

Index

a

ABX₃ perovskite 228, 229
 acidic conditions 2, 5, 6, 9, 24, 30, 75,
 100, 108, 306
 2-acrylamido-2-methylpropanesulfonate
 (AMPS) monomers 449
 activated carbon (AC) 97, 116, 378
 actuators 422–424
 acyclovir, electrooxidation behavior of
 426
 adriamycin (DOX) 169
 adsorbate evolution mechanism (AEM)
 16, 17
 Al current collectors 341
 alkaline conditions 2–4, 6, 48, 74–76
 alkaline electrolysis 4, 5
 alkaline fuel cell, PEMFC 121–124
 all-inorganic perovskite materials
 232–234
 all-organic flexible patch antenna 403
 alpha-fetoprotein (AFP) immunosensor
 426
 alternating current (AC) 319
N-2-aminoethylacrylamide hydrochloride
 (AEAM) 448
 ammonium peroxodisulfate (APS) 469
 ammonium persulfate (APS) 100, 101,
 306, 366, 470
 aniline 101, 109, 308–311, 313–315, 317,
 369, 407, 411, 426, 433, 434, 469,
 470, 475
 anion exchange membrane fuel cells
 (AEMFCs) 57
 anodic aluminum oxide (AAO) 306
 antifouling biosensor 434
 2,2'-azobisisobutyronitrile (AIBN) 455
 aqueous electrolytes 369, 384, 493, 500

aqueous zinc-ion batteries (AZIBs) 346,
 347
 atomic force microscopy (AFM) 208,
 213, 309, 463
 atomic layer deposition (ALD) 9
 Austin Model 1 (AM1) 213
 autologous nerve transplantation 407

b

Barrett–Joyner–Halenda (BJH) model
 102
 battery field 518
 benzenedithiol (BDT) 79
 benzo[ghi]perylene (BGP) 463
 bioelectric batteries, electrodes for
 352–355
 bioengineering
 actuators 422–424
 drug delivery methods 414–422
 tissue regeneration engineering
 406–414
 biofouling 433
 biological imaging 165, 168, 182, 184,
 189–190, 258
 biologically active electrochemical
 coatings 416
 biologically interfacing electrode 421
 biosensors 172, 304, 305, 315, 316, 355,
 399, 406, 424–436
 bipolar electrodes (BPEs) 319
 bis(dipyrrinato)zinc complex nanosheet
 218
 bis(dipyrrinato)zinc(II) complex
 nanosheet 212, 218, 219
 bis(terpyridine)metal complex nanosheet
 215
 bisphenol A (BPA) detection 426

- black phosphorus (BP) 275
- boron-doped carbon nanotubes (BCNTs) 77
- boron nitride nanosheets/polyvinyl alcohol (BNNs/PVA) 323
- bottom-up fabricated actuator devices 424
- Brewster angle microscopy (BAM) 214
- 11-bromoundodecyltrimethoxysilane (BTMS) 456
- Brunauer–Emmett–Teller (BET) 95
- (1-butyl-3-methylimidazolium bis(trifluoromethyl-sulfonyl)imide (BMITFSI) 121
- C**
- cadmium sulphide (CdS) nanowire 289
- CA-IL-GN actuator 422
- calcium titanate (CaTiO_3) 225
- camphor-10-sulfonic acid (β -CPSA) 414
- capacitors based on PANI nanostructures 364
- carbazole-decorated covalent triazine framework (CTF-CSU1) 118
- carbon-based organic framework 117–119
- carbon black (CB) 87, 122–124, 339, 343
- carbon dioxide reduction reaction (CO_2RR) 355, 361–363
- carbon nanocages (CNCs) 13, 101, 117
- carbon nanotubes (CNTs) 8, 12, 75, 76–80, 108, 121, 123, 124, 345, 356, 401, 452–455, 464
- carbon spheres (CS) 116, 186
- carboxymethyl guar gum (CMGG) polymers 459
- cardiac tissue engineering (CTE) 411, 413
- catalytic reactions 9, 42, 65, 67, 479, 491, 517–518
- cathode ray tubes (CRT) 184
- CDPY hybrid nanomaterials 376
- CeO_2 -based electrocatalysts 42, 44, 48, 55, 60–63
- CeO_2 -based nanomaterials 42, 64, 67
- CeO_2 composites 47, 61
- CeO_2 -embedded NiO (Ce–NiO–E) 54
- CeO_x nanoparticles (NPs) 53
- ceria-based hybrid electrocatalysts 55
- cerium-based electrocatalysts 49, 63
 - CeO_2 -based electrocatalysts 60
 - earth-abundant electrocatalysts 59
 - for HER 44–49
 - for OER 49–57
 - for ORR 57–63
 - for other electrochemical reactions 63–65
 - cerium-doped electrocatalysts 44–45, 50
 - cetyltrimethylammonium bromide (CTAB) 109, 309
 - CGHNs 107
 - Channelrhodopsin-2 (ChR2) 170
 - chemical oxidation method 306
 - chemical sensors 355, 424–436
 - chemical vapor deposition (CVD) 77, 287, 341
 - citric acid (CA) 180–182, 308
 - C-LFP-PEDOT-Al electrode 342
 - CMK-3 105, 348, 349
 - cobalt chalcogenides 14
 - Co-based oxides/hydroxides 22–23
 - CoFe_2O_4 /PANI-MWCNTs OER catalyst 356
 - computer-assisted materials discovery 28–29
 - concerted proton–electron transfer (CPET) 17
 - conducting polymer-based electrocatalysts 363
 - conducting polymer hydrogels (CPH) 400
 - conducting polymer nanomaterials
 - chemical synthesis and properties 306–314
 - electrochemical synthesis and properties 314–329
 - conducting polymers (CPs) 303
 - advantages of 338
 - anode surface 321
 - applications of 305
 - challenges of 424
 - conductivity of 337
 - for electrocatalysis 355–356
 - electrochemical properties 355
 - for electrochemical sensors 424
 - molecular structure 304
 - sulfur composites 348
 - trilayer actuators 423
 - conductivity enhanced nanocomposite (CRNc) 409
 - confocal laser scanning microscope (CLSM) 190

