

Index

Note: Page numbers in *italics* and **bold** refers to figures and tables respectively.

a

- abrasion test 29–30, 30
 - mechanical 175
 - sandpaper 25
 - Taber 170
- adhesion, coating 24, 26–27, 26
- adhesion force (AF) 295
 - ice 192
 - real 145
 - solid–liquid 103
- adhesion-peeling cycle 319–321
- adhesion strength 236, **238**, **239**
- adhesion stress 235
- adjustment reduction factor 236
- ADP. *see* aluminum dihydrogen phosphate (ADP)
- advancing contact angle (θ_{Adv}) 5, 6–7, 221, 224
- AF. *see* adhesion force (AF)
- AI. *see* artificial intelligence (AI)
- air plastron 134
- air pollutants 257, 323–324
- aluminum dihydrogen phosphate (ADP) 24–25, 25, 169, 205
- aluminum phosphate binder (AP binder) 204, 321
- 3-aminopropyltriethoxysilane (APTES) 25, 138, 275
- ammonium persulfate ((NH₄)₂S₂O₈) 147
- ammonium polyphosphate 133–134, 275
- anodizing 145, 148–149, *148–151*
- antibacterial CuS agent 204
- antibacterial properties 115, 128, 136–137, *136*, 279, 300
- antibacterial purposes 194
- anti-biofouling superamphiphobic surfaces 306–308, *307*
- antifogging 59, 327, 329
- antifouling 21, 35, 52, 77, 105–106, 123, 132, *134*, 137–138, 194, 329–330. *see also* fouling
 - clean energy transitions 253–254
 - food industry 253
 - marine equipments 250
 - oil and gas industry 254–255
 - separation membranes 251–253
 - superamphiphobic surfaces for 250
- antifrosting function of superamphiphobic surfaces 233–235
- anti-icing 21, 35, 55, 69, 76–77, 99, 113, 181, 192–193, 265, 332
 - performance of superamphiphobic surfaces 230–233, *231*
 - total freezing delay time **232**
- antiwetting 22–23, 317
- AP binder. *see* aluminum phosphate binder (AP binder)
- armored reentrant surface (AR surface) 186, 194
- AR surface. *see* armored reentrant surface (AR surface)

Superamphiphobic Surfaces: Fabrication, Characterization, and Applications, First Edition.
Edited by Junping Zhang and Mohammad Shahid.
© 2025 Wiley-VCH. Published 2025 by Wiley-VCH.

artificial intelligence (AI) 316, 325–326
 ATP. *see* attapulgite (ATP)
 attapulgite (ATP) 98, 99–104, 100, 102, 104, 207, 269
 AZ5214 photoresist layer 56

b

BADGE. *see* bisphenol A diglycidyl ether (BADGE)
 bamboo, superamphiphobic surface
 on 279, 280
 bayerite ($\text{Al}(\text{OH})_3$) 146, 147
 1,2,3-benzotriazole (BTA) 208
 Bernoulli's equation 223
 big data analysis 316, 325–327
 bilayer superamphiphobic surface 192
 binding force, enhancing 35, 37
 bioinspired superamphiphobic surfaces 257
 bisphenol A diglycidyl ether (BADGE) 207
 bistouries 331
 boronic acid (H_3BO_3) 150
 bottom-up approaches 98, 181, 186–187
 bouncing droplet, contact time
 of 224–225, 233
 BTA. *see* 1,2,3-benzotriazole (BTA)
 building exteriors 257
 building materials
 anti-biofouling superamphiphobic
 surfaces 306–308, 307
 corrosion protection, superamphiphobic
 surfaces for 270–273, 271, 272
 damaging effects of water and water
 inhibition 291–292
 degradation 289
 highly transparent superamphiphobic
 surfaces 304–306
 historical buildings and stone
 artifacts 292
 improvement strategies 301–308
 insufficient antimicrobial effect 300, 301
 key bottlenecks 297–300
 low transparency and surface color
 change 298–300, 299
 multifunctional superamphiphobic
 protective coatings 292

patterns in outdoor environments 290
 phenomena and mechanisms 289–291
 poor chemical/mechanical
 durability 297–298
 self-healing property, enhancing durability
 through endowing 302–304
 superamphiphobic surfaces for 292–297
 surface roughness and hydrophobization,
 one-step creation of 294–297
 two-step preparation by “pre-roughening
 and post-modifying” 297
 wear-resistant micro/nanostructures,
 enhancing durability through 302, 303

c

CAH. *see* contact angle hysteresis (CAH)
 carbon nanotubes (CNTs) 76, 98, 113
 CAs. *see* contact angles (CAs)
 Cassie–Baxter equation 6, 125, 220,
 315–316, 320
 Cassie–Baxter model 23, 23, 129, 182–183,
 186–187
 Cassie–Baxter regime 5–6, 5, 297
 Cassie–Baxter wetting 23, 104, 300
 Cassie–Wenzel transition 237
 Cassie–Wenzel wetting transition 223–224
 cellulose 328
 bacterial 98
 nanofibers 109
 nanofibrils 110
 centrifugal test method 235
 ceresine wax 207–208
 chemical degradation 289
 chemical etching 45, 98, 124, 126, 129–130,
 129, 146–147, 146, 147, 322, 323
 Al alloy surfaces 38
 on SAP surfaces 321, 322
 chemical instability 321–323
 chemical vapor deposition (CVD) 25, 124,
 126, 130, 131, 272, 323
 clean energy transitions 253–254, 254
 CNTs. *see* carbon nanotubes (CNTs)
 coating adhesion 24, 26–27, 26
 coaxial electrospinning method 51, 79
 coefficient of friction (COF) 27

