

Index

a

- acetic acid 180, 385, 389, 390, 395
- acetone cyanohydrin (ACH) process 176, 177
 - advantages/drawbacks 176
 - alternative routes 177
- acid
 - catalysts 120, 141
 - base catalysis 120
 - hydrofluoric acid (HF) 141
 - sulfuric acid (H₂SO₄) 130, 141
 - gas removal 456
 - cycling/disposal 456–458
 - runaway 477
 - soluble oils (ASO) 493
- acrylamide 110, 111
 - biocatalytic production, Mitsubishi's route 111
- adipic acid (AA) 109, 367
 - cyclohexane transformation 369–372
 - green routes 413
 - growth for 367
 - KA oil oxidation with air 385–389
 - main producers 368
 - market 367
 - non-nylon uses 367
 - process block diagram 392
 - twenty-first century Co/RPC 392
 - production 374, 378, 385, 402
 - alternatives for 385–402
 - butadiene reagent 399–402
 - emerging/developing technologies 402–413
 - environmental issues 378
 - methyl acrylate dimerization 402
 - summary 374
 - production technologies 368–384
 - recovery section 387
 - selectivity 387
 - synthesis 111, 367, 402, 403
 - alternative pathways 414
 - commercial vs. proposed bioroute 111
 - cyclohexene alternative oxidant 409
 - cyclohexene oxidation, steps 403, 406, 408
 - raw material 402–411
- adsorbent treatment process, drawbacks 156
- adsorption process, key factors 378
- air
 - bag systems 68
 - based technology 372
 - emissions categories 289
- aldehydes 162
 - Meerwein–Ponndorf–Verley reduction 162
- aldol condensation 144, 149, 150
 - catalytic activities 148
- alkaloid modifiers 163
 - cinchonidine/cinchonine 163
- alkenes 83, 96
 - epoxidation 175
 - molecular transformation 75
 - oligomerization 97
- AlkyClean alkylation process 488, 494–496, 501, 502
 - block diagram 495
 - catalyst 489, 497, 499, 500
 - first-generation vs. second-generation 500
 - selection/development 489
 - comparison 502
 - competitiveness vs. liquid acid technologies 501
 - conditions optimization 492
 - cyclic operation 493
 - alternating reactors 499
 - demonstration unit 496, 503
 - objectives 497

- operation 497
 - performance processing 501, 502
 - process flow 498
 - reactor section 499
 - total installed cost (TIC) 503
 - development activities 489–491
 - environmental, cross-media effects 503
 - feed pretreatment requirements 495
 - feedstock variation effect 493
 - impurities effect 494
 - performance 494
 - reactor 496
 - cyclic operation 496
 - operating scheme 497
 - system/catalyst regeneration 495
 - solid acid catalyst (SAC) process 488, 494
 - targets 488
 - 3-alkylated pyridines 542
 - 3(5)-ethylpyridine 542
 - 2-methyl-5-ethyl-pyridine (MEP) 542
 - 3-picoline 542
 - alkylate octane number 482
 - vs. I/O ratio 482
 - alkylation reaction mechanism 127, 479, 487
 - alkylation step 480
 - bench-scale unit 490
 - initiation step 479
 - isomerization step 480
 - reaction paths 487
 - termination via hydride transfer 480
 - alternative systems 374
 - Cu-based systems 375
 - Keggin-type polyoxometalates 374
 - literature 374
 - vanadium-based complexes 375
 - aluminium chloride process, flow chart 532
 - American Chemical Society (ACS) 1, 13
 - amine
 - sweetening units process 455
 - units, design 456
 - ammonia 52
 - ammoxidation process 167
 - anionic peroxy species 403
 - anisole 132, 535
 - acylation by acetic anhydride 535
 - Friedel–Crafts acylation 132
 - benzylation with benzoyl chloride 537
 - anti-Parkinson drug, L-Dopa 164
 - Monsanto synthesis process 165
 - aqueous biphasic systems (ABS) 83, 84
 - operations 79–84
 - aqueous two-phase systems, *see* aqueous biphasic systems (ABS)
 - ARCO integrated process, block diagram 340
 - aromatic ethers 529
 - anisole acylation 530–533
 - by acetic anhydride 530
 - industrial processes 531–533
 - catalysts deactivation 534–536
 - Friedel–Crafts acylation by zeolites 529
 - literature background 530
 - phenol ether benzylation 536–539
 - veratrole acylation 533, 534
 - by acetic anhydride 533
 - flow chart 534
 - with acetic anhydride 534
 - aromatic polycarbonates 30
 - melt polymerization production 30
 - non-phosgene process 30
 - atom economy (AE) 31, 32, 296–304, 551
 - definition 296
 - efficiency 297
 - atomic force microscopy 65
 - autoxidation mechanism 339, 370, 409
 - Co role 369
- b**
- Baeyer–Villiger oxidation 151, 152, 173
 - ϵ -caprolactone 389
 - ketone 174
 - melonal 173, 174
 - ring enlargement 404
 - Basell spherizone technology 563
 - evolution 563–567
 - portfolio 572
 - BASIL process 93
 - 1-alkylimidazole 93
 - batch system 343
 - chemical reactor 49
 - process 443, 444, 537, 538
 - aspects 444
 - Bayer's process 354
 - Baylis–Hillman reaction 552
 - sequence 554
 - Beckmann rearrangement process 135, 136, 139
 - bench-scale tests program 489, 500
 - unit 499, 500
 - benzene 129, 373, 402
 - alkylation 127, 131
 - advantages/disadvantages 127
 - reaction pathway 131
 - direct oxidation 507, 516
 - to phenol with hydrogen peroxide 516
 - hydrogenation 373, 402
 - flow sheet 373
 - benzoylating agent 536
 - best-available-technology (BAT) 36

