

Contents

About the Editors *xiii*

Preface *xvii*

1 Bioinspired Polydopamine and Composites for Biomedical Applications 1
Ziyauddin Khan, Ravi Shanker, Dooseung Um, Amit Jaiswal, and Hyunhyub Ko

1.1 Introduction 1

1.2 Synthesis of Polydopamine 2

1.2.1 Polymerization of Polydopamine 2

1.2.2 Synthesis of Polydopamine Nanostructures 3

1.3 Properties of Polydopamine 5

1.3.1 General Properties of Polydopamine 5

1.3.2 Electrical Properties of Polydopamine 6

1.3.2.1 Amorphous Semiconductor Model (ASM) of Melanin Conductivity 7

1.3.2.2 Spin Muon Resonance Model (SMRM) of Melanin Conductivity 8

1.4 Applications of Polydopamine 10

1.4.1 Biomedical Applications of Polydopamine 11

1.4.1.1 Drug Delivery 11

1.4.1.2 Tissue Engineering 12

1.4.1.3 Antimicrobial Applications 12

1.4.1.4 Bioimaging 15

1.4.1.5 Cell Adhesion and Proliferation 16

1.4.1.6 Cancer Therapy 16

1.5 Conclusion and Future Prospectives 21

References 23

2 Multifunctional Polymer-Dilute Magnetic Conductor and Bio-Devices 31
Imran Khan, Weqar A. Siddiqui, Shahid P. Ansari, Shakeel Khan, Mohammad Mujahid Ali khan, Anish Khan, and Salem A. Hamid

2.1 Introduction 31

2.2 Magnetic Semiconductor-Nanoparticle-Based Polymer Nanocomposites 34

2.3 Types of Magnetic Semiconductor Nanoparticles 34

2.3.1 Metal and Metal Oxide Nanoparticles 34

2.3.2	Ferrites	35
2.3.3	Dilute Magnetic Semiconductors	36
2.3.4	Manganites	37
2.4	Synthetic Strategies for Composite Materials	37
2.4.1	Physical Methods	38
2.4.2	Chemical Methods	40
2.4.2.1	<i>In Situ</i> Synthesis of Magnetic Nanoparticles and Polymer Nanocomposites	40
2.4.2.2	<i>In Situ</i> Polymerization in the Presence of Magnetic Nanoparticles	41
2.5	Biocompatibility of Polymer/Semiconductor-Particle-Based Nanocomposites and Their Products for Biomedical Applications	42
2.5.1	Biocompatibility	42
2.6	Biomedical Applications	43
	References	43
3	Polymer-Inorganic Nanocomposite and Biosensors	47
	<i>Anish Khan, Aftab Aslam Parwaz Khan, Abdullah M. Asiri, Salman A. Khan, Imran Khan, and Mohammad Mujahid Ali Khan</i>	
3.1	Introduction	47
3.2	Nanocomposite Synthesis	48
3.3	Properties of Polymer-Based Nanocomposites	48
3.3.1	Mechanical Properties	48
3.3.2	Thermal Properties	51
3.4	Electrical Properties	52
3.5	Optical Properties	53
3.6	Magnetic Properties	54
3.7	Application of Polymer-Inorganic Nanocomposite in Biosensors	54
3.7.1	DNA Biosensors	54
3.7.2	Immunosensors	58
3.7.3	Aptamer Sensors	61
3.8	Conclusions	62
	References	63
4	Carbon Nanomaterial-Based Conducting Polymer Composites for Biosensing Applications	69
	<i>Mohammad O. Ansari</i>	
4.1	Introduction	69
4.2	Biosensor: Features, Principle, Types, and Its Need in Modern-Day Life	70
4.2.1	Important Features of a Successful Biosensor	71
4.2.2	Types of Biosensors	71
4.2.2.1	Calorimetric Biosensors	71
4.2.2.2	Potentiometric Biosensors	72
4.2.2.3	Acoustic Wave Biosensors	72
4.2.2.4	Amperometric Biosensors	72
4.2.2.5	Optical Biosensors	72

4.2.3	Need for Biosensors	72
4.3	Common Carbon Nanomaterials and Conducting Polymers	73
4.3.1	Carbon Nanotubes (CNTs) and Graphene (GN)	73
4.3.2	Conducting Polymers	73
4.4	Processability of CNTs and GN with Conducting Polymers, Chemical Interactions, and Mode of Detection for Biosensing	74
4.5	PANI Composites with CNT and GN for Biosensing Applications	75
4.5.1	Hydrogen Peroxide (H_2O_2) Sensors	75
4.5.2	Glucose Biosensors	76
4.5.3	Cholesterol Biosensors	77
4.5.4	Nucleic Acid Biosensors	78
4.6	PPy and PTh Composites with CNT and GN for Biosensing Applications	79
4.7	Conducting Polymer Composites with CNT and GN for the Detection of Organic Molecules	80
4.8	Conducting Polymer Composites with CNT and GN for Microbial Biosensing	83
4.9	Conclusion and Future Research	83
	References	84
5	Graphene and Graphene Oxide Polymer Composite for Biosensors Applications	93
	<i>Aftab Aslam Parwaz Khan, Anish Khan, and Abdullah M. Asiri</i>	
5.1	Introduction	93
5.2	Polymer–Graphene Nanocomposites and Their Applications	96
5.2.1	Polyaniline	97
5.2.2	Polypyrrole	102
5.3	Conclusions, Challenges, and Future Scope	106
	References	108
6	Polyaniline Nanocomposite Materials for Biosensor Designing	113
	<i>Mohammad Oves, Mohammad Shahadat, Shakeel A. Ansari, Mohammad Aslam, and Iqbal IM Ismail</i>	
6.1	Introduction	113
6.2	Importance of PANI-Based Biosensors	118
6.3	Polyaniline-Based Glucose Biosensors	118
6.4	Polyaniline-Based Peroxide Biosensors	120
6.5	Polyaniline-Based Genetic Material Biosensors	121
6.6	Immunosensors	122
6.7	Biosensors of Phenolic Compounds	123
6.8	Polyaniline-Based Biosensor for Water Quality Assessment	123
6.9	Scientific Concerns and Future Prospects of Polyaniline-Based Biosensors	124
6.10	Conclusion	126
	References	126

