

Index

a

AB-type ladder PIMs 417
 acid separation 266–268
 acid stable Zr-MOF NH₂-UiO-66 380
 activated carbon 5–7, 77, 82, 124, 330
 activated carbon fibers (ACFs) 6, 82
 activated carbon monoliths (ACMs) 6
 activated charcoal 5
 active polyamide (PA) film 140
 addition-type poly(trimethylsilyl norbornene) 22
 adsorption-diffusion model 367
 Ag/polyacrylic acid (PAA)-CNTs hybrid microporous membranes 125
 air-liquid interfacial synthesis 298–300
 air separation 226, 228–230, 247, 423–427
 alcohol dehydration 260–264
 aligned AlPO₄-5 crystals 228
 alkylamines 335, 341–343, 353
 ALL-CRAFT program 7
 allotropes 8, 11, 13, 77
 α-Al₂O₃ microfiltration layer 263
 α-alumina supported ZIF-8 membranes 402
 AlPO-18 235, 240
 aluminium-rich MFI-type zeolite membrane 263
 aluminum tri-sec-butylate sol 63
 Amberlyst coupled modernite 270
 3-aminopropyl triethoxysilane (APTES) 64, 100, 290, 429
 3-aminopropyltrimethoxysilane (APMS) 172, 313

amorphous silica layer 60, 245
 amorphous silica membranes 59, 67
 amyloid fibrils 124
 annealing process 165, 173
 anodic aluminum oxide (AAO) 97, 129, 419
 archetypal PIM-TB 416
 aromatic-rich HCP
 α,α'-dichloro-*p*-xylene (*p*-DCX) 182
 artificial ceramic membranes 3
 as-synthesized CNT arrays 9
 as-synthesized UiO-66 membranes 371
 asymmetric membranes 35, 163, 225
 azeotropic alcohol-water mixtures 67

b

1, 4-benzenedicarboxylic acid (H₂BDC) 19
 benzene-1,3,5-tricarboxylate (BTC) linkers 178
 β-lactoglobulin 124
 bicontinuous cubic (Cubbi) membrane 123
 bilayered silicalite-1/ZSM-5 membranes 208
 bilayer membranes 207–208
 bimetallic MOF nanocages 379
 bio-diaphragm 1
 bioethanol 262, 263, 377
 biological pollutants 115, 116, 118, 131–134
 bioreactors 3
 1,4-bis-(4-pyridyl)benzene (bipyb) 398

- 2,2-bis(trifluoromethyl)-4,5-difluoro-1,3-dioxole 22
- block copoly(ether-urethane-urea) 162
- block copolymers (BCPs) 70, 97, 133, 162
- Blue Membranes GmbH 82, 83
- Boehmite precursor nanoparticle dispersion 58
- b*-oriented MFI layer 205
- b*-oriented MFI zeolite membranes 244
- boron-ZSM-5 233
- Böttcher and Higuchi models 167
- Bruggeman model 167
- Brunauer, Paul Hugh Emmett and Edward Teller (BET) theory 303
- BTESE-derived hybrid silica membranes 67, 68
- bulk nanotube materials 10

- C**
- carbonaceous materials
 - activated carbon 5–7
 - carbon nanotubes 8–11
 - graphene 11–14
- carbonaceous nanofiber (CNF) membrane 125
- carbon aerogels 6
- carbon based membranes
 - advantages of 86–87
 - CMS
 - post-treatment of 81–82
 - precursors 79–80
 - pre-treatments of 81
 - production of 79
 - pyrolysis environment for 80–81
 - structures of 77, 78
 - CNTs 87–92
 - disadvantages of 87
 - graphene
 - electron beam and ultraviolet induced oxidative etching, holes 95
 - focused electron beam irradiation 92
 - gas separation and water purification 94
 - GOMs 92
 - MD simulations 92
 - NPG 92
 - permeability and selectivity of 94, 95
 - PTMSP surfaces 96
 - rejection of 98
 - structure of 77, 78
 - water flux 97
 - water treatment membranes 99
- MMMs 99–102
- SSF 84–85
- strategic directions of
 - concentration polarization 103–104
 - cost 106–107
 - fouling 104–105
 - mechanical stability 105–106
 - scalability 106
- carbon capture and storage (CCS) 419
- carbon fabric (CF) membrane 127
- carbonization 5, 38, 78–80, 84, 198
- carbonized-template molecular sieving silica (CTMSS) membranes 60
- Carbon Membranes Ltd. (Israel) 83
- carbon molecular sieves (CMS) 226
 - module construction of 82–84
 - post-treatment of 81–82
 - precursors 79–80
 - pre-treatments of 81
 - production of 79
 - pyrolysis environment for 80–81
 - structures of 77, 78
- carbon nanotubes (CNTs) 8, 122, 125
 - functionalization 90–92
 - mixed membranes 87, 89
 - MWNTs 78
 - structure of 77
 - SWNTs 78
 - VA-CNT 87
 - well-aligned 125
 - well-dispersed 1D 133
- carbon template silica (CTS) membranes 70

