

Index

a

accessibility

- acid sites 465
- Bronsted acid sites 469
- desilicated zeolites, acid sites 481–487

ACE testing. *see* advanced cracking evaluation testing (ACE) testing

acid sites accessibility 465

acidic properties, hierarchical zeolites. *see also* zeolite acidity studies

- advantages 463, 464
- ammonia sorption 463
- Bronsted type 461
- ¹³C NMR 461
- calorimetric data 462
- chemical shift, ¹H signal 461
- gravimetric and volumetric experiments 463
- hydrocarbon cracking reactions 463
- IR spectroscopy 462
- Lewis acid sites 461
- limitations 463, 464
- microcalorimetry 462
- proton NMR 461
- signal position, Si(OH)Al 461
- spectroscopic methods 461
- temperature-programmed desorption (TPD) 462

acidity

- control 259
- organosilanes 171–173

adsorbent surface 353

adsorptive 356

adsorptive separation process 341–344, 342t, 343f

advanced cracking evaluation testing (ACE) testing

– CPS-deactivated incumbent 2/MH-1 catalysts. 339–340, 341t

– equilibrium catalyst 338–339, 340t

– fluid catalytic cracking 335–341, 336f, 337t

aging of synthesis mixture 87

Al content 259

Al-grafted MCM-48 materials

- hydrothermal stability 134
- textural properties of 135t

alkali treatment

- mesopore formation 263–272, 269f–271f

– partial detemplation and desilication 271f

– SEM image 267f

– structure-directing agent 268

– temperature and duration 260–263, 262t

alkalinity 87

alkanes, cracking activities of 125t

alkoxysilane-containing surfactant/polymers 465

alkyltriethoxysilanes 164

Al-MCM-41 185

Al-rich zeolite Y 554

aluminophosphate (AlPO) 16, 63f

aluminophosphate nanometric-sized crystals 35t–39t

aluminosilicate zeolite ZSM-5 single crystals 450–451

aluminosilicates. *see also* mesostructured and mesoporous aluminosilicates

- acidity 150t

– 4,6-DMDBT 152f

– nitrogen sorption isotherms 151f

– from pentasil zeolite seeds 145–152, 147f, 148t–149t

– synthesis, zeolite/mesoporous composite material 116–124

aluminosilicates. *see also* mesostructured and mesoporous aluminosilicates (*contd.*)

- textural properties 150t
- zeolite/mesoporous composite 116

aluminum

- organosilanes 171–173
- postsynthesis grafting of 133–135, 134t, 135t

Al-ZSM-5 212

3-aminopropyltrimethoxysilane (APTMS) 163

ammonia temperature programmed desorption 171

amphiphile organosilanes 175–179, 176f, 177f

anomalous crystallization mechanism 60

apparent accessible area 364

argon 355

Atlas of Zeolite Structures 7

autocatalytic nucleation 86

automated diffraction tomography (ADT) 431

b

Bacillus subtilis 250

baptize 1

Barrett-Joyner-Halenda (BJH) mesopore size distributions 100, 101f

BEA zeolite 205–206, 206f

benzothiophene (BT) 186

BET area 364

beta zeolites (Beta-H), by PDADMAC polymer 200–201

beta zeolites using phenylaminopropyltrimethoxysilane (PHAPTMS) 160

beta/MCM-41 composite 125

- acidity of 125, 126t
- properties of 123
- *p*-xylene selectivity 126
- textural properties of 123t
- ¹²⁹Xe NMR chemical shifts of 123t

bimodal porosity 465

biodiesel 503

biofuels 503

biological templates 250

bio-oil coprocessing technology 505f

biphenyl (BP) transalkylation 306

bottom-up methods 500

BP700 and BP2000 232

Bronsted acid sites accessibility 469

Brunauer-Emmett-Teller (BET) surface 157, 326

c

calcination 54

carbon aerogel 20, 20f, 241–242

carbon black, hierarchical zeolites 232–233, 233f

carbonate-hydroxyapatite (CHA) structure 11

carbon-templating methods 468

catalyst

- development cycle 542f
- industrial perspectives, mesoporous zeolites 555
- renewable/biomass-derived fuels and chemicals 503–508

catalytic activity

- Al-MCM-41 190
- applications 180
- epoxidation 184
- hierarchical (mesoporous) zeolites 547
- of h-ZSM-5 181, 190
- of ODS reaction 187
- and SBA-15 181