- Bhopal accident 14, 17, 20, 26
 - management systems 17
 - rigorous process safety procedures 17
 - root causes 19
- Bhopal union carbide process 15, 19
 - emergency relief effluent treatment system 19
 - flow chart 15
 - MIC storage tank 16
 - safeguards 16
 - water entrance route 18
- BIC/Solutia process 384
 - integration 384
 - zeolite use 384
- bio-based economy 59–61
 - development 59
- biocatalysis process 59, 77, 79, 103–105, 114, 116
 - advantages 105–107
 - biocatalysts 107
 - industrial uses 104, 105
 - limits 105–107
 - progresses 114–116
 - trends in research 105–107
- biodiesel production process 156, 442
 - homogeneous process 442–445
 - global scheme 442
- bioethanol 466
 - origin 466
 - production 465
- biofuels 63, 283, 463
 - debt repayment time 283
 - market 465
 - production 465
 - promotion 465
- bioinspired models 118
 - copper proteins 118
- biomass 9
 - handling 9
 - derived components 439
- biomimetic catalysis 117–125
- biomimetic catalyst *see* bioinspired catalysts
- biopolymer polylactic acid (PLA) 61
- bioprocessing, elements 104
- biotechnology 59, 60
 - impact 60
 - role 61
 - white 103, 109
- biotransformations 104, 106
 - pros/cons 106
- biphasic systems 97, 517, 518
 - disadvantage 97
 - homogeneous catalysis 86
 - organic solvents 103
- bisphenol-A 147
 - synthesis 507
- black chemistry 20
- Boraskov Institute of Catalysis 383
- Brønsted acids 187, 343, 345
 - acidity 121
 - aluminium sites 174
- butadiene 400, 401
 - hydroxycarbonylation 401
 - methoxycarbonylation 400
 - transformation 401
- c**
- caprolactam synthesis 135–140
 - alternative process 139
 - commercial vs. Sumitomo process 135
 - manufacturing process 135, 138
- carbon
 - debt concept 282
 - efficiency 298
 - footprint 282
 - nanofibers (CNF) 148
 - steel valve 19
 - supported catalysts 33
- Cargill Dow's bio-polymer, PLA 60
- cascade reactions 124, 153, 184, 185
- catalysis process 8, 9, 63, 74, 75, 162
 - aqueous two-phase 83, 84
 - bioinspired host-guest 119
 - challenges for 9
 - extraction using supercritical solutions (CESS) 96
 - role 8–10, 63, 74, 75, 162
- catalyst 64, 74, 77, 76, 170, 332, 564, 565
 - alkaline, sodium hydroxide/methylate 442
 - Amberlyst 143
 - Au-based 352
 - bifunctional, formation 405
 - bioinspired 103, 117
 - biomimicking 117
 - characteristic 565
 - classification 76
 - composition 64
 - cycle 519
 - high-valent iron species intervention 519
 - deactivation 332, 356, 491, 565
 - definition 74
 - first generation 170
 - formulation, improvements to 348
 - generations 564
 - high selectivity (HY/HS) catalysts 565
 - high-temperature 565
 - immobilization 96
 - improvements 576

- manufacturing process 565
 - consequences on 565
- modifiers 348
 - gold 348
 - rhenium 348
 - tungsten 348
 - use 348
- nucleophilic 93
- performance 76, 564
- pre-treatment 349
- residuals 565
- role 64
- stability testing 435
- structure 64
- system 343, 350, 390, 403, 404, 407, 480
 - corrugated/flat steel nets 343
 - reactor vessel 343
 - results 350
- turnover numbers (TON) 77
- catalytic distillation process 214
 - advantages 215
 - autocatalytic processes 215
 - benefits 215
 - heterogeneous/homogeneous catalysis 215
 - packed bed columns 213
 - reaction equilibrium barrier 214
- catalytic hydrogenation reactions 158, 159
- catalytic microporous inorganic membranes 264
- catalytic partial oxidation (CPO) 271
- catalytic systems 350, 390, 403, 407
 - results 350
- cavitation process 238, 239
 - acoustic cavitation 238, 242
 - energy 242
- chemical processing applications 240
 - intensification 240
 - used in 240
- heterogeneous systems 240
- hydrodynamic cavitation 239, 242, 243
 - devices 243
- optic cavitation 239
- particle cavitation 239
- C₄-based technology 400
 - implementation 400
- cephalexin synthesis 110
 - chemo-route vs. bio-route 110
- chemical industry 6, 7, 12, 20, 41, 58, 280
 - down-sizing chemical production, advantages 6
 - F³-factory 6
 - foster innovation 6
 - goal 20
 - industrial process 5, 7, 299
 - industrial plants 273
 - separation processes 273
 - sustainability evaluation 299–304
 - innovation index 58
- chemical leasing (ChL) business models, application 43
- chemical processes 14, 20, 21, 48, 184, 309, 551, 557
 - Bhopal accident 14
 - environmental impact 557
 - EATOS parameters 557
 - hazardous intermediates generation 14
 - inherently safer design 48
 - plants 47
 - quantitative evaluation 551
 - safety strategies 48
 - sustainability measurement, indicators 309
 - using oxygen-enriched air 184
- chemical production industry (CPI) 22, 25
 - equipment, hazardous materials 22
 - future vision 25
- chemical(s) 41, 42, 46
 - conventions 46
 - industry 167
 - selective oxidation processes 167
 - inherent safety 42
 - solvent processes 457
 - sustainability 42
 - unsustainable vs. sustainable substances 42
- Chemistry Research Applied to World Needs (CHEMRAWN) Committee 3
- chemoselectivity 159
 - hydrogenation 160
- chloro-fluorocarbons (CFCs) 50
- chlorophenol, photodegradation 236
- circulating fluidized beds (CFBs) 573
- Claisen–Manasse reaction 377
- Claisen–Schmidt condensation 149
- classical mass/heat transfer operations 259
 - vs. membrane operation 259, 262
- Clean Air Act Amendments (CAAA) 464
- carbon dioxide (CO₂) 95, 179, 348, 439, 452, 546
 - activation mechanism 452
 - equilibrium solubility 452
 - quantities 550
- combination processes 141
 - alkylation 141
 - etherification 141
 - polymerization 141
- commercial catalysts 97
 - copper chloride-based Deacon catalysts 97

