

Index

a

- accelerated stability testing (AST) 244
- additive manufacturing technology 55
- air gap membrane distillation (AGMD) 154, 202
- ALD route 126
- alkaline anion-exchange membrane (AAEM) 28
- alkaline degradation mechanism, of PVDF 13
- amorphous PVDF 12
- amphiphilicity 208
- amphiphilic membranes 208
- anaerobic membrane bioreactor (AnMBR) configurations, for municipal sewage treatment 96, 97, 180, 181, 188
- anaerobic membrane bioreactor coupled with forward osmosis (AnOMBR) 181
- anion exchange ionomers (AEI) 251, 252, 255–257
- anion exchange membrane fuel cell (AEMFC) 234, 236–237, 250–254 fluoropolymers 250–254
- AnMBR-UASB system 181
- anti-fouling mechanism, of hydrophilic membrane 82, 84
- aqueous Li-air battery 279
- atom transfer radical polymerization (ATRP) 19, 62–63
- ATR-FTIR spectra, of virgin and irreversibly fouled membranes 182

b

- ball-and-disk friction test 128
- Bellcore process 277
- BIOS satellite program 233
- blending 61, 87, 125, 127, 255
- BTMA-g-ETFE 258

c

- cathode catalyst layer, of PEMFC 235
- cationic polymers 169
- cation selective membrane 280
- chemical degassing 132
- classical Donnan equilibrium theory 239
- CNTO/PAA/PTFE UF membrane 218
- commercial PTFE membrane 117, 136
- composite membrane separators 271–272
- composite separator

 - PVDF based polymer electrolytes 276
 - copolymerization 14, 15, 18, 19, 61–62, 149, 163, 168–170, 237, 239

- cross-linked ETFE-g-PSSA/PVTMS membranes 246
- cross-linked polymer electrolyte hybrid membrane 29, 30 preparation 30
- Cytop 161, 169, 200

d

- degassing process 132
- desalination

 - by membrane distillation
 - using PVDF membranes 87–91
 - seawater desalination 183–185

- desalination (*contd.*)
 thermal desalination 183, 201
- digital ultraviolet (UV) lithography-based
 3D micro-printing 56
- direct contact membrane distillation
 (DCMD) process 60, 85, 87, 154,
 167, 187, 202, 204, 205, 208
- directed tissue regeneration 22
- directional freezing technique 81
- direct methanol fuel cell (DMFC) 20,
 235
- fluoropolymers for 248–249
- methanol crossover (MCO) 236
- polymer electrolyte membrane
 requirements 235
- direct radical copolymerization, of
 fluoroalkenes with fluorinated
 functional monomers 237
- drinking water purification procedure
 176
- dry process 268, 270, 271, 281
- dry-wet spinning method 119–120
- e**
- ECTFE-g-PSSA membranes 150, 158
- electrically driven membranes 186
- electric vehicle (EV) 267
- electroactive phase improvement
 methods, of PVDF 86, 87
- electrochemically polymerized sulfonated
 poly(oxyphenylene) 248
- electrolyte separators 272
- electrospinning 22, 24, 25, 52–56, 77–79,
 124, 200
- equivalent weight (EW), of ionized
 polymer 239
- ETFE-based AEI powders 257
- ETFE-based cross-linked membranes
 246
- ETFE-based fuel cell membranes 245
- ETFE-based grafted membranes 29
- ETFE-based radiation grafted PEMs
 245, 246, 250, 251
- ETFE-g-poly(methylstyrene sulfonic
 acid-co-methacrylonitrile) 246
- ethylene-chlorotrifluoroethylene
 (ECTFE) 29, 197, 200
- chemical structure 30, 31
- in membrane distillation 205
- membrane modification 143
- cross-section structure 147
- graft copolymerization 149–150
- molecular structure 144
- surface oxidation 150–151
- thermally induced phase separation
 method 144, 149
- membrane process 151
- for membrane condenser 151–153
- for membrane distillation 153–155
- for oil-water emulsion separation
 157–158
- for organic solvent filtration
 155–157
- for proton exchange membrane fuel
 cell 157
- ethylene tetrafluoroethylene
 copolymer-ETFE 29
- evaporation induced phase separation
 method 79–81
- extrusion-stretching-heat setting method
 117
- f**
- Fickian diffusion coefficient 241
- coating 58, 59
- flat sheet PTFE/PP bi-composite
 membrane 204
- Flory–Huggins theory 147
- fluorinated block copolymers 162–163
- fluorinated ethylene propylene (FEP)
 28–29, 213, 214, 242, 245–247, 250
- films 247
- fluoropolymer-based separators, for LIBs
 273–274
- fluoropolymer compounds 161
- fluoropolymeric membrane fabrication
 additive manufacturing technology 55
- digital ultraviolet (UV)
 lithography-based 3D
 micro-printing 56
- electrospinning 52–54
- non-solvent induced phase separation
 42–46
- solvent evaporation 42
- stretching methods 54–55
- thermally induced phase separation
 46–49
- vapor-induced phase separation
 49–52
- fluoropolymeric membrane modification
 59