catalytic cracking, vegetable oils 514–516

catalytic fast pyrolysis (CFP) 508–513

cationic polymer templating

- PDADMAC 200–201
- PDDAM 201–202

cavitation-induced evaporation 360f

cellulose. *see* lignocellulosic biomass

cetyltrimethyl ammonium bromide (CTAB) 117, 325, 465

clear homogeneous synthesis mixtures 33, 34sch

clear solution synthesis 87, 88t–89t, 90

CMK-1 and CMK-3 237

CMK-L 238, 238f

CO₂ adsorption 356

coated mesoporous zeolites (RZEO-1) 301, 303

- acidity 305–306
- advantage 307
- catalytic properties 306, 307f
- characteristics 305
- hard coke 307–308
- morphology 305
- soft coke 307–308
- structural, textural, and morphological characteristics 303, 304f
- XRD data 304–305

coke formation, MTH reactions 188, 188f

collective/chemical diffusivity 389

collidine 483

colloidal suspensions 51f

colloidal zeolite 44

- colloid-imprinted carbons (CICs) 234, 235f
 - commercial NaX adsorbent
 - physical properties 342, 342t
 - pulse-test experiments on 342–343, 343f
 - confined space synthesis (CSS) 46, 46f, 91–95, 92f–95f. *see also* Hierarchical zeolites, by CSS
 - crystallization 230–232
 - crystallization, under hydrothermal conditions 228–230, 228sch
 - gel preparation 230
 - principles 228
 - single crystalline mesoporous zeolites 227, 228f
 - zeolite nanocrystals 227, 228f
 - contrast transfer function (CTF) 433
 - controlled desilication 500
 - conventional electron diffraction 428–430
 - core-shell zeolite composites 429
 - C-PSt-co-P4VP 218–219
 - cracking activity 125, 125t
 - vegetable oils 514–516
 - cross-linked polyacrylamide (C-PAM) 216
 - crude oil cracking, catalytic performance 467
 - crystal growth 21, 83, 83f
 - crystal size 3, 79, 87, 90
 - crystalline aluminosilicates 1
 - crystallization
 - amorphous phase 82
 - confined nucleation and growth 11–13, 12f
 - within confined space 228f
 - crystal growth, blocking agents for 13
 - crystal shapes 10, 10f
 - crystal size 9, 9f, 10
 - crystalline phase 82
 - cube-shaped morphology 10
 - curves 52f
 - kinetics 53f
 - liquid phase 82
 - mesopore zeolites 11
 - needle-shape morphologies 10
 - pore-forming agents, presence of 18–21, 19f
 - precursor nanoparticles 229
 - seeded growth method 231–232
 - Si-based frameworks 11
 - silanization methods 13–15, 14f
 - silicalite-1(MFI) 229f
 - silicoaluminophosphates, synthesis of 16–17, 17f
 - solid pathway 82f, 83, 86
 - solution pathway 82, 82f, 83, 86
 - steam-assisted 231
 - structure-directing agents 228
 - temperature 32, 87
 - time 33f
 - UL-ZSM-5 130f, 131f
 - vapor-phase transport 231
 - cumene conversion 129t
- d**
- 2D materials 21, 22f
 - 3D crystals 21
 - 3D reconstruction HRTEM 437–440
 - Davison circulating riser (DCR) testing 335–336
 - DCR testing. *see* Davison circulating riser (DCR) testing
 - dealumination
 - Al atoms removal 470
 - desilication 470
 - depolymerization 295
 - derivative thermogravimetry (DTG) 299
 - desilication 295–296, 470
 - acid sites accessibility 481–487
 - degree of 301
 - multitasking character 471
 - RZEO-1 materials 301, 303
 - RZEO-2 materials 303
 - zeolites acidity studies 471–481
 - desilication, acid sites accessibility
 - collidine 483
 - hierarchical (mesoporous) 547
 - IR bands 484
 - Lewis acid sites 486
 - microporosity benefits 481
 - pivalonitrile 483
 - role 481
 - desilication, alkali treatment 260–263
 - for applications 280–284
 - ion-exchange capacity 289
 - isotherms for samples 274
 - multidimensionalization 277–280, 278t
 - Si/Al content 263–272
 - silicalite-1 273–276, 275f
 - superior diffusion 284–289
 - test reactions 280–284
 - tetrahedral Al species 272
 - ZSM-5, temperature and time 263
 - destructive approaches, hierarchical (mesoporous) zeolites 547
 - dibenzothiophenes (DBTs) 186
 - diffusion measurement
 - fundamentals 389–392
 - techniques 392–400
 - types of pore space hierarchies 400–416
 - dimethyl ether (DME) 310, 525–526

