

Index

- Absorption spectra
 - electrochromic devices
 - nickel oxide 257
 - polymer electrochromic performance 232
 - nickel bromide-polyether electrolytes 130–3
 - temperature dependence 140–3
- Accumulation amperometric sensors 330–2
- Acetone 123–5
- Acetonitrile 45
- Acidity and electrochromic devices 235–6
- Alkyl groups 242
- Alkyloxy groups 242
- Ambient temperature solid-state lithium batteries 104–9
- Amorphous polymers 78–95
- Amorphous regions of polymers 3–7, 10–11
 - conductance 21
- Amperometric sensors 330–4
- Amphiphilic molecules 296–300
- Amphiphilization 300
- Anions
 - electropolymerization 36
 - insertion 31–3
 - Katzin effect 119–20
 - mobility 11, 14, 21–2, 114
 - QCM measurements 48–54
 - solutes 15
- Anodes, lithium polymer batteries 184
- Anodic ion-insertion electrochromic materials 256–63
- Aprotic solvents 116
- Aqueous solutions 45
- Armand, M.B. 2
- Aromatic compounds
 - electropolymerization 36–7
 - lithium batteries 155
- Arrhenius relationship 11, 12
- Atacticity 10

- Band structure, *see* Electronic structure
- Barrier layers 315–17
- Batteries
 - Armand 2
 - highly conductive polymer electrolytes 75–6
 - ambient temperature solid-state lithium 104–9
 - lithium ion batteries 110
 - lithium, with polymer electrodes 150–6, 175–8
 - materials 156–75
 - lithium polymer 182–4
 - advantages 192–7
 - concept 184–91
 - development, current status of 212–16
 - future direction of 218–20
 - problems 197–212
 - scale-up of 216–18
 - polyaniline 235

- Beer's law 132, 135, 136
- Bilayer model
 electropolymerization 38
 impedance 69
- Biosensors 315, 332–4
- Bipolarons
 electrochemical devices 225
 mobility 35–6
 optical sensors 336
- Block copolymers 9
- Born model 117
- Branched alkyl chains 242
- Capacity
 highly conductive polymer electrolytes 109–10
 lithium polymer batteries 207–12, 213–16
 redox 60–3
 impedance 63–6
- Casting procedure 182–3
- Cathodes, lithium polymer batteries 184
- Cathodic ion-insertion electrochromic materials 252–6
- Cations
 insertion 31–3
 Katzin effect 119–20
 mobility 11, 14, 114
 solutes 14–15
- Cavity formation 117
- Centrifugal method 19
- Ceramic powders 200–1
- Charge-controllable conducting polymers 291–4
- Charge-discharge characteristics
 functional molecules 293–4
 lithium battery electrodes 177
 polyacetylene 159–60
 polyaniline 167–72
 polyazulene 174
 polypyrrole 162–5
 polythiophene 173
 lithium polymer batteries 208–11
- Charge transfer
 impedance 68–9
 interface 23
 sensors 312–13
 potentiometric 325–6, 328
- Chelate effect 121–2, 147
- Chelate rings 122, 127–8
- Chemical polymerization 156–7, 175
 functional molecules 285–6
 polyaniline 170–1
 polypyrrole 163–5
 polythiophene 173
- Chemical sensors, *see* Sensors
- Chemiluminescent conducting polymer film 288–90
- Chemiluminescent spectra 289
- Chemiresistors 334–6
- Chronocoulometric responses 235
- Cobalt (II) ion 122–5
- Cobalt bromide-polyether systems 125–8
- Cobalt oxide, lithiated 271
- Comb polymers 9
 glass transition point 83–5
- Compatibility, electrode-electrolyte 22–3
- Complexation 116–22
 cobalt (II) ion 122–5
 nickel (II) ion 136–40
- Complex impedance spectra 90–2
 non-conventional polymer electrolytes 99
- Compositional superlattices 305
- Concentration
 nickel (II) complexation 136–40
 redox potential 44–8
- Concentration cells 18
- Concentration effects 17
- Conductance 21
- Conductimetric sensors 334–6
- Conductivity
 electronically conducting polymers 34–6
 electropolymerization 40
 redox polymers 31
 ion conducting polymers 21
 conventional 95–6
 see also Highly conductive polymer electrolytes
 lithium polymer batteries 200–1
 nickel bromide-polyether electrolytes 136–40
 temperature dependence 144–6
- Conjugated polymers 224–5
- Constant phase element behaviour 7

