

Contents

1 Biofunctionalization of Nanomaterials	1
1.1 Introduction.....	1
1.2 Biofunctionalization Method of Nanomaterials.....	2
1.2.1 Biofunctionalization by Noncovalent Assembly.....	2
1.2.2 Covalent Route for the Biofunctionalization of Nanomaterials	5
1.3 Biofunctional Nanomaterials	10
1.3.1 Carbon-Based Nanomaterials.....	10
1.3.2 Metal Nanoparticles	12
1.3.3 Semiconductor Nanoparticles	14
1.3.4 Magnetic Nanoparticles	15
1.3.5 Other Biofunctional Nanomaterials	17
1.4 Characterization of Biofunctional Nanomaterials.....	19
1.5 Applications of Biofunctional Nanomaterials.....	21
1.5.1 Optical Sensing	21
1.5.2 Electrochemical Sensing	27
1.6 Conclusions.....	32
References.....	32
2 Signal Amplification for Nanobiosensing.....	39
2.1 Introduction.....	39
2.2 Nanoparticle-Amplified Optical Assay	40
2.2.1 Colloidal Gold Nanoparticle-Based Amplification	40
2.2.2 Semiconductor Nanoparticle-Based Amplification.....	48
2.2.3 Nanoparticle-Amplified Chemiluminescence and Electrogenerated Chemiluminescence Assay.....	49
2.3 Nanoparticle-Amplified Electrochemical Detection.....	54
2.3.1 Enhanced Conductivity with Nanoparticles.....	54
2.3.2 Detection of Nanoparticle Label with Stripping Voltammetry	57
2.3.3 Nanoparticle-Enhanced Impedance Signal	58
2.3.4 Nanoparticle-Enhanced Voltammetric Signal	62

2.4	Nanoparticles as Carrier for Signal Amplification.....	65
2.4.1	Gold Nanoparticles as Tracer.....	65
2.4.2	Carbon Nanotubes as Carrier	73
2.4.3	Silica Nanoparticles as Carrier.....	75
2.4.4	Other Materials as Carrier.....	77
2.5	Conclusions.....	79
	References.....	79
3	Nanostructured Mimic Enzymes for Biocatalysis and Biosensing.....	85
3.1	Introduction.....	85
3.1.1	Need for Nanostructured Mimic Enzymes.....	85
3.1.2	Developments in Nanostructured Mimic Enzymes.....	86
3.2	Nanostructure Used in Artificial Mimic Enzymes.....	87
3.2.1	$K_3Fe(CN)_6$	87
3.2.2	Fe_3O_4	89
3.2.3	FeS	93
3.2.4	Polystyrene.....	95
3.2.5	Breslow's Mimics.....	96
3.3	Mimic Enzymes for Sensors	98
3.3.1	H_2O_2 Sensors	98
3.3.2	Glutamate Sensors.....	98
3.3.3	Glucose Sensors	99
3.3.4	Nonelectroactive Cation Sensors	100
3.3.5	Easily Oxidizable Compounds and Other Nontraditional Sensors	100
3.3.6	Transition Metal Hexacyanoferrate Sensors	101
3.4	Conclusions.....	102
	References.....	102
4	Porphyrin-Based Nanocomposites for Biosensing	111
4.1	Introduction.....	111
4.1.1	Porphyrin: A Mimic of Enzymes	111
4.1.2	Significance of the Porphyrinic Nanocomposite.....	112
4.2	Assembly of Porphyrins on Carbon-Based Nanomaterials.....	112
4.2.1	Carbon Nanotubes	113
4.2.2	Optical and Electrochemical Biosensing	117
4.2.3	Carbon Nanohorns	119
4.2.4	Graphene Sheets.....	120
4.3	Assembly of Porphyrins on Semiconductor Nanoparticles	122
4.3.1	TiO_2 -Porphyrin Nanocomposite	122
4.3.2	Quantum Dots	129
4.3.3	Fe_3O_4 Nanoparticles	131
4.4	Assembly of Porphyrins on Metal Nanoparticles	131
4.4.1	Au Nanoparticles.....	131
4.4.2	Ag Nanoparticles.....	134
4.4.3	Pt Nanoparticles	135