double-four-membered rings (D4Rs), zeolites
(*contd.*)

double-four-membered rings (D4Rs), zeolites
8

dual-template synthesis methods 550

e

electron diffraction

– conventional 428–430

– geometry 427–428

– intensities 426

– positions, diffraction spots 426

– three-dimensional (3D) 430–432

electron diffraction tomography (EDT) 222

electron tomography (ET) 440–449

equilibrium catalyst (E-cat) 335

– ACE testing 338–339, 340t

– MAT testing 338

– zeolite surface area 338, 340f

Equisetum arvense 250

ethane diffusivities 411

f

fast-exchange model 414–415

fatty acid methyl esters (FAME) production
193

FAU (faujasite) zeolite 41

FAU (faujasite) zeolite precursors 202

FCC. *see* fluid catalytic cracking (FCC)

films growth 44, 45f

fine chemistry, hierarchical zeolites

180–185, 183f, 184f

fluid catalytic cracking (FCC) catalysts 34,

79, 323, 331, 333, 387, 407

– advanced cracking evaluation testing
335–341, 336f, 337t

– commercial applications 335

– Davison circulating riser testing
335–336

– functional matrix 334–335

– GRX-3 catalyst 338

– hydrocracking applications 331

– industrial process 334

– laboratory testing 335

Fourier transform infrared spectroscopy
(FTIR) 305, 327

framework density (FD) 5, 6, 7f, 8

frequency response (FR) technique 393

fuels, production of 189–193, 192f

g

gas adsorption. *see* physical adsorption

gas diffusion 355

gas pressures 353

gasoline 40f, 125

gel viscosity 169–171

grand canonical monte-carlo GCMC/DFT
368

gravimetric method 352

green chemistry 259

green gasoline and diesel 503

GRX-3 catalyst 338

h

hard mesopore template 499

hard template, hierarchical/mesoporous
zeolites 551

heteronuclear chemical shift correlation
(HETCOR) 162

HF (hierarchy factor) 286, 288f

hierarchical micro-mesoporous materials
295

hierarchical pore systems, mass transport
measurement

– diffusion fundamentals 389–392

– diffusion measurement techniques
392–400

– types of pore space hierarchies 400–416

hierarchical zeolites 157, 165f

– Al-rich zeolite Y 554

– catalytic activity 547

– catalytic applications 180

– desilication process 471–487, 547

– destructive approaches 547

– dual-template synthesis methods 550

– experimental methods 461–463

– hard template 551

– microactivity test (MAT) 554

– micro-mesoporous crystalline materials
549f

– molecular highway 554

– phenylaminopropyl-trimethoxysilane
(PHAPTMS) 548

– propylene conversion 548f

– recrystallization method 552–553

– RZEO-1 and RZEO-2 553

– templating and dealumination, composite
materials 463–470

– three-dimensional dealuminated mordenite
(3-DDM) 547

– ultrastabilized form (USY) 546

– zeolites acidity studies (*see* zeolite acidity
studies)

hierarchical zeolites, by CSS

– carbon aerogel 241–242

– carbon black materials 232–233, 233f

– nanotubes, and nanofibers 234

– organic aerogels 242f

- polymer and microemulsions 248–250
- RF aerogels 242
- SAC and VPT methods 234–241
- seeded growth method 243–248
- single crystalline mesoporous zeolites 233f
- high cycle oil (HCO) 125
- high-density polyethylene (HDPE) 190
- high-resolution transmission
 - electronmicroscopy (HRTEM)
 - contrast transfer function (CTF) 433
 - 3D reconstruction 437–440
 - electron-beam-sensitive materials 434–435
 - power 433
 - structure projection reconstruction 435
 - zeolite images 436f
- Horváth-Kawazoe (HK) micropore 100, 101f
- hybrid ordered mesoporous (HZM) material 181
- hydrocracking 506
- hydrodeoxygenation 508
- hydrodesulfurization (HDS) 127
- hydroisomerization 311–312, 506
- hydrophilicity index 356
- hydroprocessing, biomass-derived feeds 516–524
- hydrothermal crystallization 41f
- hydrothermal dealumination process 323, 323f
- hydroxyl nests 324
- hysteresis impact 415–416
- hysteresis scanning 362f
- hysteresis types 359f
- hysteretic adsorption/desorption 362
- h-ZSM-5, catalytic conversion of 191

