

Index

a

adsorbed-phase transport mechanism 39
adsorption energy 41
aliphatic ethylenediamine (EDA) 96
amino acids arginine (R) 97
amphiphilic carbonaceous material (ACM) 294
amphoteric membranes 322
Ångström-sized channels 338
anion exchange membranes (AEM) 322
anodic alumina oxide (AAO)
membranes 15, 318, 343
applied potential effects 93
applied pressure effects 93
arc discharge method 329
armchair (AC) edges 53
aromatic *p*-phenylenediamine (PPD) 96
Arrhenius equation 39
artificial nanofluidic systems 328
as-charged GO sheets 91
atomic layer deposition (ALD) 115
atomically thin nanopores 333
Avogadro's number 335

b

back-calculation method 351
ball-milling exfoliations 4

ball-milling method 5
1,4-benzene-dicarboxylic acid (BDCA) 11, 194
1,3,5-benzenetricarbonyl trichloride (TMC) monomers 100
bilayer graphene 55
bipolar membranes 322
bis-1,5(tripropyl ammonium) pentamethylene diiodide (dC5) 10, 194
blade stirred tank reactors 5
block copolymer film 57
Boltzmann's constant 335
boron nitride (BN) 188, 294
boron nitride nanotubes (BNNTs) 329
brine desalination process 150
Brodie and Staudenmaier methods 7
butylenediamine (BDA) 96, 128, 153
1-butyl-3-methylimidazolium tetrafluoroborate ([Bmim] [BF₄]) 45

c

capillary condensation 319
carbon molecular sieves (CMS) 36, 153, 315
carbon nanotubes (CNTs) 315
catalytic polymerization (coupling) 51
cation exchange membranes (CEM) 322
cation-tailoring method 96

- cetyltrimethylammonium bromide (CTAB) 191
- channel-pore design 104
- charged membranes 316, 321
- charge modification for desalination 132
- charge screening effects 338
- chemical affinity quantum sieving (CAQS) 341
- chemical etching 55
- CO₂ 60–62
 - O₂ 58–60
 - O₃ 62–67
 - plasma treatment 56–57
- chemical potential difference 313
- chemical vapor deposition (CVD) 4, 9, 10, 49, 61, 115, 194, 329
- chitosan (CS) 159
- CNT-rGO hybrid membranes 94
- co-doping of GO nanosheets 282
- commercial polymeric RO membrane 117
- contra-diffusion method 27
- conventional gas permeation membranes 36
- conventional gas separation processes 35
- covalent-bonded lattice, of graphene 37
- covalent organic frameworks (COFs) 1, 329
- constructing hierarchical structures in MMMs 291
- facilely-tailored functionality 290–291
- increasing molecule transport channels 289
- two-dimensional material as continues phase of flexible polymers 301
- modulating crystallinity, porosity, mechanical properties 302–303
- two-dimensional materials as dispersed phase of constructing hierarchical structures in MMMs 290
- facilely-tailored functionality 289
- increasing molecule transport channels 288
- covalent organic nanosheets (CONs) 288
- crack formation 38
- crack-free membrane 70
- cyclodehydrogenation 51
- d**
- Debye length 91, 335
- Debye overlap displaying ionic current-voltage relation 337
- decoupled pore nucleation 54
- defect-engineering approach 343
- dehydrogenative cross-coupling 51
- density functional theory (DFT) 40, 115, 333
- desalination 259, 260
- diamine monomers 128
- diffusion coefficient 337
- diffusivity 320
- dimethyl carbonate (DMC)/water mixture 15
- N,N*-dimethylformamide (DMF) 5, 10
- dimethyl sulphoxide (DMSO) 256
- diphenyl-10,10'-dibromo-9,9'-bianthracene (DP-DBBA) 51
- Donnan effect 116, 120, 316
- Donnan exclusion mechanism 340
- Donnan potential 322
- drilled nanopores 1, 3
- dual-layer reinforcement approach 70
- dyes and natural organic matter rejection 265