- Construction, lithium polymer batteries 193
- Contact areas 22–3
- Conventional polymer electrolytes
 - conductivity limit 95–6
 - highly conductive 76–8
 - dimensional stability 87–93
- Coordination chemistry 8–9, 120–1
 - cobalt (II) ion 122–5
 - nickel (II) ion 128–9
- Copolymerization 314–15, 317
- Copolymers 8–9, 13–14
 - functionalized conducting polymer membranes 303
 - highly conductive polymer electrolytes 82
 - types 9–10
- Costs, lithium polymer batteries 197, 198
- Coulombic efficiency
 - electrochromic devices 229, 234, 239, 246
 - lithium battery electrodes 177
 - polyacetylene 159–60
 - polyaniline 167–70
 - polyazulene 174
 - polypyrrole 163, 165
 - polythiophene 173
 - lithium polymer batteries 207–10
- Counter-electrodes 223–4, 237, 239, 252
 - electrochromic displays 263–4
 - electrochromic windows 268–72
- Counterions 35
- Cross-links
 - stability 92–3
 - transient 8
- Crystalline regions of polymers 3–7, 10
- conductance 21
- Crystallinity
 - electropolymerization 38
 - highly conductive polymer electrolytes 78
- Cyclic voltammetry
 - electrochromic materials
 - anodic ion-insertion 257–8, 259–61
 - cathodic ion-insertion 253–4
 - displays 264–5
 - windows 269–70, 272–5, 278–9
 - electronically conducting polymers
 - impedance 64
 - ion insertion 57–60
 - oxidation 45–7
 - redox capacity 62
 - lithium battery electrodes
 - polyacetylene 157–8
 - polyaniline 167–9
 - polyazulene 174–5
 - poly(paraphenylene) 175–6
 - polypyrrole 161
 - polythiophene 171
 - lithium polymer batteries 201–3, 206
 - sensors, amperometric 331–2
 - solid-state lithium batteries 104–5
- Cycling, lithium polymer batteries 204, 207–12, 213–15
- DC polarization 19
- Decoupling index 95
- Delocalization 34
- Density
 - crystallinity 4
 - energy 192–3, 214–15
 - optical 229, 231
- Deposition
 - electropolymerization 37–40
 - sensors 311, 316
- Depth profiles 303–5
- Device electrochromic performance 236–42
- Dielectric constant 117–18
- Diffraction 3–4
- Diffusion
 - and conductivity 30, 95
 - non-conventional polymer electrolytes 100–1
 - transference number determination 19
- Diffusional impedance 66–8
- Dimensional stability 87–93
 - non-conventional polymer electrolytes 97–8
- Displays, electrochromic 263–7
- Doctor Blade coating method 193–4
- Donor numbers 118–19
- Doping
 - electrochromic devices 224–8
 - polymer electrochromic performance 233–4