- CoNS/RGO/PPy nanocomposites 432
 constriction resistance model 400, 401
 contact angles (CAs) 309, 323
 continuous-wave (CW) 258
 Co₃O₄ (spinel oxides) 51
 cooperative upconversion (CU) 144
 coprecipitation method 149, 178, 183
 coprecipitation synthesis 178
 CoPt nanowires 514
 CO₂ reduction reaction (CO₂RR) 41, 517, 518
 Co₃S₄/PANI, specific capacitance of 384
 PANI nanosheets/Ni foam
 electrocatalyst 361
 Co-terpyridine nanosheets 217
 coulombic efficiency 215, 216, 341, 343, 348
 covalent organic framework (COF) 75
 CR(NMe)EKA/PEDOT 418, 419
 cross-linked liquid crystal polymer (CLCP) 175
 cross relaxation (CR) 144, 160
 crystal field theory 502
 CsPbX₃ crystal structures 234
 Cu based oxides/hydroxides 24
 Cu–Ce–O oxide 60
 CuO/MoS₂-based heterostructure flexible photodetector 290
 Cu₂O nanoparticles decorated PANI matrix (PANI/Cu₂O) catalyst 363
 4-cyanopentanoic acid dithiobenzoate (CPADB) 463
 cyclic voltammograms (CVs) 81, 83, 216, 312, 313, 360, 377, 385
 Cys-Arg-Glu-Lys-Ala (CREKA) 419
- d**
- decyltrimethylammonium bromide (DTAB) 309
 defective carbon nanomaterials 116
 deionized (DI) 313, 366, 367, 457, 468, 470
 density functional theory (DFT) 9, 42, 44, 114, 208, 236, 255, 353
 dexamethasone phosphate (DexP) release pattern 420
 DHPZDA 453–455
 dicyandiamide (DCDA) 103
 2-(diethylamino)ethyl methacrylate (DEAEMA) 457
 drift current 278, 279
 2,5-dihydroxyterephthalaldehyde (DHTA)-COF) 103
 diisooctylphosphinic acid (DIOP) 243
 N,N-dimethylacetamide (DMAC) 452
 dimethylammonium (DMA⁺) 228, 232
 dimethyl sulfoxide (DMSO) 103, 245
 dioctylamine (DOAm) 243
 diphenyl diselenide (DDS) 106
 4,4'-dipyridyl disulfide (DPDS) 211
 dipyrin ligand molecule 212
 direct piezoelectric effect 277
 dispersion copolymerization 458–461
 dispersion polymerization 447, 458–462, 471, 473, 474
 dithienylethene (DTE) molecules 175
 docetaxel (Dtxl) therapy 170
 dopamine (DOPA)-coated PPy/PGA spring 414
 dopamine (DA) detection 432
 downconversion nanoparticles (DCNPs) 142
 LaPO₄:Ce³⁺, Tb³⁺ 187–189
 LnVO₄:Ln³⁺ (Ln = La, Gd, Y; Ln³⁺ = Eu³⁺, Dy³⁺, Sm³⁺) 186–187
 SrAl₂O₄:Eu²⁺, Dy³⁺ 182–184
 Y₂O₃:Eu³⁺ 184–186
 Y₃Al₅O₁₂:RE (RE = Ce³⁺, Tb³⁺) 178–182
 dual-layer conducting polymer/acid functionalized carbon nanotube (fCNT) microelectrode 416
 dye-sensitized solar cells (DSSCs), electrodes for 352
- e**
- earth-abundant electrocatalysts 59–60
 earth-abundant metallic nanomaterials
 hydrogen evolution reaction 6–16
 oxygen evolution reaction 16–27
 edge-halogenated graphene nanoplatelets (XGnPs) 89, 90
 electrical healing, of pure PEDOT:PSS film 404
 electrocatalytic activity 41, 44, 45, 53, 60, 76, 82, 85, 87, 89, 103, 111, 125, 352, 355, 356, 358, 360, 425, 432
 electrochemical atomic force microscopy (EC-AFM) 319
 electrochemical capacitors 363
 electrochemical DNA (E-DNA) sensors 432, 433

- electrochemical impedance spectroscopy (EIS) 107
- electrochemical reaction 76, 121, 355, 402, 498
- cerium-based electrocatalysts 63–65
- electrochemical surface area (ECSA) 16, 30, 358
- electrochemical system
- in aqueous solution 492–495
 - spin states of electrocatalysts 495–496
- electrochemical water splitting
- current techniques 4–5
 - overpotential and Tafel slope 3–4
 - principle 1–3
- electrodeposition 45, 361, 434, 491, 496–498, 519–521
- electrodes
- for all-polymer batteries 350–351
 - for aqueous zinc-ion batteries 346
 - for bioelectric batteries 352–355
 - for dye-sensitized solar cells 352
 - for lithium–sulfur batteries 348–350
 - for sodium ion batteries 345
- electrodes for lithium-ion batteries
- HClO₄-doped PANI nanotubes 339
 - PEDOT-LiFePO₄ films 338
 - Si anodes 342
- electro double-layer capacitor (EDLC) 363
- electrokinetic drug nanocarriers, delivery 415
- electroluminescence (EL) 254, 255
- electromagnetic interference (EMI) 304, 386, 465
- electron beam lithography (EBL) 291
- electronic interaction mechanism 492
- electronic skin (E-skin) 399
- energy-saving 405–406
 - self-healing 403–405
 - wearable electronic devices 400–403
- electron spin resonance (ESR) 54
- electron transportation 289
- electropolymerization 315, 317–319, 338, 345, 426, 429, 434
- electroproperties 215–217
- electrospinning 52, 183–184, 305, 322, 323, 325–329, 414–416, 419, 470
- emulsion polymerization 310, 419, 447, 448, 456–458
- energy-dispersive X-ray spectrum (EDS) 94
- energy migration-mediated upconversion (EMU) 145
- energy-saving E-skin 405–406
- energy transfer upconversion (ETU) 143–144
- epoxidized natural rubber (ENR) 464
- ethylenediamine tetraacetic acid ester (EDTA) 149, 185
- 3,4-ethylenedioxythiophene (EDOT) 306, 319, 325
- excited-state absorption (ESA) 143
- exciton binding energy 240, 241, 258
- ## f
- FAPbI₃ 228
- Faradaic efficiencies (FEs) 4, 63, 64, 66, 362
- Faraday's constant 1
- Faradic pseudocapacitors 363
- fast crystallization-deposition (FDC) method 246
- [Fe(acac₂-trien)][MnCr(Br₂-An)₃] · (CH₃CN)₂ 210
- (Fe)-based MOFs 175
- Fe-based oxides/hydroxides 24
- Fe-diterephthalate grid 209
- Fe-doped β-Ni(OH)₂ porous 22
- Fe³⁺ doped PTh electrode on carbon cloth 385
- Fermi level pinning 282
- Fe-terpyridine nanosheet 217
- few-layer oxidized graphdiyne (FLGDYO) 96
- field emission displays (FEDs) 184
- field-emission scanning electron microscope (FESEM) 94, 95
- flexible polythiophene (e-PTh) on titania (Ti) wire electrode material 379
- flexible symmetric PPy hydrogel supercapacitors 366
- 4-fluorophenylmethylammonium-trifluoroacetate (FPMATFA) 255
- fluorescence resonance energy transfer (FRET) 162, 171–172
- fluorescent ink 191–192
- formamidinium (FA) 228, 239
- free-standing electrodeposited PPy film electrodes 350
- fuel cells, application in 120–129
- ## g
- gas/liquid interfacial synthesis 213–214
- Ge-based perovskites 235, 236