e

eccentricity 43
 electrical double layer (EDL) effect 91, 335
 electrical potential difference 313
 electrical resistance 39
 electrochemical oxidation method 7
 electrodialysis (ED) 321
 electron-density-gap 37, 40, 64
 electrophoresis deposition (ED) method 17, 221
 electrostatic repulsion 91
 engineering gas-selective vacancy defects 48–49
 bottom-up synthesis of, N-SLG 49–51
 postsynthetic etching of, SLG 51
 chemical etching methods 55–58, 60–67
 physical etching methods 52–54
 enhanced molecular sieving 17
 equilibrium molecular dynamics (EMD) 333
 etching nanopores 69
 ethyl acetate (EA) molecules 162
 ethylenediamine (EDA) 128, 153
 extended Nernst–Plank equation 316
 external environment-mediated transport 91
 external field modulated ion transport 134
 external forces (EFs) 19

f

fabrication methods, for 2D membranes of large-area N-SLG membranes 67–71
 and membrane structures 11
 two-dimensional-material laminar membranes 15–24
 two-dimensional-material nanosheet membranes 11–14

nanosheets, synthesis of 4
 bottom-up method 9–11
 top-down method 4–7
 few-walled CNTs (FWCNTs) 329
 Fick's law of diffusion 321
 filtration-assisted assembly 196, 198
 flow batteries 321
 flow enhancement 333
 focused-ion beam (FIB) 53
 forward osmosis (FO) 105, 241, 314
 free standing GO membranes 128
 fuel cells 321

g

gas permeance 36, 44
 gas separation
 applications 35
 H_2/CO_2 , H_2/N_2 , and H_2/CH_4 separations 201
 MXene 268
 potential of, N-SLG membranes 37–48
 gas-impermeable graphene lattice 48
 gas-sieving nanopores 48
 gasification process 61
 GO-incorporated polyether block amide (PEBA) membranes 24
 GO laminates 15
 GO–PEI membranes 99
 Gouy–Chapman model 335
 graphene basal plane 41
 graphene-based materials
 graphene oxide 179
 nanoporous graphene 176–179
 graphene-based membranes for water separation
 external environment-mediated transport 91
 forward osmosis 105
 guest material-mediated transport 94
 internal geometry-mediated transport 84

- graphene-based membranes for water separation (*contd.*)
- nanofiltration 100
 - reverse osmosis 105
 - surface chemistry-mediated transport 88
- graphene lattice 44, 53
- graphene nanomesh 14
- graphene nanopore 39, 44
- graphene nanosheets 7
- graphene oxide (GO) 7, 114, 179, 315
- two-dimensional material as
 - continues phase of
 - controlling interlayer spacing 296–298
 - physical/chemical
 - microenvironment 296–297
 - two-dimensional material as
 - dispersed phase of
 - functional sites for facilitated transport 284
 - increasing molecular transport channels 282
 - reducing non-selective defects 283
 - graphene oxide-framework (GOF) membrane 152
 - graphene oxide membranes
 - charge modification for desalination 132
 - external field modulated ion transport 134
 - interlayer spacing control for desalination 126
 - ion selectivity 123
 - ion transport through planar GO laminates 135
 - microstructure optimization for desalination 124
 - structure 121
 - ultrafast water permeability 121
- graphene oxide (GO) nanosheets 146
- graphene, discovery of 173
- graphitic carbon nitride ($\text{g-C}_3\text{N}_4$) 185, 293
- guest material-mediated transport 94
- h***
- Hagen-Poiseuille equation 318
- halloysite nanotubes (HNTs) 270
- H_2/CO_2 , H_2/N_2 , and H_2/CH_4 separations 201
- H_2 diffusion 38
- Henry's coefficient 39, 40
- heterogeneous GO membranes 134
- hexagonal boron nitride (hBN) 315
- hexaiodo-substituted macrocycle cyclohexa-m-phenylene (CHP) 41, 49, 51
- highly charged nanochannels 132
- high-resolution transmission electron microscopy (HRTEM) 88
- high-temperature etching approach 65
- honeycomb lattice 38
- hot-drop casting method 13
- H_2 transport 50
- Hummers' method 7
- hydration force 91
- hydrazine vapor 17
- hydro/solvothermal synthesis 3, 4, 10
- hydrolyzed polyacrylonitrile (PAN) 156
- hydrophilic chitosan (CS) layer 23
- hydrotalcite (HT) 221
- i***
- ice-involved flowing mode 89
- in-plane nanopores/slits 1
- in-suit polymerization method 25
- integrally skinned asymmetric (ISA) membranes 315
- intercalated compound 7
- intercalating nanomaterials 162
- interfacial synthesis 3, 4
- interlaminar molecular bridge 22