- commercially operating processes 102
 - Ruhrchemie/Rhône-Poulenc/SHOP 102
- Commission on Sustainable Development (CSD) indicator 283
- Common Energy Policy 465
- competitive business models 7
- compound annual growth rate (CAGR) 76
 - catalyst market 76
- comprehensive process safety management program 48
- computational modeling 66
- condensation reactions 148
 - Claisen–Schmidt 148
 - Knoevenagel 148
- continuous stirred tank reactor (CSTR) 156
- conventional hydroperoxidation technology 343
- conventional hydroprocessing technology 427
- conventional oxo process 82
 - schematic flow-sheet 82
- cooling system 15, 392
- co-processing operation 431
 - problems 431
 - route 431
- cracking 9, 120, 141, 356, 472, 480, 487
- crystallization–distillation hybrid separation processes 217
 - advantage 217
- cumene process 125, 130, 508
 - cleavage/workup 511
 - concentration 510
 - considerations 512–514
 - Hock process 508
 - hydroperoxide intermediate 299
 - oxidation 510
 - plant 509
 - block scheme 509
 - material balance 510
 - synthesis process 130–132, 299, 507–514
 - alkylation 508–510
- cumyl hydroperoxide (CHP) 325, 510
- centre for waste reduction technologies (CWRT) metrics 306, 307
 - aspects 307
 - categories 307
- cyclic carbonates synthesis 125, 153
 - acid–base bifunctional reaction mechanism 153
 - transesterification 125
- cycloaddition reaction 554, 555
- cyclohexane 369, 374, 375, 389–393, 395, 396, 398
 - conversion 390
 - homogeneous autoxidation 370, 389–393
 - catalyzed by Co/Mn/Cu 389
 - oxidation process 140, 374, 391, 393–395, 398
 - aerobic 393
 - alternative homogeneous catalysts 374
 - catalytic 398
 - direct oxidation 389–399
 - environmental impact 140
 - flow-sheet 371
 - heterogeneous catalysis 393, 394
 - *N*-hydroxyphthalimide catalyst 395
 - literature reporting 396
 - results 398
 - Rhodia approach diagram 391
 - transformation to adipic acid 375
- cyclohexanol 370, 389
 - mixtures 516
 - oxidation 389
 - aerial 388
 - to adipic acid 389
 - formation 370
 - synthesis 372–374
- cyclohexanone 138, 385, 388
 - mixtures 516
 - activation mechanism via enol tautomer 385
 - conversions 388
 - oxidation 389
 - aerial 388
 - with O₂ 386
 - oxime 136, 137, 139
 - conversion 139
 - coordination 137
 - synthesis 372–374
- cyclohexene 404–406, 408–410
 - alternative oxidant 409
 - direct oxidative cleavage reaction network 404
 - oxidation 406, 408, 410
 - via 1,2-cyclohexandiol 406
 - via epoxide 408
 - oxidative cleavage reaction network 405
 - catalyzed by TAPO-5 405
- cytochrome P450-dependent monooxygenases 118

d

- Davy process technology (DPT) 33
- DDT 15, 280, 281, 552
- Degussa/Uhde process 339
 - hydrocarbon-rich stream 339
 - liquid stream separation section 339
 - block diagram 339

- methanol-water-rich stream 339
 - delivery systems 64
 - nanoparticles application 64
 - demo reactor 497
 - catalyst replacement 500
 - unit operation processing 500
 - dendrimers 87, 88
 - nomenclature 88
 - structure 88
 - dense/microporous materials 262
 - process performance control 262
 - dibasic acid (DBA) recovery 387
 - Diels–Alder reactions 118
 - 2,5-dihydrofuran production 93
 - Difasol process 90, 91
 - catalyst 92
 - diisopropylbenzene (DIPB) 131, 132, 509
 - column 509
 - Dimersol process 90
 - Difasol package reaction 92
 - schematic flow-sheet 92
 - usage 91
 - X process 91
 - dimethyl carbonate (DMC) 26
 - based procedures 30
 - classification 28
 - comparative evaluation 31
 - mass indexes 32
 - model transformations assessment 31
 - photochemical ozone creation potential 28
 - production process 28, 29
 - conceptual scheme 29
 - non-corrosive catalyst 29
 - synthesis 33
 - routes 28
 - use 28
 - dimidiation process 91
 - direct oxidation process 546
 - disproportionation reaction 480
 - distillation process 52, 53
 - conventional column system 217
 - dividing wall distillation column 216, 217
 - fractional distillation 82
 - gas-liquid mass transfer 200
 - heterogeneous/homogeneous reactive 214
 - traditional vs. reactive 53
 - domino catalytic reactions 184–186
 - ether synthesis 186
 - Dow chemical exposure index 22
 - down-stream processing/unit operations 541, 547
 - goal 547
 - DRIFT spectrum 354
 - drinking water 263
 - toxic substances 263
 - DSHP-HPPO technology 344, 345
 - by Degussa Evonik/headwaters 344
 - DSM process 138
 - dynamic kinetic resolution (DKR) 108
- e**
- E-factor (E) 296–304, 551, 552, 556, 557
 - comparison 556, 557
 - product 551
 - sub-categories 297
 - Eastman process 52, 94
 - eco-efficiency analysis 288, 289, 291–293
 - assessment 288
 - definition 307
 - environmental profile 289
 - innovative eco-efficient process 67
 - life cycle assessment 289
 - metrics 283–292
 - preconditions 288
 - ecofining process 427, 429, 431, 434, 436
 - by-products 428
 - flow-scheme 436
 - improvement 427
 - products yield 436
 - two-stage process 432
 - ecological footprint 281–283
 - sustainability indicators 281, 283
 - ecological indicators 283
 - ecological metrics 284
 - economic indicators, objective 294
 - effective mass yield (EMY) 297
 - electric fields 232
 - mechanisms 232
 - static/dynamic 232
 - electrodialysis (ED) process 258, 271, 272
 - electrohydrodimerization process 287
 - electron-withdrawing fluorine ligands 90
 - Elliot's alcohol 552, 554, 555, 561
 - alternative route 552, 554–556
 - comparative assessment 555
 - E-factors comparison 556
 - feedstock environmental impact comparison 559
 - waste environmental impact comparison 557
 - alternative synthesis 554
 - preparation 561
 - structure 552
 - energy 62
 - alternative forms 224
 - aspects 62

