

Contents

1 Introduction	1
References	4
2 Classification of Electrochemically Active Polymers	7
2.1 Redox Polymers	7
2.1.1 Redox Polymers Where the Redox Group Is Incorporated into the Chain (Condensation Redox Polymers, Organic Redox Polymers)	8
2.1.2 Redox Polymers with Pendant Redox Groups	9
2.1.3 Ion Exchange Polymers Containing Electrostatically Bound Redox Centers	12
2.2 Electronically Conducting Polymers (Intrinsically Conducting Polymers—ICPs)	14
2.2.1 Polymers from Aromatic Amines	14
2.2.2 Polymers from Aromatic Heterocyclic Compounds	23
2.2.3 Polymers from Nonheterocyclic Aromatic Compounds	40
2.2.4 Other Polymers	43
2.3 Electronically Conducting Polymers with Built-In or Pendant Redox Functionalities	44
2.3.1 Poly(5-Amino-1,4-Naphthoquinone) (PANQ)	44
2.3.2 Poly(5-Amino-1-Naphthol)	45
2.3.3 Poly(4-Ferrocenylmethylidene-4 <i>H</i> -Cyclopenta- [2,1- <i>b</i> ;3,4- <i>b'</i>]-Dithiophene)	45
2.3.4 Fullerene-Functionalized Poly(Terthiophenes) (PTTh–BB)	46
2.3.5 Poly[Iron(4-(2-Pyrrol-1-Ylethyl)-4'-Methyl-2,2'-Bipyridine) ₃ ²⁺]	46
2.3.6 Polypyrrole Functionalized by Ru(bpy)(CO) ₂	47
2.3.7 Poly(Tetra-Substituted Porphyrins) and Poly(Tetra-Substituted Phtalocyanines)	47
2.3.8 Poly[4,4'(5')-Bis(3,4-Ethylenedioxy)Thien-2-Yl] Tetrathiafulvalene (PEDOT–TTF) and Poly {3-[7-Oxa-8- (4-Tetrathiafulvalenyl)Octyl]-2,2'-Bithiophene} (PT–TTF)	48

2.4 Copolymers	49
2.4.1 Poly(Aniline- <i>co</i> -Diaminodiphenyl Sulfone)	50
2.4.2 Poly(Aniline- <i>co</i> -2/3-Amino or 2,5-Diamino Benzenesulfonic Acid)	51
2.4.3 Poly(Aniline- <i>co</i> - <i>o</i> -Aminophenol)	51
2.4.4 Poly(<i>m</i> -Toluidine- <i>co</i> - <i>o</i> -Phenylenediamine)	51
2.4.5 Poly (Luminol-Aniline)	52
2.4.6 Other Copolymers	53
2.5 Composite Materials	53
2.5.1 Composites of Polymers with Carbon Nanotubes and Other Carbon Systems	54
2.5.2 Composites of Polymers with Metal Hexacyanoferrates	55
2.5.3 Conducting Polymer Composites with Metals	55
2.5.4 Conducting Polymer and Metal Oxides Composites	56
2.5.5 Conducting Polymer-Inorganic Compounds Composites	57
2.5.6 Polymer-Polymer Composites	58
References	60
3 Methods of Investigation	83
3.1 Electrochemical Methods	84
3.1.1 Cyclic Voltammetry	84
3.1.2 Chronoamperometry and Chronocoulometry	87
3.1.3 Electrochemical Impedance Spectroscopy	90
3.2 In Situ Combinations of Electrochemistry with Other Techniques ...	104
3.2.1 Electrochemical Quartz Crystal Nanobalance	105
3.2.2 Radiotracer Techniques	112
3.2.3 Probe Beam Deflection Technique	115
3.2.4 Ellipsometry	118
3.2.5 Bending Beam Technique	118
3.2.6 Spectroelectrochemistry	122
3.2.7 Scanning Probe Techniques	125
3.2.8 Conductivity Measurements	129
3.3 Other Techniques Used in the Field of Conducting Polymers	131
3.3.1 Scanning Electron Microscopy	131
3.3.2 X-Ray Photoelectron Spectroscopy	132
3.3.3 X-Ray Diffraction and Absorption	132
3.3.4 Electrospray Ionization Mass Spectrometry	132
References	133
4 Chemical and Electrochemical Syntheses of Conducting Polymers ...	149
References	167
5 Thermodynamic Considerations	173
5.1 Neutral Polymer in Contact with an Electrolyte Solution	174
5.2 Charged Polymer in Contact with an Electrolyte Solution	178
5.2.1 Nonosmotic Membrane Equilibrium	178

5.2.2 Osmotic Membrane Equilibrium and Electrochemical and Mechanical Equilibria	181
5.3 Dimerization, Disproportionation, and Ion Association Equilibria Within the Polymer Phase	189
References	190
6 Redox Transformations and Transport Processes	191
6.1 Electron Transport	194
6.1.1 Electron Exchange Reaction	194
6.1.2 Electronic Conductivity	200
6.2 Ion Transport	211
6.3 Coupling of Electron and Ionic Charge Transport	216
6.4 Other Transport Processes	221
6.4.1 Solvent Transport	221
6.4.2 Dynamics of Polymeric Motion	222
6.5 Effect of Film Structure and Morphology	223
6.5.1 Thickness	224
6.5.2 Synthesis Conditions and Nature of the Electrolyte	225
6.5.3 Effect of Electrolyte Concentration and Temperature	225
6.6 Relaxation and Hysteresis Phenomena	230
6.7 Measurements of the Rate of Charge Transport	239
References	239
7 Applications of Conducting Polymers	245
7.1 Material Properties of Conducting Polymers	245
7.2 Applications of Conducting Polymers in Various Fields of Technologies	247
7.2.1 Thin-Film Deposition and Microstructuring of Conducting Materials (Antistatic Coatings, Microwave Absorption, Microelectronics)	247
7.2.2 Electroluminescent and Electrochromic Devices	249
7.2.3 Membranes and Ion Exchanger	257
7.2.4 Corrosion Protection	257
7.2.5 Sensors	259
7.2.6 Materials for Energy Technologies	270
7.2.7 Artificial Muscles	274
7.2.8 Electrocatalysis	276
References	282
8 Historical Background (Or: There Is Nothing New Under the Sun) ...	295
References	297
About the Author	299
About the Editor	301
Index	303

Conducting Polymers

A New Era in Electrochemistry

Inzelt, G.

2012, X, 310 p., Hardcover

ISBN: 978-3-642-27620-0