- level 225
- lithium batteries with polymer
 - electrodes 150–1, 176–8
 - polyacetylene 157–8
 - polyaniline 170–1
 - polyazulene 174
 - poly(paraphenylene) 175
 - polypyrrole 161–5
 - polythiophene 173–4
- sensors 312
 - optical 336–7
- superlattice 303, 305
- see also* Oxidation
- Doping–undoping process
 - electrochromic devices 224
 - polymer electrochromic performance 229, 233–4
 - functional molecules 291–3
- Dynamic mechanical analysis 10
- Effective diffusivity 68
- Efficiency, *see* Coulombic efficiency;
Electrochromic efficiency
- Eisenmann–Nikolskij equation 321, 328
- Elastomers 8
- Electrical transport 15–22
- Electric vehicles 197, 199, 213, 220
- Electrochemical doping, *see* Doping
- Electrochemical polymerization, *see*
Electropolymerization
- Electrochemical sensors 321–36
- Electrochemistry
 - basic principles 151–2
 - lithium battery electrodes
 - polyacetylene 157–8
 - polyaniline 166
- Electrochromic conducting polymer film 286–8
- Electrochromic devices 223–4, 247
 - anodic ion-insertion 256–63
 - basic concepts 225–9
 - cathodic ion-insertion 252–6
 - device electrochromic performance 236–42
 - displays 263–7
 - polymer electrochromic performance 236–42
 - 'tailor-made' colour contrast 242–6
 - windows 267–9
- Electrochromic displays 263–7
- Electrochromic efficiency 229, 234, 246
 - anodic ion-insertion 260, 263
 - cathodic ion-insertion 255
- Electrochromic response time 246
 - device electrochromic performance 237–8
 - polymer electrochromic performance 229, 230–1, 234, 235–6
- Electrochromic windows 267–79
- Electrochromism 225–9, 250–1
- Electrode interfaces 22–3, 201–7
- Electrodeposition
 - electronically conducting polymers 37–40
 - sensors 311, 316
- Electrodes
 - electrochromic 223–4, 236–7
 - lithium batteries with polymer 150–6, 175–8
 - materials 156–75
- Electrogenerated chemiluminescent conducting polymer film 288–90
- Electrolytes
 - electrochromic displays 264
 - lithium batteries with polymer electrodes 156
 - lithium polymer batteries 202–5
- Electrolytic polymerization, *see*
Electropolymerization
- Electronically conducting polymers 29–40, 69–70
 - impedance 63–9
 - stoichiometry of oxidation 43–63
 - thermodynamics of intercalation 40–3
- Electronic contributions 20
- Electronic structure
 - electrochromic devices 225–6
 - electronically conducting polymers 34–6
- Electron pairs 118
- Electropolymerization
 - electrochromic devices 228–9, 242–5
 - electronically conducting polymers 36–41
 - functionalized conducting polymer membranes
 - functional molecules 284
 - structural control 296–7, 302–3, 306

- lithium batteries with polymer
 - electrodes 157, 175
 - polyaniline 167–70
 - polyazulene 174
 - polypyrrole 161–3
 - polythiophene 171, 174
 - sensors 313–14, 316–17
 - potentiometric 321, 330
- Electrostatic interactions 116
- Electrosynthesis 232
- End-capping 8
- End-group effects
 - ion conducting polymers 8
 - solvation mechanisms 127
- Energy density 192–3, 214–15
- Enthalpic interactions 116–17
- Epoxy-based polymer electrolytes 102
- Equivalent molar conductivity 138–40

- Faradaic reactions 66
- Fillers, inert
 - ion conducting polymers 14
 - lithium polymer batteries 199–201
- First generation polymer ionic membranes 199
- Framework structures 30
- Free volume theories 10–11
- Fringed micelle model 4–5
- Functionalized polymers 283, 307–8
 - by incorporation of functional molecules 283–95
 - by structural control 295–308
- Functional molecules 283–95

- Galvani potential difference 326
- Galvanostatic polarization 258–9
- Gibb's free energy 116
- Glass transition point 10–11, 14
 - highly conductive polymer electrolytes 77–8
 - amorphous polymers 78–95
- Gutmann scale 118–19

- Halides, cobalt 123–5
- Heterocyclic compounds 155
- Heteromultilayers, conducting polymer 301–8
- Highly anisotropic conducting polymer LB multilayers 295–300

- Highly conductive polymer electrolytes 75–8, 96–103, 109–10
 - amorphous 78–95
 - solid-state lithium batteries 104–9
- Highly dispersed metal incorporating conducting polymers 295
- Hydrogen bonding 118

- Imide salt 86
- Impedance
 - electronically conducting polymers 63–9
 - lithium polymer batteries 210–11
- Impedance spectra
 - complex 90–2
 - non-conventional polymer electrolytes 99
 - transference number determination 18
- Inert fillers
 - ion conducting polymers 14
 - lithium polymer batteries 200–1
- Inorganic compounds 29–30
- Intercalation
 - electrode interface 206–7
 - electronically conducting polymers 29–30
 - thermodynamics of 40–3
 - level 188
 - lithium polymer batteries 187–8
- Interpenetrating networks 9–10
- Ion clusters 17, 22
- Ion conducting polymers
 - conductivity limit 95–6
 - electrical and electrochemical properties 1–15
 - electrical transport, mechanism of 15–22
 - electrode–polymer interface, properties of 22–3
 - highly conductive 75–8, 96–103, 109–10
 - amorphous 78–95
 - solid-state lithium batteries 104–9
- Ion exchangers 310
- Ionic conductivity 136–40
- Ion insertion
 - electrochromic materials 251–2
 - anodic 256–63
 - cathodic 252–6