- atom transfer radical polymerization (ATRP) 62–63
- blending 61
- copolymerization 61–62
- pore filling method 61
- surface coating 58–60
- surface grating 60
- fluoropolymer membrane
- industrial wastewater treatment 186
 - for municipal sewage treatment 179–183
 - for producing drinking water 177–178
 - for seawater desalination 183–184
- fluoropolymers 197
- as binder material 254–257
 - for fuel cells 237–241
 - in membrane contractors 201–216
 - membrane distillation 201–203
 - for membranes 4
 - chemical structures 6
- forward osmosis (FO) process 181
- fouling rate 180, 219
- freeze-gelation technique 82
- g**
- gas diffusion electrodes (GDE) 255
- gas separation, of PCTFE 171
- gas-sparged AnMBR 180
- gel polymer electrolyte 272–273, 277
- gel polymer membrane, in Li-O₂ cell 279
- global desalination installation capacity 184
- graft copolymerization 149–150, 163
- graft copolymers 62, 149, 163, 168, 239
- “grafting from” method 62
- h**
- Halar® 29, 143, 155, 200
- Hansen solubility parameters 46, 49
- hexafluoropropylene (HFP) 5, 18, 28–29, 166, 213
- Hildebrand’s solubility parameters 45, 46
- homopolymeric PTFE 22–26
- homopolymeric PVDF 5, 10–14
- household water purification system 178
- hybrid membrane 29, 30, 201, 208
- hydrophilic glass fiber membranes 208
- hydrophilic modification, of PVDF membrane 82–84
- hydrophobic amorphous fluoropolymers 161
- hydrophobicity, in MD applications 205–207
- hydrophobic modification, of PVDF membrane 84–85
- Hyflon 60, 161, 197, 200–201, 205, 216, 237
- Hyflon AD 161, 163
- application 164–165
 - preparation process 164
- Hyflon AD composite PVDF membrane 95
- Hyflon AD40 164, 200
- Hyflon AD40H/PVDF hollow fiber membranes 206
- Hyflon AD40L/PVDF hollow fiber membranes 206
- Hyflon AD modified PVDF membranes 206
- Hyflon AD 60X 165
- Hyflon/PVDF composite membranes 60, 216
- Hyflon/PVDF membranes 205, 216
- i**
- immersion coating method 60
- industrial wastewater 1, 129, 131, 175, 179, 185–189
- treatment by fluoropolymer membrane 186–189
- inorganic filler 127
- interaction parameters, ECTFE vs. different solvents 146
- intramolecular chain transfer reactions 14
- ion exchange membranes 21, 186, 242
- j**
- Janus (hydrophilic-on-hydrophobic) membranes 85
- l**
- laboratory-scale AnMBR experimental bioreactors 97
- LDPE-based AEMs 257
- Li-air batteries 265, 266, 277–280
- Li-Air Battery Separator 279–280

Li-based batteries
 electrochemical reactions in 278
 “like-dissolve-like” principle 12
 liquid entry pressure (LEP) 60, 164, 205–207, 216
 liquid-phase photografted electrolyte membranes 245
 Li-S battery 279–282
 Li-S Battery Separator 280–281
 lithiated Nafion membrane 281
 lithium ion batteries (LIBs) 265
 battery market 266–268
 separator
 parameters 268, 269
 requirements 268–270
 role 265
 types and fabrication 270–272
 lithium-ion gel polymer cells 276
 Loeb-Sourirajan technique 42

m

membrane absorption 130
 for carbon dioxide removal 131–132
 characterization 130–132
 deamination 131–132
 membrane aerated bioreactor (MABR) 133–135
 membrane biofilm reactors (MBfR) 1, 179
 membrane bioreactor (MBR) 96, 117, 133, 179, 180
 membrane condenser (MCo) 94–95, 151–153, 158, 197, 214–216
 membrane contactors (MCs) 4, 54, 132, 151, 164, 197, 201–216
 membrane crystallization (MCr) 4, 87–94, 167, 197, 208–210
 of PVDF-based membranes 210
 membrane distillation (MD) 24, 129, 167, 201
 advantages 201
 configurations 202–203
 hydrophobicity 205–207
 operative problem 202
 process 16, 87
 PTFE membranes 204
 PVDF membranes 204
 membrane dryer (MDr)
 objective 210

