaccharides	49
3.2.1	Difficulties in Synthesizing Synthetic Polysaccharides	49
3.2.2	Automated Glycan Assembly.....	50
3.2.3	Enzymatic Synthesis	53
3.2.4	Chemical Polymerization	55
3.2.5	Chemical Synthesis	56
3.3	Chemical Structure and Diversification (Classification) of Synthetic Polysaccharides	57
3.3.1	Homo Synthetic Polysaccharides	58
3.3.2	Hetero Synthetic Polysaccharides	58
3.3.3	According to Molecular Weight.....	60
3.3.4	Reactivity Toward Functional Groups.....	61
3.3.5	According to Ionic Nature.....	62
3.4	Fabrication Techniques of Synthetic Polysaccharides.....	62
3.4.1	Solution Casting	62
3.4.2	Electrospinning	63
3.4.3	Blending	63
3.4.4	Layer-by-Layer Assembly	64
3.4.5	Sol-Gel Processing	65
3.4.6	Microfluidics	65
3.4.7	Photolithography	66
3.4.8	Microencapsulation	66
3.5	Versatile Application of Synthetic Polysaccharides in Different Fields	66
3.5.1	Uses in Vaccine	66
3.5.2	Applications in Biomedical Fields	67
3.5.3	Drugs, Vaccine Delivery, and Tissues Engineering.....	67
3.5.4	Application in Antitumor and Immunomodulatory Activities.....	69
3.5.5	Antioxidative Applications.....	71
3.5.6	Other Applications	71
3.6	Synthetic Polysaccharides: Future Prospective, Limitation, and Challenges	72
3.6.1	Adored Synthetic Polysaccharides	72
3.6.2	Deplored Synthetic Polysaccharides	73
3.6.3	Ubiquitous Synthetic Polysaccharides	73
3.7	Conclusions.....	73
	References	74

Chapter 4 Design and Structure of Polysaccharide-Based Nanoparticles: State of the Art 81*Tabassum Khan, Deepika Tiwari, and Nikita Sanap*

4.1	Introduction	81
4.2	Nanoparticles.....	81
4.2.1	Types of Nanoparticles	82
4.3	Polysaccharide-Based Nanoparticles.....	83
4.4	Design and Functionalization of Polysaccharide-Based Nanoparticles.....	84
4.4.1	Synthesis of Polysaccharide Nanoparticles.....	84
4.5	Structure and Design of Polysaccharide-Based Nanoparticles	85
4.5.1	Chitosan.....	85
4.5.2	Functionalization of Chitosan	86
4.5.3	Synthesis of Chitosan Nanoparticles.....	86
4.5.4	Synthesis of Chitosan-Dicarboxylic Acid NPs	87
4.5.5	Galactosylated Chitosan Nanoparticles	87
4.6	Properties of Polysaccharide-Based Nanoparticles.....	88
4.7	Applications of Polysaccharide-Based Nanoparticles.....	89
4.8	Advantages and Limitations.....	90
4.9	Conclusion and Future Perspective	91
	References	91

Chapter 5 Polysaccharides as Adhesive: Sweet Solutions to Sticky Situations 94*Jeffy Joji, Swetha K.S., Anila Antony, and Neetha John*

5.1	Introduction	94
5.2	Types of Polysaccharides-Based Adhesive.....	94
5.2.1	Chitosan-Based Adhesive.....	94
5.2.2	Cellulose Based Adhesive	96
5.2.3	Starch-Based Adhesive.....	98
5.2.4	Pullulan-Based Adhesive	98
5.2.5	Levan-Based Adhesive	99
5.2.6	Dextran-Based Adhesive.....	99
5.2.7	Xanthan Based Adhesive	99
5.2.8	Gum Arabic.....	100
5.2.9	Gellan Gum.....	100
5.3	Mechanism of Adhesion.....	100
5.3.1	Mechanical Tests for Adhesion Strength	101
5.4	Applications of Polysaccharide-Based Adhesive	101
5.4.1	Biomedical and Pharmaceutical Applications	101
5.4.2	Industrial Applications	102
5.4.3	Food and Packaging Application	102
5.5	Conclusion	104
	References	104