- catalytic cracking deposition (CCD)
 247, 269
 (catalytic) membrane reactor 268
 cellulose acetate (CA) 2, 162
 ceramic membranes 3
 CHA-type small pore
 silicoaluminophosphate zeolite
 238
 chemical absorption 324, 326–328
 chemical-looping combustion (CLC)
 system 324, 334–335
 chemical vapor deposition (CVD) 16,
 56, 89
 graphene 94
 ZIF-8 membrane 296
 chemisorption 20, 21, 330
 China-based 2D Carbon Graphene
 Material Co. Ltd. 13–14
 chiral MOFs 394, 401
 chiral Ni₂(L-asp)₂(bipy) (Ni-LAB)
 membrane 400
 chiral resolution 362, 394–401
 closed pores 414
 CNT-based yarns 11
 CO₂ capture 230, 419
 and separation strategy
 chemical absorption 327–328
 CLC system 334–335
 cryogenic purification technology
 331
 inorganic membranes 333
 oxyfuel combustion 326–327
 physical absorption 328–330
 polymeric membranes 332–333
 post-combustion 325–326
 pre-combustion 326
 silica membrane 334
 zeolite membrane 333–334
 composite membranes 67, 124, 131,
 375, 378, 388, 389, 430
 concentration-dependent diffusion
 coefficient 259
 concentration polarization (CP) 30,
 31, 43, 103, 256, 258, 380
 conjugated microporous polymers
 (CMP) 24, 413, 430
 continuous and defect polycrystalline
 MOF membrane 366
 continuous MOF (Zn₂(BDC)₂DABCO)
 membrane 367
 continuous thin ZIF-8 membrane 386
 continuous two-dimensional
 imine-linked COF-LZU1
 membrane 429
 continuous UiO-66 polycrystalline
 membranes 370
 CO₂/N₂ using Faujasite-type zeolite
 (NaY) membranes 230
 conventional polymeric membrane 86,
 102
 CoO_xSi xerogels 70
 copoly(ether urethane) 162
 copper 10, 11, 13, 98, 118, 139, 147,
 149, 178, 294, 309, 348
 CO₂ separation, microporous silica
 membranes 63–66
 counter electrode (CE) 295
 covalent functionalization 91, 92
 covalent organic frameworks (COFs)
 24, 181, 413, 429
 robust 184
 covalent triazine-based frameworks
 (CTFs) 24, 413
 covalent-triazine-framework
 membranes (CTF-0) 428
 critical flux 29
 cryogenic purification technology 331
 crystalline/semi-crystalline
 triazines-based materials 24
 crystalline TFPDHF 2D COF membrane
 431
 crystalline zeolite membranes 227
 crystallization by microwave heating
 200–201
 C4 to C8 hydrocarbon isomers 216
 Cubbi-membrane 123
 cubic LTA (Linde Type A) zeolite
 crystals 143
 Cu-MOFs 178, 179
 [Cu₂(bdc)₂(bpy)]_n 376
 [Cu₂(bdc)₂(bpy)]_n/SPES-C MMMs
 376
 Cussler model 100

d

- dabco, 4,4-bipyridine (bipy) 398
- 3D all-carbon scaffolds 8
- DD3R membrane 272
- defect-free Al-containing zeolite membrane 202
- defect-free silicalite-1 zeolite membranes 272
- defect-free thin composite membranes 378
- defect-free zeolite membranes 215
- defined-nanostructure membranes 162
- dehydrated ethanol 260
- desalination 134
 - microporous silica membranes 69–72
- 3,5-diamino-*N*-(4-2-aminophenyl)-benzamide (DABA) 141
- diethanolamine (DEA) 328
- diffuse reflectance infrared fourier transform spectroscopy (DRIFTS) 302, 307–308
- diffusion-based Kr/Xe separation mechanisms 243
- diffusivity coefficient (D_A) 167
- 9,9-dihexylfluorene-2,7-diamine (DHF) 431
- dimethyl terephthalate (DMT) 367
- diphenyldiethoxysilane (DPDES) 60
- direct dimethyl ether (DME) synthesis 271
- disc-shaped membranes 256
- dissolved oxygen (DO) 124
- dry (alumino) silicate gel 208
- dry/wet process 163
- dynamic nuclear polarization (DNP) 307

e

- electrically charged membranes 36
- electro-dialysis (ED) 3
- electron-deficient metallocenes 10
- electron-rich metallocenes 10
- electrophoretic deposition (EPD) 294, 295
- electro-spinning technique 293

- electrospun nanofibrous scaffold 131
- enhanced oil recovery (EOR) 331
- ethyl tertiary butyl ether (ETBE) 260
- evaporation-controlled filler positioning (EFP) method 387

f

- fabricate defect-free membranes 72
- fabricated PAF-56P/PSF membranes 182
- FAU-type zeolite membranes 272
- 6FDA-HAB/DABA polyimide 380
- Fick's first law 364, 365
- “film-like” MFI-alumina membrane 276
- filtered MFI nanosheet film 266
- Fischer–Tropsch synthesis 271
- Flory–Huggins theory 365
- flue gas desulphurization (FGD) process 325
- fluorinated carbon nanotubes 127
- fluor process 330
- forward osmosis (FO) 116, 120, 380
- fouling 29, 31, 41, 43, 87, 103–105, 107, 129, 131, 134, 136, 139, 142, 143, 147, 149, 150, 152, 153, 258, 327
- fouling resistance (R_f) 104
- free volume concept 415
- Friedel–Crafts acylation technique 91
- functionality insertion method 337
- functionalized PAFs 181
- functional zeolite film 208–210

g

- γ -alumina layer formation 62
- gas/liquid chromatography 257
- gas mixture permeation 211, 348
- gas permeation 53, 62, 100, 171, 172, 211, 212, 225, 227, 233, 234, 238, 309, 313–315, 346–348, 350, 368, 371, 404, 427
- gas separations 39, 427
 - with zeolite membranes
 - air separation 228–230
 - CO₂ capture 230–235
 - H₂S capture 238