i

- induction period, crystalline 81
- industrial perspectives, mesoporous zeolites
 - catalytic performance 555
 - soft template 557
 - transmission electron micro graphs 556f
- International Zeolite Association (IZA) 5, 34
- interparticle meso-/macropores 497
- intracrystal mesopores 499
- IR spectroscopy
 - acidic properties, hierarchical zeolites 462
 - desilicated zeolites, acid sites accessibility 484
- isobutene, catalytic production of 189f
- isobutyltriethoxysilane (IBTES) 163
- ITQ-51 432
- IZA. *see* International Zeolite Association (IZA)

j

- Kelvin approach 358
- Knudsen diffusion 323, 323f
- Knudsen relation 391
- krypton adsorption 357

l

- lamellar zeolites 3
- Lewis acid sites 461
 - nature and origin 477–481
- light cycle oil (LCO) 34, 40f, 125
- lignocellulosic biomass 508–513
- Linde type-A (LTA) zeolites 388
- liquid phase, nuclei growth 86

m

- macro-/mesoporous monolithic materials 387
- magnetic resonance imaging (MRI) 397
- mass transport measurement, hierarchical pore systems
 - diffusion fundamentals 389–392
 - diffusion measurement techniques 392–400
 - types of pore space hierarchies 400–416
- MAT testing, equilibrium catalyst 338
- Maxwell-Stefan self-exchange diffusivity 390
- MCM-41 306, 316
 - FTIR absorption spectra of 129f
 - silica fibers 250
- mesopore zeolite 3
- mesoporous aluminosilicate composite materials 128
- mesoporous cellular foam (MCF) aluminosilicate 129
- mesoporous materials
 - acidity 124t
 - application of 115–116
 - elemental composition 124t
 - textural properties 124t
- mesoporous materials with zeolitic fragments in the walls (RZEO-3) 303
 - acidic properties 314
 - advantage 314, 316
 - Bronsted/Lewis site ratio 314
 - catalytic properties 314, 315f
 - characteristics 312
 - hydrothermal stability 313–314
 - N₂ adsorption-desorption isotherms 312–313, 313f
- mesoporous MFI zeolites (ZSM-5-H), by PDDAM 201–202, 201f
- mesoporous NaX zeolites (Meso-NaXs) 202–203, 203f