- interlayer channels 1
 interlayer gallery-based separation 1,
 221
 pristine interlayer gallery-based
 separation 226–228
 regenerated interlayer gallery-based
 separation 229–231
 interlayer spacing control for
 desalination 126
 internal concentration polarization
 (ICP) 106
 internal geometry-mediated transport
 84
 intrinsic or artificial nanopores 1
 ion exchange membranes, IEMs 321
 ionic-liquid gated N-SLG membranes
 45
 ion-intercalation exfoliation 6
 ion selectivity 123
 ion transport through planar GO
 laminates 135
 isomer cataloging problem (ICP) 44
- k**
 kinetic quantum sieving (KQS) effects
 341
 Knudsen diffusion 318
 Knudsen flow 319, 333
 Knudsen number 333
 Knudsen selectivity 58, 222
- l**
 laminar membrane 3
 Langmuir–Schaefer (LS) transfer 199
 large-scale fabrication 30
 layered double hydroxides (LDHs) 1,
 190
 blending with polymers 226
 geometric shape-based separation
 232
 gas separation 232, 234
 geometric shape-based gas
 separation 233
 liquid separation 234
 particulate matter capture 236
 sacrificing templates 236
 hydrophilicity-based water treatment
 forward osmosis 244, 245
 microfiltration 243
 nanofiltration 243
 reverse osmosis 244
 ultrafiltration 243
 interlayer gallery-based separation
 pristine interlayer gallery-based
 separation 226–228
 regenerated interlayer
 gallery-based separation
 229–231
 $[\text{Mg}_6\text{Al}_2(\text{OH})_{16}]\text{CO}_3 \cdot 4\text{H}_2\text{O}$ 221
 photocatalytic activity-based
 separation 238
 positive surface charge-based
 separation
 forward osmosis 241
 nanocomposite membranes
 241–242
 nanofiltration 239–240
 reverse osmosis 240
 ultrafiltration 239
 post-synthetic deposition 224
 solution-based in situ growth 223
 thermal behavior-based separation
 236
 layer-by-layer assembly method 199
 LDHs. *See* layered double hydroxides
 (LDHs)
 Lennard–Jones potential 334
 Lewis–Nielsen model 353
 Li-intercalated compound 6
 liquid separation
 desalination 259–260
 dyes and natural organic matter
 rejection 265
 oil–water separation 267
 OSN 261

