

Contents

Preface *ix*

Part I Natural and Artificial Polymers *1*

- 1 DNA Nanoengineering and DNA-Driven Nanoparticle Assembly** *3*
Alain Estève and Carole Rossi
- 1.1 Introduction *3*
- 1.2 From the DNA Molecule to Nanotechnologies *6*
- 1.3 DNA Nanostructures: From Holliday Junctions to 3D Origami *7*
- 1.4 DNA-Directed Assembly of Particles: From Concepts to the Realization of Ordered Assemblies *10*
- 1.4.1 DNA/Nanoparticle Assembly: Primary Functionalization Strategies *12*
- 1.4.2 Toward High-Order Crystalline Structures *12*
- 1.4.3 Crystallization of Heterogeneous Systems *16*
- 1.4.4 DNA/Nanoparticle Assembly: Applications *19*
- 1.5 Nanoengineering of DNA Self-Assembled Al/CuO Nanothermite *20*
- 1.5.1 Fundamentals and Characterization of DNA/Surface Chemistry and Grafting Strategies *21*
- 1.5.1.1 DNA/Alumina Interaction Evaluation Through Infrared Spectroscopy and First Principles Calculations *22*
- 1.5.1.2 Functionalization Protocol and Colloidal Characterization *24*
- 1.5.1.3 Quantification of Streptavidin and DNA Surface Densities *26*
- 1.5.2 Kinetics of DNA-Directed Assembly of Al and CuO Nanoparticles *28*
- 1.5.2.1 Design and Impact of the DNA Coding Sequence *29*
- 1.5.3 Structural and Energetic Properties of the Al/CuO Bionanocomposite *32*
- 1.6 Conclusion *35*
- References *36*
- 2 Polysaccharides and Glycoproteins** *43*
Sujit Kootala and Susana C.M. Fernandes
- 2.1 Introduction *43*
- 2.2 Polysaccharides from Plants *45*

2.3	Polysaccharides from Microorganisms	47
2.4	Polysaccharides from Marine Organisms	49
2.5	Glycoproteins from Animal Sources – Mammals	52
2.6	Summary	56
	References	56
3	Engineered Biopolymers	65
	<i>Tugba Dursun Usal, Cemile Kilic Bektas, Nesrin Hasirci, and Vasif Hasirci</i>	
3.1	Polyhydroxyalkanoates	65
3.1.1	Medium-Chain-Length Polyhydroxyalkanoates	67
3.1.2	Poly(3-hydroxybutyrate)	70
3.1.3	Poly(4-hydroxybutyrate)	71
3.1.4	Poly(3-hydroxyvalerate)	71
3.1.5	Poly(3-hydroxybutyrate-co-3-hydroxyvalerate)	71
3.2	Poly(lactic acid) (PLA)	72
3.2.1	Poly(L-lactic acid)	73
3.2.2	Poly(D-lactic acid)	75
3.2.3	Poly(DL-lactic acid)	75
3.3	Genetically Modified Polymers	76
3.3.1	Genetically Modified Amino Acid-Based Polymers	76
3.3.1.1	Elastin-Like Recombinamers (ELRs)	76
3.3.1.2	Inorganic-Binding Peptides	78
3.3.2	Genetically Modified Saccharide-Based Polymers	80
3.3.2.1	Bacterial Cellulose	80
3.4	Conclusion	81
	References	81
4	Engineered Hydrogels	89
	<i>Cemile Kilic Bektas, Tugba Dursun Usal, Nesrin Hasirci, and Vasif Hasirci</i>	
4.1	Properties of Hydrogels	89
4.1.1	Modification and Functionalization	90
4.1.1.1	Methacrylation	90
4.1.1.2	PEGylation	93
4.1.1.3	PNIPAm Conjugated Hydrogels	95
4.1.1.4	Hydrogels of Recombinant Polymers	96
4.1.2	New Approaches for 3D Hydrogel Preparation	98
4.1.2.1	Cryogels	98
4.1.2.2	Bottom-Up 3D Hydrogel Preparation Methods	100
4.2	Conclusion	106
	References	106
Part II Macromolecular Assemblies 115		
5	Lipid Membranes: Fusion, Instabilities, and Cubic Structure Formation	117
	<i>Angelina Angelova, Borislav Angelov, and Yuru Deng</i>	
5.1	Introduction to Lipid Self-assembly and Membrane Organization	117

