

Contents

Preface	xv
Part 1: New Materials and Methods	1
1 ZnO and Graphene Microelectrode Applications in Biosensing	3
<i>Susana Campuzano, María Pedrero, Georgia-Paraskevi Nikoleli, José M. Pingarrón, Dimitrios P. Nikolelis, Nikolaos Tzamtzis and Vasillios N. Psychoyios</i>	
1.1 Biosensors Based on Nanostructured Materials	4
1.2 Graphene Nanomaterials Used in Electrochemical Biosensor Fabrication	5
1.3 ZnO Nanostructures Used in the Fabrication of Electrochemical Biosensors	7
1.4 Miniaturized Graphene and ZnO Nanostructured Electrochemical Biosensors for Food and Clinical Applications	10
1.4.1 Amperometric Biosensors	10
1.4.2 Potentiometric Sensors	21
1.5 Conclusions and Future Prospects	30
Acknowledgements	32
References	32
2 Assembly of Polymers/Metal Nanoparticles and Their Applications as Medical Devices	37
<i>Magdalena Stevanović</i>	
2.1 Introduction	38
2.2 Platinum Nanoparticles	40
2.3 Gold Nanoparticles	41
2.4 Silver Nanoparticles	44

2.5	Assembly of Polymers/Silver Nanoparticles	45
2.6	Conclusion	51
	Acknowledgements	51
	References	52
3	Gold Nanoparticle-Based Electrochemical Biosensors for Medical Applications	63
	<i>Ülkü Anik</i>	
3.1	Introduction	63
3.1.1	Electrochemical Biosensors	64
3.2	Gold Nanoparticles	64
3.2.1	Preparation of AuNPs	65
3.2.2	AuNP Modified Electrodes	65
3.2.3	AuNP-Based Electrochemical Biosensors for Medical Applications	66
3.3	Conclusion	76
	References	76
4	Impedimetric DNA Biosensors Based on Nanomaterials	81
	<i>Manel del Valle and Alessandra Bonanni</i>	
4.1	Introduction	82
4.1.1	DNA Biosensors (Genosensors)	83
4.1.2	Electrochemical DNA Biosensors	84
4.2	Electrochemical Impedance Spectroscopy for Genosensing	85
4.2.1	Theoretical Background	86
4.2.2	Impedimetric DNA Biosensors	89
4.3	Nanostructured Carbon Used in Impedimetric Genosensors	91
4.3.1	Carbon Nanotubes and Nanostructured Diamond	91
4.3.2	Graphene-Based Platforms	94
4.4	Nanostructured Gold Used in Impedimetric Genosensors	97
4.4.1	Gold Nanoelectrodes	97
4.4.2	Gold Nanoparticles Used as Labels	99
4.5	Quantum Dots for Impedimetric Genosensing	100
4.6	Impedimetric Genosensors for Point-of-Care Diagnosis	101
4.7	Conclusions (Past, Present and Future Perspectives)	102
	Acknowledgements	104
	References	104

5	Graphene: Insights of its Application in Electrochemical Biosensors for Environmental Monitoring	111
	<i>G.A. Álvarez-Romero, G. Alarcon-Angeles and A. Merkoçi</i>	
5.1	Introduction	112
5.1.1	Graphene (GR)	112
5.1.2	Electrochemical Sensors	114
5.1.3	Graphene-based (bio)sensors: Generalities	115
5.2	Environmental Applications of Graphene-based Biosensors	117
5.2.1	Heavy Metals	117
5.2.2	Phenols	122
5.2.3	Pesticides	124
5.2.4	Other Pollutants	129
	5.2.4.1 Hydrogen Peroxide	129
	5.2.4.2 Microorganisms.	130
5.3	Conclusions and Perspectives.	133
	References	134
6	Functional Nanomaterials for Multifarious Nanomedicine	141
	<i>Ravindra P. Singh, Jeong-Woo Choi, Ashutosh Tiwari and Avinash Chand Pandey</i>	
6.1	Introduction	142
6.2	Nanoparticle Coatings	145
6.3	Cyclic Peptides	147
6.4	Dendrimers	149
6.5	Fullerenes/Carbon Nanotubes/Graphene	156
6.6	Functional Drug Carriers	157
6.7	MRI Scanning Nanoparticles	162
6.8	Nanoemulsions	165
6.9	Nanofibers	166
6.10	Nanoshells	169
6.11	Quantum Dots	171
6.12	Nanoimaging	179
6.13	Inorganic Nanoparticles	180
6.14	Conclusions	182
	Acknowledgement	183
	References	183