operating principles and disadvantages 211
 membrane electrode assembly (MEA) 132, 233, 243–245, 247, 248, 255
 membrane emulsification (ME) 135–137, 197, 210–214
 membrane fouling 2, 96, 97, 122, 135, 180, 207, 218
 membrane separation 175
 benefits 175
 categories 186
 for industrial wastewater treatment 185–189
 membrane technology 1–3, 129, 130, 135, 161, 175–176, 183, 186
 metal filler filled PTFE 127
 metal-organic framework (MOF)/GO-based battery separator 281
 microbial fuel cells (MFC) 20, 95
 microfiltration (MF) 4, 114, 115, 122, 133, 179, 186, 187, 197, 218–219
 microporous membranes 16, 21, 29, 30, 54, 57, 58, 94, 114, 117, 121, 130, 132, 143, 144, 147, 149, 210, 270–272, 281
 microporous plasticized PVDF-HFP based polymer electrolyte 277
 microporous polymer separators 270
 monolayer separator 273, 276
 PVDF based polymer electrolytes 273
 monotectic point 47, 72
 Morgane ADP membrane 249
 moving bed biofilm reactor (MBBR) 179
 moving continuous phase emulsification configurations 212
 “moving membrane” emulsification configurations 212
 MPRD-containing ETFE-AEMs 257
 multi-effect distillation (MED) 201
 multilayer separator
 PVDF based polymer electrolytes 276
 multi-stage flash distillation (MSF) 183, 184, 201
 municipal tap water treatment 178
 municipal wastewater treatment by fluoropolymer membranes 179–183

n

Nafion 27, 117, 248
 chemically modified PTFE membrane 126
 perfluorinated membranes 239
 hydrogen permeability of 240
 water sorption and transport properties of 240
 Nafion membrane 234
 degradation 244
 dehydration 244
 Nafion NR111 membrane, degradation behaviors 243
 Nafion/PVDF blends 255
 Nafion/TiO₂ composites 244
 nanofiltration 115, 186, 216
 nano material filled PTFE 127
 nanomaterials membranes MBR (NMs-MBR) 179
 near-field electrospinning (NFES) method 213
 non-porous, dense, non-expandable and impermeable dense polytetrafluoroethylene membrane (n-PTFE) 129
 non-solvent induced phase separation (NIPS) 42–46, 71–73, 144, 199
 non-solvent thermally induced phase separation (N-TIPS) 71, 75–77
 non-woven fabric-based membranes 205
 non-woven membranes 271
 nonwoven separator
 PVDF based polymer electrolytes 276
 Nucleation-Growth (NG) paradigm 49

o

OCMCS/PEI-GA PTFE membrane 219
 oil-in-water (O/W) 24, 129–130, 187, 212
 oil-water emulsion separation, ECTFE membrane for 157
 omniphobicity 85, 207–208
 organic filler filled with PTFE 127
 O₂ selective membrane 279
 oxygen selective membrane 279
 oxygen transport, in Nafion 240

p

paste extrusion-stretching method 120
 PBI-based H₂-air fuel cell electrodes 255

PCTFE 170

applications 171–172
 molecular formula 171
 preparation process 171
 PDA/PTFE coating 128
 perfluorinated film-based membranes 246

PerfluoroPolyethers (PFPE) 166
 application 167–168
 preparation process 166–167
 types 166

perfluorosulfonic acid (PFSA) 25–28, 167, 239, 257

periodical pressure cycling piezoelectric membrane filtration devices 96

permselective GO membrane 281

PFPE-based thermoplastic fluoropolymers 166

PFSA-based PEMFCs 243

phase demixing mechanism 47

phase inversion process 41, 271, 281

β -phase PVDF membranes

NIPS method 73, 74

TIPS method 75

phase separation mechanism 47, 74

phase separation methods 41, 43, 71–72, 79–81

phosphoric acid doped graft ETFE membrane 249

photoorganocatalyzed

reversible-deactivation radical alternating copolymerization, of chlorotrifluoroethylene and vinyl ethers 169, 170