- Kr/Xe separation 238–244
 - N₂/CH₄ separation 235–238
 - post-synthesis modification 245
 - g-C₃N₄ nanosheets 126
 - gel polarization model 29–30
 - Gesellschaft Für Trenntechnik (GFT) 3
 - Ge-ZSM-5 membrane 207, 267
 - glassy polymer membranes 230
 - glassy polymers 162, 163, 179, 182, 230, 415
 - GO-based nanoporous membranes 128
 - Gonzo-Parentis-Gottifredi (GPG) model 168
 - GO/PES 389
 - grafting 20, 91, 104, 105, 147, 176, 247, 342
 - graphene 11
 - electron beam and ultraviolet induced oxidative etching, holes 95
 - focused electron beam irradiation 92
 - gas separation and water purification 94
 - permeability and selectivity of 94, 95
 - PTMSP surfaces 96
 - rejection of 98
 - structure of 77, 78
 - water flux 97
 - water treatment membranes 99
 - graphene oxide (GO) 77, 92, 128, 346, 381
 - graphene oxide membranes (GOMs) 92, 95, 97, 98, 122
 - growth of oriented zeolite layers on supports 205
- h**
- Henry's law 328, 365
 - hetero-SURMOFs 394
 - hexagonal microporous silica 16, 56
 - hexane isomers 265
 - high-aspect-ratio-SAPO-34 236
 - higher boiling point octanol 387
 - high free-volume glassy polymers 21
 - highly cross-linked PIM-1 421
 - highly permeable and selective membranes 225
 - highly porous polymers, high free-volume glassy polymers 21–23
 - high performance GO-TiO₂ microsphere hierarchical membrane 129
 - high-performance superhydrophobic/superoleophilic membrane 125
 - high-purity exfoliated MFI nanosheet 266
 - high-quality ZIF-8/PSS membrane 391
 - HKUST-1 single crystals 291
 - hollow-fiber membrane modules 42
 - hollow fibre MFI zeolite membrane reactor configuration 273
 - hollow fibre SAPO-34 membranes 242
 - homochiral MOF membrane [Ni₂(mal)₂(bpy)]₂H₂O (Ni-MB) 400
 - homochiral, pillared-layer [Cu₂(D-cam)₂(P)] 398
 - homochiral poly(L-DOPA) thin film 399
 - homochiral [Zn₂(bdc)(L-lac)(dmf)] membrane 399
 - homogeneous membranes 35, 364
 - homogeneous nanodispersed ZIF-8/PDMS membrane 375
 - homogeneous ZIF-8/silicone rubber nanocomposite membrane 375
 - H₂-permselective CuO/ZnO/Al₂O₃/MFI membrane reactor 273
 - H₂S capture 226, 238
 - hybtonite carbon nanoepoxy resins 10
 - hydrogen recovery 85, 225, 416–419
 - hydrogen separation
 - in dehydrogenation reactions 271–273
 - microporous silica membranes 60–63
 - in syngas production 273–274
 - in water gas shift reaction 273

- hydrolysis/peptization method 57
 hydrophilic graphene oxide (GO)
 nanosheets 389
 hydrophilic LTA membranes 260
 hydrophilic membranes 149, 210, 212,
 261, 263, 271
 hydrophilic organic polymer
 membranes 269
 hydrophilic zeolites 143, 210, 211, 266,
 271
 hydrophilic ZSM-5 zeolite membrane
 267
 hydrophobic membranes 151–153,
 212, 263
 hydrophobic small-pore zeolite
 membranes 232
 hydroxy sodalite zeolite membranes
 271
 hypercrosslinked polymers (HCPs) 24,
 182, 413
 H-ZSM-5 membranes 275
- i**
i-butane 227, 271, 272
 ideal gas separation membrane 225
 immobilizing Aquaporin
 Z-reconstituted liposomes 122
 inductive coupled plasma optical
 emission spectroscopy
 (ICP-OES) 306
 industrial membrane-based separation
 technologies 195
 inorganic fillers 87, 162, 165, 166, 169,
 176, 210, 362, 365
 inorganic membranes 333
 inorganic-organic hybrid membranes
 134
 inorganic pollutants 118
in-situ aging 200
in-situ aging–microwave synthesis 200
in-situ crystallization 187, 196–198,
 210, 231, 288–291
 MOF 289
 inter-grown MFI nanosheets 266
 intergrowth supporting substances
 201
 interstitial free volume 415
- iso-electric point (IEP) 70
 isomer separation 275
- k**
 Kang–Jones–Nair (KJN) model 169
 KAUST-PI-1 membranes 427
 Knudsen diffusion
 behaviour 309
 mechanism 85
 Knudsen model 89
 Knudsen number 28
 Knudsen separation factor 201
 Knudsen separation mechanism 332
 Kr/Xe separation 238–244
 K-SAPO-34 242
- l**
 laminar MoS₂ membrane 129–131
 Langmuir–Blodgett (LB) method 301,
 431
 Langmuir–Blodgett (LB) strategy 300
 Langmuir–Schäfer layer 300
 large-pore ZIF-68 membranes 368
 layer-by-layer (LBL) polyamide/ZIF-8
 nanocomposite membrane 392
 layer deposition (LB)
 Langmuir–Blodgett layer 300
 Langmuir–Schäfer layer 300
 layered WS₂ nanosheet membrane 131
 Lewis–Nielsen model 168
 linear layer by layer (LBL) growth 296
 liquid-liquid interfacial synthesis 298
 liquid membranes 35, 36, 40
 liquid phase epitaxy (LPE) 296–298,
 394
 liquid separation 1, 27, 72, 101, 225,
 361–406, 428
 lithium-coated graphene 12
 lithium silicate (Li₄SiO₄) 331
 lithium zirconate (Li₂ZrO₃) 331
 low molecular weight materials
 (LMWMs) 172
 LTA zeolite membranes 200, 270
- m**
 Materials Institute Lavoisier (MILs)
 177–178