- based sustainability index (ESI) 310
 - consumption 205, 289
 - intensity 304, 305
 - problem 62
 - resources 62
 - transfer 262
 - enhance oil recovery (EOR) 456
 - environmental analysis metrics 283–292
 - environmental assessment 288
 - environmental assessment tool for organic syntheses (EATOS) 305, 552, 559
 - environmental analysis 559
 - tool 556, 561
 - inspection 556
 - environmental impact indicators 305, 306
 - usage 305
 - environmental performance index (EPI) 9, 285, 286
 - construction scheme 286
 - environmental objectives 285
 - environmental protection process 382
 - environmental quotient (EQ) 305, 551, 557
 - environmental sustainability index (ESI) 285
 - enzymes 60, 113
 - catalyzed polymer synthesis 113
 - classification 113
 - immobilization technology 116
 - membrane 270
 - polymerization 113
 - reactions 269
 - use 60
 - epoxidation process 151, 330
 - catalyst 327
 - reaction mechanism 151
 - reactor 336
 - epoxides 409
 - oxidation 409
 - ring opening 409
 - solvolysis products 332
 - epoxybutene, isomerization 94
 - Escherichia coli* 109, 411
 - ethanol 467
 - disadvantages 467
 - issue 467
 - ethene oxychlorination 301, 302
 - air/O₂-based process 302
 - vent composition 302
 - etherification process 142, 143, 469, 472
 - operating conditions 472
 - ethylbenzene (EB) 125, 127
 - column 128
 - Mobil–Badger process 130
 - catalyst, ZSM-5 130
 - ethylene 91
 - ethyl esters 447, 448
 - ethyl 2-oxo-4-phenylbutyrate (EOPB) 163
 - enantioselective hydrogenation 163
 - ethyl *sec*-butyl ether (ESBE) 467
 - ethyl *tertiary*-butyl ether (ETBE) 142, 439, 463
 - kinetics 469
 - role 463
 - specification 473
 - synthesis 467–469
 - catalyst deactivation causes 468
 - MTBE catalysts 468
 - resin deactivation causes 469
 - technology 466
 - ETBE process 469, 472
 - production 467
 - properties 466
 - reactors 469–472
 - EU Chemicals Agency 37
 - EU platform on life cycle assessment (LCA) 46
 - European Association for Bioindustries (EuropaBio) 6
 - European Chemical Industry Council 6, 59
 - European Commission 5
 - fifth Framework program 5, 59
 - European Technology Platform on Sustainable Chemistry (ETP SusChem) 6, 25, 41
 - exergy 304
 - based sustainability parameter 305
 - definition 304, 305
- f**
- fabrication technology 245
 - fatty acid methyl esters (FAME) 157, 427, 443
 - qualities 427
 - feedstock effects 483
 - feed impurities 483
 - olefins 483
 - Fenton system 516, 518
 - radical mechanism 518
 - fermentation process 61
 - ferrocenyl diphosphine ligands 165
 - preparation 165
 - structure 165
 - F³-factory (future, fast, flexible) 6, 7
 - challenge 6
 - micro-reaction technology 6
 - modularization 6
 - vision of 7
 - Fischer–Tropsch synthesis 85
 - fixed-bed reactor 167, 182, 303, 343, 345, 380, 445, 522

- fluidized-bed oxidation catalysts 547
 - operations 182
 - process, flow chart 532
 - technology 302, 531, 533
 - fluid catalytic cracking (FCC) 473, 475
 - fluorescence-based technology 65
 - fluorous biphasic system 88, 89
 - catalysis 88
 - catalysts 89
 - ligands 90
 - solvents 88–90
 - fossil
 - derived methanol 447
 - energy consumption 436
 - fuel-based polymers 61
 - development 61
 - innovation 62
 - foster innovation 6, 58, 73
 - free fatty acids (FFA) 157, 443
 - Friedel–Crafts reaction 529
 - acylation 132, 536
 - benzoylation 536
 - alkylation 514
 - catalyst 127
 - drawback 529
 - Fries rearrangement 529
 - fuel cells 10, 227, 427
 - application 10
 - cold flow properties 427
 - DAFC-type cells 10
 - efficiency 10
 - ethanol direct fuel cells 10
 - hydrogen/methanol 227
 - fuel ethers, synthesis 52
- g**
- G8 Ministers for Research 3
 - galvanostatic 272
 - gasoline 439, 464, 466, 475
 - components 463, 467, 475
 - butane 467
 - high quality oxygenated 463
 - pentane 467
 - ETBE 466
 - key specifications 475, 476
 - octane quality 467
 - pool 464
 - refining sources 475
 - gas-phase propene oxide (PO) synthesis 356, 357
 - alternatives for 356, 357
 - gas-phase oxidation with N_2O 356, 357
 - gas-phase oxidation with O_3 357
 - gas-phase reaction 346, 350
 - oxidation process 346, 548, 565
 - *b/w* propene and HP vapors 346
 - promoters 353, 358
 - reductants 354
 - technology 547
 - trimethylamine, role 353
 - gas separation (GS) 258, 260, 262
 - globally harmonized system (GHS) 38, 46
 - aims 38
 - classification and labeling of chemicals 38, 46
 - global product strategy (GPS) 44, 45
 - global warming potential (GWP) 311, 379
 - CH_4/CO_2 emission 311
 - glucose 411
 - biocatalytic microbe-based conversion 411
 - enzymatic transformation 411
 - two-step transformation 411
 - glycerol 445
 - governmental initiatives/regulations 45
 - green chemistry 1, 2, 4, 11, 73, 75, 81, 96, 303, 307
 - aspects 73
 - assessment indicators 296
 - catalysis 11
 - center for 4
 - challenge 1, 4
 - definition 14
 - focus 14
 - industrial motivation 13
 - metrics 307, 308
 - atom efficiency 307
 - mission, factors 11
 - movement, cultural context 12
 - number of publications 4
 - parameter, E-factor 281
 - party members 5
 - atomic energy 5
 - genetic engineering projects 5
 - principles 11–14, 26, 296
 - resource exchange 1
 - risk 11, 14–20
 - vs. sustainable chemistry 5
 - green chemistry expert system (GCES) 2
 - green diesel 428, 433, 436
 - advantages 428
 - blending component 434
 - vs. conventional biodiesel, properties 428
 - vs. FAME biodiesel 437
 - vs. mineral ULSD 428
 - production 428–434
 - vs. petroleum diesel 437
 - LCA analysis comparison 437

greenhouse gases 9, 204, 282, 300, 378, 436
 – emissions 9, 204, 436
 – factors 9
 – reduction 204
 – nitrous oxide 300, 378
 – environmental issues 378
 green improvement, EATOS tool 561
 green metrics 551
 – effective mass yield (EMY) 551
 – mass intensity (MI) 551
 – process reaction design 551
 – lab bench stage 551
 – reaction mass efficiency (RME) 551
 green process, requirements 541
 Green Public Procurement (GPP) 45, 46
 Green & Sustainable Chemistry Network (GSCN) 4
 green taxes concepts 41
 green technology 13, 26, 475
 – evolution 475
 green traffic fuels 140–144
 Grignard reagent 250
 Gulf process 390