- electronically conducting polymers
 - 54–60
 - lithium 2
 - sensors 312
- Ion–matrix interactions 16
- Ionophores 310
- Ion pairing
 - ion conducting polymers 11–12, 14
 - solvation mechanisms 118
- Ion–polymer interaction 13
- Ion sites 16
- Iridium oxide 256, 269–70
- Irradiation cross-linked linear polymers 9
- Isosbestic points 337
- Isotacticity 10
- Itaconates 85

- Katzin effect 119, 146–7
- Katzin, L. 119–20
- Kelvin probe 323–4, 327, 329
- Kinetic limitations, lithium polymer batteries 209

- Ladder polymers 9
- Laminated electrochromic materials
 - 250–2, 279–80
 - anodic ion-insertion 256–63
 - cathodic ion-insertion 252–6
 - displays 263–7
 - windows 267–9
- Lamination, lithium polymer batteries 194–6
- Langmuir–Blodgett (LB) multilayers
 - 295–300
 - sensors 313
- Lattice energy 85
- Lewis acid–base interactions 117
- Ligands 120–2, 123
- Linear chains
 - electropolymerization 242
 - ion conducting polymers 8
- Lithiated cobalt oxide 271
- Lithiated nickel oxide 257–62, 269
 - laminated 272–5
- Lithiated niobium oxide 271
- Lithium
 - Armand 2
 - batteries with polymer electrodes 150–6, 175–8
 - materials 156–75
 - highly conductive polymer electrolytes
 - solid-state batteries 104–9
 - transport 93–5
 - ion batteries 110
 - polymer batteries 182–4
 - advantages 192–7
 - concept 184–91
 - development, current status of 212–16
 - future direction of 218–20
 - problems 197–212
 - scale-up of 216–18
- Lithium bromide 134
- Lithium polymer rocking-chair batteries 271

- Macrocyclic effect 122
- Manganese dioxide 190–1
- Mass sensors 317–21
- Mead electrolytes 102–3, 104
- Mechanical properties, lithium polymer batteries 199–201
- MEEP, *see* Poly[bis-(methoxy ethoxy ethoxy) phosphazene]
- Meldola blue 333
- Melting process 3–4
- Memory, optical 229, 234, 246, 247
- Mers, *see* Structural repeat units
- Mesoscopic level, conducting polymer heteromultilayers in 301–8
- Methacrylate networks 102–3
- Microdendrites 210
- Miniaturization, chemical sensors 336, 339
- Molecules, functional 283–95
- Monomer units, *see* Structural repeat units
- Morphology 3–5, 10
 - amorphous polymers 79
 - conductance 21
 - electrochromic materials
 - anodic ion-insertion 263
 - cathodic ion-insertion 255
 - lithium battery electrodes
 - polyaniline 167, 170
 - polypyrrole 163
 - lithium polymer batteries 195–6
- Mullikan electronegativity 325, 328