- Matrimid 78, 80, 165, 170, 171, 175, 176, 184, 188, 210
- Matrimid/ β -cyclodextrin membranes 186
- Maxwell model 99, 168
- Maxwell–Wagner–Sillar model 167
- medium-pore zeolites 196, 231, 333
- melt extrusion 36
- membrane-based separation processes 225
- membrane characterization 211–215, 402
- membrane configurations
- carbonization 38
 - melt extrusion 36
 - membrane modules 40–43
 - slip coating-sintering procedure 37
 - sol-gel method 37–38
 - solution casting 36
 - spin coating 37
 - spinning 37
 - structures 35–36
 - technologies 38–40
- membrane desalination 142, ZIF-8
- composite membranes 134
 - cubic LTA (Linde Type A) zeolite crystals 143
 - mixed matrix (MM) CNT membranes 135
 - modified CNT membranes 136
 - monolayer graphene 137
 - multi-walled carbon nanotubes 135
 - nano- and micron-sized porous GO membranes 139
 - nanoscale metals 134
 - photocatalyst nano-TiO₂ 134
 - porous MCM-41 nanoparticles 142
 - single-walled carbon nanotubes 135
 - TFC membrane technology 141
 - thin film composite membrane 140
 - tip modified CNT membranes 136
 - titanium (Ti) nanoparticles 134
 - vertically aligned (VA) CNT membranes 135
 - zeolites 143
- membrane permeability 152, 272, 333, 363
- membrane permeation 1, 27, 272, 364
- membrane science and technology 1, 413
- membrane selectivity 40, 104, 153, 176, 229, 244, 247, 364, 372, 375
- membrane separation 1
- definition 27
 - membrane transport for gas systems 27–29
 - membrane transport for liquid systems 29
 - transport mechanism in the ED membrane 32–34
- membrane surface engineering
- hydrophobic membranes 151–153
 - nanoparticles 147–151
- membrane technology 1–3, 38–40, 69, 125, 134, 141, 153, 225, 235, 238, 247, 324, 331–334
- membrane transport
- for gas systems 27–29
 - for liquid systems 29–32
- mesoporous silica spheres (MSS) 378
- Me-substituted α -cyclodextrin 187
- metal-doped silica membranes 59
- metal-organic framework (MOF) membranes
- characterization techniques
 - DRIFTS 307–308
 - ICP-OES 306
 - nitrogen adsorption and desorption 303–304
 - NMR spectroscopy 306–307
 - PXRD pattern 302–303
 - scanning electron microscope (SEM) 305–306
 - SS-NMR spectroscopy 307
 - thermal gravimetric analysis (TGA) 304–305
- CO₂ capture and separation strategy
- chemical absorption 327–328
 - CLC system 334–335
 - cryogenic purification technology 331
 - inorganic membranes 333
 - oxyfuel combustion 326–327
 - physical absorption 328–330

- metal-organic framework (MOF)
- membranes (*contd.*)
 - polymeric membranes 332–333
 - post-combustion 325–326
 - pre-combustion 326
 - silica membrane 334
 - zeolite membrane 333–334
- CO₂ recognition
 - alkylamine incorporation 341–343
 - core-shell materials 341
 - polar functional groups 336–339
 - pore size and function control 339–341
 - unsaturated metal sites 335–336
- CO₂ separation 344–353
- fabrications of
 - polycrystalline membranes 288–296
 - solution based and vacuum-based techniques 288
 - SURMOFs membranes 296–300
- H₂ separation 308–315
- metal organic frameworks (MOFs) 19, 361
 - chiral resolution 394–401
 - organic solvent nanofiltration 381–394
 - selective separation of chemicals *via* pervaporation 364–381
 - stability 401–404
- metathesis of propene 274–277
- methanol separation in hydrogenation reaction 274
- methylated silica membranes 259
- methyl diethanolamine (MDEA) 328
- MFI-type zeolite (ZSM5) membranes 170, 195, 230, 269
- MFI zeolite crystals 199
- microfiltration (MF) 2, 3, 116, 263
- micrometer-sized ZIF-71 filled membranes 377
- micropollutants 90, 115, 134, 136, 391
- micropores 6, 44, 60, 62, 68, 78, 82, 212–214, 235, 240, 353, 419, 427
- microporous materials
 - carbonaceous materials 4–14
 - different species of 4
 - high free-volume glassy polymers 21–23
 - metal-organic frameworks 19–21
 - microporous silica 14–16
 - porous organic frameworks 23–26
 - zeolites 16–19
- microporous membranes 35
 - features of 43–45
- microporous organic framework materials
 - air separation 423–427
 - CO₂ capture 419–423
 - gas separations 427–428
 - hydrogen recovery 416–419
 - liquid separation 428–431
 - porous structures and free volumes 413–416
- microporous polymeric materials 4
- microporous silica membranes 14
 - carbon dioxide separation 63–66
 - CVD 56–57
 - desalination 69–72
 - future aspect 72–73
 - hydrogen separation 60–63
 - intermediate layer 53
 - intermediate layers 57–58
 - modification of 58–60
 - pervaporation 66–69
 - schematic diagram of 54
 - sol-gel synthesis processes 54
 - support layer 58
 - templating approach 55–56
- microstructures of zeolite films 210–211
- MIL-68(Al)/polyimide MMMs 178
- mixed matrix (MM) CNT membranes 135, 138
- mixed matrix membranes (MMMs) 99, 210, 362
 - fabrication and drying techniques 163–166
 - historical growth of academic publications 161
 - mass transport theory and models 166–169
 - MOFs based 173–180, 373