Part 2: Principals and Prospective	199
7 Computational Nanochemistry Study of the Molecular Structure, Spectra and Chemical Reactivity Properties of the BFPF Green Fluorescent Protein Chromophore	201
<i>Daniel Glossman-Mitnik</i>	
7.1 Introduction	201
7.2 Theory and Computational Details	202
7.3 Results and Discussion	206
7.3.1 Molecular Structures	206
7.3.2 IR and UV-Vis Spectra	208
7.3.3 ECD Spectra	220
7.3.4 Dipole Moments and Polarizabilities	220
7.3.5 HOMO and LUMO Orbitals	225
7.3.6 Chemical Reactivity	225
7.4 Conclusions	233
Acknowledgements	234
References	234
8 Biosynthesis of Metal Nanoparticles and Their Applications	239
<i>Meryam Sardar, Abhijeet Mishra and Razi Ahmad</i>	
8.1 Introduction	240
8.2 Synthesis of Metal Nanoparticles	241
8.2.1 Biosynthesis of Metal Nanoparticles by Microbes	242
8.2.1.1 Bacteria	246
8.2.1.2 Yeast	246
8.2.1.3 Fungi	247
8.2.1.4 Biosynthesis of Metal Nanoparticles by Plants	248
8.2.1.5 Biosynthesis of Metal Nanoparticles by Biomolecules	251
8.3 Applications	253
8.4 Conclusions	255
Acknowledgement	256
References	257
9 Ionic Discotic Liquid Crystals: Recent Advances and Applications	267
<i>Santanu Kumar Pal and Sandeep Kumar</i>	
9.1 Introduction	268
9.2 Part I: Chromonic LCs	271

9.2.1	Structure-Property Relationship of Chromonic Mesogens	271
9.2.2	Applications of Chromonic Mesophases	277
9.2.2.1	Polarizing Materials	278
9.2.2.2	Monolayer and Multilayer Deposition of Chromonic LCs	279
9.2.2.3	Micropatterned Anisotropic Chromonic Films	279
9.2.2.4	Organic Electronics	281
9.3	Part II: Thermotropic Ionic Discotic Liquid Crystals	282
9.3.1	Classification Based on Different Cores	283
9.3.1.1	Benzene	283
9.3.1.2	Triphenylene	286
9.3.1.3	Perylene	292
9.3.1.4	Anthracene	293
9.3.1.5	Tricycloquinazoline	293
9.3.1.6	Triazolephthalocyanine	293
9.3.1.7	Porphyrin	296
9.3.1.8	Hexa-peri-hexabenzocoronene	296
9.3.1.9	4,4-Difluoro-4-bora-3a,4a-diaza-s-indacene (BODIPY)	299
9.3.1.10	Trisimidazole	300
9.3.1.11	Quinolizinophenanthridinylium Cation	300
9.3.1.12	Trialkyltriazaatriangulenium Cation	300
9.3.1.13	2,4,6-Triarylpyrylium Tetrafluoroborates	302
9.3.2	Ionic Metallomesogens	302
9.3.3	Ionic Discotic Compounds of Crown Ethers	306
	Acknowledgement	309
	References	309