4.5	Other Nanomaterials	137
4.5.1	Polymer Nanoparticles	137
4.5.2	Silica Nanomaterials	138
4.5.3	Calcium Phosphate Nanoparticles.....	140
4.6	Conclusions	141
	References	142
5	Carbon Nanofiber-Based Nanocomposites for Biosensing.....	147
5.1	Introduction	147
5.2	Synthesis of Carbon Nanofiber	149
5.3	Why Carbon Nanofiber?	151
5.4	Carbon Nanofiber-Based Electrochemical Biosensors and Bioassays	151
5.4.1	Glucose Sensors	151
5.4.2	Ethanol Sensors	154
5.4.3	Acetylthiocholine Sensors.....	155
5.4.4	Phenol Sensors	156
5.4.5	Hydrogen Peroxide Sensors	157
5.4.6	NADH Sensors	159
5.4.7	Protein Electron Transfer (ET).....	160
5.4.8	Immunosensors	162
5.4.9	Vertically Aligned Carbon Nanofiber Array-Based Biosensors	162
5.5	Conclusions	166
	References	167
6	Biosensors Based on Nanoporous Materials.....	171
6.1	Introduction	171
6.2	Why Are Proteins Immobilized?.....	172
6.3	Biosensors Based on Mesoporous Materials.....	173
6.3.1	Factors Affecting Protein Immobilization.....	173
6.3.2	Methods for Protein Immobilization on Mesoporous Material	177
6.3.3	Biosensors Based on Mesoporous Silica.....	178
6.3.4	Biosensors Based on Mesoporous Carbon.....	185
6.3.5	Biosensors Based on Mesoporous Metal Oxide.....	191
6.3.6	Biosensors Based on Mesoporous Hybrid Nanocomposite.....	192
6.4	Biosensors Based on Nanoporous Gold.....	196
6.4.1	Enzyme Biosensors Based on Nanoporous Gold.....	196
6.4.2	DNA Biosensors Based on Nanoporous Gold	198
6.4.3	<i>Escherichia coli</i> Biosensors Based on Nanoporous Platinum-Coated Gold Nanoporous Film.....	199
6.5	Conclusions	200
	References	200

7	Electrochemical Biosensing Based on Carbon Nanotubes	207
7.1	Introduction	207
7.1.1	Structure of CNTs	207
7.1.2	Advantages of CNT-Based Electrochemical Sensors	208
7.2	Functionalization Strategy of CNTs.....	208
7.2.1	Noncovalent Interaction	209
7.2.2	Covalent Interaction	213
7.3	Fabrication and Characterization of CNT-Based Sensors.....	214
7.3.1	Scanning Electron Microscopy and Transmission Electron Microscopy	215
7.3.2	Fourier Transform Infrared	215
7.3.3	Atomic Force Microscopy.....	216
7.3.4	Raman Spectrum	216
7.4	Amplification of Signal Transduction	218
7.5	Electrochemical Biosensing Based on Functional CNTs.....	220
7.5.1	Deoxyribonucleic Acid	220
7.5.2	Antigen–Antibody.....	222
7.5.3	Cells.....	224
7.5.4	Other Biomolecules.....	226
7.6	SWCNT-Based Field-Effect Biosensing	229
7.6.1	Detection of Proteins by SWCNT-Field-Effect Transistor.....	229
7.6.2	Detection of Nucleic Acids by SWCNT-Field-Effect Transistor.....	231
7.7	SWCNT Forest in Electrochemical Biosensing	231
7.8	Conclusions	233
	References	234
8	Biosensing with Nanoparticles as Electrogenated Chemiluminescence Emitters.....	241
8.1	Introduction	241
8.2	Principle of ECL from Nanoparticles	242
8.2.1	ECL Mechanism of NPs.....	242
8.2.2	Generation Type for NP ECL.....	244
8.2.3	Coreactant System for NP ECL	247
8.3	Biosensing Strategy and Corresponding Application	251
8.3.1	Direct Determination of Biochemical Coreactant.....	252
8.3.2	Improved ECL Performance for Higher Sensitivity.....	253
8.3.3	Analyte-Inhibited (or -Enhanced) ECL Emission.....	254
8.3.4	Determination Based on Resonance Energy Transfer.....	255
8.3.5	Determination with Enzyme-Catalyzed Reaction.....	255
8.3.6	Immunoreactions or DNA Hybridization-Coupled Sensing.....	257
8.4	Conclusions	260
	References	260