- coefficient of restitution 226–227, 227
 - COF. *see* coefficient of friction (COF)
 - commercial solar panels 191
 - complete rebound, threshold velocities for 222–224
 - condensate droplets 233–235
 - distribution of 235
 - freezing of 233
 - condensate halo 229–230
 - condensation frosting 229, 233, 234, 240
 - conducting polymers 84, 145, 154–158, 155–158
 - contact angle hysteresis (CAH) 4, 6–7, 22, 56, 221, 296
 - contact angles (CAs) 22, 22, 24–25, 25, 30, 45, 123, 219, 264, 294–295
 - advancing 5, 6–7, 221, 224
 - oil 83, 201, 320
 - receding 5, 6–7, 22, 221
 - static 4–6, 97, 165, 181, 185
 - water 75, 230, 320
 - contact time of bouncing
 - droplet 224–225, 240
 - copper (Cu) 9, 147
 - copper oxide (CuO) nano-needles 147, 147
 - core-shell droplets 195
 - corrosion protection 282
 - building material corrosion protection 270–273
 - fabric corrosion protection 274–279
 - for magnesium alloy 104
 - metal corrosion protection 265–270
 - of metallic equipment 250, 252
 - substrate corrosion protection 279–281
 - superamphiphobic surfaces applications in 264
 - superwetting surfaces 266
 - corrosion resistance 36, 45, 55, 87, 106, 150, 191–192, 272, 276, 278–279, 281
 - cotton fabrics 106, 128, 263, 307
 - flame retardancy of 275
 - surface of 137
 - coupling hardness with softness
 - superamphiphobic surface 174–177, 177
 - crush test 30–31, 31
 - CTAB. *see* hexadecyl trimethyl ammonium bromide (CTAB)
 - CVD. *see* chemical vapor deposition (CVD)
- d**
- decafluoropentane 183
 - 1-decane-thiol (DT) 9
 - deep learning 325–326
 - desublimation 229–230
 - dip coating technique 58–62, 59, 60, 62, 85–86, 86, 126–128, 127, 181
 - disulfide bonds 209–210, 268–269
 - dodecyltrimethoxysilane (DTMS) 89
 - drop impact test 30–31, 31
 - droplet freezing fundamentals on solid surfaces 227–230, 228
 - droplet–surface friction (W_f) 227
 - dropwise freezing 233
 - dry etching 53
 - DSPUA. *see* UV light curable polyurethane acrylic resin (DSPUA)
 - DTMS. *see* dodecyltrimethoxysilane (DTMS)
 - dual-channel spray-assisted nanocoating
 - hybrid of shellac/copper nanoparticles 136
 - dual self-healing superamphiphobic coating 206
 - DuPont Zonyl321 fluorocarbon surfactant 10
 - dynamic pressure 223–224
 - dynamic reversible chemical bonds 208–209
 - dynamic reversible molecular self-healing 202, 208–210
- e**
- EDOT. *see* 3,4-ethylenedioxythiophene (EDOT)
 - electrochemical processes 145
 - anodizing 148–149, 148–151
 - chemical etching 146–147, 146, 147
 - electrodeposition 149–158
 - superamphiphobic surfaces by 145
 - electrodeposition 33, 45, 83–85, 84, 149–158
 - conducting polymers 154–158, 155–158
 - metals 149–154, 152–154