h

Haber–Weiss mechanism 370, 390
 hazard and operability (HAZOP) studies 50, 56
 hazardous substance 22, 25, 26, 51
 – DataBank 558
 – inventory 22, 25
 – possibilities 22
 – replacement 26–35
 – substitution 51
 healthcare, challenges 63
 heating/cooling fluid, film coefficient 202
 heat transfer 259, 302
 – operation 259
 – properties 302
 heterogeneous catalysis 355, 446, 448, 519
 – by titanium silicalite 519
 heterogeneous catalysts 78, 145, 159, 163, 395, 405, 529
 – development 163
 – parameters affecting performance 159
 – zeolites 529
 heterogeneous system 346, 374, 394, 405
 hexamethylenediamine (HMDA) 137, 286, 287
 – manufacturing process 286
 – production 287
n-hexane 412
 HiGee, *see* high-gravity fields
 high-gravity fields 230
 high gravity technology 201
 – Dow's hypochlorous acid process 230
 – mass transfer processes 230, 231
 – unit 202
 – vacuum tower deaeration system 231
 highly-functionalized hydrotalcite catalysts 152
 – designing strategy 152
 Hock process, *see* cumene process
 holistic approach 7, 67, 69
 homogeneous catalysis 77, 78, 80, 162, 374, 447, 517
 – biodiesel plants 445
 – by iron complexes 517
 – biphasic Fenton reagent 517
 – tungstic acid catalyst 407
 homogeneous systems 374, 387, 408
 – mechanistic investigations 408
 horseradish peroxidase (HRP) 114
 – single-chain β -type hemoprotein 114
 hybrid process 267, 457
 – electrodialysis 271, 272
 – membrane-assisted fluidized bed reactors 270, 271
 – nanofiltration-coupled catalysis 267–269
 – supercritical fluid-assisted membrane separation 269, 270
 – use 267
 hydrocarbon 508
 – co-extraction 460
 – high molecular weight 508
 hydrocyanation process 287
 hydrofluoric acid (HF) 476
 – alkylation 127, 493
 – properties 476, 477
 hydrodeoxygenation reaction (HDO) 522, 524
 – section, performance 524
 hydrogen-oxygen-propene-oxide (HOPO) 324, 351, 353
 – Au-based catalytic systems 351
 – performance 351
 – direct synthesis 353
 hydrogen peroxide (HP) 300, 324, 329–333, 336, 341, 353, 525
 – chemical applications 341
 – direct synthesis 353
 – *in situ* generation 332, 341, 525
 – RAQ/RAHQ process 331
 – methanol solution 343
 – oxidant 300
 – plant 336

- producer 336
 - synthesis 330
 - use 329
 - hydrogen peroxide propene peroxide (HPPO)
 - process 324, 330, 333, 335, 336, 341, 342, 344, 358
 - BASF catalysts 342
 - HP generation by direct oxidation of H₂ 341
 - industrial implementation 358
 - *in situ* 341
 - plant 333
 - redox cycles 329
 - hydrogen transfer reactions 483
 - hydrogenation process 373
 - catalysts 159
 - technology 373
 - hydroisomerization catalyst 432
 - hydroperoxidation method 322
 - hydroperoxide synthesis 369
 - rate-limiting step 369
 - hydrophilic liquids 100
 - ethylene glycol 100
 - glycerol 100
 - hydrophilic reaction 517
 - hydrotalcite (HT) 122, 145–148, 151, 152, 154
 - basic sites 151
 - derived materials 147, 149, 154
 - formula 146
 - properties 148
 - structure 146
- i**
- immobilization methods 116
 - Implementation Action Plan (IAP) 58, 59
 - INCA, *see* Interuniversity Consortium Chemistry for the Environment
 - indigo dye 290, 291
 - eco-efficiency *vs.* total cost 291
 - environmental fingerprint 290
 - industrial biotechnology 59
 - industrial process 12, 14, 105, 146, 162, 166, 171, 442
 - selective oxidation technology 168, 170
 - trends/developments 170
 - survey 162
 - industrial sustainability 73
 - information and communication technology (ICT) 64
 - inherently safe chemicals (ISCs) 41
 - inherently safer process 21–23, 56
 - design concept 21–23, 47, 52, 54
 - alternative reaction routes 55
 - consequence reduction 54
 - energy limitation 55
 - hazard elimination 54
 - intensification 54
 - likelihood reduction 54
 - modified storage arrangements 55
 - strategies 21
 - substitution 55
 - life cycle 57
 - procedures 56
 - inorganic matrixes 394
 - active carbon 394
 - aluminophosphates 394
 - zeolites 394
 - Institution of Chemical Engineers (ICChemE) 306
 - indicators 306, 307
 - metrics 307
 - integrated process 339, 340
 - disadvantage 340
 - Integrated Product Policy (IPP) 45, 46
 - intensification approach 346
 - interesterification 270
 - International Chemicals Policy 43
 - International Council of Chemical Association (ICCA) 44
 - International Green Network (IGN) 3
 - International Union of Pure and Applied Chemistry (IUPAC) 3
 - Chemistry Research Applied to World Needs (CHEMRAWN) 3
 - synthetic pathways and processes in green chemistry 3
 - Interuniversity Consortium Chemistry for the Environment 3
 - ion-exchange resin 123, 142, 144
 - classes 123
 - structure 144
 - ionic liquids (ILs) 90–95, 103
 - advantage 90, 93
 - characterization 90
 - disadvantage 93
 - problems 94
 - isobutene
 - alkylation 479, 483
 - butene isomers 483
 - dichloride 554
 - oxidation 179
 - isobutene to-olefin (I/O) ratio 481, 482
 - iso-butylaldehyde 83
 - RCH/RP process *vs.* Co high-pressure oxo-synthesis 83
 - environmental advantages 83
 - isomerization reactions 434, 487

isooctane 142, 143
 – production, reaction network 143
 ISO 14040 standard 310

k

Keggin-type polyoxometalates 178, 374
 Keggin unit 388
 α -ketoesters 163
 – enantioselective hydrogenations 163
 ketone/alcohol (KA) oil 368, 376, 387, 399, 414
 – aerial oxidation 414
 – Baeyer–Villiger oxidation strategy 399
 – oxidation mechanism 376, 377, 385, 387
 – to adipic acid 377
 – Asahi process block-diagram 387
 – flow sheet 376
 Knoevenagel condensation reaction 144, 149, 154

l

laboratory experimental program 391
 layered double hydroxides (LDHs) 145
 Lewis acid 120, 122, 126, 534, 536
 – basicity 155
 – catalyst 93
 – sites 122
 life-cycle assessment (LCA) 56, 281, 288, 310–313, 435
 – databases 312
 – definition 310
 – evaluation program 435
 – limitations 312
 – methodology 308
 – stages 310
 – studies 56
 – tools 310–314
 life-cycle costing (LCC) 310, 313
 – studies 313
 life cycle management (LCM), *see* life cycle costing (LCC)
 light 225
 – artificial/solar 225
 – use 225
 light cycle oil (LCO) 431
 linear alkylbenzenes (LAB) 125
 linear olefins etherification 467
 lipase 113
 lipophilic acid 391
 – catalyst 391
 – use 391
 liquid acid
 – alkylation, products 478
 – catalysts 476–484