10 Role of Advanced Materials as Nanosensors in

Water Treatment 315

Sheenam Thatai, Parul Khurana and Dinesh Kumar

10.1	Introduction	315
10.2	Nanoparticles	318
10.3	Different Fabrication Methods of Nanoparticles	319
10.4	Core Material/Nanofillers	321
10.4.1	Synthesis of Fe_3O_4 Nanoparticles	322
10.4.2	Synthesis of TiO_2 Nanoparticles	323
10.4.3	Synthesis of CdS, PbS and CuS Nanoparticles [10]	323
10.4.4	Synthesis of SiO_2 Nanoparticles	324

10.5	Shell Material/Nanomatrix	324
10.5.1	Au Nanoparticles	325
10.5.2	Ag Nanoparticles	326
10.6	Core-Shell Material	326
10.6.1	SiO ₂ @Ag Core-Shell Nanocomposites	328
10.6.2	SiO ₂ @Au Core-Shell Nanocomposites	328
10.6.3	Fe ₃ O ₄ @Au Core-Shell Nanocomposites	330
10.6.4	Ag@Au Core-Shell Nanocomposites	330
10.7	Properties of Metal Nanoparticles and Core-Shell Nanocomposites	330
10.8	Detection of Heavy Metals Using Smart Core-Shell Nanocomposites	333
10.9	Conclusions	337
	Acknowledgement	337
	References	338
Part 3:	Advanced Structures and Properties	345
11	Application of Bioconjugated Nanoporous Gold Films in Electrochemical Biosensors	347
	<i>Leila Kashefi-Kheyrabadi, Abolhassan Noori and Masoud Ayatollahi Mehrgardi</i>	
11.1	Introduction	348
11.2	Fabrication of Nanoporous Gold	349
11.2.1	Dealloying Procedure	349
11.2.2	Template-Assisted Method	350
11.2.3	Electrochemical Method	351
11.3	Nucleic Acids (NAs)-Based Biosensors	351
11.3.1	NPG-Based DNA Sensors	352
11.3.2	NPG-Based Aptasensors	355
11.4	Protein-Nanostructured Gold Bioconjugates in Biosensing	356
11.4.1	Conjugation of Proteins to Nanoparticles	356
11.4.1.1	Covalent Protein–Nanoparticle Conjugates	357
11.4.1.2	Noncovalent Protein–Nanoparticle Conjugation	357
11.4.2	Nanoporous Materials	358
11.4.2.1	Enzyme-Modified NPG-Based Biosensors	358

11.4.2.2	Antibody-Modified NPG-Based Biosensors	360
11.4.2.3	Bioconjugation of Other Proteins to NPG	364
11.5	Conclusion	369
	References	369
12	Combination of Molecular Imprinting and Nanotechnology: Beginning of a New Horizon	375
	<i>Rashmi Madhuri, Ekta Roy, Kritika Gupta and Prashant K. Sharma</i>	
12.1	Introduction	376
12.1.1	What Is “Imprinting”?	376
12.1.2	The MIP ‘Rule of Six’	380
12.1.3	Downside of ‘Imprinted Materials’	380
12.1.4	How to Overcome the Problems	381
12.2	Classification of Imprinted Nanomaterials	383
12.2.1	Imprinting onto the Nanostructure Surfaces	383
12.2.1.1	Imprinted Novel Metal Nanoparticles (NPs)	383
12.2.1.2	Imprinted Magnetic Nanoparticle	384
12.2.1.3	Silica Nanoparticles	391
12.2.1.4	Core–Shell Nanoparticle	395
12.2.1.5	Quantum Dots	401
12.2.1.6	Nanobeads	407
12.2.1.7	Nanowires/Fibers	407
12.2.1.8	Carbon Nanotubes (CNTs)	408
12.2.1.9	TiO ₂ Nanotubes	412
12.2.1.10	Nanocomposite Materials	413
12.2.2	Thin-Film Imprinting	419
12.3	Imprinted Materials at Nanoscale	421
12.3.1	Imprinted Nanoparticle	421
12.3.2	Nanospheres	424
12.3.3	Comparative Study between Micro- and Nano-imprinted Materials	426
12.3.4	Imprinted Nanogel	426
12.3.5	Nanoimprint Lithography	427
12.4	Conclusions and Future Outlook	427
	Acknowledgements	428
	References	428

