
Contents

1 Water Soluble Poly(fluorene) Homopolymers and Copolymers for Chemical and Biological Sensors

<i>G.C. Bazan and S. Wang</i>	1
1.1 Introduction	1
1.2 General Structures and Properties	2
1.2.1 Design, Synthesis, and Structural Properties	2
1.2.2 Optical Properties	6
1.3 Signal Transduction Mechanisms in Sensors	9
1.4 Chemo- and Biosensor Applications	15
1.4.1 DNA Sensors	15
1.4.2 RNA Sensors	23
1.4.3 Protein Detection	25
1.4.4 Glucose Sensors	28
1.4.5 Detection of Other Small Molecules	30
1.5 Heterogeneous Platforms	31
1.6 Summary and Outlook	32
References	34

2 Polyelectrolyte-Based Fluorescent Sensors

<i>K. Ogawa, K.E. Achyuthan, S. Chemburu, E. Ji, Y. Liu, G.P. Lopez, K.S. Schanze, and D.G. Whitten</i>	39
2.1 General Introduction	39
2.1.1 Amplified Fluorescence Quenching	39
2.1.2 General Sensor Schemes: Bioassays Based on Quench/Unquench	43
2.2 Enzyme Activity Assays	44
2.2.1 Assay Formats and Types	44
2.2.2 Proteolytic Enzyme Assays Using Conjugated Polyelectrolytes	45
2.2.3 Phospholipase Assays Using Conjugated Polyelectrolytes	46
2.2.4 Assays Based on “Frustrated Super-Quenching”	49

2.2.5 Supramolecular Self-Assembly and Scaffold Disruption/Destruction Assays	50
2.2.6 Cyanines and Supra-Molecular Self-Assembly	50
2.2.7 Cyanine Chemistry	51
2.2.8 Glycosidases and Scaffold Disruption/Destruction Assay	52
2.3 Conjugated Polyelectrolyte Surface-Grafted Colloids	54
2.4 Summary and Conclusions	57
References	58

3 Structurally Integrated Photoluminescent Chemical and Biological Sensors: An Organic Light-Emitting Diode-Based Platform

<i>R. Shinar and J. Shinar</i>	61
3.1 Introduction	61
3.1.1 Photoluminescence-Based Sensors	61
3.1.2 Structurally Integrated OLED/Sensing Component Modules	62
3.1.3 Structural Integration of the OLED Array/Sensing Film	63
3.2 Single Analyte Monitoring	64
3.2.1 Gas-Phase and Dissolved Oxygen	64
3.2.2 Enhanced Photoluminescence of Oxygen-Sensing Films Through Doping with Titania Particles [70]	69
3.2.3 Glucose	71
3.2.4 Hydrazine (N_2H_4)	77
3.2.5 Anthrax Lethal Factor (LF)	79
3.3 Advanced Sensor Arrays	81
3.3.1 OLED-Based Multiple Analyte Sensing Platform	81
3.3.2 Extended Structural Integration: OLED/Sensing Component/Photodetector Integration	87
3.4 Future Directions	90
3.4.1 Improved OLEDs	90
3.4.2 Sensor Microarrays	91
3.4.3 Autonomous Field-Deployable Sensors for Biological Agents	91
3.5 Summary and Concluding Remarks	92
References	92

4 Lab-on-a-Chip Devices with Organic Semiconductor-Based Optical Detection

<i>O. Hofmann, D.D.C. Bradley, J.C. deMello, and A.J. deMello</i>	97
4.1 Introduction	97
4.1.1 Microfluidics and Lab-on-a-Chip	97
4.1.2 Detection Problem at the Microscale	102
4.2 Fabrication	103
4.2.1 Microfluidic Systems	103

4.2.2 Organic Semiconductor-Based Light Sources and Detectors	108
4.2.3 Towards Mass Manufacture	112
4.3 Functional Optical Components	116
4.3.1 OLED Light Sources for Microchip Analysis	116
4.3.2 Organic Photodetectors for Chemiluminescence Assays	118
4.3.3 Optical Filters for Head-On Fluorescence Detection	123
4.4 Applications	126
4.4.1 Microalbuminuria Determination On-Chip	127
4.4.2 Chemiluminescence-Based Diagnostic Tests	131
4.4.3 Towards Portable and Disposable Diagnostic Devices	135
4.5 Conclusions and Outlook	137
References	139
5 Solid-State Chemosensitive Organic Devices for Vapor-Phase Detection	
<i>J. Ho, A. Rose, T. Swager, and V. Bulovič</i>	141
5.1 Introduction	141
5.1.1 Chemical Sensors and Electronic Noses	141
5.2 Survey of State-of-the-Art Vapor-Phase Solid-State Chemosensing Organic Devices	142
5.2.1 Electrical Odor Sensors	144
5.2.2 Optical Odor Sensor	152
5.2.3 Summary	160
5.3 Recent Advances	160
5.3.1 Chemosensing Lasing Action	160
5.3.2 Chemical Sensing Heterojunction Photoconductors	172
References	180
6 Detection of Chemical and Physical Parameters by Means of Organic Field-Effect Transistors	
<i>A. Bonfiglio, I. Manunza, P. Cosseddu, and E. Orgiu</i>	185
6.1 Introduction	185
6.2 An Overview of Organic Field-Effect Sensors	186
6.3 (Bio)chemosensing in Solution	188
6.3.1 Ion Sensitive Organic Field-Effect Transistors (ISOFETs)	188
6.4 Strain and Pressure Sensors	193
6.4.1 State of the Art of Mechanical Sensors Including OFETs	194
6.4.2 Flexible Structures for Mechanical Sensors	199
6.5 Design and Technology of Organic Field-Effect Sensors	202
6.6 Applications for Organic Field-Effect Sensors	205
6.6.1 Artificial Sense of Touch	206
6.6.2 E-Textiles	208
6.7 Conclusions	210
References	210