- liquid separation (*contd.*)
- pervaporation solvent dehydration 263–264
- local spin density approximation (LSDA) 62
- lower critical solution temperature (LCST) 97
- m**
- macrovoids 87, 107
- MAF-6 287
- mass flux 316–318, 351
- mass-transport mechanism
- GO membrane 147–150
 - pervaporation process 146–147
- materials preparation 365
- Maxwell–Wagner–Sillars model 352
- mean free path 39, 54, 318, 333
- mechanical-force exfoliation 3–6
- mechanical resonance 13–14
- membrane-based separation processes 35, 246, 326
- membrane capacitive deionization (MCDI) 321
- membrane fabrication 3, 11, 17, 30, 38, 83, 123, 124, 160, 173, 189, 198, 199, 343, 365–366
- membrane-formation mechanism 29, 30
- membrane skin layer 37
- metal–organic cages (MOCs) 329
- metal–organic frameworks (MOFs) 1, 181, 315, 329
- interfacial compatibility between nanomaterials and polymers 287
- membrane 12–13
- two-dimensional material as
- continues phase of enhancing processability and stability of 299
 - modulating the physical/chemical microenvironment 299, 300
- two-dimensional material as
- dispersed phase of increasing molecular transport channels 286
 - ZIF 286
- 1-Methyl-2-pyrrolidinone (NMP) 5
- microfiltration 226, 238, 243, 246, 314, 317
- micromechanical force 4
- microporous inorganic membranes 321
- microporous materials 11
- microporous polymers 27, 315
- microstructure optimization for desalination 124–125
- minimally intensive layer delamination (MILD) method 255
- mixed cellulose ester (MCE) filters 265
- mixed-matrix membranes (MMMs)
- definition 279
 - fabrication methods of 24–25
- 2D materials-embedded 350–355
- two-dimensional material as
- continues phase of covalent organic frameworks 300–303
 - graphene oxide (GO) 295–297
 - metal–organic framework 297–300
- two-dimensional materials as
- dispersed phase of constructing hierarchical structures in 290–292
 - covalent organic frameworks 287
 - facilely-tailored functionality 289–290
 - graphene oxide (GO) 282
 - graphite carbon nitride 293–294
 - metal–organic frameworks 285–286
 - molecule transport channels 288–289

- MXenes 294
 TMDs nanosheets 292
 molecular dynamics (MD) simulations 13, 41, 44, 115, 147, 176, 178, 332, 333, 338, 345
 molecular/ionic transport pathway 1
 molecular selectivity 41
 molecular separation 2, 3, 28, 37, 51, 153, 253–271, 279, 280, 287, 292, 304, 305, 341
 molecular-sieve membranes 12, 13
 molecular-sieving mechanism 319
 molecular transport channels 29, 161, 282–283, 285–286, 304
 molybdenum disulfide (MoS_2) 315
 monolayer of, ionic liquid
 (1-ethyl-3-methylimidazolium tetrafluoroborate or
 [emim][BF_4^-]) 45
 multi-walled carbon nanotube (MWCNT) 104, 329
 multi-walled carbon nanotube (MWCNT)-GO graphene-based membrane 104
 MXenes 185
 atomic-thickness 253
 fabrication of single MXene flakes 255–257
 molecular separation for
 gas separation 268–270
 liquid separation 258–268
 molecular sieving 254
 multilayered MXene powders,
 synthesis of 254–255
 preparation of
 drop-coating 258
 pressure-assisted filtration 258
 spraying- or spinning coating 258
 surface properties of MXene flakes 257
 two-dimensional materials as
 dispersed phase of 294
- n**
- Nafion® 322
 nanochannel characterization 29
 nanoconfinement effects 188, 189, 327–329, 338
 nanofiltration (NF) 2, 17–19, 24, 29, 84, 93, 100–105, 107, 226, 229, 239–240, 243–244, 246, 258, 260–263, 265–267, 299, 314, 318, 341, 344, 349, 350
 nanofluidic transport through confined dimensions
 artificial nanofluidic systems 328–330
 atomically thin nanopores 333–334
 confinement effects at
 sub-nanometer scale 338
 continuum modeling 330–333
 electrical double layer effect 335–338
 nanoporous atomically thin membranes (NATMs) 179, 333, 342–345
 nanoporous carbon (NPC) film 69
 nanoporous gas-permeable polymeric film 71
 nanoporous graphene 37, 41, 42, 51, 114–120, 137, 176–179, 339, 345
 nanoporous ZIF-8 nanoparticles 339
 nanosheet coating 11
 nanosheet membranes 1–3, 11–14, 176, 181, 182, 185, 186, 196, 200, 201, 300
 nanosheets, synthesis of
 bottom-up method
 chemical vapor deposition 9–10
 hydro/solvothermal synthesis 10
 interfacial synthesis 10–11
 top-down method
 ion-intercalation exfoliation 6–7
 mechanical-force exfoliation 4–6
 oxidation-assisted exfoliation 7–8
 selective-etching method 8–9
 nanosized 2D channels 85