– advantages vs. disadvantages 484
 – operating variables 481–484
 – properties 477
 – reaction mechanism 479–481
 – technologies 493
 liquid barrier stream, use 570
 liquid film 200
 liquid/gas propylene stream 570
 – stripping zone 570
 liquid hourly space velocity (LHSV) 473
 liquid-liquid biphasic systems 86
 – catalysis 87
 liquid oxidation reactor (LOR) 372
 liquid phase 99, 170
 – catalyst 97
 – catalytic oxidations 171, 399
 – classification 171
 – technological issues 171
 – diffusivities 99
 – industrial processes 170, 171
 – selective oxidation 170, 171
 lithography 244, 266, 267
 Lonza's niacinamide process 112, 548
 – advantages 112
 – features 112
 – green principles 548–550

m

macroporous hydrophobic membrane 266
 – mass transfer 266
 maleic anhydride 180
 Marrakech process 44–46
 mass index (MI) 31, 32
 mass intensity indicators 298, 303
 mass transfer 201, 223, 231, 232, 237–240, 258, 259, 266, 276
 – barriers 96
 – coefficient 230
 – convection/diffusion mechanism, in slugs 247
 – designs 22
 – rate 226
 materials flow accounting (MFA) 310
 materials input per unit service (MIPS) 310
 Meerwein–Ponndorf–Verley reduction 186
 membrane
 – concepts, uses 261
 – contactor 260
 – crystallization 266
 – distillation 265
 – evaporation process 265
 – filtration 273

- fouling 88
- function 261
- mesoporous/macroporous 264
- operation 259, 262
 - performance 262
- pressure-driven process 267
- membrane assisted fluidized bed reactor (MAFBR) 271, 272
- membrane technology 182, 261, 271, 525
 - deployment 261
 - perspectives 525
- l*-menthol 165
- mesoporous materials 122, 133
- mesoporous silicas 158
- metal-oxide-semiconductor technology 65
- methacrolein 178, 179
- methacrylic acid, methyl ester 176
- methane, catalytic partial oxidation 218
- methanol 180, 427, 443
 - alkaline catalyst-mixture 443
 - carbonylation technology 180
- methyl acetate synthesis 216
 - distillation process 216
- tertiary*-methyldiethanolamine (MDEA) 450–454
 - unit 454
 - use 451–455
 - for acid gas removal 451
 - sour gas treatment 454
 - Elf activated process 453, 454
 - performance 454
- methylene blue, photocatalytic degradation 236
- methylenedianiline (MDA) 133–135
- 2-methyl-5-ethylaniline (MEA) 164
 - Pt-catalyzed reductive alkylation 164
- 2-methyl-5-ethylpyridine (MEP) 542, 545
 - liquid-phase oxidation 545, 546
 - use 542
- methyl isobutyl ketone (MIBK) 147, 523
 - process cycle 523
 - production 147
 - separation 523
- methyl isocyanate (MIC) 15, 23, 26
 - amount 26
 - on-demand synthesis 23
 - quantity 17
 - storage capacity 20
 - use 26
 - volatilization 19
- 2-methylpentanediamine (MPDA) 548
 - cyclization step 548, 549
- methyl *tert*-butyl ether (MTBE) 142, 464
 - impact on human 464
 - industrial production 464
 - methanol concentration effect 470
 - use 464
 - water accumulation 464
- methyltrioxorhenium (MTO) 175
- metolachlor synthesis 164, 165
 - old vs. new enantioselective process 164
- metric 286, 287, 306
 - characteristic 287
 - decision-support tool 286
 - use 306
- Michael condensation 144, 150
- microchannel 226, 355
 - filling/coating 246
 - immiscible liquids 247
 - longitudinal interface 247
 - Nusselt number 226
 - reactors 355
 - surface roughness 246
 - walls, catalytic coating 263
 - zeolite-coated 246
- micro-engineering techniques 266
- microfabricated chemical systems 225
- microfluidic systems 226, 267
 - heat/mass transfer 226
- microreaction technology 228, 346
 - role 228
- microreactor technology 6, 23, 25, 210, 247
 - (*S*)-2-acetyltetrahydrofuran synthesis 250
 - azo pigment yellow 12, 248
 - gas/liquid-phase 213
 - hydrogen peroxide synthesis 248, 249
 - liquid/liquid-phase reactions 213
 - materials, fabrication methods 244
 - microstructured reactors 227
 - phenyl boronic acid synthesis 248
- microscale structures, top-down techniques 267
- microstructured reactor (MSR) 245
 - catalyzed gas-phase reactions 245
 - micro-packed bed reactor 245
- microtiter plates (MTP) 116
- microwave 232
 - accelerate chemical reactions 224
 - electromagnetic field 232
 - polymer processing, use of 234
 - thermal effect 233
- microwave irradiation 234
 - polymer processing reactors 234
 - polymerization process 234