- mesoporous zeolite 324f
 - bottom-up approaches 324–325
 - industrial assessment 555–559
 - LTA 451–452
 - top-down approaches 325
 - zeolite catalysts effectiveness 543–555
 - mesoporous zeolite catalysts
 - bottom-up methods 500
 - catalysts, renewable/biomass-derived fuels and chemicals 503–508
 - catalytic cracking, vegetable oils 514–516
 - catalytic fast pyrolysis (CFP), lignocellulosic biomass 508–513
 - controlled desilication 500
 - hard mesopore template 499
 - hydroprocessing, biomass-derived feeds 516–524
 - interparticle meso-/macropores 497
 - intracrystal mesopores 499
 - methanol to hydrocarbons 524–533
 - pore size distributions 501f
 - preparation methods 498f
 - SEM images 501f
 - soft mesopore template 499
 - TEM images 501f, 502f
 - top-down methods 500
 - mesostructured and mesoporous aluminosilicates
 - zeolite crystals 135–141
 - from zeolite seeds/nanoclusters 141
 - mesostructured NaX adsorbent
 - physical properties 342, 342t
 - pulse-test experiments on 342–343, 343f
 - mesostructuring process 326
 - methanol-to-hydrocarbons (MTH) 185, 507, 524–533
 - methanol to dimethyl ether (DME) 525–526
 - methanol-to-gasoline (MTG) 507, 527–533
 - methanol-to-olefins (MTO) 507, 527–533
 - MFI zeolites (ZSM-5-H)
 - by PDDAM 201–202, 201f
 - microactivity test (MAT) 327, 554
 - microcalorimetry 462
 - microemulsion 94f, 95f
 - hierarchical zeolites, by CSS 248–250
 - microfluidic synthesis, of mesoporous zeolites 220
 - micro-mesoporous crystalline materials 549f
 - micro-mesoporous nanocomposites (RZEO-2) 303
 - acidic properties 308–309, 309f
 - advantages 309–310
 - catalytic properties 309–310, 311f
 - characteristics 308
 - hydroisomerization 311–312
 - hydrothermal stability 308
 - mesoporous phases 308
 - nanocomposite materials 309
 - pore mouth catalysis 310
 - zeolitic phases 308
 - micropore diffusivities 391
 - micropores, zeolites 2, 3
 - microporous hybrid aluminosilicates 116
 - microporous zeolite
 - beta/MCM-41 composite materials 121, 121f, 122f, 123t
 - catalytic evaluation 124–128
 - crystallization methodology 117, 118f, 118t
 - hydrothermal stability 119
 - *in situ* synthesis 116, 119
 - MCM-41 phase 119, 120f
 - ZSM-5 synthesis 117
 - Mobil's Selective Toluene Disproportionation Process (MSTDP) 542
 - molecular highway
 - hierarchical (mesoporous) zeolites 554
 - mordenite (MOR) 324
 - morphology control, of mesoporous zeolites 212–218
 - MSU zeolites 158
 - m*-xylene 215
- n**
- nanometer-sized zeolites 31
 - nanometric-sized faujasite crystals 47
 - nanoslab hypothesis 84f
 - nanozeolite(s)
 - advantages of 79
 - application of 106–109
 - diffusion in 108f
 - disadvantage 108
 - nanozeolite composites
 - acidity determine 103
 - cracking 107
 - crystallization 102, 102f
 - crystallization time 105
 - Fourier transform infrared spectroscopy (FTIR) 100
 - *in situ* synthesis 98
 - MFI zeolite structure 105–106
 - pyridine adsorption/desorption experiments 103, 103f
 - titanium silicalite 104, 105f
 - UL-ZSM-5 99, 104f
 - vs. mesoporous zeolites 99

- X-ray diffraction (XRD) 99, 100f
- nanozeolite(s), synthesis of
 - from clear solutions 87, 88t–89t, 90
 - confined space synthesis 91–95, 92f–95f
 - principles 81–87, 81f–86f
 - using growth inhibitor 90–91
 - using organic media 95–98, 96f–98f, 99f
- NaX zeolites (Meso-NaXs) 202–203, 203f
- NaY zeolite 40
- n*-butane 285, 286f
- neopentane 285
- n*-heptane cracking 125
- nitrogen molecule 354–355
- NLDFT method 369–370
- nonionic polymer templating
 - F127 223
 - P123 223
 - PVB 225
 - TIPB 224
- nonlocalized density functional theory (NLDFT) 170
- NOVA concept 353
- n*-propane diffusivities 413f
- o**
- octadecyltrimethoxysilane (ODTMS) 163
- oil refining and petrochemistry 185–189, 187f–189f
- ordered mesoporous carbons
 - CMK-1 237
 - CMK-3 237
 - CMK-L 238, 238f
 - RMM-1 and RMM-3 237
 - SAC approach 235
 - SBA-15 240
 - silica MCM-48 236
 - VPT method 239, 240f
- organic aerogels 242f
- organic media, synthesis of nanozeolites 95–98, 96f–98f, 99f
- organic-functionalized molecular sieves (OFMSs) 158
- organosilane hexadecyltrimethoxysilane 166
- organosilane-directed synthesis method 466
- organosilanes
 - alcohols 168–169
 - aluminum 171–173
 - C-Si bond 157
 - fundamentals of method 158–162, 160f, 161f, 162f
 - influence of 163–166
 - postsynthesis methods 158
 - silica source, influence of 168–169
- oriented mesoporous channels 218–220
- oxidative desulfurization (ODS) process 186
- p**
- PAM (polyacrylamide) 216, 217
- parent mesoporous aluminosilicates (PMesoAS) 132, 133t
- PDADMAC polymer. *see* Polydiallyldimethylammonium chloride (PDADMAC) polymer
- PFG NMR diffusion measurement 398
- Y-type zeolites 407–409
- pH scale 259
- PHAPTMS 163
- phenylaminopropyl-trimethoxysilane (PHAPTMS) 163, 548
- physical adsorption
 - adsorbent surface 353
 - adsorptive 356
 - argon 355
 - cavitation-induced evaporation 360f
 - CO₂ adsorption 356
 - gas diffusion 355
 - gas pressures 353
 - gravimetric method 352
 - hysteresis scanning 362f
 - hysteresis types 359f
 - hysteretic adsorption/desorption 362
 - krypton adsorption 357
 - nitrogen molecule 354–355
 - NOVA concept 353
 - pore condensation 357
 - pore size analysis 366–376
 - probing hierarchy and pore connectivity 376–378
 - surface area 363–366
 - volumetric/manometric method 352–353
 - water removal 354
- pivalonitrile 483
- plastic wastes, catalytic cracking of 190
- polyacrylonitrile (PAN) 128
- polydiallyldimethylammonium chloride (PDADMAC) polymer
 - beta zeolites (Beta-H), mesoporosity in 200–201
 - NaX zeolites 202–203, 203f
 - NMR and thermogravimetry (TG) 223
- polyethylene (PE)
 - catalytic degradation of 327
 - pyrolysis of 281
- polymer hydrogels
 - hierarchical zeolites, by CSS 248–250
- polymer templates
 - cationic polymer 200–203