- nanowrinkles 84–86, 93, 100, 103, 104, 106, 107, 130
 Navier–Stokes equation 327, 330, 331, 355
 N-doped nanoporous graphene 116
 NiAl–CO₃ LDH membranes 224, 226, 227
 nitrogen-passivated pore rim 44
 nonequilibrium molecular dynamics (NEMD) 332, 333
 nonporous membranes 314, 316, 319–321, 323, 326
 nonporous nanosheets 1
 non-solvent induced phase inversion 287
 non-solvent induced phase separation (NIPS) technique 71, 239
 nonzero energy barrier 39
 no-slip Hagen–Poiseuille relation 331
- O**
- oil–water separation 234, 235, 258, 267–268, 271
 olefin/paraffin separation 35
 1D-confined nanofluidics 329
 one-dimensional (1D) nanotubes 328, 338
 1D sacrificial Cu(OH)₂ nanostrands 103
 one side decoration method 105
 O₃ physisorption 62
 organic nanotubes 329
 organic solvent nanofiltration (OSN) 229, 258, 261–263, 314, 343
 oxidation-assisted exfoliation 4, 7–8
 oxygen adsorbate 64
 ozone physisorption 62
- P**
- partial dehydration or desolvation 339–340
 PDASA(Na⁺)/GO membrane 156
 perfluorosulfonic acid polymer membranes 322
 permeability–selectivity trade-off for polymers 324–326
 pervaporation (PV) 145
 solvent dehydration 258, 263–264
 pervaporation technology
 GO membranes 150–151
 mass transport mechanism 147–150
 phenylalanine (F) 97
 physisorption energy 50, 62, 63
 pinholes 11, 84–86, 88, 107, 119, 123
 planar heterogeneous GO membranes (PHGOM) 135
 plasticization 315, 321, 366
 PNIPAM–PNIPAM intra/intermolecular hydrogen bonds 97
 Poiseuille flow 318, 333
 polyacrylic acid (PAA) 132
 polyallylamine hydrochloride (PAH) 132
 polyamide thin-film composite (PA TFC) membrane 113
 poly diallyl dimethyl ammonium (PDDA) 132
 polydopamine (PDA) 22, 165, 235, 294, 296
 polyethersulfone (PES) 198, 239, 258, 279, 288, 347
 polyethylene glycol and polyethyleneimine (PEG-PEI-GO) 283
 poly(ethylene glycol)-dimethyl-ether (PEGDE) oligomer 46
 polyethyleneimine (PEI) 98, 132, 135, 158, 230, 283, 297
 poly(glycidyl methacrylate-sulfobetaine methacrylate) 165
 polyhedral-oligomeric-silsesquioxane 343
 polymer-based MMMs 280, 304