- Cu-MOFs 178–179
 Materials Institute Lavoisier
 177–178
 MOF-74 series 179–180
 UiO-66 series 174–176
 zeolitic imidazolate frameworks
 176–177
 MOP-18/Matrimid 184
 polymer phase 162–163
 porous molecular compounds 184
 porous organic frameworks 181
 solvents 163
 zeolites 169–173
 mixture separation factor 202, 215,
 227, 231, 233, 276, 314, 346–351,
 366
 modernite membrane 270
 modified CNT membranes 136
 modified emulsion precipitation
 methods 57
 modified hydrophilic mZIF
 nanoparticles 390
 modified UiO-66-NH₂ nanoparticles
 175
 MOF-based film materials 394
 MOF [Cu₂(D-cam)₂(dabco)] thin films
 398
 MOF metacrystal 399
 MOF-74 series 179–180
 molecular dynamics (MD) simulations
 92, 122
 molecular sieves 18, 78–82, 169, 201,
 235, 236, 260, 268, 275, 313, 330
 monoethanolamine (MEA) 327
 monolayer graphene 92, 94, 97, 98,
 122, 137, 139
 monolith membranes 256, 257
 Monsanto Prism membrane 3
 8 MR zeolite membranes 212
 10 MR zeolite membranes 212
 MTES-templating silica sol 65
 multi-layer zeolite membranes 207
 multistage flash distillation (MSFD)
 369
 multi-walled carbon nanotubes
 (MWCNTs) 8, 9, 100, 125, 135
 multi-walled nanotubes (MWNTs) 8,
 78
 MXene-membrane 123
- n**
- NaA zeolite membranes 270, 271
 nano- and micro-sized porous GO
 membranes 139
 nano-confined composite membranes
 (NCC) 388
 nanofiltration (NF) membranes 122,
 428
 nanoparticles 91, 102, 118, 147–151,
 161, 170, 175, 176, 179, 346
 nanoporous graphene (NPG) 92
 nanoporous silicon nitride membrane
 124
 nanoscale metals 134, 323
 nanosheets 102, 126, 129, 142, 300,
 378, 381, 390
 nanosized MIL-101(Cr) 385
 narrow pore all-silica zeolite
 membranes 227
 natural rubber 21
 natural zeolites 16, 17
 NaY and NaX zeolite membranes 264
 NaY zeolite membrane 265
 N₂/CH₄ separation 226, 235–238
n-hexane 101, 212–214, 265, 366, 393
n-hexane/2,2-DMB separations 265
 NH₂-UiO-66/PEI composite
 membranes 380
 Ni-doped porous silica membranes 62,
 63
 nitrocellulose membranes 1
 nitrogen adsorption and desorption
 303–304
N-methyl-*N*-(trimethylsilyl)-
 trifluoroacetamide (MSTFA)
 385
 5-nm γ -Al₂O₃ nanofiltration 263
 non-covalent functionalization 91, 92
 norbornene (NBE) 21
 Noria 188
 Noria-Boc 188
 Noria-CO^tBu 188

- Noria/6FDA-DAM membranes 188
 N-rich Schiff based material (SNW-1) 423
 nuclear magnetic resonance (NMR) spectroscopy 302, 306
- O**
- obtained GO-membrane 129
 Office of Saline Water (OSW) 2
 olefin/paraffin separation 427
 one-dimensional conductors 10
 O₂/N₂ separation factor 64, 65, 80, 229, 230
 open pores 43, 44, 414, 427
 organic membranes 134
 organic–organic mixtures 68, 69, 255, 264, 361, 364
 organic pollutants 115, 118, 124–131
 organic polymer membranes 86, 195, 268, 269
 organic solvent nanofiltration (OSN) continuous thin ZIF-8 membrane 386
 evaporation-controlled filler positioning method 387
 GO/PES 389
 higher boiling point octanol 387
 high-quality ZIF-8/PSS membrane 391
 hydrophilic graphene oxide (GO) nanosheets 389
 micropollutants 391
 MMMs 385
 nano-confined composite membranes 388
 nanosized MIL-101(Cr) 385
N-methyl-*N*-(trimethylsilyl)-trifluoroacetamide (MSTFA) 385
 PA-SNW-1/PES membrane 393
 PA/UiO-66 membranes 392
 polyamide (PA)/ZIF-8 nanocomposite membrane 391
 polymeric membranes 385
 poly(sodium 4-styrenesulfonate) modified ZIF-8 390
 polytetrafluoroethylene double layer microfiltration membrane 391
 positively charged MOF/chitosan NF membranes 393
 thin-film nanocomposite membranes 385
 tubular ceramic ZIF-8/PSS hybrid membrane 387
 ZIF-8/GO nanocomposites 390
 ZIF-8/GO thin-film nanocomposite membrane 390
 ZIF-8/PEI hybrid NF membrane 393
- organic-water mixture 69
 organic–organic separation 264
 organophilic pervaporation (OPV) membranes 374
 O₂-selective microporous organic membranes 427
 oxyfuel combustion 326
 oxygen plasma etching approach 122
o-xylene 207, 212, 367, 368
- P**
- PAF-56P/PSF membranes 182
 Pal model 168
 PA modified UiO-66-NH₂/Matrimid 176
 PA-SNW-1/PES membrane 393
 pathogenic microorganisms 131
 PA/UiO-66 membranes 392
 PA/ZIF-8 (LBL) membrane 391
 PDA-coated microporous membrane 122
 PDMS/HKUST-1 layer 349
 peptization 37, 57
 perfluoropolymers 21, 22
 permoporosimetry 212
 measurements 204
 pervaporation 3, 39, 101
 process 66–69
 separation index 375
 with zeolite membranes
 acid separation 266–268
 alcohol dehydration 260–264
 disc-shaped membranes 256
 gas/liquid chromatography 257