- millennium development goals (MDGs)
 - indicators 283
- miniature bioreactors (MBRs) 116
- Mitsui petrochemical acetone recycle process 513
- mixed matrix membranes (MMM) 155, 262, 263
 - covalent linking 263
 - polymer matrix 263
 - post-synthesis approaches 155
- monomeric V complex 388, 408
- Montedison slurry process 566
- Montreal Protocol 50
- MORI survey 11
- motor fuel 440
- motor octane number (MON) 476
- multicomponent catalytic reactions 186, 187
- multi-national organizations 3
 - role in green chemistry 3
- multiphase operations process 77, 79, 81
 - aspects 79
 - pros/cons 81
 - role 77, 78
- multi-zone circulating reactor (MZCR) 569, 574
 - polymerization unit 569, 574
 - process flow diagram 569
- n**
- N-hydroxyphthalimide (NHPI) 395, 398, 399
 - based industrial process 398
 - development 398
 - use 395, 398, 399
- N-methyl 2-naphthyl carbamate 27
 - Bhopal/alternative routes 27
- nabumetone 184, 185
 - anti-inflammatory agent 184
 - synthesis 185
- nanofiltration (NF)
 - coupled catalysis 268
 - membrane 268
 - molecular weight cut-off (MWCO) 268
- nanofluids, heat transfer 210
- nanomaterials 65
- nanotechnology 63, 65, 267
- nanotubes, 1D elements 101
- Navier–Stokes equations 226
- neutralization 469, 511
 - of acidic mixture 511
 - cations 469
 - strong/weak nitrogen bases 469
- niacin 542, 545
 - manufacturing 542–548
 - significance 542
 - usage 545
- niacinamide, Lonza's production 548
- nicotine 543
 - liquid-phase oxidation 543
 - chromic acid oxidation 543
- nicotinic acid 543, 545
 - Lonza process 545
 - precursor 543
- nitrous oxide (N₂O) 378–380
 - abatement technologies 379–383
 - atmospheric lifetime 379
 - catalytic abatement 380–382
 - schematic diagram 381
 - concentration 379
 - cycle 384
 - decomposition process 381
 - flow sheet 382
 - Radici process flow sheet 381
 - downstream applications 383
 - from waste compound to reactant 383
 - facts about 385
 - use 384
- non-governmental organizations (NGOs) 45
- Novartis Crop Protection Inc. 33
 - phosgene manufacturing equipment 33
- NO_x 221, 379
 - recovery 379
 - trap catalysts 221
- nylon-6,6 109, 136, 137, 367
 - fibers, applications 367
 - adiponitrile 137
 - polyurethane 109
 - resins 367
- o**
- Office of Pollution Prevention and Toxics (OPPT) 1
 - alternative synthetic pathways for pollution prevention program 1
- olefin 187, 347, 404, 406
 - conceptual mechanism 481
 - *syn* dihydroxylation 406
 - epoxidation 347, 404
 - osmium-catalyzed dihydroxylation 406
 - oxidative cleavage 404
 - paraffin alkylation 475, 476, 481
 - protonation 479
 - rhodium-catalyzed
 - hydroaminomethylation 187
 - olefin space velocity (OSV) 484, 487, 493
 - oligomerization biphasic process 86, 480
 - flow-sheet 86
- organic biphasic operations 84–86

- organic chemical process 92
 - esterification 92
- organic fuels 63
 - butanol/ethanol/methanol 63
- organic ligands 404
- Organization for Economic Co-operation and Development (OECD) 2, 44
 - recommendations 3
- organocatalysis process 187, 188
- oscillatory baffled reactor (OBR) 223
 - dynamic operations 223
 - plug flow conditions 223
- oxo process 80, 82
- oxygen
 - based process 303, 347
 - decarbonylation 432
 - decarboxylation 432
 - hydrodeoxygenation 432
 - removal unit 472
 - transfer agents 167
- oxygenate compounds 463, 466
 - properties 466
 - use 463
- p**
- palm oil 158
- pentenoic acid 400, 401
 - conversion 400
- peroxide species 352
- pharmaceutical industry 107
 - biocatalysis 107, 108
- phase-transfer catalysis 218, 403
- phase transitions 95
 - pressure-temperature diagram 95
- phenetole benzylation 537
 - *o*-benzophenone 538
 - with *p*-chlorobenzoyl chloride 537
 - flow chart 538
- phenol 372, 507, 513, 516, 520
 - consumption 507, 513
 - cumene process 513
 - direct synthesis 176
 - formaldehyde resins 114
 - hydrogenation 372
 - plant 511
 - block scheme 511
 - material balance 512
 - selective synthesis 516
 - sulfolane complex 521
 - synthesis routes 300
 - TS-1-catalyzed hydroxylation 520
- phenyl *p*-chlorobenzoate 539
- phosgene 23, 24, 27, 33
 - consuming regions 33
 - generation 33, 34
 - on-demand synthesis 23
 - micro-fabricated silicon packed-bed reactor 24
 - reactor design 34
 - substitution 35
 - threshold limit value (TLV) 35
- photocatalysis process 77
 - microstructured reactors 236
 - photocatalytic reactors 225
- photochemical reactions 136, 234
 - difficulty 235, 236
- 3-picoline 543, 544, 546, 548, 549
 - advantages 548
 - ammoxidation 549
 - direct oxidation 546, 547
 - gas-phase oxidation 547
 - liquid-phase oxidation 544
 - manufacture 549
 - permanganate oxidation 545
- Polimeri Europa process 524
- TS-1/H₂O₂ process 522, 523
 - block scheme 523
 - material balance 524
- pollutants 8
 - CO 8
 - emissions 8
 - hydrocarbons 8
 - NO_x 8
- pollution
 - emission factors 9
 - prevention concepts 2
- polycarbonates 28, 33
- polylactic acid (PLA) 112
- polymer
 - recirculation rate 571
 - supported alkyl sulfonic acid 133
 - membranes, liquid phase 266
- polymerization process 142
 - inhibitor 110
- polyoxometalates (POMs) 178, 408
 - catalysts, structure 178
- polypropylene processes 564
 - licensing technologies 563
- poly(vinyl chloride) (PVC) 287
 - metrics 287
 - supply chain 287
 - stacking metrics 287
- ponytails, 90 *see also* electron-withdrawing fluorous ligands
- porous silicon (PS), electroluminescence 236
- porous thin layers 266, 267
 - micro-engineering techniques 266, 267
 - nano-engineering techniques 266, 267