7	Recent Advances in Chitosan-Based Films for Novel Biosensor	137
	<i>Akil Ahmad, Jamal A. Siddique, Siti H. M. Setapar, David Lokhat, Ajij Golandaj, and Deresh Ramjugernath</i>	
7.1	Introduction	137
7.2	Chitosan as Novel Biosensor	139
7.3	Application	151
7.4	Conclusion and Future Perspectives	152
	Acknowledgment	153
	References	153
8	Self Healing Materials and Conductivity	163
	<i>Jamal A. Siddique, Akil Ahmad, and Ayaz Mohd</i>	
8.1	Introduction	163
8.1.1	What Is Self-Healing?	163
8.1.2	History of Self-Healing Materials	163
8.1.3	What Can We Use Self-Healing Materials for?	164
8.1.4	Biomimetic Materials	164
8.2	Classification of Self-Healing Materials	164
8.2.1	Capsule-Based Self-Healing Materials	165
8.2.2	Vascular Self-Healing Materials	165
8.2.3	Intrinsic Self-Healing Materials	167
8.3	Conductivity in Self-Healing Materials	169
8.3.1	Applications and Advantages	170
8.3.2	Aspects of Conductive Self-Healing Materials	171
8.4	Current and Future Prospects	171
8.5	Conclusions	172
	References	173
9	Electrical Conductivity and Biological Efficacy of Ethyl Cellulose and Polyaniline-Based Composites	181
	<i>Faruq Mohammad, Tanvir Arfin, Naheed Saba, Mohammad Jawaid, and Hamad A. Al-Lohedan</i>	
9.1	Introduction	181
9.2	Conductivity of EC Polymers	183
9.2.1	Synthesis of EC–Inorganic Composites	183
9.2.2	Conductivity of EC-Based Composites	184
9.3	Conductivity of PANI Polymer	187
9.3.1	Synthesis of PANI-Based Composites	189
9.3.2	Conductivity of PANI-Based Composites	190
9.4	Biological Efficacy of EC and PANI-Based Composites	192
9.5	Summary and Conclusion	194
	Acknowledgments	195
	References	195

10	Synthesis of Polyaniline-Based Nanocomposite Materials and Their Biomedical Applications	199
	<i>Mohammad Shahadat, Shaikh Z. Ahammad, Syed A. Wazed, and Suzylawati Ismail</i>	
10.1	Introduction	199
10.2	Biomedical Applications of PANI-Supported Nano hybrid Materials	201
10.2.1	Biocompatibility	201
10.2.2	Antimicrobial Activity	202
10.2.3	Tissue Engineering	204
10.3	Conclusion	211
	Acknowledgment	211
	References	211
11	Electrically Conductive Polymers and Composites for Biomedical Applications	219
	<i>Haryanto and Mohammad Mansoob Khan</i>	
11.1	Introduction	219
11.2	Conducting Polymers	219
11.2.1	Conducting Polymer Synthesis	221
11.2.1.1	Electrochemical Synthesis	221
11.2.1.2	Chemical Synthesis	221
11.2.2	Types of Conducting Polymer Used for Biomedical Applications	221
11.2.2.1	Polypyrrole	221
11.2.2.2	Polyaniline	222
11.2.2.3	Polythiophene and Its Derivatives	222
11.3	Conductive Polymer Composite	223
11.3.1	Types of Conductive Polymer Composite	223
11.3.1.1	Composites or Blends Based on Conjugated Conducting Polymers	223
11.3.1.2	Composites or Blends Based on Non-Conjugated Conducting Polymers	224
11.3.2	Methods for the Synthesis of Conductive Polymer Composites	225
11.3.2.1	Melt Processing	225
11.3.2.2	Mixing	225
11.3.2.3	Latex Technology	225
11.3.2.4	<i>In Situ</i> Polymerization Method	225
11.4	Biomedical Applications of Conductive Polymers	226
11.4.1	Electrically Conductive Polymer Systems (ECPs) for Drug Targeting and Delivery	226
11.4.2	Electrically Conductive Polymer System (ECPs) for Tissue Engineering and Regenerative Medicine	227

- 11.4.3 Electrically Conductive Polymer Systems (ECPs) as Sensors of Biologically Important Molecules 227
- 11.5 Future Prospects 228
- 11.6 Conclusions 228
- References 228

Index 237