- hydrogen separation in
 - dehydrogenation reactions 271–273
- hydrogen separation in syngas production 273–274
- hydrogen separation in water gas shift reaction 273
- isomer separation 275–277
- metathesis of propene 274
- methanol separation in
 - hydrogenation reaction 274
- monolith membranes 256
- multi-channel monolith support 256
- organic–organic separation 264–266
- pervaporation fluxes 256
- schematic 255
- surface diffusion 258
- tubular membranes 256
- vapor permeate 256
- water separation 268–271
- zeolite membrane encapsulated catalyst 277
- phase inversion 101, 126, 150, 163, 165, 171, 172
- phenolic resins (PRs) 79
- phenyltriethoxysilane (PTES) 60
- photocatalyst nano-TiO₂ 134
- physical absorption process 329
- physical adsorption 92, 324, 330–331
- physisorption 20, 330
- PIM-BTrip-TB 425, 426
- PIM-1/cage MMMs 188
- PIM-300-2.0d membrane 421
- PIM-6FDA-OH membrane 427
- PIM-1/nanocage membranes 188
- PIM-PI-1 membranes 427
- PIM-TB membranes 417
- pinhole-free zeolite membranes 198
- plate-and-frame modules 2, 41
- plugging–filling method 375
- poly(ethylene oxide-bamide) (Pebax) 162
- poly(furfuryl alcohol) (PFA) 79
- poly(methyl methacrylate) (PMMA) 188
- poly(styrene-butadiene-styrene) (SBS) 162
- polyacrylonitrile (PAN) 6, 38, 77, 79, 348, 381, 393, 430
- polyacrylonitrile fiber 6
- polyamide (PA) 88, 162, 379, 393
- polyamide-nanofilm-based NF membranes 430
- polyamide (PA)/ZIF-8 nanocomposite membrane 391
- poly(zwitterionic) CNT (ZCNT) 104
- polycrystalline membranes
 - assembly of MOF nanocrystals 296
 - CVD 296
 - direct synthesis
 - controlled deposition 291
 - in-situ* crystallization approach 288–299
 - slow diffusion of reactants 291
 - electro-chemical deposition 294–295
 - seeded growth
 - coordination polymer 294
 - nanocrystals 292
 - thin Film 294
 - stepwise dosage of reagents 296
- polycrystalline MOFs membranes 365, 394
- polycrystalline UiO-66(Zr)-(OH)₂ membranes 372, 404
- polycrystalline zeolite layer 196, 199, 213, 258
- polydopamine (PDA) 152, 346
- polyether-block-amide (PEBA) 375
- polyetherimide (PEI) UF-membrane 151
- polyethersulfone (PES)
 - supported
 - silicalite-1/polydimethylsiloxane (PDMS) mixed matrix membrane 243
- polyethersulfone (PES) 162, 171, 225
- polyethylene glycol (PEG) 131, 151, 329, 391
- polyethyleneimine (PEI) 188, 292
 - modified MIL-101(Cr) fillers 178
- polyimides (PI) 21, 79, 162

- polymer-copper nanocomposite 149
- polymeric membrane 3, 4, 118, 127, 134, 136, 139, 150, 152, 161, 177, 195, 226, 229, 243, 258, 332–334, 344, 346, 361, 385, 392, 413, 423
- polymer-melt-compounding exfoliation technique 266
- polymers of intrinsic microporosity (PIMs) 24, 181, 413
- poly(sodium 4-styrenesulfonate) (PSS) modified ZIF-8 (mZIF) 390
- polypropylene (PP) 36, 162, 196
- poly(norbornene)s 21, 22
- polystyrene (PS) 16, 56, 88, 131, 188
- polystyrene-block-poly(methyl methacrylate) copolymer (PS-*b*-PMMA) 131
- polysulfone (PSF) 162, 172
nanofibers 127
support membranes 392
- polytetrafluoroethylene (PTFE) double layer microfiltration membrane 391
- poly[(1-trimethylsilyl)-1-propyne] [poly(11)] 22
- polyvinyl acetate (PVAc) 151
- polyvinyl alcohol (PVA) 101, 149, 151
- polyvinylidene fluoride (PVDF) 162, 163
- polyvinylpyrrolidone (PVP) 151, 165, 188
- pore-plugging type zeolite/alumina nanocomposite membrane 275
- porous aromatic frameworks (PAFs) 24, 181, 413
- porous cages (PCs) 24, 188, 413
- porous carbons 77, 99, 107
- porous coordination polymers (PCPs) 361
- porous MCM-41 nanoparticles 142
- porous molecular compounds 184
- porous organic cages (POCs) 186, 418
- porous organic frameworks (POFs) 4, 23–26, 181, 413–432
- porous pure-silica materials 209
- porous structures and free volumes 413–416
- positively charged MOF/chitosan NF membranes 393
- powdered activated carbons (PACs) 6
- powder X-ray diffraction (PXRD) 302–303
- pressure-assisted self-assembly (PASA) filtration technique 381
- pressure swing adsorption (PSA) process 85, 86, 260
- priming 172, 173
- pristine graphene 77, 92, 95
- PSF/modified SAPO-34 membranes 172
- PTMSP/PAF-Li₆C₆₀ membranes 181
- PTMSP/*p*-DCX MMMs 182
- pure-silica zeolites 209
- p*-xylene 182, 206–208, 212, 266, 275, 276, 367, 368
- r**
- reactive seeding (RS) 292, 293, 347, 366, 368, 399
- rectangular silicalite-1 nanoblocks 197
- rectisol process 329
- reduced graphene oxide (rGO) 77, 133
- reduced permeation polarizability 168
- rejection factor 363
- relative recovery 363
- resistance model 30–32
- retention factor 363
- reverse osmosis (RO) 2, 3, 71, 116, 364, 369
- rubbery polymers 25, 162, 163, 179
- s**
- Safe Drinking Water Act 7
- SAPO-34 236, 243
membranes 231
zeolite 172
- scanning electron microscope (SEM) 305
- SDA-containing MFI films 210
- secondary building units (SBUs) 19, 178
- seed crystals 197, 199, 204, 261, 292, 293, 368, 400
- segmented polyurethane (SPU) 102