9	Biosensing Applications of Molecularly Imprinted Nanomaterials	265
9.1	Introduction	265
9.2	Molecular Imprinting Technology	268
9.2.1	Noncovalent Approach	269
9.2.2	Covalent Approach	270
9.2.3	Other Approaches	271
9.3	Types of MIP Materials	271
9.3.1	Organic Materials	272
9.3.2	Inorganic Materials	272
9.4	Development of MIP Nanomaterials	273
9.4.1	Limitation of Traditional MIPs	273
9.4.2	Exploration of Novel Molecular Imprinting Strategies	274
9.4.3	Attractiveness of MIP Nanomaterials	275
9.5	MIP-Based Biosensors	276
9.5.1	Molecular Recognition of MIP-Based Biosensors	276
9.5.2	Interfacing the MIPs with a Transducer	278
9.5.3	Electrochemical Sensors	279
9.5.4	Optical Sensors	282
9.5.5	Mass-Sensitive Devices	288
9.6	Conclusions	294
	References	294
10	Biosensors Based on Sol–Gel Nanoparticle Matrices	305
10.1	Introduction	305
10.2	Sol–Gel Chemistry	306
10.2.1	What Is Sol–Gel?	306
10.2.2	The Sol–Gel Process	306
10.2.3	Nanoparticles from the Sol–Gel Process	309
10.3	Biosensors Based on Sol–Gel Nanoparticle Matrices	309
10.3.1	Silica Nanoparticle for Biosensing	310
10.3.2	Sol–Gel-Derived Metal Oxide Nanoparticle	316
10.3.3	Sol–Gel Nanocomposite Matrix for Biosensing	319
10.4	Conclusions	326
	References	326
11	Nanostructure for Nitric Oxide Electrochemical Sensing	333
11.1	Introduction	333
11.2	Nanostructure for Nitric Oxide Determination	334
11.3	Nanomaterials for Modification of NO Electrochemical Sensors	336
11.4	Conclusions	344
	References	345

12	Assembly of Nanostructures for Taste Sensing	349
12.1	Introduction	349
12.2	Nanoassembled Films for Taste Sensor Application.....	350
12.2.1	Nanoassembled Conducting Polymers for Taste Sensor Application	350
12.2.2	Carbon Nanotube Polymer Composite for an Impedimetric Electronic Tongue	352
12.3	Sensor Array Based on Gold Nanoparticle–Fluorophore Complexes	352
12.3.1	Detection of Proteins	353
12.3.2	Detection of Bacteria and Mammalian Cells.....	355
12.4	Catalytic Nanomaterial-Based Optical Sensor and Sensor Array	356
12.4.1	Nanomaterial-Based Cataluminescence Sensors for Vapor Sensing	356
12.4.2	Catalytic Nanomaterial-Based Optical Chemosensor Array for Recognition and Discrimination Odors	358
12.4.3	Recognition of Organic Compounds in Aqueous Solutions by Chemiluminescence on Catalytic Nanoparticle Arrays	361
12.5	Conclusions	363
	References	363
13	Nanostructured Biosensing for Detection of Insecticides	365
13.1	Introduction	365
13.1.1	Conventional Strategies for Detection of Pesticides	365
13.1.2	Developments in Pesticide Biosensors	366
13.2	Enzymes Used in Pesticide Biosensors	367
13.2.1	ChE–ChO Bienzyme-Based Biosensors for Pesticides	367
13.2.2	AChE-Based Biosensors for Pesticides	369
13.2.3	OPH-Based Biosensors for Pesticides	371
13.3	Nanostructured Biosensor Design for Pesticide Analysis	372
13.3.1	Carbon Nanotube–Based Nanobiosensor for Pesticides	372
13.3.2	Gold Nanoparticles as Transducer for Detection of Pesticide	375
13.3.3	Quantum Dots as Transducers for Detection of Pesticides	376
13.4	Pesticide Immunosensors	377
13.4.1	Detection Methods for Pesticide Immunosensors	377
13.4.2	Immunosensors for Pesticides	378