- Gibbs free energy 1, 9, 10, 17, 18, 22, 51, 54
- GO/PANI/silk composite scaffold 407
- Goldschmidt tolerance factor 235
- grafted PAN nanofibers (GPN) 327
- graphdiyne 94–97, 121, 122, 125, 127, 129
- graphene foam/PPy composite stretchable electrodes 374
- graphite oxide composite 91
- grazing incidence X-ray diffraction (GIXRD) 213
- ground state absorption (GSA) 144
- guanidinium (GA⁺) 228, 232
- h**
- Haber–Bosch method 63
- halogen ions 238
- HClO₄-doped PANI nanotubes 338
- HCS/PANI-based E-DNA sensor 433
- hematoporphyrin (HP) 168, 170
- heteroatom-doped carbon-based materials 75, 105, 129
- heteroatom-doped carbon nanotubes 76–80
- heteroatom-doped composite materials 105–108
- heteroatom-doped graphdiyne 94–97
- heteroatom-doped graphenes 80–94
- heteroatom-doped nanocarbon materials 105, 129
- heteroatom-doped porous carbon nanomaterials 97–105, 117, 118
- heteroatom-substituted CNTs 78, 79
- hierarchically porous carbon materials (HPCMs) 99, 100
- highly ordered pyrolytic graphite (HOPG) 208
- highly oriented pyrolytic graphite (HOPG) 105
- high-resolution TEM (HRTEM) 45, 88, 103, 106, 211
- histamine acrylamide hydrochloride (HisAM) 449
- homogeneous field 491
- homojunction 285, 286
- host matrix screening 157–158
- hot injection method 242–244, 255
- H₂TCPP molecular structures 213
- humidity sensing 256, 257
- hydrogen evolution reaction (HER) 1, 41, 357, 491, 498, 504
- CeO₂ composites 45
- cerium-based electrocatalysts 44
- energy diagram 45
- mechanism 6–7
- metal (M⁰) nanoparticles 7–8
- metal (M⁰) single-atom catalysts 8–11
- metal carbides 15
- metal chalcogenides 12–14
- metal nitrides 14–15
- metal oxides/(oxy)hydroxides 15–16
- metal phosphides 11–12
- metal single-atom electrocatalyst 9
- hydrogen gas 6, 498
- hydrogen oxidation reaction (HOR) 73
- Hydrosorb dressings, for wound healing 407
- hydrothermal method 15, 149, 182–184, 191, 290, 293, 468
- 2-hydroxypropyl methacrylate (HPMA) 450
- hypophosphorous acid 235
- i**
- imidazolium tetrafluoroborate (IMBF₄) 237–238
- immobilization method 410, 411
- indium selenide (InSe) 283
- indium tin oxide (ITO) 215, 318
- infrared radiation (IR) 290
- intermediate-spin state (IS) 60, 507
- interparticle energy transfer 158
- inverse opal carbon (IOC) 61
- ionic liquid-modified (RGO-IL/PANI) composite 370, 374
- iontophoretic skin drug delivery system 415
- isopropanol (IPA) 181, 188, 247, 366, 452
- k**
- KillerRed-UCNPs 169
- Koutecky–Levich (K–L) equation 87
- l**
- lactate dehydrogenase (LDH) 428
- Langmuir isotherm 214
- lanthanide-doped upconversion nanocrystals 147
- lanthanide ions 141, 156, 158, 159, 162
- LaPO₄:Ce³⁺, Tb³⁺ 187–189
- lattice oxygen mechanism (LOM) 16, 17
- layered double hydroxide (LDH) 16, 44, 378, 507