- selective separation of chemicals *via* pervaporation
 Fick's first law 364
 MOFs based MMMs 373
 polycrystalline MOF membranes 365–373
 solution-diffusion mechanism 364
- selective surface flow membranes (SSF) 84–85
- self-cross-linked PIM-1 membranes 419
- self-polymerized chiral monomer L-DOPA 399
- semipermeable membrane 1, 27
- short branched linear polymers 15, 55
- Si/Al-O-Al/Si (zeolite) repeating unit 176
- silane agents 172
- silica-free zeolite-like materials 17
- silicalite-1 195–197, 199, 200, 206, 208, 209, 212, 213, 227, 230, 232, 233, 244, 247, 259, 264, 266, 267, 272, 274, 275, 277
- silicalite-1/ α -Al₂O₃ zeolite membranes 275
- silicalite-1 coated ZSM-5 catalysts 275
- silicalite-1 membrane crystallization 200
- silicalite-1 membranes 197, 200, 201, 206, 212, 213, 215, 227, 232, 233, 237, 267, 275
- silica membrane 15, 53–73, 334
- silica nanoblocks 197
- silica-titania composite membranes 68
- single-crystal membranes 315
- single-layer freestanding graphene membrane 122
- single-layer graphene 12, 13, 92, 94, 104–106
- single-walled carbon nanotubes 8, 135
- single-walled nanotubes (SWNTs) 8, 78
- size exclusion mechanism 99, 116, 139
- slip coating-sintering procedure 37
- small-pore zeolite DD3R membranes 272
- small-pore zeolites 170, 196, 210, 231
- SNW-1/PSF membranes 423
- sodium-alumino-phosphate (SAPO)-based MMMs 171
- sol-gel method 37, 60, 70, 334
- sol-gel synthesis processes 14, 54
- solid state nuclear magnetic resonance (SS-NMR) spectroscopy 302, 307
- solubility coefficient 167, 329
- soluble anionic MOP (Na₆H₁₈-[Cu₂₄(5-SO₃-1,3-BDC)₂₄(S)₂₄] \cdot *x* S 184
- solution based fabrication techniques 288
- solution-casting method 36, 165, 185
- solution-diffusion mechanism 28, 118, 332, 364, 365
- solvent resistant nanofiltration 381
- solvents 3, 4, 9, 19, 22, 36, 163, 184, 188, 306, 326–328, 364, 368
- sonochemicals method 57, 58
- specific surface area (SSA) 4, 77, 414
- specific van der Waals volume 415
- spin coating 36, 37, 226, 292, 293, 298, 419
- spinning 36, 37, 43, 122, 133, 177, 210, 302
- spin-on silicalite-1 films 209
- spiral wound module 41, 42, 84
- SSZ-13 zeolite membranes 238, 268
- stable UiO-66 membranes 372
- 1-stage or 2-stage filtration principle 7
- stainless-steel-net-supported zeolite NaA membrane 229
- starbons 6
- submicrometer-sized ZIF-71 crystals 377
- submicrometer-sized ZIF-71 filled PDMS membranes 377
- substituted polyacetylenes 21, 22
- sulfonated PIs 80
- superhydrophobic PVDF-*co*-hexafluoropropylene nanofiber membrane 122
- superoleophobic poly(acrylic acid)-grafted PVDF (PAA-*g*-PVDF) membrane 126