Chapter 6	Carbohydrate-Based Therapeutics: Evolution from Wellness Pursuit to Medical Treatment	109
	<i>Shradha S. Tiwari, Surendra G. Gattani, Bhasha Sharma, and Md Enamul Hoque</i>	
6.1	Introduction	109
6.2	Classification of Carbohydrates.....	110
6.3	Carbohydrates as Therapeutics.....	110
6.3.1	Glycoconjugates as Therapeutic Agents.....	110
6.3.2	Carbohydrate-Based Antibiotics	111
6.3.3	Carbohydrate-Based Vaccine	112
6.3.4	Carbohydrate-Based Anticancer Therapeutics	112
6.3.5	Carbohydrate-Based Diagnosis	114
6.3.6	Carbohydrate-Based Antiviral Drugs	114
6.3.7	Carbohydrate-Based Antidiabetic Agents.....	115
6.3.8	Carbohydrate-Based Central Nervous System Drugs	116
6.4	Carbohydrates in Cardiovascular Diseases	116
6.5	Carbohydrates for Biomedical Applications	117
6.6	Carbohydrates in Gene Therapy.....	117
6.7	Other Carbohydrate-Based Therapeutics and Adjuvants	118
6.8	Conclusion	119
	List of Abbreviation.....	121
	References	121
Chapter 7	Starch-Based Advanced Materials and Their Applications	124
	<i>Aiswarya P. R. and Sabu Thomas</i>	
7.1	Introduction	124
7.2	Why Starch Is a Promising Material for Advanced Applications.....	124
7.3	Starch-Based Advanced Materials	125
7.3.1	Modification of Native Starch	126
7.3.2	Starch-Based Materials with Filler/Reinforcement	127
7.3.3	Starch Blends with Biodegradable Polymers	128
7.3.4	TPS Blends with Synthetic Polymers.....	130
7.3.5	Starch-Based Composite Materials	131
7.4	Applications of Starch-Based Advanced Materials.....	132
7.4.1	Application in the Food Industry	132
7.4.2	Pharmaceutical and Biomedical Application.....	134
7.4.3	Applications of Starch in Water Treatment.....	134
7.4.4	Application of Starch in Porous Foam Structures.....	135
7.4.5	Application of Starch in Self-Healing Polymeric Materials	135
7.4.6	Other Advanced Applications of Starch and Its Derivative Materials	136
7.5	Conclusion	136
	References	137

Chapter 8	Chitin and Chitosan Derivatives to Proffer New Functional Materials	140
	<i>Abdellah Halloub, Raji Marya, Hamid Essabir, Rachid Bouhfid, and Abou el kacem Qaiss</i>	
8.1	Introduction	140
8.2	Processing of Chitosan	140
8.3	Chitosan Modifications for New Functional Materials	142
8.4	Application Field	142
8.4.1	Chitin and Chitosan Functional Materials in Food Packaging Activities.....	142
8.4.2	Chitin and Chitosan Functional Materials in Wound Healing Activities	143
8.4.3	Chitin and Chitosan Functional Materials in Water Treatment Process	144
8.5	Conclusion	150
	References	150
Chapter 9	Glucans: Safe-by-Design and Applications	155
	<i>Nishat Khan and Seema Garg</i>	
9.1	Introduction	155
9.2	Sources of Active Glucan	155
9.3	Structural Activity of Glucan	156
9.4	Effect of Glycosidic Bonding	156
9.5	Effect of Main Chain Configuration	157
9.6	Effect of Substitution Degree, Length, and Position of Branch	157
9.7	Effect of Relative Molecular Weight	158
9.8	Effect of Viscosity	158
9.9	Classification of Glucans	159
9.9.1	α -Glucans	159
9.9.2	Sources of α -Glucan.....	159
9.9.3	Stereoselective Synthesis of α -Glucans.....	161
9.9.4	Applications of α -Glucan	163
9.9.5	β -Glucan.....	164
9.9.6	Sources of β -Glucan.....	165
9.9.7	Stereoselective Solid-Phase Synthesis of β -Glucans.....	165
9.9.8	Applications of β -Glucan	167
9.10	Conclusion	168
	References	168
Chapter 10	Polysaccharides in Sensors and Actuators	170
	<i>Richika Ganjoo, Shveta Sharma, Humira Assad, Abhinay Thakur, and Ashish Kumar</i>	
10.1	Introduction	170
10.2	Polysaccharides in Sensors and Actuators	170
10.2.1	Cellulose in Sensors and Actuators.....	170