13.5	Nanotechnology for Biomonitoring of AChE Activity and Pesticides	381
13.5.1	Biomarkers of Organophosphate Pesticide Exposure.....	381
13.5.2	Biomonitoring of ChE Activity	382
13.6	Conclusions	384
	References	385
14	Carbohydrate Detection Using Nanostructured Biosensing	393
14.1	Introduction	393
14.2	Structural Depiction of Glycans	394
14.2.1	Basic Structural Unit of Glycans	394
14.2.2	Glycoconjugate.....	394
14.2.3	Major Classes of Glycoconjugates and Oligosaccharides	394
14.3	Biological Roles of Glycans	396
14.4	Difficulty in Studying Genetic Glycosylation Defects.....	397
14.5	Protein–Glycan Interactions	397
14.6	Techniques Used to Identify a Carbohydrate and Its Derivates	398
14.6.1	General Considerations for Analyzing the Primary Structure of a Carbohydrate.....	398
14.6.2	Detection of Carbohydrates	399
14.6.3	Linkage Analysis	400
14.7	Nanotechnology.....	402
14.7.1	Analysis of Carbohydrates in Biological System with Nanostructure Device/Components.....	402
14.7.2	Other Principles of Direct Carbohydrate Detection.....	404
14.7.3	Carbohydrate Components in Biosensors	413
14.8	Conclusions	420
	References	420
15	Nanomaterials for Immunosensors and Immunoassays.....	425
15.1	Introduction	425
15.2	Principle of Immunoassays and Immunosensors	426
15.2.1	Antigen, Antibody, and Their Recognition Reaction	426
15.2.2	Immunoassays and Immunosensors	427
15.3	Immunosensors Based on Biocompatible Nanomaterials	429
15.3.1	Nanomaterials Used as Immobilization Substrates	429
15.3.2	Nanomaterials Used as Signal Tags.....	436
15.3.3	Nanomaterials Used as Probe Carriers	444
15.4	Conclusions	447
	References	448

16 Nanostructured Biosensing and Biochips for DNA Analysis	453
16.1 Introduction	453
16.2 Nanostructures in DNA Biosensing	455
16.2.1 Carbon Nanotubes for DNA Analysis	455
16.2.2 Metal Nanoparticles for DNA Analysis	464
16.2.3 Semiconductor Nanostructures for DNA Analysis.....	467
16.3 Nanostructures for DNA Biochips	471
16.3.1 Optical Techniques for DNA Biochips.....	471
16.3.2 Electrochemical Methods for DNA Biochips.....	474
16.4 Conclusions	475
References	479
17 Cytosensing and Cell Surface Carbohydrate Assay	
by Assembly of Nanoparticles.....	485
17.1 Introduction	485
17.2 Why Use Nanomaterials in Cytosensing?	486
17.3 Cytosensing by Assembly of Nanomaterials.....	487
17.3.1 Fluorescence Imaging by Assembly of Nanoparticles.....	488
17.3.2 Magnetic Resonance Imaging by Assembly of Magnetic Nanoparticles	499
17.3.3 Cellular Surface-Enhanced Raman Scattering (SERS) Detection by Assembly of Nanoparticles	506
17.3.4 Colorimetric Cytosensing by Assembly of Nanoparticles.....	511
17.3.5 Electrochemical Cytosensing by Assembly of Nanomaterials	511
17.4 Cell Surface Carbohydrate Assay by Assembly of Nanoparticles	517
17.4.1 Cell Surface Carbohydrate Assay Based on Nanomaterial Substrates	518
17.4.2 Cell Surface Carbohydrate Assay Based on Nanoprobes	520
17.5 Conclusions	527
References	528
18 Nanobiosensing for Clinical Diagnosis.....	535
18.1 Introduction	535
18.2 Nanotechnologies in Biosensing	536
18.2.1 Nanomaterials for Biological Detection.....	536
18.2.2 Nanofabrication	544
18.2.3 Nanodevices.....	548
18.3 Nanobiosensing for Clinical Diagnosis	555
18.3.1 Glucose Detection	555
18.3.2 Disease Protein Biomarker Detection.....	556

18.3.3	DNA Detection	558
18.3.4	Virus Detection	560
18.3.5	Bacteria Detection	561
18.3.6	Cancer Cell Detection.....	561
18.4	Conclusions	562
	References	562
Index		569



<http://www.springer.com/978-1-4419-9621-3>

NanoBiosensing

Principles, Development and Application

Ju, H.; Xueji, Z.; Wang, J.

2011, XV, 586 p., Hardcover

ISBN: 978-1-4419-9621-3