- surface anchored MOFs (SURMOFs) 394
 surface diffusion 28, 29, 85, 230, 231, 244, 258, 287, 332, 351, 422
 surface supported metal-organic frameworks (SURMOFs) membrane
 interfacial synthesis
 air-liquid 298–300
 Langmuir–Blodgett (LB) strategy 300
 Langmuir–Schäfer layer 300
 liquid-liquid 298
 liquid phase epitaxy (LPE) 296
 syngas production 273–274
 synthetic zeolites 18, 210
- t**
- Teflon AF1600 22
 Teflon AF2400 22
 templating molecules 15, 16, 55, 56
 terephthalic acid (TPA) 208, 367
 tetraethoxysilane $\text{Si}(\text{OC}_2\text{H}_5)_4$ (TEOS) 54
 tetraethyl orthosilicate (TEOS) 60, 70
 tetraethyl orthosilicate $\text{Si}(\text{OC}_2\text{H}_5)_4$ (TEOS) 14
 5,5',6,6'-tetrahydroxy-3,3,3',3'-tetramethyl-1,1'-spirobisindane 25
 tetramethoxysilane $\text{Si}(\text{OCH}_3)_4$ (TMOS) 14, 54
 tetrapropylammonium ions (TPA^+) 198
 TFC membrane technology 141
 TFMPSPIM-1 membrane 425
 thermally-rearranged polymers 21
 thermogravimetric analysis (TGA) 302, 304
 thermotropic liquid-crystal (LC) molecules 123
 thin film composite (TFC) membrane 140, 379
 thin-film nanocomposite (TFN) membranes 379, 385
- three-dimensional (3D) zeolite membranes 266
 Ti-exchanged UiO-66 175
 TiO_2 147
 nanoparticles 129
 nanowire ultrafiltration (UF) membranes 131
 tip functionalization 90
 tip modified CNT membranes 136
 titanium (Ti) nanoparticles 134
 titanosilicate zeolites 171
 toluene 125, 126, 277, 368
 transmembrane pressure (TMP) 104, 389, 401
 2,4,6-triaminopyrimidine (TAP) 173
 triazine-framework-based membrane 422
 1,3,5-triformylbenzene and (R,R)-1,2-diaminocyclohexane (CC3) 188
 1,3,5-triformylphloroglucinol (Tp) 431
 1,3,5-triisopropylbenzene (TIPB) 368
 triisopropyl orthoformate (TIPO) 101
 trimesoyl chloride (TMC) 141, 385
 Tsapatsis 207
 T-type zeolite membranes 231
 tubular ceramic ZIF-8/PSS hybrid membrane 387, 388
 tubular membrane modules 41, 256
 tubular ZeoSepA membranes 260
 tunable pore size, MOF 351
 two-dimensional (2D)
 graphene based materials 122
 nanosheets 129
 ZIF-L nanosheets 378
 2D zeolite membranes 266
 two-layered MOR (acid resistant separative layer)/H-ZSM-5(catalyst) membrane 270
 two-steps crystallization 199
 type-A zeolite membranes 260
- u**
- UiO-66 243, 295, 338
 UiO-66- NH_2 membranes 372
 UiO-66/PEBA MMMs 175

- UiO-66 series 174–176
 ultrafiltration (UF) membranes 3, 90, 116
 ultrathin (~22–53nm thick)
 2D-graphene membrane 128
 ultra-thin MFI membranes 229
 ultra-thin (~0.5 μ m in thickness) MFI membranes 229
 ultrathin MOF/organosilica MMMs 176
 unmodified MIL-53(Al) containing MMMs 178
 unsaturated metal sites 19, 179, 323, 335–336
- V**
- vacuum-based fabrication techniques 288
 vacuum swing adsorptive (VSA) 330
 van't Hoff equation 1
 vertically aligned CNT membranes (VA-CNT) 87, 135
 arrays 8
 vertically-aligned multi-walled carbon nanotubes (VAMWCNTs) 125
 vycor glass 57
- W**
- waterborne diseases 115, 131
 water desalination 70
 water gas shift (WGS) reaction 62, 85, 273
 water purification
 biological pollutants 131–134
 inorganic pollutants 118–124
 membrane desalination 134–144
 membrane surface engineering 147–151
 organic pollutants 124–131
 types and state-of-the-art microporous membrane 116–118
 water separation 97, 125, 127, 153, 268–271
 water-stable, exfoliated imine-based COFs 183
- water-stable polycrystalline UiO-66(Zr)-(OH)₂ membranes 404
 well packed graphene layer membrane 128
 wet process 163
 Williams–Landel–Ferry (WLF) equation 415
 working electrode (WE) 295
- X**
- X-ray amorphous metal oxide membranes 199, 226, 227, 261
 xylene isomers 206, 266, 275, 276, 367, 368
- Z**
- zeolite imidazolate framework (ZIF) based membranes 345
 zeolite membrane encapsulated catalyst (ZMEC) 277
 zeolite membranes 4, 16, 143, 169, 333
 bi-layer membranes 207–208
 characterization 211–215
 conventional hydrothermal synthesis 198
 crystallization by microwave heating 200–201
 functional zeolite film 208–210
 growth of oriented zeolite layers on supports 205–207
 intergrowth supporting substances 201–205
 microstructures of zeolite films 210–211
 mixed matrix membranes 210
 synthesis techniques 196–197
 two-steps crystallization 199
 zeolitic imidazolate frameworks (ZIFs) 176–177, 312, 366
 zeolitic molecular sieve membranes 268
 ZeoSepA membranes 260, 261
 zero-dimensional ZIF-8 nanoparticles 378

- ZIF-78 347
- ZIF-90 290
- ZIF-71 filled MMMs pervaporation performance 378
- ZIF-8/GO nanocomposites 390
- ZIF-8/GO thin-film nanocomposite (TFN-ZG) membrane 390
- ZIF-8 membrane 142, 243, 345
 - MMMs 176
- ZIF-71 membrane 366
- ZIF-95 membrane 347
- ZIF-100 membrane 347
- ZIF-8 nanoparticles 374
- ZIF-8/PEI hybrid NF membrane, 393
- ZIF-8/PMPS membrane 374
- zirconium(IV)-carboxylate MOFs (Zr-MOFs) 369
- Zn-based ZIF membranes 369
- Zn₂(D/L-cam)₂dabco (diazabicyclo[2.2.2]-octane, dabco) 394
- ZnO incorporated PVDF membrane 150
- Zr-based MOF 338, 369, 372
- ZSM-5 195
 - MFI-type zeolite 170
- ZSM-5/Matrimid MMMs 171
- ZSM-5/silicalite bilayer membranes 273
- Zyvex Performance Materials 10