- electroless deposition 146, 152
 - electrospinning 45, 51–53, 52, 78–80, 79, 98, 252, 323
 - enhancement strategies of superamphiphobic surface 170
 - coupling hardness with softness
 - superamphiphobic surface 174–177, 177
 - framework structure 170–172, 173, 174
 - organic/inorganic binder reinforcement
 - superamphiphobic surface 167–170, 168, 169
 - self-repairing superamphiphobic surface 172–174, 175, 176
 - self-similar structure superamphiphobic surface 170, 171, 172
 - environment-friendly production of SAP surfaces 327–328
 - erosion 165, 270, 275, 321–322
 - etching 53–55, 54, 56, 329
 - chemical 38, 45, 306, 322–323
 - dry 53
 - HCl 55
 - laser 54, 323
 - plasma 45
 - procedure 10–11
 - reactive ion 13
 - time 55
 - wet 53
 - ethyl 2-cyanoacrylate 134, 275
 - 3,4-ethylenedioxythiophene (EDOT) 89
 - extrinsic self-healing 302–303
- f**
- fabrication methods 45–46
 - dip coating technique 58–62, 59, 60, 62
 - electrospinning 51–53, 52
 - etching 53–55, 54
 - lithography 56–58, 57
 - sol-gel method 62–66, 63, 64, 65
 - spray-coating technique 46–51
 - of superamphiphobic fabrics 126–131
 - template-assisted technique 66–69, 67, 68
 - fabric corrosion protection,
 - superamphiphobic surfaces for 274, 276, 277, 278
 - fabric roughness 124–126
 - falling 319–321
 - FAS. *see* fluorinated alkyl silane (FAS); fluoroalkyl silane (FAS)
 - FD-POSS. *see* fluorinated decyl polyhedral oligomeric silsesquioxane (FD-POSS)
 - femtosecond laser ablation 181
 - flame retardancy 133–134, 134, 275
 - fluorinated alkyl compounds 319, 328
 - fluorinated alkyl silane (FAS) 10, 13, 89–90, 193, 202, 278
 - fluorinated alkyl silane-modified silica (F-SiO₂) 276
 - fluorinated attapulgite (fluoroATP) 208
 - fluorinated decyl polyhedral oligomeric silsesquioxane (FD-POSS) 85, 89–90, 202
 - fluorinated multiwalled carbon nanotubes (F-MWCNTs) 13, 14, 299
 - fluorinated polycaprolactone (PCL-b-PTFOA) 52
 - fluorinated polyhedral oligomeric silsesquioxanes (F-POSS) 274
 - fluorinated polymers (F-polymers) 8, 8, 84, 124
 - fluorinated polyurethane (FPU) 10, 80, 89
 - fluorine chemistry 327
 - fluoroalkanes 8–9
 - fluoroalkyl silane (FAS) 35, 85, 89, 110, 126, 135, 188–189, 298
 - fluoroalkyl surface-modified silica nanoparticles (FS-NPs) 85
 - fluoroATP. *see* fluorinated attapulgite (fluoroATP)
 - fluoro-attapulgite (fluoro-ATP) 46, 47
 - fluorodecyl polysiloxane (fluoroPOS) 99–100
 - fluoropolymers 8–10, 125–126, 188, 253, 277
 - fluoroPOS. *see* fluorodecyl polysiloxane (fluoroPOS)
 - fluorosilanes 9, 187, 202

- fluorosurfactants 8, 10, 11
 fluoroethiols 9
 F-monomers 8
 F-MWCNTs. *see* fluorinated multiwalled carbon nanotubes (F-MWCNTs)
 food industry 253
 fouling 76, 191, 194, 250, 252, 254. *see also*
 antifouling
 environments 249
 membrane 252
 proteins/minerals 253
 in seawater 300
 four-tier hierarchical macro/micro/
 nanostructure superamphiphobic
 surfaces 193
 FPU. *see* fluorinated polyurethane (FPU)
 friction 315, 319–321, 329
 current-carrying 112
 droplet–surface 227
 surface 201
 frosting
 condensation 229, 233, 234, 240
 phenomena on solid surfaces 227–235
 FS-61 fluorinated kaolin 204
 FS-NPs. *see* fluoroalkyl surface-modified
 silica nanoparticles (FS-NPs)
- g**
- gecko state 5, 6
 Gibbs free energy
 barrier for heterogeneous and homogenous
 ice nucleation 230
 density 125
 glass transition temperatures (T_g) 208
 green chemistry 35
 envisioned production of SAP surfaces
 based on 328
 short-chain fluorinated chemicals
 in 327
- h**
- halloysite nanotubes (HNTs) 98–99,
 104–106, 105, 106, 190
 hammer pressure 223–224
 healable SAP surfaces 328–330
 heptadecafluorodecyltriethoxysilane
 (FAS) 276
 hexadecane 7–8, 38, 49, 66, 79, 84, 89–90,
 112, 132, 147, 150–151, 156, 184, 299
 contact angle 58, 82–83, 110
 droplets 109, 127, 280
 hexadecyltriethoxysilane 99
 hexadecyl trimethyl ammonium bromide
 (CTAB) 307
 hexafluoropropylene (HFP) 276
 HF acid solution. *see* hydrofluoric acid
 solution (HF acid solution)
 HFP. *see* hexafluoropropylene (HFP)
 highly transparent superamphiphobic
 surfaces 304–306
 high-speed impinging water droplets 237
 HNTs. *see* halloysite nanotubes (HNTs)
 1H,1H,2H,2H-
 perfluoroalkyltriethoxysilanes 170
 1H,1H,2H,2H-perfluorodecane-1-thiol
 (PFDSH) 8
 1H,1H,2H,2H-perfluorodecyl (FD-POSS) 10
 1H,1H,2H,2H-perfluorodecyl acrylate
 (PFDAE) 8
 1H,1H,2H,2H-perfluorodecyl trichlorosilane
 (PFDTS) 8–9, 8
 1H,1H,2H,2H-perfluorodecyltriethoxysilane
 (PFDTES) 8, 9, 99, 113, 127, 138
 1H,1H,2H,2H-perfluorooctanoic acid
 (PFOA) 8, 8–9
 1H,1H,2H,2H-perfluorooctyl (FO-POSS) 10
 1H,1H,2H,2H-perfluorooctyl phosphate
 (PFOP) 8
 1H,1H,2H,2H-perfluorooctyl trichlorosilane
 (PFOTS) 8, 8, 9, 35, 275
 hydrofluoric acid solution (HF acid
 solution) 146
 hydrophobicity 4, 5, 7, 52, 130, 134, 136,
 264. *see also* superhydrophobicity
 biphilic pattern of alternating 105
 reduction of 305
 surface 231, 234
 for water and glycerol 54