5.2	Lipid Membrane Instabilities and Phase Transitions	120
5.3	Shape Deformations and Membrane Curvature	123
5.4	Membrane Fusion	125
5.5	Cubic Membranes <i>In Vivo</i> and Bio-inspired Materials with Cubic Membrane Topology	132
5.6	Conclusion and Outlook	134
	Acknowledgments	135
	References	135
6	Small Molecule Inhibitors for Amyloid Aggregation	153
	<i>Anisha Thomas, Gagandeep Kaur, Rafat Ali, and Sandeep Verma</i>	
6.1	Introduction	153
6.2	Targeting Strategies for Inhibition of Amyloid Aggregation	154
6.3	Classes of Inhibitors	155
6.3.1	Peptide-Based Amyloid Inhibitors	156
6.3.1.1	Peptides Derived from the Native Protein Sequence	156
6.3.1.2	Metal Ion Scavenging Peptides	161
6.3.1.3	β -Sheet Breaker Peptides	161
6.3.1.4	Peptides Containing D-Amino Acids	165
6.3.1.5	Molecules Targeting α -Helical State of Amyloid Proteins	165
6.3.1.6	Peptidomimetics	167
6.3.1.7	Cyclic Peptide Amyloid Inhibitors (CPAIs)	171
6.3.2	Non-peptide-Based Small Molecules	174
6.3.2.1	Quinones/Polyphenols/Natural Compounds	175
6.3.2.2	Macrocyclic Inhibitors	179
6.4	Future Outlook	181
	Acknowledgments	181
	References	182
7	Inorganic Nanomaterials as Promoters/Inhibitors of Amyloid Fibril Formation	195
	<i>Monika Holubová</i>	
7.1	Introduction	195
7.2	Nanodiamonds	201
7.3	Carbon Nanotubes	202
7.3.1	Multiwalled Carbon Nanotubes	203
7.3.2	Single-Walled Carbon Nanotubes	204
7.4	Fullerenes-C ₆₀	205
7.5	Graphene/Graphene Oxide	208
7.6	Quantum Dots	209
7.7	Semiconductor Quantum Dots	211
7.8	Carbon/Graphene Quantum Dots	211
7.9	Iron Nanoparticles	212
7.10	Titanium Dioxide Nanoparticles	214
7.11	Gold Nanoparticles	216

- 7.12 Other Nanoparticles Based on Metals/Metalloids 218
- 7.13 Conclusion 218
- Acknowledgment 221
- References 222

Part III Mechanobiology 229

- 8 Mechanobiology 231**
Menekşe Ermis, Esen Sayın, Ezgi Antmen, and Vasif Hasirci
- 8.1 Extracellular Matrix (ECM) 231
 - 8.1.1 ECM Structure and Composition 232
 - 8.1.1.1 Proteins of ECM 232
 - 8.1.1.2 Glycosaminoglycans 235
 - 8.1.1.3 Growth Factors 235
 - 8.1.2 ECM Functions 235
 - 8.1.3 ECM Properties 237
 - 8.1.3.1 Physical Properties 237
 - 8.1.3.2 Chemical Properties 237
 - 8.1.3.3 Mechanical Properties 238
- 8.2 Cell Adhesion 238
 - 8.2.1 Molecules in Cell Adhesion 238
 - 8.2.2 Cell-to-Cell Interactions 240
 - 8.2.2.1 Cell Junctions 240
 - 8.2.2.2 Cell Polarity 241
 - 8.2.3 Signaling Pathways in Cell Adhesion 241
 - 8.2.3.1 Principles of Cell Adhesion Signaling 241
 - 8.2.3.2 Tissue-Specific Cell Adhesion Molecules 242
 - 8.2.3.3 Cell Migration Guidance 242
- 8.3 Cell-to-ECM Interactions 243
- 8.4 Interactions with Substrate and Tissue Engineering 244
 - 8.4.1 Properties of Substrates 245
 - 8.4.1.1 Physical Properties 245
 - 8.4.1.2 Chemical Properties 251
 - 8.4.1.3 Mechanical Properties 252
- 8.5 Mechanobiology, Mechanotransduction, and Force Transmission 252
 - 8.5.1 Concepts 253
 - 8.5.1.1 Mechanobiology 253
 - 8.5.1.2 Force Transduction 253
 - 8.5.1.3 Mechanotransduction 253
 - 8.5.2 Cell Surface Receptors as Mechanosensors 255
 - 8.5.3 Focal Adhesion Kinase Signaling 257
 - 8.5.4 Cytoskeleton as a Force-Transducing Element 258
- 8.6 Conclusion 263
- References 263

Index 271