13 Structural, Electrical and Magnetic Properties of Pure and Substituted BiFeO₃ Multiferroics	433
<i>S. Jangid, S. K. Barbar and M. Roy</i>	
13.1 Introduction	434
13.1.1 Ferroics	434
13.1.2 Classification of Ferroics	434
13.1.2.1 Some Important Features of Ferroelectrics	435
13.1.2.2 Ferromagnetics	436
13.1.2.3 Ferroelastic	439
13.1.2.4 Ferrotoroidic	440
13.1.3 Multiferroics	440
13.1.3.1 History of Multiferroics	441
13.1.3.2 Properties of Multiferroics	442
13.1.4 Previous Work Done on Multiferroic BiFeO ₃	444
13.2 Synthesis of Materials	446
13.2.1 Materials Preparation Method	447
13.2.1.1 Sol-Gel Process	447
13.2.1.2 Wet Chemical Method	447
13.2.1.3 Autocombustion Technique	447
13.2.1.4 Gel Casting Method	448
13.2.1.5 Coprecipitation Method	448
13.2.1.6 Hydrothermal Method	449
13.2.1.7 Solid-State Reaction Method	449
13.3 Structural and Morphological Analyses	454
13.3.1 X-ray Diffraction	454
13.3.1.1 Introduction	454
13.3.1.2 A Brief Theory of X-ray Diffraction	455
13.3.1.3 Full-Pattern Analysis – the Rietveld Method	455
13.3.1.4 Actual Experimental Condition for X-ray Diffraction	456
13.3.1.5 Some of the Important Results on Structural Analysis	456
13.3.2 Morphological (SEM) Analysis	464
13.3.2.1 Actual Experiment	464
13.3.2.2 Some of the Important Results	464
13.4 Electrical Properties	467
13.4.1 Dielectric Studies	467

13.4.1.1	Basic Concept of Dielectric Constant	467
13.4.1.2	Factors Affecting the Dielectric Constant of a Material	468
13.4.1.3	The Dielectric Loss	469
13.4.1.4	Dielectric Measurements	470
13.4.1.5	Results and Discussion	470
13.4.2	DC Conductivity	473
13.4.2.1	Basic Laws and Electrical Properties of Materials	473
13.4.2.2	Measurement	474
13.4.2.3	Some of the Results on BiFeO ₃ and Its Substituted Compounds	475
13.5	Magnetic Properties	476
13.5.1	Introduction	476
13.5.2	Classification of Magnetic Materials	477
13.5.3	Different Types of Magnetic Measurement Process	479
13.5.4	Magnetic Properties of Multiferroic BiFeO ₃	482
13.5.5	Experimental	484
13.5.6	Some of the Important Results on Pure and Substituted BiFeO ₃	484
13.5.6.1	M~H at 300K (± 14 T)	484
13.5.6.2	M~T at 0.1T (FC and ZFC)	487
13.6	Thermal Analysis (MDSC Studies)	489
13.6.1	Introduction	489
13.6.2	Different Types of Thermal Analysis Processes	490
13.6.2.1	Differential Scanning Calorimetry	491
13.6.2.2	Modulated Differential Scanning Calorimetry	492
13.6.3	Experimental	494
13.6.4	Some of Important Results on Pure and Substituted BiFeO ₃	494
13.7	Summary and Conclusion	496
	References	498
14	Synthesis, Characterization and Rietveld Studies of Sr-modified PZT Ceramics	507
	<i>Kumar Brajesh, A.K. Himanshu and N.K. Singh</i>	
14.1	Introduction	508
14.2	Experiment	509

xiv CONTENTS

14.3	Rietveld Refinement Details	510
14.4	Results and Discussion	511
14.5	Conclusions	521
	References	521
Index		523