- lead-based perovskite materials 234
 - Lewis bases 105, 248, 249, 251
 - ligand-assisted reprecipitation (LARP)
 - method 242, 244, 245
 - light emitting diodes (LEDs) 238, 251, 254–256, 278, 355, 402
 - Li-ion batteries 518
 - limited anion-exchange reaction (LAER) 189
 - linear conjugated polymers (LCPs) 127
 - linear sweep voltammetry (LSV) 47, 78
 - Li-PANI battery 338
 - liquid-phase exfoliation 209–211, 276
 - liquid–solid-solution (LSS) 149
 - lithium electrodeposition 521
 - lithium-ion batteries (LIBs)
 - applications 338
 - Ni-rich cathode materials 340
 - Si anodes for 342
 - ZMO anode 345
 - lithium metal anode 522
 - lithium–sulfur battery (Li–S battery) 93, 348–350
 - $\text{Li}_3\text{V}_2(\text{PO}_4)_3/\text{PEDOT}$ composite 340
 - $\text{LnVO}_4:\text{Ln}^{3+}$ (Ln = La, Gd, Y; $\text{Ln}^{3+} = \text{Eu}^{3+}, \text{Dy}^{3+}, \text{Sm}^{3+}$) 186–187
 - Lorentz force 492–494, 496, 499–501, 515, 520, 521
 - low critical solution temperature (LCST) 479
 - low graphitic carbon (LGC) 65
 - low-lead perovskite material 234–238
 - low-temperature magnetic force microscopy (LT-MFM) 220
- m**
- magnesium oxide (MgO) 99
 - magnetic field template 497
 - magnetohydrodynamic (MHD) 491
 - magnetohydrodynamic convention (MHDC) 492
 - magnetomechanic mechanism 491
 - magnetoproperties 219–221
 - MAPbI_3 228–230, 232, 234, 236, 238–240, 245, 247, 252, 253, 258
 - mechanical exfoliation 208–209, 289
 - melamine fiber (MF) 99, 101
 - membrane electrode assembly (MEA) 121
 - metal carbides 15, 207
 - metal chalcogenides/nitrides/phosphides 12, 26–27
 - metal complex nanosheets
 - electroproperties 215
 - gas/liquid interfacial synthesis 213–214
 - liquid/liquid interfacial synthesis 211–213
 - liquid-phase exfoliation 209–211
 - magnetoproperties 219–221
 - mechanical exfoliation 208–209
 - photoproperties 217–219
 - vacuum phase fabrication 208
 - metal halide perovskite (MHP) 225–258
 - all-inorganic perovskite materials 232–234
 - crystal structure and phase 225–227
 - excellent charge transport performance 240
 - high absorption coefficient 239
 - hot injection method 243–244
 - lead-free perovskite materials 234–238
 - ligand-assisted reprecipitation method 244
 - optoelectronic devices 258
 - organic–inorganic hybrid perovskite materials 228–232
 - photodetector 257
 - photoluminescence properties 240–242
 - sensing 256–257
 - solution deposition methods 244–245
 - tunable bandgap 238–239
 - metal (oxy)hydroxides 16
 - metal-ion batteries 338–348
 - metallic (M^0) nanoparticles 19
 - metal (M^0) nanoparticles 7–8
 - metal nitrides 14–15, 26, 48
 - metal–organic frameworks (MOFs) 9, 27, 53, 99, 117, 175, 207, 210, 345, 382, 383, 461
 - metal oxides/(oxy)hydroxides 15–16
 - metal oxides/hydroxides 19
 - Co-based oxides/hydroxides 22–23
 - Fe-based oxides/hydroxides 24
 - Ni-based oxides/hydroxides 19–22
 - metal phosphides 11–12, 26, 27, 47, 48
 - metal–semiconductor junction 282–284
 - metal/semiconductor/metal (MSM) 258
 - metal–semiconductor (M–S) system 282

- metal (M^0) single-atom catalysts 8–11
 metal (Mn^+) single-atom catalysts 25–26
 metal-to-ligand charge transfer (MLCT) 215
 methacrylic acid (MAA) 457
 methylammonium (MA) 228, 232, 238, 239, 256
 [2-(methacryloyloxy)ethyltrimethylammonium salt ([META⁺])] 449
N,N'-methylene bis(acrylamide) (MBA) 457
 2,2'-methylenebis(2-methoxy-4-methylphenol) 317
 Mg-air biobattery 352, 353, 355
 micromanipulation tools 424
 microporous polycarbonate filters 306
 microwave-assisted method 150, 183
 mix-dimensional (MD) heterojunctions 286
 mixed A-site cation perovskite 229–232
 mixed cellulose ester filter films (MCEFs) 97
 Mn-based cathode materials, for ZIBs 347
 molecularly engineered conductive polymer binders 343
 molecularly imprinted polymer (MIP)-modified SnO_2 electrode 429
 molecularly imprinted polypyrrole/graphene quantum dots (MIPPy/GQDs) as electrochemical sensor 426
 molecule-based nanosheets 207, 214
 molybdenum disulfide (MoS_2) 280
 M–OOH, linear scaling relation of 18
 MoS_2 nanosheet 290
m-phenylenediamine (*m*-PDA) 369
 MSC-EV biotin immobilization method 411
 multiple-walled carbon nanotubes (MWCNTs) 122, 464
 multiple-walled nanotube (MWNT) 452
 multiwalled carbon nanotubes/lauric acid/thermoplastic polyurethane (MWCNTs/LA/PU) 326
 mussel-inspired poly(ATMA-co-DOPAMA-co-PEGMA) bioadhesive 412
 MUV-1-Cl 219, 220
 MWNT-DHPZDA 453–455
 MXenes 207
- n**
 N and S dual-doped carbon (NSC) 61
 nanoclusters (NCs) 46
 nanowires arrays (NWAs) electrodes 62
 1,4,5,8-naphthalenetetracarboxylic dianhydride (NTCDA) 118
 naphtho[2,3-*b*]thieno[3,4-*e*][1,4]dioxine (NaphDOT) 317
 natural rubber/rGO/ Fe_3O_4 (NMGO) 475
N-bromosucinimide (NBS) 455
 ND-GLC 97, 98, 126
 N-doped carbon foam (CF_N) 99
 N-doped carbon nanocages (NCNCs) 101
 N-doped carbon nanoribbon (NCNR) 101
 N-doped carbon nanosheets (NDCNs) 109
 N-doped fullerene-like carbon shell (NDCS) 97, 99
 N-doped graphdiyne (N-GD) 94–97
 N-doped graphdiyne (N-GDY) 94–97
 N-doped graphene/CNT composite (N-G-CNT) 122
 N-doped graphene framework (NGF) 85
 N-doped graphene quantum dots (N-GQDs) 83, 84
 N-doped graphene structure 87
 N-doped mesoporous carbon nanospheres (NMCNs) 100
 N-doped porous carbon (NPC) electrocatalysts 55
 N-doped reduced graphene oxide (N-rGO) 107
 N-dual-doped graphene 85
 near-infrared (NIR) 156, 174, 176, 191, 236, 238, 254, 419
 next-generation wearable systems 403
 N/F co-doped graphdiyne (NFGD) 122
 Ni-based oxides/hydroxides 19–22
 Ni–C electrocatalyst 9
 nickel foam (NF) substrate 45
 NiCo-LDH nanocages 378
 NiCo/PPy/RGO nanocomposite 431, 432
 NiDI 215, 216
 NiFe layered double hydroxide 45
 Nile Red Derivative (NRD) 172
 Ni–P deposited PPy film 358
 Ni-rich cathode 339, 340
 nitrogen-doped carbon materials 10, 75, 98