10.2.2	Starch in Sensors and Actuators.....	175
10.2.3	Chitin and Chitosan in Sensors and Actuators.....	176
10.3	Conclusion	179
	References	179
Chapter 11	Polysaccharide Applications in Functional Textiles and Textile Wastewater Treatment.....	182
	<i>Tanvir Mahady Dip, Md Humayun Kabir, and Muhammet Uzun</i>	
11.1	Introduction	182
11.2	Polysaccharides for Textiles Applications.....	183
11.2.1	Alginate.....	183
11.2.2	Chitin and Chitosan.....	184
11.2.3	Starch.....	185
11.3	Polysaccharide Composites	186
11.4	Other Polysaccharides	187
11.5	Polysaccharide Applications in Multilayers of Textile Activities	189
11.5.1	Thickener for Textile Printing.....	189
11.6	Antimicrobial Finishing	190
11.7	Surface Modification and Multifunctional Textiles	192
11.8	Polysaccharide-Based Textiles for Medical Applications	198
11.8.1	Therapeutic Applications	198
11.8.2	Wound Dressing	198
11.9	Polysaccharides for Textile Industrial Wastewater Treatment	199
11.9.1	Polysaccharide Adsorbents.....	200
11.9.2	Modified or Activated Polysaccharides.....	201
11.9.3	BioFlocculation or Coagulation	202
11.10	Conclusion and Outlook	204
	References	205
Chapter 12	Alginate-Based Nanocomposites for Smart Technology of Food Packaging.....	212
	<i>Md. Sohel Rana, Most. Afroza Khatun, Biplob Kumar Biswas, Shahanaz Parvin, Md. Wasikur Rahman, M. Azizur R. Khan, and Sk Md Ali Zaker Shawon</i>	
12.1	Introduction	212
12.2	Alginate: Source, Structure and Cross Linking	212
12.3	Nanocomposites.....	214
12.3.1	Alginate-Based Silver Nanocomposite	215
12.3.2	Alginate BSilver-Montmorillonite (MMT) Nanocomposite.....	215
12.3.3	Alginate-Based Titanium Nanocomposites	216
12.4	Alginate-Based Nanocomposites Applications in Smart Technology	219
12.4.1	Intelligent Packaging Technology	219
12.5	Alginate-Based Nanocposites Applications in Intelligent Food Packaging Materials	224
12.5.1	Seafood.....	224
12.5.2	Meat.....	225
12.5.3	Dairy Products	225
12.5.4	Fruits, Vegetables, and Other Foods	226

12.6	Bionanocomposites and Safety	226
12.7	Impact of Using Bionanocomposites on Human Health	226
12.8	Future Trends and Conclusion	227
	Acknowledgements	227
	References	227
Chapter 13	Polysaccharide-Based Adsorbents for Water Treatment	234
	<i>Subrata Mondal</i>	
13.1	Introduction	234
13.2	Characteristics of Wastewater	235
13.3	Adsorbents for Wastewater Treatment.....	235
13.4	Various Polysaccharide-Based Adsorbents	236
	13.4.1 Chitin as Adsorbents	236
	13.4.2 Chitosan as Adsorbents	237
	13.4.3 Starch as Adsorbents	240
	13.4.4 Cyclodextrin as Adsorbents.....	240
13.5	Summary	242
	References	242
Chapter 14	Polysaccharides in Energy Storage	247
	<i>Nizam P. A. and Sabu Thomas</i>	
14.1	Introduction	247
14.2	History and Evolution of Energy Storage.....	248
14.3	An Overview of Energy Storages.....	248
14.4	Polysaccharides in Supercapacitors.....	250
	14.4.1 Cellulose.....	250
	14.4.2 Chitosan.....	252
	14.4.3 Starch.....	253
	14.4.4 Alginates	253
14.5	Polysaccharides in Battery	254
14.6	Polysaccharides in Fuel Cells	256
14.7	Polysaccharides in Nanogenerators	258
14.8	Conclusion	259
	References	260
Chapter 15	Polysaccharides for Agricultural Applications: A Growing Presence on the Farms.....	263
	<i>Enock Siankwilimba, Bhasha Sharma, and Md Enamul Hoque</i>	
15.1	Introduction	263
	15.1.1 Polysaccharides from Industrial Biomass in a Wasted World.....	264
	15.1.2 Polysaccharides from Cassava Production and Marketing in Zambia.....	268
	15.1.3 Processing of Cassava Ethanol to Create Ethanol-Based Products.....	268
	15.1.4 Carbohydrates and Fiber Are Two Macronutrients.....	269
	15.1.5 The Fundamentals of Superabsorbent Hydrogels (SH).....	271

15.1.6	Cellulose a Form of Polysaccharide	272
15.1.7	Chitosan/Chitin Use in Agriculture	274
15.1.8	Development of Agriculture Using Inulin.....	277
15.1.9	Algae and the Enrichment of Carbohydrates	279
15.1.10	Opportunity for Circular Economy	279
15.2	Conclusion	280
	References	281
Chapter 16	Polysaccharide-Based Fluorescent Materials for Sensing and Security Applications	287
	<i>Akhil Padmakumar, Drishya Elizebeth, Jith C. Janardhanan, Rakesh K. Mishra, and Vakayil K. Praveen</i>	
16.1	Introduction: Polysaccharides	287
16.2	Polysaccharide-Based Fluorescent Materials for Sensing.....	291
16.2.1	Nitroaromatic Sensing.....	291
16.2.2	Gas Sensing.....	292
16.2.3	Metal Ion Sensing.....	293
16.2.4	Biosensing	295
16.2.5	pH Sensing and Food Freshness Monitoring	296
16.3	Polysaccharide-Based Fluorescent Materials for Anti-Counterfeiting	298
16.4	Conclusions and Future Perspectives	303
	Acknowledgments	303
	References	303
Index		307