hydrophobization
 one-step creation of 294–297
 surface 297
 hysteresis (H) 145

i

ice adhesion
 force 192
 icephobic performance 236–239, 237
 strength 235–237, 239
 on superamphiphobic surfaces 235
 test methods 235–236
 ice bridge 229
 icephobic surfaces 236
 ice propagation mechanism 229
 icing 331. *see also* anti-icing
 issues in aerospace industry 332
 phenomena on solid surfaces 227–235
 immersion-stable superamphiphobic
 surfaces 189
 impact phase diagram 221–222
 impact test 30–31
 drop 30–31
 sand 27
 water 27, 31
 impact toughness 27, 28
 impalement resistance 97, 113, 181,
 188–189, 195
 of liquids 183
 surface 187–188
 impalement-resistant superamphiphobic
 surfaces 181–182, 188–190
 anticorrosion performance, difference in 192
 applications 191–195
 controllable structure parameters and
 bouncing behaviors of ethanol
 droplet 185
 delay water freezing time 193
 hierarchical structures 187
 liquid repellency of double re-entrant
 PDMS microfibrils 184
 other structures 188
 reentrant structures 182–187
 special structures 182–188
 surface chemical enhancement 188–191
 intrinsic self-healing 206, 302

j

Jeffamine D230 207

k

kaolin 98, 106–108, 107
 FS-61 fluorinated 204
 particles 132

l

Laplace's law 31
 laponite RD 99
 lap shear test 235
 laser etching 53–54, 267, 323
 lauryl methacrylate (LMA) 130
 liquid droplets 30, 138, 145, 184, 187, 221, 229
 contact angles of 183
 control and transport of 194
 penetration of 181
 suspension of spherical 319
 liquid-infused state 5, 6
 liquid marbles 138, 329
 magnetic 103
 versatile 332
 liquid repellency 13–14, 130, 136, 186,
 188, 257
 corrosion 132
 of double re-entrant PDMS
 microfibrils 184
 fabric's 125
 imparting 133
 properties of 105
 lithography 45, 56–58, 57, 69, 80–82, 81,
 156, 323
 colloidal 82
 reverse imprint 13
 soft 13
 three-dimensional diffuser 80
 LMA. *see* lauryl methacrylate (LMA)
 lotus effect 76, 125
 low surface energy materials 128, 181, 183,
 204, 253
 deposit layers of 130
 design of 124–125
 directional migration of 303
 rough substrate with 45
 self-healing of 201–202

low surface energy substances 126,
175, 271
multilevel micro/nanostructures and
self-healing of 202, 203

m

machine learning 316, 325–327
magnesium (Mg) 149, 265
alloys 27, 103, 192, 298
substrates 149
marine equipments 250, 251
Martindale method 202
maximum Laplace pressure 224
maximum spreading factor 224–225,
225, 240
maximum spreading radius 222, 224
mechanical durability 21, 275, 298, 302
abrasion test 29–30, 30
binding force, enhancing 35, 37
categories of properties 23, 24
characterization methods of 27–33
coating adhesion 26–27, 26
crush test 31, 31
drop impact test 30–31, 31
impact test 30–31
impact toughness 27, 28
key parameters 24–27
multifunctional coatings to
strengthen 36–38, 38
nanoscratching test 27–28, 29
stable construction to enhance 33, 34
strategies to improve 33–38
surface chemical modulation to
improve 35, 36
tape stripping test 33, 33
theory of wetting 22–24
washing test 31–33, 32
water impact testing 31, 31
wear resistance 24–26, 25
mechanical fragility 319–321
mechanically durable superamphiphobic
surfaces 165–167
enhancement strategies of
superamphiphobic surface 170–177
future perspectives 177
wetting states of oil droplet 166

medical equipment 255–256
membrane-based filtration processes 251
membrane fouling 252
metal corrosion protection, superamphiphobic
surfaces for 265–270, 267, 268, 269
metals 123, 126, 149–154, 152–154, 264–265,
281, 306, 323
electrodeposition of 145
long-term corrosion protection of 270
superamphiphobic surfaces on 45
metastable Cassie state 5, 6
methanol 80, 183–184
3,4-methylenedioxy pyrrole (F-EDOP) 84
microcapsule self-healing 201
microchannels 194
microfluidic(s) 195, 255
applications 194
control 316
manipulation 194–195
transport 181
micro/nano reentrant superamphiphobic
surface 186
micropumps 194
micro-scale roughness 65, 280
microvalves 194
MI-dPG. *see* mussel-inspired dendritic
polymer (MI-dPG)
moisture 124, 263–264
absorption capacity of cotton fabrics 137
droplet 22
sensitivity 105
montmorillonite 98–99
and clay minerals 99, 108–109
particles on polyamide 66 fabrics 108
multifunctional coatings 35–38, 38
multifunctional superamphiphobic coatings,
fabrication of 206, 206
mussel-inspired dendritic polymer
(MI-dPG) 85, 86

n

nanolithography 181
nanoscale roughness 51, 80, 187, 280
nanoscratching
technology 27–28
test 27–28, 29