- nitrogen-doped carbon nanotubes (N-CNT) 76, 107
- nitrogen-doped graphene 76
- nitrogen-rich polymer PANI catalyst 361
- N*-methyl-2-pyrrolidone (NMP) 453
- noble metals 5, 8, 19, 25, 26, 30, 41, 42, 46, 57–59, 61, 62, 65, 77, 80, 190, 356, 357
- N,P-co-doped CGHNs (N,P-CGHNs) 107
- N/P co-doped hierarchical carbon (NPHC) 125
- N₂ reduction reaction (NRR) 41
- N-rGO-CNT-0.2 107
- N/S-co-doped carbon aerogel (NSCA) 110
- N/S-co-doped graphene (NSG) 90–92
- nuclear magnetic resonance (NMR) technology 153
- O**
- 1-octadecene (OD) 146
- octafluoronaphthalene (OFN) 463
- octyltrimethylammonium bromide (OTAB) 309
- oleamine (OM) 146
- oleic acid (OA) 146, 153, 154, 169, 186, 243, 459
- oleylamine (OAm) 243
- 1D cesium lead bromide (CsPbBr₃) nanowires 287
- one-dimensional (1D) cylindrical giant molecules 76
- 1D–2D homojunction photodetectors 286–289
- o*-phenylenediamine (*o*-PDA) 124, 369
- OPPy/CNT/GCE electrochemical electrode 425, 426
- optical microscopy (OM) 211, 321, 457, 458
- optical sensing 256, 257
- optogenetics 170–171
- organic–inorganic hybrid perovskite materials 228
- MAPbI₃ 228
- mixed A-site cation perovskite 229–232
- FAPbI₃ 228–229
- organic light-emitting diode (OLED) 254
- organic molecular beam epitaxy (OMBE) 208
- ORR-active carbon nanocages (CNCs) 117
- oxidation template assembly (OTA) 311
- oxygen evolution reaction (OER) 1, 41, 356, 491, 504, 512, 513
- catalyst design 17, 29
- CeO₂ composites 50
- computer-assisted materials discovery 28
- mechanism 16–19
- metal chalcogenides/nitrides/phosphides 26
- metal (Mn⁺) single-atom catalysts 25–26
- metal oxides/hydroxides 19
- oxygen reduction reaction (ORR) 356–357, 504–513
- acidic medium 108–111
- electrocatalysts 57–58, 88
- electrochemical experiment 112
- fuel cells 120–121
- heteroatom-doped graphenes 80–94
- oxygen vacancies (OVs) 15, 23, 42, 43, 47, 50, 51, 53–55, 61–65, 380
- P**
- PAAMPSA/PANI/PA regenerative polymer complex 404
- strain sensor 404
- paclitaxel-loaded polycaprolactone (PCL-PTX) mats 419
- PANI-poly(ethylene oxide) (PEO) 328
- PANI/PES nanofibrous scaffolds 413
- PANI-PPy coated Pt electrodes 360
- PANI/PPy composite nanofibers 366, 370
- paramagnetic gradient force 492, 493
- partial density of states (PDOS) 52
- particle track-etched membranes (PTM) 306
- Pb-based perovskite 235–237
- PCL/PEDOT/CUR 415
- PCPZ hydrogel 407, 408
- PDA-PPy-PAM hydrogel 400
- Pd electrode 358
- Pd nanoparticle-dispersed PEDOT (Pd-PEDOT)
- CeO₂ model 46
- thin film on gold substrate as HER catalyst 358
- P-doped graphene (PG) 86

- PEDOT-coated cathode materials 339
- PEDOT-coated CNT/polypropylene plate electrode 352
- PEDOT-coated LNMO 339, 340
- PEDOT/dexamethasone (PEDOT/Dex) films 416
- PEDOT functionalized with anthraquinone (PEDOT-AQ) 351
- PEDOT functionalized with benzoquinone (PEDOT-BQ) 351
- PEDOT-LiFePO₄ composite film 338
- PEDOP loaded with IBU, in implantable drug delivery device 418
- PEDOT/paper 370, 371
- PEDOT/prednisolone phosphate (PEDOT/PreP) films 416
- PEDOT PSS-coated CMK-3/sulfur composite 349
- PEDOT PSS-PAAm organogels 402
- PEDOT PSS/RGO composite sponge 433, 434
- 1,1,4,7,7-pentamethyldiethyltriamine (PMDETA) 455
- perfluorooctane sulfonic acid (PFOSA) 312
- perfluorooctanoic acid (PFOA) 309
- perovskite films 245
- perovskite light-emitting diode (PeLED) 254–256
- perovskite nanoparticles (PeNPs) 255
- perovskite oxides 60, 504, 506
- perovskite quantum dots (PQDs) 163, 242, 257
- perovskite solar cells (PSCs) 177, 178, 238, 247, 249–253
- phase-transition-assisted (PTA) strategy 99
- phenylethylammonium iodide (PEAI) 253, 255
- phenylpropylammonium iodide (PPAI) 256
- photoacoustic (PA) 168, 191
- photo atom transfer radical polymerization (photoATRP) 459
- photocatalysis 42, 173–175, 304, 305
- photo(electro)catalytic activity 24
- photodynamic therapy (PDT) 168, 170, 175
- photoelectrochemical sensor, for BPA detection 429, 430
- photoisomerization 175
- photoluminescence properties 240–242
- photoluminescence quantum yield (PLQY) 240
- photon avalanche (PA) 144
- photoproperties 217–219
- physical vapor deposition (PVD) 289
- phytic acid (PA) 103, 366, 404
- phytic acid-doped PANI on medical titanium (Ti) tablets 411
- piezoelectricity 275, 277, 278, 284, 291
- piezo-phototronics 275
- fundamental physics 277–278
- metal–semiconductor junction 282–284
- P–N junction 278–281
- piezoresistive pressure sensors 402
- piezotronics 275, 277, 278, 282, 292, 295
- platinum nanoparticle-polypyrrole-3-carboxylated nanofiber composites (Pt&score;cPPyNFs) 431
- PLLA/PPy composites 328
- PNIPAM-based temperature-sensitive acidic triblock polymer 420
- P–N junction photodetectors 278
- based on 1D–2D homojunction 286–289
- based on 2D homojunction 285–286
- based on 2D–2D homojunction 289–293
- based on 3D–2D homojunction 293–294
- P(NIPAM-co-ETMA) 479
- polyacetylene (PA) 303, 306
- poly(acrylic acid-*b*-*N*-isopropylamide-*b*-acrylic acid) (PNA) 420, 421
- polyacrylonitrile (PAN) 110, 327
- poly[3-amino-5-mercapto-1,2,4-triazole] 91
- polyaniline (PANI) 303, 309, 469, 470
- cytosensor 427
- nanofibers 313, 314
- nanostructures 364, 365
- poly(3-aminobenzoic acid) 426
- polyaniline/graphene/MnO₂ (PANI/G/MnO₂) paper 381, 382
- poly-ATMA-*co*-DOPAMA-*co*-PEGMA conductive copolymers 411
- poly(2,2'-bithiophene) (PBTh) catalyst, for HER 357
- poly((butylene adipate-*co*-terephthalate) (PBAT) 463