physical degassing 132

piezoelectric membrane filtration system 96

piezoelectric modification, of PVDF membrane 85–87

piezoelectric PVDF artificial blood vessel 99

piezoelectric PVDF fabrication procedure 87

piezoelectric PVDF membrane process 96–100

for reducing membrane fouling 96

plasma treatment 22, 125

plastic lithium-ion cell (PLIOJN) 276

poly(ethylene oxide) (PEO) based systems 273

- polylactic acid (PLA) core-shell microspheres 137
- polymer electrolytes advantages 273–277 defined 273–277
- polymer/protein complexes 169–170
- polymorphism of PVDF 10, 74
- polytetrafluoroethylene (PTFE) 197 chemical structures 22–23 homopolymeric PTFE 22–26 membrane 111 development 111–112 fabrication 115–123 flat membranes 114–115 hollow fiber membranes 114 molecular structure formula 111 performance parameters 113 properties 112–113 tubular membranes 115
- perfluorosulfonic acid-PFSA 25–28
- poly(tetrafluoroethylene-*co*- perfluoropropyl vinylether) (PFA) 27–28
- polytetrafluoroethylene (PTFE)/graphene nanocomposites 127
- poly(tetrafluoroethylene-*co*- perfluoropropyl vinylether) (PFA) 27–28
- polyvinyl chloride (PVC) membranes 177
- polyvinylidene difluoride (PVDF) membranes 177
- poly(vinylidene fluoride) (PVDF) membrane electrospinning 77–79 evaporation induced phase separation method 79–81 freezing 81–82 hydrophilic modification 82–84 hydrophobic modification 84–85 overview 71 phase separation method 71–72 non-solvent induced phase separation 71–73 non-solvent thermally induced phase separation 71, 75 thermally induced phase separation 71, 73–75 vapor induced phase separation 71, 77 piezoelectric modification 85–87
- poly(vinylidene fluoride-*co*- chlorotrifluoroethylene) P(VDF-*co*-CTFE) 19, 20, 61
- poly(vinylidene fluoride-*co*-hexafluoropropene) (P(VDF-*co*-HFP)) 18–19, 61, 280
- poly(vinylidene fluoride) fluoride-*co*-tetrafluoroethylene (PVDF-*co*-TFE) 5, 14–17
- poly(vinylidene fluoride)-g-poly(styrene sulfonic acid) PVDF-g-PSSA 19–21
- poly(vinylidene fluoride-*co*- trifluoroethylene) (P(VDF-TrFE)) 21–22
- polyvinylidene fluoride (PVDF) 197 critical surface tensions 4, 10 homopolymeric 10–14 membrane 188 physical and mechanical properties 12
- poly(vinylidene fluoride)-g-poly(styrene sulfonic acid) PVDF-g-PSSA 19–21
- poly(vinylidene fluoride-*co*- chlorotrifluoroethylene) P(VDF-*co*-CTFE) 19, 20
- poly(vinylidene fluoride-*co*- hexafluoropropene) (P(VDF-*co*-HFP)) 18–19
- poly(vinylidene fluoride-*co*- tetrafluoroethylene) (PVDF-*co*-TFE) 14–17
- poly(vinylidene fluoride-*co*- trifluoroethylene) (P(VDF-TrFE)) 21–22
- properties with different polymorphs 10–11
- pore diameters, of PTFE membranes 24
- pore filling method 61
- pore-forming agent assisted sintering method 121–122
- porous carbon nanowire (N-PCNW) 281
- porous ECTFE membranes 145
- porous PAN/GO membrane separator 281
- porous PTFE hollow fiber membranes 118
- porous PTFE membrane preparation 24, 25, 122
- powder-type AEI in AEMFCs 256