- polymer templates (*contd.*)
 - features 224
 - hard and soft templates 199–200
 - microfluidic synthesis of mesoporous zeolites 220
 - morphology control, of mesoporous zeolites 212–218
 - nonionic polymer 203–207
 - nonsurfactant cationic polymer 220–224
 - oriented mesoporous channels 218–220
 - polymer-surfactant complex 210–212
 - silane-functionalized polymer 208–210
 - polymer-surfactant complex templating 210–212, 211f, 212sch
 - polystyrene-*co*-4-polyvinylpyridine 218–219
 - polyvinyl butyral (PVB) polymer 205–226
 - pore condensation 357
 - pore size
 - analysis 366–376
 - distributions 170t, 501f
 - zeolites 5–9
 - pore space hierarchies, mass transport measurement
 - diffusion fundamentals 389–392
 - diffusion measurement techniques 392–400
 - macro/meso 400–401
 - macro/micro 401–404
 - meso/meso 404–406
 - meso/micro 407–416
 - types of pore space hierarchies 400–416
 - pore systems
 - alkali treatment 260–263
 - for applications 280–284
 - ion-exchange capacity 289
 - isotherms for samples 274
 - multidimensionalization 277–280, 278t
 - Si/Al content 263–272
 - silicalite-1 273–276, 275f
 - superior diffusion 284–289
 - test reactions 280–284
 - tetrahedral Al species 272
 - ZSM-5, temperature and time 263
 - pore-directing agent 268
 - postsynthesis methodologies
 - crystal bulk, removal/reorganization of T atoms in 23–24, 24f
 - layered zeolites 21–23, 22f
 - pressure swing adsorption (PSA) process 342
 - probe accessible area 363
 - probing hierarchy and pore connectivity 376–378
 - propylene conversion 548f
 - protozeolitic nanounits, functionalization of 160, 160f
 - protozeolitic particles 466
 - pseudomorphic transformation 296, 328
 - p*-xylene 215
- q**
- quasicrystalline phase 86
- r**
- realumination 476–477
 - recrystallization 325–326, 328–330, 330f
 - hierarchical (mesoporous) zeolites 552–553
 - of MFI 310
 - of MOR 306–307
 - recrystallization, zeolite 295
 - adsorption and ion exchange 299
 - in alkaline solution 296, 297f, 298
 - heating of reaction mixture 299–300
 - hydrothermal treatment 300
 - mesoporous phase formation 300
 - mesoporous phase nucleation 303
 - of MFI 310
 - micelles formation 301
 - micro-mesoporous materials 300
 - of MOR 306–307
 - mordenite 298f
 - N₂ adsorption-desorption isotherms 299f
 - RZEO-1 materials (*see* coated mesoporous zeolites (RZEO-1))
 - RZEO-2 materials (*see* micro-mesoporous nanocomposites (RZEO-2))
 - RZEO-3 materials (*see* mesoporous materials with zeolitic fragments in the walls (RZEO-3))
 - siliceous species condensation 300
 - treatment with alkali 298
 - types 301, 302f, 303
 - RED method 431, 432
 - resorcinol-formaldehyde (RF) aerogels 241
 - RF aerogels 242
 - RMFI-2
 - acidic properties of 308–310
 - selectivity and stability 310–311
 - RMM-1 and RMM-3 237
 - RZEO-1. *see* coated mesoporous zeolites (RZEO-1)
 - RZEO-2. *see* micro-mesoporous nanocomposites (RZEO-2)
 - RZEO-3. *see* mesoporous materials with zeolitic fragments in the walls (RZEO-3)