7 Performance Requirements and Mechanistic Analysis of Organic Transistor-Based Phosphonate Gas Sensors	
<i>K. See, J. Huang, A. Becknell, and H. Katz</i>	213
7.1 Overview of Electronic Sensors for Chemical Vapors and Warfare Agents	213
7.1.1 Introduction and Response Targets	213
7.1.2 Selectivity	214
7.1.3 Stability	215
7.1.4 Response Time	216
7.1.5 Power Consumption and Form Factor	216
7.2 Organic Semiconductor Transistor Sensors	216
7.2.1 Organic Electronics and Chemical Sensing	216
7.2.2 Electronic Transduction Mechanism	218
7.3 Testing Environments for Prototype Sensing Elements	219
7.3.1 Test Chambers	219
7.3.2 Device Packaging	225
7.4 Electrical Test Procedures	225
7.4.1 Generation of Saturation Curves at a Fixed Time Interval	225
7.4.2 Generation of Transfer Curves at a Fixed Time Interval	226
7.4.3 Pulsed Vs. Nonpulsed Measurements	227
7.4.4 Erasing Electrical History	227
7.5 Responses of Functionalized Organic Semiconductors to DMMP	228
7.5.1 Responses of Functionalized Hole-Transporting Oligomers, Including Blends and Surface Modifications	229
7.5.2 Responses of Electron-Transporting Films, Including Hydroxylated Island Overlayers	232
7.6 Data Analysis	234
7.6.1 Sensitivity of an OFET Sensor: Gate Voltage Dependence and Contributions of Mobility and Threshold Voltage Changes	234
7.6.2 Self-Consistent Equation Based on Simple Saturation Current	235
7.6.3 Contributions of Gate Dependent Mobility and Contact Resistance	238
7.7 Sensing Mechanisms and OFET Models	239
7.8 Summary and Outlook	242
References	243
8 Electrochemical Transistors for Applications in Chemical and Biological Sensing	
<i>A. Kumar and J. Sinha</i>	245
8.1 Introduction	245
8.2 Sensors Based on Electrochemical Transistors	247
8.2.1 Sensor Mechanisms	248
8.2.2 Enzyme-Based Sensing	251

8.2.3 Antibody–Antigen-Based Sensing	255
8.2.4 DNA-Based Sensing	257
8.3 Recent advances in Design and Fabrication of Electrochemical Transistors	258
8.4 Summary and Future Directions	260
References	261
9 PEDOT:PSS-Based Electrochemical Transistors for Ion-to-Electron Transduction and Sensor Signal Amplification	
<i>M. Berggren, R. Forchheimer, J. Bobacka, P.-O. Svensson, D. Nilsson, O. Larsson, and A. Ivaska</i>	263
9.1 The PEDOT:PSS-Based Electrochemical Organic Thin Film Transistor	263
9.1.1 Electrochemical Transistors: A Brief Introduction and a Short Historical Review	263
9.1.2 The Operation Principle of the PEDOT:PSS-Based Electrochemical Organic Thin Film Transistor	264
9.1.3 Design Criteria and Device Operation Parameters	265
9.1.4 Manufacturing Techniques	267
9.2 The PEDOT:PSS OECT as an Ion-to-Electron Transducer	269
9.2.1 Different Sensor Principles of the PEDOT:PSS Electrochemical Transistor	269
9.2.2 Humidity Sensing	269
9.2.3 Ion-Selective Membranes	270
9.3 The PEDOT:PSS Electrochemical transistor in logic and amplification circuits	272
9.3.1 Introduction to Electrochemical Circuits and Systems	272
9.3.2 Electrochemical Digital Circuits	273
9.3.3 Electrochemical Analog Circuits	273
9.3.4 The Differential Amplifier	276
9.3.5 Zero Detector	277
9.3.6 Oscillators	277
9.4 Outlook	278
References	279
Index	281