- polycarbonate membrane (PCM) 315
 poly((diethylamino)-ethyl methacrylate)-*co*-sodium methacrylate (PDEAEMA-*co*-SMA) 457
 poly(2,6-dimethyl-1,4-phenylene oxide) (PPO) 455
 polydimethylsiloxane (PDMS) 283, 402
 polydopamine (PDA) 97, 102, 109, 400, 479
 poly-3,4-ethylenedioxythiophene/
 polystyrene sulfonate (PEDOT:PSS)
 hydrogel, crosslinking process of 354
 nanosheets 402
 printed fabric 403
 printing ink 329
 poly(3,4-ethylenedioxythiophene) (PEDOT) 315, 319
 concentration 325
 hydrogel 354
 MoS₂/PEDOT asymmetric supercapacitor 374
 nanoneedles 313, 314
 NTs 307
 polyethylene glycol (PEG) 167, 433
 polyethylene glycol polymer onto
 polyaniline (PANI/PEG)
 nanofibers 433–435
 polyethyleneimine (PEI) 149, 165
 polyethylene terephthalate (PET) 283, 403
 poly glycidyl methacrylate (PGMA) 469
 poly2-hydroxypropylmethacrylamide (PHPMA) 449
 polyion complexes (PIC) 449
 poly1-IrO_x composite film modified
 electrode 356
 poly(lactic-*co*-glycolic acid) 171
 poly(L-lactide) (PLLA) 416, 464
 polymer composites 255, 323, 356, 447, 448, 449, 455, 456, 458, 460, 461, 463, 465, 466, 475, 481
 polymerization-induced self-assembly (PISA) 450, 463
 polymer precursors 448
 polymers/metal nanoparticles 469
 polymers nanocomposites
 application 474–481
 emulsion polymerization 456–458
 in situ polymerization 466–471
 synthesis 448–451
 solution mixing 451–456
 tailoring 471–474
 polymersome pickering emulsion (PPE) 456
 polymer sulfonate (PSS) 307, 315
 poly-[2-(methacryloyloxy)ethyl phosphorylcholine]-*b*-poly[2-(dimethylamino)ethyl methacrylate]-*b*-poly(2-hydroxypropylmethacrylate) (PMPC-*b*-PDMA-*b*-PHPMA_z) 471
 poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV) 325
 poly(methylacrylic acid) (PMAA) 463
 poly(*N*-vinylpyrrolidone) (PVP) 310, 339
 polyoxovanadate (POV) 307
 poly(phthalazinone ether sulfoneketone)s (PPESK) 453
 poly(*p*-phenylene) (PPP) 303, 304, 337
 poly(*p*-phenylenevinylene) (PPV) 303, 304, 337
 poly(3,4-propylenedioxythiophene) (PProDOT) 318
 polypyrrole coated on nanospherical platinum (Pt/PPy NSs) composites 424
 poly(3,4-propylenedioxythiophene) (PProDOT) 318, 319
 poly(styrene-*block*-2-vinylpyridine-*block*-ethylene oxide) (P(S-*b*-2VP-*b*-EO)) 456
 polystyrene-*b*-poly(acrylic acid) (PS-*b*-PAA) 456
 polythiophene polymer (PTPA) 479
 polythiophene (PTh) 303, 304, 337, 348, 370, 379, 479
 poly(triphenylimidazole) 481
 polyvinylidene difluoride (PVDF) 448
 polyvinylidene fluoride (PVDF) 315
 poly(4-vinylpyridine) 451
 polyvinylpyrrolidone (PVP) 149, 190
 porous carbon materials 99, 100, 103, 117
 porous nanocarbon materials 124
 porous N-doped carbon 97, 100, 101, 124
 poly(L-lactic acid) (PLLA) 327
 positron emission tomography (PET)
 technique 168
 potassium peroxodisulfate (K₂S₂O₈) 469
 potassium persulfate (KPS) 457