s

Saam–Cole theory 358
 SAC approach 235
 SBA-15 240
 SDA. *see* structure directing agent (SDA)
 seed crystals 246
 seed film method 44
 seeded growth method
 – composition of zeolites 247
 – crystal growth 244
 – 3DOm-i LTA 244
 – LTL crystals 245, 245f
 – silicalite-1 samples 246, 246f
 selected area electron diffraction (SAED)
 patterns 429, 436f
 self-pillared zeolites with interconnected
 micropores and mesopores 452–454
 Si(OH)Al signal position 461
 silane-functionalized polymer templating
 – intracrystal mesopores and, 208sch
 – MSU-MFI zeolite 209–210, 209f, 210f
 – nitrogen sorption isotherms 209
 – polyethylenimine (PEI) polymers 209
 silanization-based methods
 – catalytic behavior 159
 – mesoporosity 163
 – organosilanes 159–163, 160f, 161f
 – zeolite crystallization 159
 silanized protozeolitic nanounits 160
 silanols 472–473
 silica MCM-48 236
 silica/carbon composites 239
 silicoaluminophosphate (SAPO-34) 11,
 16–17, 17f, 18, 18f, 63f, 388
 silicoaluminophosphate nanometric-sized
 crystals 35t–39t
 siloxy group 466
 silylated polymers, use of 173–175, 173f
 simulated moving bed (SMB) process 334,
 342–343
 single crystalline mesoporous zeolites 227,
 228f
 SMB process. *see* simulated moving bed (SMB)
 process
 sodium dodecylsulfate (SDS) 47
 soft template
 – industrial perspectives, mesoporous zeolites
 557
 – mesoporogen 499
 solid-state secondary crystallization, zeolites
 99
 spherical nanocrystals, surface-to-bulk atom
 ratios for 80f
 structure directing agent (SDA) 81, 90

structure projection reconstruction, HRTEM
 435
 styrene, oligomerization of 281–282
 surface area 363–366
 surfactant templating approach
 – acid strength 467
 – acidic properties 466
 – alkoxysilane-containing surfactant/polymers
 465
 – bimodal porosity 465
 – carbon-templating methods 468
 – cetyltrimethyl ammonium bromide (CTAB)
 465
 – crude oil cracking, catalytic performance
 467
 – hierarchically porous structures 467
 – hydrothermally stable composite materials
 467
 – layered materials 469
 – mesopore 466
 – mesopores 465
 – mesoporous zeolites 468
 – meso-ZSM-5 466
 – organosilane-directed synthesis method
 466
 – protonic sites 466
 – protozeolitic particles 466
 – siloxy group 466
 – ultrathin zeolites 469
 surfactant-templated mesostructuring of
 zeolites 326–334
 – adsorptive separation process 341–344,
 342t, 343f
 – cetyltrimethylammonium bromide 325
 – crystal rearrangement mechanism
 327–332, 328f
 – diffusion limitations 322
 – fluid catalytic cracking process 334–341
 – FTIR 327
 – hydroxyl nests 324
 – pH adjustment 329
 – polyethylene catalytic degradation 327
 – SEM 330–331, 331f
 – TEM 326–328, 330–331, 331f
 – triisopropylbenzene cracking 327
 – X-ray diffraction 326
 – Y zeolite 321, 323

t

tapered element oscillating microbalance
 (TEOM) 392
 temperature programmed desorption (TPD)
 171, 462
 tetraethoxysilane (TEOS) 16

- tetraethylammonium hydroxide (TEAOH) 53
- tetrahedral Al species 266
- tetramethylammonium hydroxide (TMAOH) 24, 50
- tetrapropyl ammonium bromide (TPABr) 56
- tetrapropylammonium hydroxide (TPAOH) 56, 57f, 58f, 68f, 90, 166
- thermodynamic factor 390
- three-dimensional dealuminated mordenite (3-DDM) 547
- three-dimensional (3D) electron diffraction 430–432
- toluene, alkylation of 126f
- top-down methods 500
- TPAOH. *see* tetrapropylammonium hydroxide (TPAOH)
- TPA-silicalite crystallization 43
- (*trans*)esterification reactions 507
- transport pores. *see* mass transport
 - measurement, hierarchical pore systems 1,3,5-triisopropylbenzene (TIPB) 223, 146f
- triisopropylbenzene cracking 327
- Tyndall effect 33