- polymers of intrinsic microporosity (PIMs) 35–36, 293, 315, 321, 329
- poly(N-isopropylacrylamide-*co*-benzo-15-crown-5-acrylamide)* (PNB) copolymers 124
- poly(*N,N*-dimethylaminoethyl methacrylate)* (PDMAEMA) 133
- polystyrene sulfonate (PSS) 132
- poly[1-(trimethylsilyl)-1-propyne]* 71
- poly(vinyl alcohol)* (PVA) 160
- poly(vinylidene fluoride)* (PVDF) 161, 235, 259, 279
- pore density 14, 37, 38, 41, 42, 44, 48, 49, 51, 54–58, 61, 64, 65, 67, 72, 176, 185, 343, 351, 355, 365
- pore-edge functionalization 37, 64
- pore-flow model 316, 355
- pore geometry 41–44, 243
- pore-size distribution (PSD) 37, 48, 176, 177, 315, 319, 329, 342–344
- pore-translocation 39, 40, 47
- porous aromatic frameworks (PAFs) 329
- porous graphene-based nanosheet membranes 2
- porous graphene lattice 42, 46, 48
- porous graphene membrane 13–14, 118–120, 176, 339
- porous graphene oxide (PGO) 355
- porous membranes 316–319
- porous polycarbonate track-etched membrane (PCTEM) 69
- porous stainless steel hollow fiber (PSSHF) 17
- positively charged GO membranes 132, 133
- positron annihilation spectroscopy (PAS) 153
- postcombustion capture 36, 46, 60
- post-synthetic deposition 223–226
- p*-phenylenediamine (PPD) 96, 128, 153
- pressure-assisted self-assembly (PASA) 153, 156, 162, 198
- pristine graphene-based membrane 94, 108
- pristine graphene oxide (pGO) nanosheets 282
- Prussian blue (PB) nanoparticles 162
- pyridinic nanoporous graphene 116
- q**
- quantitative ionic flux 323
- quantum effects 341, 355
- r**
- Raman spectroscopy 49, 57, 66
- rate-determining step (RDS) 60
- reduced graphene oxide (rGO) membranes 86, 130
- relative humidity (RH)-dependent CO₂ separation efficiency 347
- relative water movement 90
- reverse electrodialysis (RED) 314, 321
- reverse osmosis (RO) 2, 13, 84, 93, 100, 105, 107, 113, 146, 226, 240–241, 244, 246, 314
- reverse selectivity 42, 339, 348
- Robeson upper bound 26, 35, 183, 286, 324
- s**
- Scotch-tape method 4, 192
- selective-etching method 3, 4, 8–9
- separation processes 1, 13, 29, 35, 36, 93, 94, 118, 123, 164, 173, 174, 190, 210, 238, 243, 246, 253, 254, 290, 304, 305, 314, 315, 318, 324, 326, 366
- shear force 4, 5, 15, 16, 19, 181, 192, 266
- side-pinning effect 90, 122
- silicon carbide (SiC) 329

- silicon nanotubes (SiNTs) 329
 silicon nitride (SiN) 118, 178, 329
 single-digit nanopores 327
 single-layered graphene/GO/rGO
 nanosheets 107
 single-layer graphene (SLG) 36
 experimental validation 118–120
 sheet 13
 theoretical calculations 115–118
 single-layer nanoporous graphene
 116–119
 single-walled carbon nanotubes
 (SWCNTs) 14, 70, 329
 size-controlling effects 96
 slip-flow theory 89
 slip length 331–333
 slit-like two-dimensional (2D)
 nanochannels 328
 small-scale decentralized operation 35
 smart gating effects 97–100
 sodium alginate (SA) 132, 163, 199,
 264, 282
 sodium cholate (SC) 4
 sodium dodecylbenzenesulfonate
 (SDBS) 4
 sodium 1,4-phenylenediamine-2-
 sulfonate (PDASA(Na⁺)) 156
 solution chemistry effects 91–92
 solution–diffusion model 316, 320,
 327, 342, 349, 355
 solvent-controlling drying method
 107
 solvo/hydrothermal syntheses 194
 sonication 4–7, 11, 87, 192, 253, 255,
 256
 sp³-bond carbon 88
 spherical polyelectrolyte brush (SPB)
 162
 spin-coating method 15
 spiral-wound membranes 38
 stabilizing effects 94–95
 staked 2D membranes with laminar
 structure 316, 342, 345–350
 Stokes equation 331
 subnanometer nanopores 55
 sulfobetaine methacrylate (SBMA)
 239
 sulfonated graphene oxide (SGO)
 membrane 164
 sulfosuccinic acid (SSA) 96, 157
 super-hydrophilic MOF
 UiO-66(Zr)–(COOH)₂ 162
 surface chemistry-mediated transport
 88–91
 surface chemistry-modifying effects
 96–97
 surface-promoted aryl–aryl coupling
 51, 120
- t**
- temperature-gated GO membrane 97
 temperature-sensitive polymerized
 N-isopropylacrylamide
 (PNIPAM) 97
 terminal oxygen atoms 63
 thermally rearranged (TR) polymers
 27, 315, 321, 329
 thin-film composite (TFC) membranes
 28, 239, 315
 thin-film nanocomposite (TFN)
 membranes 240, 261
 thiourea (TU) 153
 Ti₃C₂T_x 253
 TiO₂ nanotubes 329
 top-down micromechanical exfoliation
 36
 track-etched polycarbonate membranes
 318
 transfer graphene 68
 transferred energy 52
 transition metal carbide (Mxene) 8,
 253, 315
 transition metal dichalcogenides
 (TMDs) 8, 173, 188, 253,
 292–293