- Multidentate ligands 121
- Nernst equation 326, 327
- Network polymers 9
 - glass transition point 83
- Neutral species, contribution of 20–1
- Nickel (II) ion 128–9
- Nickel bromide-polyether electrolytes 130–46
- Nickel oxide 256–63, 269
 - device electrochromic performance 236–7
 - lithiated 257–62, 269
 - laminated 272–5
- Nikolskij–Eisenmann equation 321, 328
- Niobium oxide, lithiated 271
- Non-conventional polymer electrolytes 96–103
- Nonelectrostatic interactions 117
- Octahedral coordination
 - cobalt (II) ion 123–8
 - nickel (II) ion 128–41
- Oligomers 7
- Open circuit voltage (OCV) 187–90
- Optical density 229, 231
- Optical memory 229, 234, 246, 247
- Optical sensors 336–9
- Ormocers 14
- Ormolytes 14
- Oxidation
 - levels 34–5
 - stoichiometry 43–63
 - see also* Doping
- Oxyalkyl groups 242–3
- Passivation, lithium 202–6
- Patterning, conducting polymer 300–1
- Performance
 - conductive polymer electrodes 155–6
 - device electrochromic 236–42
 - lithium polymer batteries 217
 - polymer electrochromic 229–36
- Permselective membranes 316–17
- pH and electrochromic devices 235–6
- Photoelectric converting conducting polymer film 289–91
- Photopolymerization 286, 300–1, 306
- Phthalocyanine 336
- Plasticizers 7
 - highly conductive polymer electrolytes 78
 - glass transition point 85–7
 - non-conventional 96–7, 103
- Plating-stripping process 201–3
- Polarons
 - mobility 35–6
 - optical sensors 336
- Polyacetylene 152–5, 157–60, 176–7
- Polyaniline
 - electrochromic devices 235–6, 239–42
 - LB multilayers 297
 - lithium battery electrodes 165–71, 176–7
- Polyazulene 174–5, 177
- Poly[bis-(methoxy ethoxy ethoxy) phosphazene] (MEEP)
 - dimensional stability 87–92
 - glass transition point 79–80, 83
 - lithium ion transport 93–5
 - solid-state lithium batteries 104, 108
- Polycarbazole 175
- Polycyclic compounds 155
- Poly(dialkyl siloxane)s 82
- Polyethers, low molecular weight 113–22, 146–7
 - cobalt bromide-polyether systems 125–8
 - coordination chemistry
 - cobalt (II) 122–5
 - nickel (II) 128–9
 - nickel bromide-polyether electrolytes 130–46
- Polyethylene glycol 115
- Polyethylene glycol dimethyl ether 115
- Poly(ethyleneimines) 267
- Poly(ethylene oxide)
 - conductivity 13
 - electrochromic displays 264–6
 - glass transition point 79–83
 - linear 8
 - studies 114–15
- Polyiminodibenzyl 175, 177
- Polyisothionaphthene 228, 230–1
- Polymer electrochromic performance 229–36
- Polymer electrolytes, *see* Ion conducting polymers

- Polymerization, *see* Chemical polymerization;
Electropolymerization;
Photopolymerization
- Polymethylmethacrylate 273
- Poly(oxymethylene-oligo-oxyethylene)s 80–2
- Poly(paraphenylene) 175
- Poly(phenylacetylene) 322
- Polyphosphazenes 83
- Poly(propylene oxide) 79–80
- Polypyrrole
 electrochemical properties 33
 electrochromic performance 231
 electropolymerization 36, 37
 ion insertion 54–60
 LB multilayers 296–7, 298–9
 lithium battery electrodes 160–5, 176–7
- Polypyrrole-glycose oxidase 333
- Polythiophene
 electrochromic performance 231–2
 electropolymerization 228–30, 242–3
 lithium battery electrodes 171–4, 177
 sensors 321–2
- Poly(triphenylamine) 175
- Poly(vinylferrocene) 31, 33
 anion injection 48–54
 concentration dependence 44–8
- Porosity 162, 163
- Porous capacitor model 65–6
- Potential
 electrodeposition 39
 intercalation 41
 redox 44–8
- Potentiometric sensors 321–30
- Primary batteries 150
- Prussian Blue 241
- Pseudocapacitance, *see* Redox capacity
- Quartz crystal microbalance (QCM)
 technique
 electronically conducting polymers
 anion injection 48–54
 electropolymerization 38
 ion insertion 56–7, 59–60
 mass sensors 317–19
- Rechargeability, solid-state lithium batteries 108, 109
- Redox capacity 60–3
 impedance 53–6
- Redox polymers 31–4
- Redox potential 44–8
- Reliability, lithium polymer batteries 196–7
- Resistance, lithium polymer batteries 205–6, 207
- Response time, *see* Electrochromic response time
- Rhodium oxide 262
- Rocking-chair batteries 216
- Safety, lithium polymer batteries 216
- Salts, phase separation 12
- Scale-up of lithium polymer batteries 216–18
- Scanning electron microscopy 5
- Second generation polymer ionic membranes 199
- Selectivity, sensitive layer 313–15
 amperometric sensors 331–2
 potentiometric sensors 327–9
- Self-discharge 177
 polyacetylene 160
 polyaniline 169–70
 polypyrrole 165
- Self-doping polymers 70
- Sensitive layer, selectivity of 313–15
 amperometric sensors 331–2
 potentiometric sensors 327–9
- Sensors 310–17, 339–40
 electrochemical 321–36
 functionalized conducting polymer membranes 294–5
 mass 317–21
 optical 336–9
 thermal 340
- Shelf-life of lithium polymer batteries 196, 215
- Shirakawa method 157
- Silicones 82
- Smart windows 267–79
- Solid-state lithium batteries 104–9
- Solutes 14–15
- Solvation
 ion conducting polymers 15–16
 low molecular weight polyethers 113–22, 146–7