- p*-phenylenediamine (p-PDA) 369
 PPy/ABTS 350
 PPy/AQS/RGO composite 354
 PPy-based piezoresistive sensors,
 electrical conductivity of 401
 PPy-based wearable
 single-electrode-mode TENG
 (PPy-WSEM-TENG) device 405
 PPy/carbonaceous nanospheres
 (PPy/CNSs) 425
 PPy/CNTs-MIPs preparation 432, 433
 PPy-coated GdNi₄Al intermetallic alloy
 catalyst 358
 PPy-coated microribbons 422, 423
 PPy-functionalized PCL-PTX membrane
 fabrication 419
 PPy hydrogels 366, 369, 401, 415
 PPy/IC materials 350
 PPy/IL nanoparticles 356, 357
 PPy/MoS_x co-polymer film 358, 359
 PPyNPs nanocomposite 431
 PPy, ZMO anode, for LIBs 345
 printed smart electronic skin 405
 projected DOS (pDOS) 509
 proton exchange membrane (PEM)
 electrolysis 4, 108
 proton exchange membrane fuel cell
 (PEMFC) 57, 108, 123, 124
 Pt-based electrocatalysts 44, 75
 Pt/C electrocatalyst 93
 Pt_cPPyNF sensors 431
 Pt [1,8-dihydroxynaphthalene-3,6-
 disulfonatoferrate(II)] complex
 immobilized PANI/Prussian
 blue-laminated catalyst 363
 PTh/MWCNT composites 370, 372
 Pt nanoparticle (Pt NP)-PANI hydrogel
 based glucose sensor 428
 PVA-PPy hydrogel, conductivity of 415
 pyridine analogue of graphdiyne
 (PyN-GDY) 127
 pyridinium chlorochromate (PCC) 287
- q**
- quantum yields (QYs) 155, 158, 182, 185,
 189, 218, 240, 244
- r**
- radiative energy transfer (RET) 146, 162,
 187
 radiotherapy (RT) 170
- rare earth based DCNPs
 LaPO₄:Ce³⁺, Tb³⁺ 187–189
 LnVO₄:Ln³⁺ (Ln = La, Gd, Y; Ln³⁺ =
 Eu³⁺, Dy³⁺, Sm³⁺) 186–187
 upconversion material development
 142–143
 upconversion mechanism
 cooperative upconversion 144
 cross relaxation 144
 energy migration-mediated
 upconversion 145
 energy transfer upconversion
 143–144
 excited-state absorption 143
 photon avalanche 144
 Y₂O₃:Eu³⁺ 184–186
 Y₃Al₅O₁₂:RE (RE = Ce³⁺, Tb³⁺)
 178–182
- rare earth luminescent material 141
 rate-determining step (RDS) 6, 45, 50,
 506, 514
 RbCsMAFA-based perovskite 232
 reactive oxygen species (ROS) 168, 190,
 426
 redox reactions 27, 215–217, 350, 351,
 355, 363, 380, 511
 reduced graphene oxide (RGO) 12, 87,
 107, 354, 407, 460, 467, 503, 518
 reduced graphite oxides (rGOs) 63, 127
 relative humidity (RH) 124, 255, 257,
 311, 404
 reverse electro dialysis (RED)-driven
 iontophoresis 416
 reversible addition-fragmentation chain
 transfer (RAFT) 456, 463
 reversible hydrogen electrode (RHE) 63,
 73, 75, 358
 RF sheet resistance 403
 roll-to-roll (R2R) 250, 341, 402
 rotating magnetic field technique (RMF)
 249
 rotating ring-disk electrode (RRDE) 83
- s**
- Sabatier principle 6
 salicylic acid (SA) 311, 470
 scanning electron microscopy (SEM) 47,
 88, 152, 211
 scanning transmission electron
 microscopy (STEM) 52, 152
 Schottky barrier height (SBH) 277, 282

- Schottky contact 276, 280, 282, 283, 285
 Schottky junction 283, 284
 Scotch tape 80, 276
 S-doped graphene (SG) 86, 90, 91, 93
 second harmonic generation (SHG) 283
 selected area electron diffraction (SAED)
 51, 151, 213
 selenium-doped CNT/graphene
 composites (Se-CNT) 106
 self-assembly method 100, 186, 187, 207,
 305, 309, 311, 312, 319, 320, 343,
 407, 409, 447, 449, 461–463, 471
 self-healing E-skin 403–405
 Shockley–Queisser model 237
 Si-doped nanosphere (Si-CNS) 80
 Si/graphite/PANI nanocomposites 342,
 343
 Si/N-co-doped nanotube (SiN-CNT) 80
 Si/PPP composites 342
 silicon nanoparticles-based LIB anodes
 343
 silver nanoparticles (Ag NPs) 306
 single-atom catalysts (SACs) 8–11, 25–26
 single photon emission computed
 tomography (SPECT) 168
 singlet-state oxygen molecule 513
 single-walled CNT 77
 single walls carbon nanotubes (SWCNTs)
 469
 slot-die coating 249, 250
 Sn-based perovskites 235–238
 S/N-co-doped CNTs (SN-CNTs) 109
 sodium bis(2-ethylhexyl) sulfosuccinate
 310
 sodium dodecyl sulfate (SDS) 309
 sodium ion batteries (SIBs) 345
 bipolar conducting polymer 345
 ClO₄-doped PPy coated
 Na_{1+x}MnFe(CN)₆ composite
 cathode for 345
 PPy NWs/CP free-standing anode 346
 sol-gel method 141, 147, 150, 178–181,
 183, 185
 solid-state laser (SSL) 184
 solution deposition method 244
 blade-coating process 249–250
 one-step method 245–247
 two-step method 247–249
 solution mixing 451–456, 464
 solvothermal reactions 118, 181
 spherical silver-incorporated conductive
 PPy (Ag/PPy) composite 377
 spin related electrode reactions 491
 battery 518–522
 catalytic reactions 517–518
 electrochemical system
 in aqueous solution 492–495
 spin states of electrocatalysts
 495–496
 electrodeposition of metals or alloys
 496–498
 hydrogen evolution reaction 498–504
 oxygen evolution reaction 504–513
 oxygen reduction reaction 513–517
 spin states of electrocatalysts 495–496
 sp-N-doped few-layer graphdiyne
 (sp-NFLGDY) 96, 97
 SrAl₂O₄:Eu²⁺, Dy³⁺ 182–184
 stimulus-responsive biomaterials 414
 sulfonate modified nanoparticle
 (SNP)-doped PEDOT composite
 421
 sulfur-doped carbon nanotubes (SCNTs)
 79
 sulfur-doped graphene nanoplatelets
 (SOGnP) 89
 supercapacitors (SC) 363
 CP as active material 364–385
 MOFs-based 383
 Superconducting Quantum Interference
 Device (SQUID) 156
 surfactant molecules 310
 synthetic metals 303
- t**
- Tafel slope 3, 4, 6, 9, 10, 14, 19, 22, 23,
 25, 44, 45, 49, 56, 57, 61, 356–358,
 361, 506, 510
 tailoring, polymers nanocomposites
 471–474
 TCNTs 114
 temperature programmed desorption
 (TPD) 54, 105
 temperature sensing 256, 257
 terephthalic acid (TPA) 208
 terpyridine ligand molecule 214
 4-*tert*-butylpyridine (TBP) 249
 1,2,4,5-tetracyanobenzene (TCNB) 463
 tetra-ethyl orthosilicate (TEOS) 121