- transmembrane pressure 40, 58, 70, 72, 242
- transmission electron microscopy (TEM) 24, 29, 44, 365
- transport mechanism 366
- transport mechanism, in
- two-dimensional (2D) membranes
 - charged membranes 321–324
 - nonporous membranes 319–321
 - permeability-selectivity trade-off for polymers 324–326
 - porous membranes 317–319
- tungsten hexachloride 9
- 2D ionic covalent organic nanosheets (iCONs) 183
- 2D lattice 38
- two-dimensional (2D) layer 36
- two-dimensional-material-based mixed-matrix membranes (MMMs) 2
- fabrication methods of 24–25
 - NATMs 343
 - other hybrid membranes 27–29
 - physicochemical properties of, 2D fillers 25–27
- 2D materials-embedded mixed-matrix membranes (MMMs) 350
- 2D materials-enabled nanochannels 328
- two-dimensional (2D) materials membranes
- assembly strategies of, laminates 15–18
 - boron nitride (BN) 188
 - bottom-up method 199–201
 - COFs 183–185
 - gas separations 201–210
 - $\text{g-C}_3\text{N}_4$ 185
 - graphene-based materials 176
 - MOFs 181
 - MXenes 185–188
 - nanostructure controlling
- interlayer channel 18–23
- surface properties 23–24
- top-down method
- coating processes 198–199
 - filtration-assisted assembly 196–198
 - layer-by-layer assembly method 199
- 2D nanosheet fabrication approach 190
- zeolites 174–176
- two-dimensional-material membranes (2DMMs) 3, 11, 16, 18
- two-dimensional-material nanosheet membranes
- MOF membrane 12–13
 - porous graphene membrane 13–14
 - zeolite membrane 11–12
- 2D nanochannels 19, 20, 121, 130, 134, 139, 328, 338
- 2D nanosheet fabrication approach
- bottom-up 194–196
 - top-down 190–193
- 2D polyphenylene networks 120
- 2D RUB-15 membrane 176
- 2D zeolite nanosheets 11

U

- Ullman coupling 51
- ultrafast water permeability 114, 120–123, 138
- ultrafiltration 2, 17, 226, 239, 243, 246, 314, 317, 318, 325, 326
- ultrathin membrane 11, 27–30, 88, 173, 229, 299, 316, 365
- ultrathin nanosheets 1, 10, 12, 16, 18, 181, 185
- uniformity 17, 57, 83, 121, 124, 226
- unique mass transport properties, in 2D membranes
- mixed-matrix membranes (MMMs) 350–355

- unique mass transport properties, in 2D membranes (*contd.*)
- nanoporous atomically thin 2D membranes (NATMs) 342–345
 - staked 2D membranes with laminar structure 345–350
- V**
- vacuum-assisted self-assembly (VASA) 196, 231, 296, 301
- van der Waals gap 38
- van der Waals interaction 4, 7, 8, 23, 189, 338
- volatile organic compounds (VOCs) 146
- volumetric slip flow 333
- W**
- water/divalent ion separation 314
- water–ethanol system 149
- water/monovalent ion separation 314
- water separation 83
- Y**
- Young’s modulus 37, 68, 292
- Z**
- zeolite imidazolate framework (ZIF) 286
- zeolitic imidazolate framework-8 (ZIF-8) 27, 104
- zeolite membrane 11–12, 36, 152, 175
- zero-dimensional (0D) nanopores 328, 338
- ZIF-8-ZnAl-NO₃ LDH 227
- ZnAl-NO₃ LDH 227, 228, 237, 238, 244
- zwitterion–hydrotalcite (ZHT) 239
- zwitterionic copolymer 165
- zwitterionic GO (ZGO) 158