- natural clay minerals 98
 - attapulgite 99–104
 - halloysite nanotubes 104–106, 105, 106
 - kaolin 106–108, 107
 - montmorillonite and clay minerals 108–109
 - superamphiphobic surfaces based on 98
- natural materials 98, 111–113, 112
- natural nanomaterials 98, 114
 - advantages and challenges 113–114
 - natural clay minerals 98–109
 - natural materials 111–113, 112
 - natural polymeric nanomaterials 109–111, 110
 - prospects 114–115
 - superamphiphobic surfaces based on 97–98
- natural polymeric nanomaterials 109–111, 110
- neopentyl glycol diglycidyl ether (NGDE) 207
- next-generation SAP surface technologies 316
- NGDE. *see* neopentyl glycol diglycidyl ether (NGDE)
- n*-heptane 105, 187
- n*-hexadecane 27, 46, 48–49, 55, 61, 68, 145, 187, 189–190, 204, 208, 269
- nickel (Ni) 150
- niobium (Nb) 149
- niobium oxide (Nb₂O₅) 149
- N-methylmorpholine-N-oxide (NMMO) 257
- NMMO. *see* N-methylmorpholine-N-oxide (NMMO)
- noncovalent bond self-healing materials 209
- O**
 - OCAs. *see* oil contact angles (OCAs)
 - octafluorocyclobutane (C₄F₈) 10–12
 - Ohnesorge number (Oh) 222
 - oil and gas industry 254–255
 - oil contact angles (OCAs) 83, 201, 320
 - oil–water separation 124, 131, 274
 - economical 137
 - self-cleaning and 131
 - oily aerosols 252
 - one-dimensional nanofiber morphology 66
 - one-pot fabrication technique 89
 - optical devices 255, 256
 - optical transmittance 67–68, 83, 109, 191, 305
 - organic/inorganic binder reinforcement
 - superamphiphobic surface 167–170, 168, 169
 - organic matter accumulation 249
 - organic solvents 165, 188, 270, 278
 - organosilanes 62, 99, 101
 - outdoor surfaces 249, 257
 - overhang structure 13, 14
 - oxygen 82, 263–264
 - oxygen-containing groups 204
 - plasma 56, 185
- P**
 - PAL. *see* palygorskite (PAL)
 - palygorskite (PAL), 99–104, 100, 102, 189. *see* attapulgite (ATP)
 - passive cooling 257
 - PDA. *see* polydopamine (PDA)
 - PDMS. *see* polydimethylsiloxane (PDMS)
 - PEEK. *see* polyether ether ketone (PEEK)
 - PEPE. *see* polyether-polyester (PEPE)
 - perfluorinated compounds (PFCs) 8, 8, 315
 - circulation of 318
 - elimination half-life of 318
 - negative impacts of 317–319
 - routes of 319
 - perfluorinated silane (PTES) 146, 152, 304
 - perfluorocarboxylic acids 9, 167, 317
 - perfluorodecanoic acid (PFDA) 8, 9
 - perfluorodecyl polysiloxane (FD-POS) 127, 274, 274
 - perfluorodecyl polysiloxane modified silica (PF-POS@silica) 172, 207
 - perfluorodecyltrichlorosilane (PFDTS) 89, 113, 278
 - 3-perfluoroether-amidopropylsilane (Si-PFE) 296
 - perfluorohexane 183
 - perfluorononanoic acid (PFNA) 8, 9