- tetrabutylammonium
hexafluorophosphate (TBAHFP)
494
- tetrabutylammonium perchlorate 83,
363
- tetrafluoroterephthalonitrile (TFP) 463
- tetrahydrofuran (THF) 308, 455
- 5,10,15,20-tetrakis(4-carboxyphenyl)-
porphyrin 210, 213
- 3D heterostructures 286, 287, 429
- 3D hierarchical PANI
micro/nanostructure (H-PANI)
supercapacitor electrode material
366, 368
- 3D macroporous PANI modified electrode
426
- 3D macroporous sponge 380
- 3D-nanostructured elastic PPy hydrogel
366
- 3D-2D homojunction photodetectors
293-294
- 3D-printed PEDOT PSS fibers 328
- thermal decomposition 141, 146-149
- thermoplastic (glycolic acid) surgical
sutures 413
- thermoplastic vulcanizates (TPV) 464
- Ti based oxides/hydroxides 24
- tissue reconstruction, high-performance
biomaterials for 409
- transition metal-based electrocatalysts
50
- transition metal chalcogenides (TMCs)
12
- transition metal dichalcogenides (TMDs)
207, 275, 280
- transition metal (TM)-LDH
electrocatalysts 50
- transition metal nitrides 14
- transition metal phosphides (TMPs) 11,
47
- transition metal sites (TM) 11
- transitional metal sulfides 340
- transmission electron microscopy (TEM)
45, 52, 152, 181, 211, 213, 374, 455,
458
- transparent conducting hydrogel 400
- triarylphosphine (TPP) 103
- 4,4',4''-(1,3,5-triazine-2,4,6-triyl)-
trianiline(TAPT) 103
- triboelectric nanogenerator (TENG)
315, 405
- triethylenetetramine (TETA) 469
- trimethoxysilane propyl methacrylate
475
- 1,3,5-trimethylbenzene (TMB) 102
- triphenylborane (TPB) 77
- triphenylphosphine (TPP) 86, 107
- 1,3,5-tris(4-aminophenyl)benzene (TAPB)
118
- tris(4-bromophenyl)amine 118
- tumor treatment 190-191
- tunable bandgap 238-239, 256
- tuning UC emission
chemical composition 156-157
core/shell structures 160
cross-relaxation processes 160
through energy migration 158-159
external stimulus 165
FRET or RETU 162-165
host matrix screening 157-158
interparticle energy transfer 158
size- and shape-induced surface effects
160-162
- turnover frequency (TOF) 12, 51, 480
- two-dimensional (2D) carbon allotrope
80
- 2D homojunction photodetector
285-286
- 2D layered piezoelectric semiconductors
283
- (2D) MnO_x/PPy nanosheets 347
- 2D PANI nanosheets 308
- 2D-2D homojunction photodetectors
289-293
- U**
- UC-based nanothermometer 172
- ultracapacitors 363
- ultra-high vacuum (UHV) 208
- undoped carbon nanomaterials 111
edge as defect 112-114
intrinsic/topological defects 114-117
- unidirectional electrical stimulation, cell
414
- upconversion (UC) 142
- upconversion nanoparticles (UCNPs)
142
activators 145-146
based drug delivery system 169
bioimaging 165-168
composition determination 154-155

- upconversion nanoparticles (UCNPs) (*contd.*)
- crystal structure identification 151–152
 - magnetic properties measurement 156
 - mediated molecular switches 175–176
 - optical properties measurement 155
 - optogenetics 170–171
 - sensing and detection 171–173
 - sensing platform 172
 - size and morphology 152–153
 - surface moieties 153–154
 - synthesis
 - coprecipitation method 149
 - hydro/solvothermal synthesis 149
 - microwave-assisted synthesis 150
 - sol–gel synthesis 150
 - therapy 168–170
- V**
- VA-BCN nanotubes 78
 - van de Waals (vdW) interactions 276
 - heterostructure photodetector 289
 - vapor-assisted solution process (VASP) 247, 248
 - V-based oxides/hydroxides 25
 - Vegard's law 236
 - ventral tegmental area (VTA) 171
 - vertically aligned nitrogen-doped CNTs (VA-NCNTs) 76, 83
 - vibrating sample magnetometer (VSM) 156
 - volatile organic compounds (VOCs) 42, 256
 - Volmer–Heyrovsky mechanism 6, 10, 45
 - Vö–V₂O₅/CP nanocables 380
- W**
- Warburg diffusion resistance, of DSSC 352
 - water-assisted wedging method, for PEDOT 404
 - water splitting to hydrogen and oxygen 1
 - wearable electronic devices 399–403, 406
 - wet chemistry method 9
- X**
- X-ray absorption fine structure (XAFS) 59
 - X-ray absorption near-edge structure (XANES) 53, 96, 156
 - X-ray absorption spectroscopy (XAS) 55, 151
 - X-ray diffraction (XRD) 151, 213, 229–231
 - X-ray photoelectron spectroscopy (XPS) 53, 82
- Y**
- Y₂O₃:Eu³⁺ 184–186
 - Y₃Al₅O₁₂:RE (RE = Ce³⁺, Tb³⁺) 178–182
 - YAG nanoparticles 178, 180, 182
- Z**
- Ziegler–Natta polymerization method 306
 - ZIF-67 383
 - NiCo-LDH nanocages 378
 - PANI composites 383
 - PEDOT heterostructure composite 384, 385
 - ZIF-PPy samples 383
 - zigzag-edged graphene ribbons 122
 - zinc–air (Zn–air)
 - battery 75, 124–130
 - fuel cell 120–122, 124, 126
 - ZnO wurtzite crystal 293
 - Zn-terpyridine nanosheet 217, 218
 - Zr-doped CeO₂ (ZDC) 61