- pre-irradiation grafted FEP-g-PSSA PEM 247
 pressing-stretching-sintering method 118–119
 pressure-driven membrane process 186
 feature 216
 limitations 216
 microfiltration 218–219
 ultrafiltration 217–218
 pressure-driven membrane separation technique 96
 proton conducting PVDF graft copolymers 62
 proton exchange membrane fuel cell (PEMFC)
 component 233
 ECTFE membrane for 157
 fluoropolymers for 243–248
 performance 234
 PTFE-based DCMD technique 187
 PTFE/CaCO₃ hybrid hollow fiber membranes 120
 PTFE composite coating 128
 PTFE/FEP membranes 214
 PTFE flat membrane preparation 117
 PTFE flat membranes 114, 117
 PTFE hollow fiber membrane preparation 117
 dry-wet spinning method 119–120
 electrospinning method 124–125
 paste extrusion-stretching method 120–121
 pore-forming agent assisted sintering method 121–122
 pressing-stretching-sintering method 118–119
 push-stretch-sintering method 118
 wrapping method 122–123
 PTFE hollow fiber membranes 55,
 114–115, 117–120
 PTFE membrane modification 125
 filler modification 127
 surface modification 125–126
 PTFE membrane process 129
 membrane absorption 130–132
 membrane degassing 132–133
 membrane distillation 129, 204
 oil-in-water emulsions 129–130
 PTFE membranes fabrication 199–200
 PTFE microporous membrane-polyurethane composite membrane 114
 PTFE stretching process 25
 PTFE tubular membranes 115
 PTFE-Pullulan hollow fiber membrane 132
 PTFE/PVA primary hollow fiber membranes 120
 PTFE-reinforced polynorbonene (PNB) based AEM 253
 PTFE/TiO₂ nanofiber membrane 125
 pulsed laser deposition method 117
 push-stretch-sintering method 118
 PVDF based polymer electrolytes 273
 PVDF-co-HFP/silicate nanocomposite electrolyte membrane 280
 PVDF crystal polymorphs 198
 PVDF-CTFE-g-PSSA composite NF membrane 19
 PVDF-HFP polymer electrolytes 277
 PVDF-HFP separator 277
 PVDF-immersed ultrafiltration membrane 181
 PVDF membrane
 fabrication 199
 for membrane condenser 94–95
 for membrane crystallization 87–94
 for membrane distillation 87, 204
 for oily wastewater separation 187
 PVDF-PC-LiClO₄ membrane 276
 PVDF-PGC membrane cross-section 74, 75
 PVDF piezoelectric nanosensor 99
 PVDF/PTFE membranes, pore morphology of 219
 PVDF/PVP mix membranes, on desalination performance 184
 PVDF/sorbitan triolate (Span 85) membranes 210
 PVDF ultrafiltration membrane 217–218
 PVDF/[VBIIm][Cl] MF membrane 219
- r**
 radiation grafting
 of ETFE with styrene 245
 modification 125, 126, 241–243
 radiation-grafted ion exchange fluoropolymers 242

- radiation-grafted PVDF based cation-and anion exchange membranes 242
- recirculated membrane bioreactor (R-MBR) 179, 180
- relative humidity 51, 52, 240
- reverse osmosis (RO) 186, 201
desalination projects 183–184
- S**
- seawater desalination
fluoropolymer membrane for 184–185
purification technology 183–184
- Shirasu-Porous Glass (SPG) membranes 137
- sodium naphthalene chemical modification 125, 126
- solid electrolytes 27, 272, 279
- solution casting method 79, 81
for PVDF-HFP film preparation 79
- solvent evaporation induced phase separation 42, 44
- stretching methods 24, 29, 54, 114, 117, 121
- styrene, radiation-grafting of 242
- submerged membrane bioreactor (S-MBR) 179, 180
- sulfonated ETFE films 249
- sulfonic acid functionalized single walled carbon nanotubes, in Nafion 244
- super hydrophobic PFPE/PVDF composite membrane 167
- superhydrophobic PVDF membranes 206
- surface coating 58–60, 149
- surface grafting 58, 60, 246
- surface oxidation 150–151
- sweeping gas membrane distillation (SGMD) 154, 202
- S-ZrO₂/Nafion 244
- T**
- Teflon® 199
- Teflon fluorocarbon resins 239
- tetrafluoroethylene (TFE) copolymers 164, 200, 239
- tetrafluoroethylene hexafluoropropylene copolymer-FEP 28–29
- tetrakis(biphenyl-4-yl)benzidine (TbBd)
modified PVDF ultrafiltration membrane 217
- thermal degassing 132
- thermal desalination 183, 201
- thermally induced phase separation (TIPS) 46, 71, 73, 181, 199, 216
- thin-film and ionomer impregnation methods, for AEM electrodes 256
- 3D printing 55, 57
- T-rGO-ZCSM photocatalytic composite membrane 82
- TTD concentration 201
- two-electrode method 234
- U**
- ultrafiltration (UF) 1, 2, 4, 115, 176–178, 186–187, 217–218
membrane 176
water purifier 178
- ultrafiltration water purification
factory equipment 177
household 177
- ultrathin graphene oxide (GO) membrane 280
- V**
- vacuum membrane distillation (VMD) 119, 154, 165, 184, 202
- vanadium redox flow batteries (VRB) 21
- vapor-induced phase separation (VIPS) 49–52, 71, 77, 199
- vinylbenzyl chloride (VBC) 28, 250, 256
- vinylidene fluoride (VDF) 14–15, 18, 19, 21
- Viton fluoroelastomers 239
- W**
- water diffusion, in Nafion membrane 241
- water management 234, 237
- water purification 2, 33, 96, 176–178
- water sorption and transport properties, of Nafion 117, 240
- water-in-oil (W/O) 24, 137, 157, 212, 213
- wet process 268, 270, 271, 281
- wetting and fouling prevention, in MD
applications 207
- wrapping method 122
- Z**
- zero-liquid discharge (ZLD) technology 208–209