- perfluorooctyl methacrylate-co-divinylbenzene 130
- perfluorooctyltriethoxysilane (FAS) 206
- perfluorosilane acids 317
- PET. *see* polyethylene terephthalate (PET)
- petal state 5, 6
- PFCs. *see* perfluorinated compounds (PFCs)
- PFDA. *see* perfluorodecanoic acid (PFDA)
- PFDTs. *see* perfluorodecyltrichlorosilane (PFDTs)
- PFNA. *see* perfluorononanoic acid (PFNA)
- photothermal self-healing, superamphiphobic coating with 204, 204
- photovoltaic modules (PV modules) 253–254
- phytic acid 275
- plasma etching 45, 80, 82–83, 124, 126, 129–130
- plasma treatment 10–12, 11, 82–83, 82, 83
C₄F₈ 10, 83
oxygen 204
two-step argon 274
- PMMA. *see* polymethyl methacrylate (PMMA)
- PMP. *see* poly-4-methyl pentene (PMP)
- polarity of liquids 315, 317, 327
- polydimethylsiloxane (PDMS) 32, 77, 80, 83, 88, 88, 108, 203–204, 302
- polydopamine (PDA) 14, 136, 204, 306–307
- polyether ether ketone (PEEK) 28, 83
- polyether-polyester (PEPE) 83
- polyethylene terephthalate (PET) 32, 89
- polyhedral oligomeric silsesquioxane (POSS) 10, 11, 79
- polymethyl methacrylate (PMMA) 82–83, 89
- poly-4-methyl pentene (PMP) 252
- polypropylene (PP) 252
- polypyrrole (PPy) 89, 99
- polystyrene (PS) 80
- polytetrafluoroethylene (PTFE) 10, 29–30, 80, 82, 86, 202, 252, 267
- poly[3-(triisopropylloxysilyl)propyl methacrylate]-block-poly[2-(perfluorooctyl) ethyl methacrylate] 87
- polyvinylidene fluoride (PVDF) 30, 35, 80, 276
- poly(vinylidene fluoride-hexafluoropropylene) (PVDF-HFP) 53, 126
- porous structures 14–15, 14
- POSS. *see* polyhedral oligomeric silsesquioxane (POSS)
- post-fluorination 297, 323
- post-modifying/modification
dip-coating 85–86, 86
electrodeposition 83–85, 84
electrospinning 78–80, 79
lithography 80–82, 81
plasma treatment 82–83, 82, 83
of pre-roughened substrates 78
two-step preparation by 297
- post-roughening 98, 293, 323
- post-roughness of pre-modified substrates 86–88
sol-gel method 86–87, 87
template method 87–88, 88
- power-law dependences 225
- prefactor function 230
- pre-fluorination 323
- pre-roughening 323
two-step preparation by 297
- “pre-roughening and post-fluorination” strategy 297
- 3,4-propylenedioxy pyrrole (F-ProDOP) 84
- protective clothing 124, 132, 134–135, 135
- protective coatings 292, 295. *see also*
spray-coating
application of 291–292
specific requirements for eligible 293
superamphiphobic 294
- PTES. *see* perfluorinated silane (PTES)
- PTFE. *see* polytetrafluoroethylene (PTFE)
- PVDF. *see* polyvinylidene fluoride (PVDF)
- PVDF-HFP. *see* poly(vinylidene fluoride-hexafluoropropylene) (PVDF-HFP)
- PV modules. *see* photovoltaic modules (PV modules)
- ## q
- QACs. *see* quaternary ammonium compounds (QACs)
- quaternary ammonium compounds (QACs) 306–307

r

Rayleigh scattering 304–306
 reactive ion etching techniques 13
 reactive oxygen species (ROS) 306
 receding contact angle (θ_{Rec}) 6–7, 22, 221
 reentrant structure 13
 relative density of fluorosilane-functionalized silica 189
 releasable capsule self-healing 205–206, 205
 reverse imprint lithography 13
 reversible covalent bonds 209–210
 reversible noncovalent bonds 209–210
 Reynolds number (Re) 221–222
 ROA. *see* roll-off angle (ROA)
 robust particle-capsules strengthened coating (RPSC) 49
 roll-off angle (ROA) 7, 22, 165, 187
 ROS. *see* reactive oxygen species (ROS)
 RPSC. *see* robust particle-capsules strengthened coating (RPSC)

s

SA. *see* sliding angle (θ_{SA})
 sand abrasion 35, 202
 sand impact testing 27, 28
 SAP surfaces. *see* superamphiphobic surfaces (SAP surfaces)
 scalable fabrication method 186
 sediment deposition 249, 254
 self-assembly technique 25
 self-cleaning 35, 132, 133, 191, 300
 fabrics 257, 258
 medical equipment 255–256
 optical devices 255
 outdoor surfaces 257
 superamphiphobic surfaces for 255
 self-healing 10, 36, 63, 315, 330
 dynamic reversible molecular self-healing 208–210
 extrinsic 302–303
 intrinsic 206, 302
 of low surface energy materials 201
 low surface energy substances 202–205, 203
 methods and mechanisms 202–210

releasable capsule
 self-healing 205–206, 205
 shape memory polymer
 self-healing 206–208
 superamphiphobic surfaces 201
 self-healing properties (SHEP) 172
 enhancing durability through endowing 302–304
 self-repairing superamphiphobic surface 172–174, 175, 176
 self-similar structure superamphiphobic surface 170, 171, 172
 separation membranes 251–253, 253
 sepiolite 98–99, 101, 108–109
 SFNs. *see* silica–fluoropolymer hybrid nanoparticles (SFNs)
 SHA. *see* shedding angle (θ_{SHA})
 shape memory polymers (SMP) 103, 269, 304
 self-healing and anticorrosion mechanisms 206, 207
 SMP-BTA/fluoroATP coatings 208
 shape memory polymers-benzotriazole (SMP-BTA) 46, 47, 269
 shear test 235, 236
 shedding angle (θ_{SHA}) 5, 7, 22
 SHEP. *see* self-healing properties (SHEP)
 silica–fluoropolymer hybrid nanoparticles (SFNs) 280
 silica nanoparticles (SNs) 86, 204
 SIMM array 13
 single-step dip coating method 59
 single-step spray coating 46–49, 47
 single-step vapor-phase polymerization technique 89
 SiO₂ NPs. *see* silica nanoparticles (SNs)
 sliding angle (θ_{SA}) 5, 7, 22, 32, 67–68, 75, 145, 221, 297, 321
 slippery liquid-infused porous surfaces (SLIPS) 159
 SLIPS. *see* slippery liquid-infused porous surfaces (SLIPS)
 SMANP. *see* surface of Al₂O₃ nanoparticles (SMANP)
 SMP. *see* shape memory polymers (SMP)