- u**
- UL zeolites 158
- ultrasmall EMT crystals with intercrystalline mesopores 452
- ultrastabilization 324–325
- ultrastabilized form (USY) 546
- ultrastable Y (USY) 323, 333
- ultrathin zeolites 469
- UL-ZSM-5 mesoporous aluminosilicate 131

- v**
- vacuum swing adsorption (VSA) process 342
- van Hove correlation function 397
- vapor-phase transport (VPT) method 239, 240f
- vegetable oils, catalytic cracking 514–516
- VGO cracking 125
- volumetric/manometric method 352–353

- w**
- water removal 354

- x**
- X-ray amorphous zeolites (XRA) 31
- X-ray diffraction (XRD) 44, 44f, 46, 72

- y**
- Y zeolite 321, 323

- z**
- zeolite(s)
 - active centers in 2
 - aging temperature 40f
 - aging time 40f
 - application 166–167
 - BEA structure 52–56
 - calcination 160
 - catalytic evaluation of 124–128
 - catalytic reactions 2
 - chemical industry, application of 2
 - commercial applications 9
 - confined nucleation and growth 11–13, 12f
 - FAU and EMT structures 34, 40–50
 - intracrystalline voids of, 4sch
 - large-pore materials 5–9, 6f
 - LTA structure 50–52
 - MFI, and MEL structures 56–65
 - nanocrystals 46
 - nucleation and growth model of 85f
 - postsynthesis chemical treatments of 5
 - shape selectivity 3
 - structures 2, 34, 40–50
 - technological development of 1
- zeolite acidity studies
 - acid sites concentration 474–475
 - acid sites strength 475–476
 - hydroxyl groups spectra analysis 471–474
 - Lewis acid sites, nature and origin 477–481
 - realumination 476–477
- zeolite beta (BEA) topology 158
- zeolite catalysts effectiveness
 - fundamental characteristic 543
 - hierarchical porous structure 546–555
 - pore size 544–546
 - size and shape 543
- zeolite crystals
 - advantages and drawbacks of 32t
 - mesostructured and mesoporous aluminosilicates 135–141
- zeolite growth 42f
- zeolite linde type A(LTA) 167
- zeolite mesostructuring process 325–326
- zeolite nanocrystals 128
- zeolite NaX crystals 48–50, 48f
- zeolite surface area (ZSA) 338, 340f
- zeolite synthesis, precrystallization of 159
- zeolite X spherulite 47f
- zeolites and mesoporous zeolite materials
 - aluminosilicate zeolite ZSM-5 single crystals 450–451
 - electron diffraction 426–432

- electron microscopy 425
- electron tomography (ET) 440–449
- high-resolution transmission electron microscopy 433–440
- mesoporous zeolite LTA 451–452
- self-pillared zeolites with interconnected micropores and mesopores 452–454
- ultrasmall EMT crystals with intercrystalline mesopores 452
- zeolites mesostructuring 296
- zeolites with organic group as lattices (ZOLs)
- zero-length column (ZLC) method 393
- ZSA. *see* zeolite surface area (ZSA)
- ZSM-5 zeolite
 - catalytic performance 214
 - chain-like morphology 214
 - CPSt-co-P4VP with 219, 219f
 - crystallization 59
 - dissolution 266
 - Fourier transform infrared spectroscopy (FTIR) 32
 - hollow ZSM-5 crystals, 218sch
 - nanocrystalline 160
 - nanometric-sized crystals 56
 - by P123 and F127 204–2050, 205f
 - by PVB 206
 - rapeseed oil, catalytic conversion of 191, 192f
 - ¹²⁹XeNMR spectroscopy 208
- ZSM-5-coated mesoporous aluminosilicates (ZCMesoAS) 133t
- ZSM-5-H, by PDDAM 201–202, 201f
- ZSM-5/MCM-41 composites
 - cracking activities of alkanes 125t
 - two-step synthesis of 117f