- cobalt (II) 122–5
- cobalt bromide-polyether systems
 - 125–8
- nickel (II) 128–9
- nickel bromide-polyether electrolytes
 - 130–46
- Solvents
 - cobalt (II) ion 123–5
 - electrodeposition 39–40
 - oxidation process 45
 - retention 12
- Specific chemical interactions 117
- Spectra, *see* Absorption spectra;
Chemiluminescent spectra;
Impedance spectra
- Spectroscopic techniques 114
- Spherulites 5–6
 - ion conducting polymers 11
- Stability
 - conductance 21
 - electrochromic devices 231
 - highly conductive polymer electrolytes
 - 87–93
 - non-conventional 97–8
 - ligands 121–2
 - lithium polymer batteries
 - electrode interfaces 202–7
 - mechanical 200–1
 - sensors 312–13
- Stereochemical transformations 129
- Stoichiometries
 - electropolymerization 37
 - oxidation 43–63
- Structural repeat units 7–8
- Substrates 40
- Sulphonic acid polymers 266–7
 - electrochromic windows 278
- Superlattices
 - compositional 305
 - doping 303, 305
- Suspended gate field-effect transistor (SGFET) 324, 327
- Switch potential 227, 246
 - device electrochromic performance 237–41
 - polymer electrochromic performance 229–30, 231–6
- Syndiotacticity 10
- Synthesis
 - conductive polymers 156–7
 - electrochromic devices 232
 - functional molecules 284
 - lithium battery electrodes 175
 - polyaniline 167–71
 - polyazulene 174
 - polypyrrole 161–5
 - polythiophene 171, 173
- Tacticity 10
- ‘Tailor-made’ colour contrast 242–6
- Temperature dependence
 - electrochromic displays 264–6
 - lithium polymer batteries 197–9, 219
 - nickel bromide-polyether electrolytes
 - absorption spectra 140–3
 - conductivity and viscosity 144–6
- Terpyridine 121
- Tetrahedral coordination
 - cobalt (II) ion 123–6
 - nickel (II) ion 128–41
- Thermal mechanical analysis 10
- Thermal sensors 340
- Thermodynamics 40–3
- Third generation polymer ionic membranes 199
- Titanium disulphide 189–90
- Titanium oxide 190, 191
- Transference numbers 17–20, 21
- Transient cross-links 8
- Transient response 19
- Transition metals 114, 120
- Transmittance
 - device electrochromic performance 236–41
 - electrochromic materials
 - anodic ion-insertion 260–2
 - cathodic ion-insertion 253–4
 - windows 269–70, 276–7, 278–9
 - polymer electrochromic performance 233–4
- Transport numbers 17–19
 - lithium 93–5
- Tungsten oxide 252–5
 - electrochromic windows 269–79
- Unidentate ligands 121
- Vanadium bronze 188–9

- Vanadium oxide
 - electrochromic windows 271–2
 - lithium polymer batteries 188
- Van der Waals structures 30
- Variable temperature polarizing microscopy (VTPM) 4–5
- Vehicular mechanism 15
- Viscosity
 - and conductivity 95–6
 - nickel bromide-polyether electrolytes 138, 141
 - temperature dependence 144–6, 147
- Vogel–Tamman–Fulcher (VTF), relationship 11, 77
- Volume changes 2
- Wagner polarization 19
- Walden’s rule 144–5
- Water 45
- Werner, Alfred 120
- Williams–Landel–Ferry (WLF) relationship 11, 77
- Windows, electrochromic 267–79
- Work function 312–13
 - potentiometric sensors 323–4, 326–30
- Zeolites 205