- SMP-BTA. *see* shape memory polymers-benzotriazole (SMP-BTA)
- sol-gel method 62–66, 63, 64, 65, 86–87, 87
- solubilized salts 291
- spray-coating 46–51, 128, 128, 181, 188–189
 single-step 46–49, 47
 two-step 49–51, 50
- stability tests 145
- stable SAP surfaces 328–330
- Staphylococcus aureus* 194
- static contact angle 4–6, 97, 165, 181, 185
- static wetting
 sessile droplet sitting on ideal solid surface 220
 on superamphiphobic surfaces 219
 water droplet, contact angles of 221
- stone biodeterioration 289–291
- stone degradation 289, 291
- substrate corrosion protection,
 superamphiphobic surfaces for 279–281
- superamphiphobic antifouling surfaces 249
- superamphiphobic bionic proboscis 194
- superamphiphobic fabrics 60–61, 123–124
 applications of 124
 challenges and perspectives 138–139
 design principles of 124–126
 fabrication methods of 126–131
 functional applications of 132–138
 testing of 131
- superamphiphobicity 4, 23, 33, 66, 99–100, 104, 113, 125–129, 298–299, 305, 327, 330–332
 characterization of 97
 chemical composition 7–8
 of coatings 101–103
 homogeneous 323
 loss of 297
 mechanism for 7–15
 natural creatures with special wettability 3–4, 4
 overhang structure 13, 14
 porous structures 14–15, 14
 restoration of 37
 of SAP surfaces 320
- special rough morphology 12–13, 12
- wettability, characterization of 4–7
- superamphiphobic materials 76, 80, 108, 201, 291, 297
 fabrication of durable 107
 with multilayer self-similar structures 170
 self-similar structure 171
 shape memory self-healing 207
 transparent 191
- superamphiphobic polymeric surfaces 75–77, 77
 fabrication of 78–90
 perspectives of 90–91
- superamphiphobic stainless steel surface 53–54, 54
- superamphiphobic surfaces (SAP surfaces) 13–14, 21, 23, 45, 181, 201, 219, 249, 315
 for antifouling 250–255
 antifrosting function of 233–235
 anti-icing performance of 230–233
 applications in corrosion protection 264–281
 based on natural clay minerals 98–109
 based on natural materials 111–113
 based on natural polymeric nanomaterials 109–111
 for building materials 292–297
 challenges in scalable production 323
 chemical instability 321–323
 current status and future research directions 257–258
 current technologies for preparing 324
 current wetting model, limitations of 316–317, 316
 environment-friendly production of 327–328
 envisioned production 328
 future prospects 325–332
 ice adhesion on 235–239
 icing and frosting phenomena on solid surfaces 227–235
 interdisciplinary applications 330–332, 331

superamphiphobic surfaces (*Continued*)

limitations 325
 main challenges of current SAP
 materials 316–325
 mechanical fragility 319–321
 mechanical impacts and consequences on
 SAP surface structures and
 wettability 320
 perfluorinated compounds, negative
 impacts of 317–319
 problems 323–325
 for self-cleaning 255–257
 stable and healable SAP surfaces 328–330
 static wetting on 219–221
 utilization of sensors for defect detection
 on 330
 utilizing
 advanced technologies 325–327, 326
 wetting dynamics on 221–227
 super-antiwetting surfaces 4, 75–76
 supercooling 227, 233
 superhydrophobicity 4, 5, 45, 49, 55, 59,
 75–76, 97–98, 111, 113, 131, 231, 236,
 265, 278
 of coatings 99
 theory of 76
 superhydrophobic surfaces 76, 97–99, 132,
 154, 165, 181, 226, 230, 237, 249, 264,
 291, 300
 adhesion strength of ice measured on 239
 anti-icing property of 231
 creation of 98
 freezing of condensate droplets on 234
 functional 99
 microscopic structures of 219
 oleophilic properties of 263
 sequential development of 86
 water-repellence of 235
 supernumerary low-surface energy
 substances 202
 superoleophobicity 6, 13, 45, 75–76, 111,
 137, 265
 superoleophobic surfaces 3, 6, 13, 75–76,
 263–265

super-repellency 13, 136, 187, 317, 321, 324,
 328, 330–331
 superwetting 22, 263
 surface chemical modulation 35, 36, 39
 surface chemistry 76, 88, 129, 188, 202, 257,
 304, 315–316, 321, 323, 325, 332
 surface fluorination 9, 51, 98, 124, 126,
 183, 252
 surface of Al₂O₃ nanoparticles
 (SMANP) 209, 210
 surface roughness 5, 9, 55, 63, 66, 77–78, 98,
 109, 126, 166, 299, 304–306
 manipulation of 86–87
 one-step creation of 294–297, 294, 296
 surface structures 66, 80, 187–188, 194, 239
 design of 125–126
 microscopic 234
 self-healing 201
 surface superamphiphobicity 78, 88–90, 90
 surface topology 12–13, 12, 63, 297, 300, 302
 surficial oil fouling 324

t

tape peeling test 26–27, 26, 58
 tape stripping test 27, 33, 33
 temperature stimulus response 202
 template-assisted spray coating
 method 305, 305
 template-assisted technique 66–69, 67, 68
 template method 87–88, 88
 templating 126, 323
 tensile stress test 236
 TEOS. *see* tetraethyl orthosilicate (TEOS)
 TEOS CVD. *see* tetraethyl orthosilicate
 chemical vapor deposition (TEOS CVD)
 tetraethyl orthosilicate (TEOS) 25, 85, 89, 99
 tetraethyl orthosilicate chemical vapor
 deposition (TEOS CVD) 25, 25
 textile coating technology 134
 three-dimensional diffuser lithography 80
 3D printing 181
 threshold velocities for complete
 rebound 222–224, 222

- tilt angle 5, 7. *see also* shedding angle; sliding angle
- tilting angle 97, 220
- titanium nanotubes arrays (TNAs) 254
- titanium (Ti) 146
- titanium dioxide (TiO₂) 323
- TNAs. *see* titania nanotubes arrays (TNAs)
- top-down approaches 98, 181
- traditional building materials 270
- triply reentrant arrays 194
- tungsten oxide (WO₃) 103
- two-layer self-healing superamphiphobic coating 103, 207–208
- two-photon polymerization-based 3D printing 185, 194
- two-step anodizing process 148–149
- two-step spray coating 46, 49–51, 50
- U**
- ultraviolet (UV) 268
 - light irradiation 36–37, 38, 210
 - UV-curable self-healing superamphiphobic coatings 209
- UV. *see* ultraviolet (UV)
- UV light curable polyurethane acrylic resin (DSPUA) 209
- V**
- vapor condensation 233–234
- viscosity of liquids 315, 317, 327
- viscous dissipation 223, 226–227
- viscous force 222, 225, 317
- VOCs. *see* volatile organic compounds (VOCs)
- volatile organic compounds (VOCs) 323
- W**
- washing test 31–33, 32
- water, damaging effects of 291–292
- waterborne polyurethane (WPU) 111, 134, 257
- waterborne superamphiphobic coating system 202
- water contact angles (θ_{CA}) 75, 230, 320
- water droplet freezing 227
- water impact testing 31, 31
- water inhibition, damaging effects of 291–292
- WBF process. *see* Wegener–Bergeron–Findeisen process (WBF process)
- WCAs. *see* water contact angles (θ_{CA})
- wear resistance 24–26, 25, 167–168
- wear-resistant micro/nanostructures, enhancing durability through 302, 303
- Weber number (We) 221–222, 225, 233
- Wegener–Bergeron–Findeisen process (WBF process) 229
- Wenzel model 23, 23, 24, 182
- Wenzel regime 5–6, 5
- wet-chemical technique 10
- wet etching 53
- wettability 22, 48, 52, 75, 106, 135, 249, 324
 - characterization of 4–7
 - contact angle hysteresis 6–7
 - disparity in 84
 - material's 7
 - natural creatures with 3–4, 4
 - pristine 329
 - rough structures enhancing 5
 - static 320
 - static contact angle 4–6
 - surface 55, 57, 75, 293
 - of viscous liquids 317
- wetted clay minerals 291
- wetting 4, 6, 299
 - coefficient of restitution 226–227
 - contact time 224–225
 - durability properties, categories of 23, 24
 - dynamics on superamphiphobic surfaces 221
 - lateral 317
 - maximum spreading factor 224–225, **225**
 - mechanical durability, categories of 23, 24
 - models 22–23, 23
 - parameters 22
 - pressure 224
 - theory of 22–24
 - threshold velocities for complete rebound 222–224, 222

windows 257
wood 10, 51, 76, 127, 271–272, 298
WPU. *see* waterborne polyurethane (WPU)

X

X-ray diffraction (XRD) 146
XRD. *see* X-ray diffraction (XRD)

Y

Young model 22–23, 23
Young's contact angle 220

Young's equation 4–5, 5, 22, 75, 315–316
Young's law 219

Z

zinc (Zn) 146
zinc oxide nanorod arrays (ZNA) 272, 273
zinc oxide (ZnO) reentrant
 structures 66–67
Zn. *see* zinc (Zn)
ZNA. *see* zinc oxide nanorod arrays (ZNA)
Zonyl321 (cationic surfactant) 202