- potency factor (PF) 306
- potential environmental impact (PEI) 305, 552, 557, 558, 560
 - feedstock 560
 - EATOS environmental indexes 560
 - graphical comparison 560
 - waste 558
 - EATOS environmental indexes 560
 - graphical comparison 558
 - quantitative comparison 558
- potential runaway reaction 20
- pressure swing adsorption (PSA) 220
- pressure swing reactor (PSR) 220
- prior informed consent (PIC) procedure 47
 - implementation 47
- process design 181–184
- process energy 304
- process hazards analysis (PHA) 50
 - hazard/operability study 50
- process intensification (PI) 6, 7, 22, 23, 199
 - acoustic energy 237–242
 - basic categories 212
 - carbon reductions 230
 - catalytic distillation 215
 - chain optimization 207
 - development 199
 - electric fields 232
 - energy
 - consumption 205
 - efficiency pocket-sized plant 228
 - of flow 242, 243
 - intensive equipment 204
 - saving estimates 229
 - thermodynamic-domain 211
 - environmental impact 228
 - equipment/technologies 23
 - generic principles 210
 - gravitational field 201, 230–232
 - centrifugal operation 230
 - industrial implementation 207
 - numerical process modeling 207
 - process analytical technology 207
 - process control systems 207
 - light 234–236
 - magnetic-driven 225
 - main domains 210
 - methodologies 213
 - emissions of greenhouse gases 228–230
 - hybrid unit operations 213–218
 - microengineering/microtechnology 225–228
 - production, operating modes 218–225
 - microdevice technology 228
 - microreactor technologies 211
 - micro(structured)-reactors 243
 - catalytic gas-phase reactions 245, 246
 - catalytic multiphase systems 246, 247
 - fabrication methods 244, 245
 - fine/functional chemistry 247–250
 - microreactor materials 244, 245
 - microwaves 232–234
 - overview of 208, 209
 - petrochemical/biotechnology industries 212
 - process and equipment design 205
 - processing flexibility 200
 - sound/flow energy 238
 - cavitation effects 238
 - use 237
 - structure spatial domain 211
 - synergy functional domain 211
 - time-temporal domain 211
 - trickle bed reactor 221
 - ultrasonic transducers 207
- process risk management strategies 49
 - categorization 49
 - examples 49
- process safety management (PSM) 47, 48
 - vs. accident prevention 47
 - milestone practices 48
- propane 358
 - direct oxidation 358
 - challenge 358
 - propene oxide 358
- propanediol (PDO) 60, 113
- propene 324, 346, 347, 349
 - epoxidation 324, 334, 349
 - flow-sheet 334
 - gas-phase 347
 - hydrogen peroxide (HP) 324
 - liquid-phase 346
 - hydrogen peroxide (HP) ratio 336
- propene oxide (PO) 319, 325, 326, 331, 343, 349
 - alternative routes 323
 - cumene hydroperoxidation technology 323
 - ethylbenzene hydroperoxide (EBHP) 321
 - introduction 319–321
 - production 325, 331, 335, 342
 - BASF/Dow process 335
 - process integration 331
 - selectivity 336, 343, 349
 - Sumitomo process 325, 326
 - synthesis 319, 342, 347, 350
 - catalysts performance 349
 - challenge 347
 - CHPO technology 321

- direct gas-phase oxidation of propene with oxygen (DOPO) 347, 349
 - gas-phase hydro-oxidation of propene with oxygen and hydrogen (HOPO) 350
 - potential future solutions 347, 350
 - SM technology 321–323
 - TBA technology 321, 322
 - uses 320
 - wastewater 323
 - protic molecules 332
 - Pt catalysts 160, 161
 - Al₂O₃ catalyst 163
 - pulse flow 222
 - schematic diagram 223
 - slugs formation 222
 - purification 274
 - classical/new approaches 275
 - schematic views 275
 - step-by-step solution process 274
 - ultrafiltration (UF) 275
 - purified terephthalic acid (PTA) 180
 - pyrethroids, insecticidal potency 552
- r**
- R&D 10, 12, 41, 56, 59
 - area of 10
 - budget percentage 41
 - long-term planning 56
 - motivations in 12
 - natural evolution 12
 - scenario for 41
 - support 59
 - racemization 107
 - Radici technology 382
 - Raney nickel 159
 - RCH/RP process 79, 82, 83, 102
 - feature of 80
 - oxo process 79
 - Registration, Evaluation, Authorisation and Restriction of Chemical Substances (REACH) 36–43
 - aim 36
 - beneficial characteristics 37, 40
 - data sharing 37
 - legislation 38, 40, 69
 - regulation 38, 39
 - substances 39
 - role for innovation 40
 - timeline 37
 - working 38–40
 - reaction mass efficiency (RME) 298
 - reactor's polymer bed, fluidization 572
 - reactor 181
 - alternative options 182
 - bubble column, oxidation 510
 - catalytic membrane 218
 - chromatographic 216
 - dehydrogenation 356, 472
 - deoxygenation 434
 - direct chlorination 302
 - evaporator concept 29
 - gas-phase 572
 - hydrodynamic cavitation 242
 - hydrotreating 432
 - industrial 181
 - monolithic-type 181
 - moving bed 515
 - multi-bed 381
 - nanoreactor 101, 264
 - role 181–184
 - redox catalysis 158–166
 - asymmetric hydrogenation 162–166
 - cations 412
 - hydrogenation 158–162
 - mechanism 181, 380
 - reducing agent, carbon monoxide 525
 - refinery 141
 - combination technologies 141
 - configurations 141
 - petrochemistry 130
 - regeneration method 491
 - alkylation/regeneration cycles 491
 - effect 490
 - high temperature regeneration (HTR) procedure 491
 - mild regeneration (MR) procedure 491
 - regeneration conditions 490
 - reid vapor pressure (RVP) 475, 493
 - renewability 305
 - biofuels 465
 - definition 305
 - non-CO₂-emitting energy technologies 463
 - geothermal 463
 - nuclear 463
 - photovoltaic 463
 - wind 463
 - replication factor 565
 - Reppe process 51
 - acrylic esters synthesis 51
 - research octane number (RON) 141, 476, 482, 492
 - gasoline, resistance measurement 141
 - reactor temperature effect 482
 - vs. time 492
 - resource intensity indicators 298
 - mass intensity 298
 - mass productivity 298
 - reverse flow reactor (RFR) 219

- heat-integrated reactor concepts 220
 - industrial processes 220
 - operating principle 219
 - reverse osmosis 258
 - Reynolds number 226
 - Rh-binap complex 165
 - Rhodia process
 - block diagrams 531
 - vanillin process 173
 - rhodium complexes 98, 100
 - ionic liquid phase 98
 - supported systems 380
 - risk 14, 21, 35, 50
 - assessment 20
 - based framework 68
 - activities 68
 - goals 68
 - management systems 21
 - minimization 21
 - reduction techniques 26, 50
 - sustainable, final remarks 35
 - Roche HIV protease inhibitor 160
 - rotating packed beds (RPBs) 230
 - high-gravity field of 230
 - methanol-ethanol distillation process 230
 - Ruhrchemie/Rhône-Poulenc's (RCH/RPs)
 - hydroformylation process 81
 - oxo process 79
 - Russell mechanism 370
- S**
- Sabic acetic acid technology 180
 - solid acid catalyst (SAC)
 - process 502, 503
 - technology 494
 - safety data sheets (SDSs) 38
 - safety-management systems 21
 - SAPC reactions 100
 - biphasic catalysis 100
 - hydroformylation 100
 - hydrogenation 100
 - oxidation 100
 - Saquinavir synthesis 160, 161
 - scaling-down chemical processes 21
 - scanning electron micrograph (SEM) 24
 - scarce resources 8
 - Schulz-Flory-type distribution 85
 - sea-water desalination 263
 - selective hydroaminomethylation 187
 - selective oxidation 167–181, 183
 - issue 183
 - role 167
 - Selenastrum capricornutum* 94
 - self-alkylation reaction 480
 - semi-batch reactor 344
 - semi-rapid diesel engines 441
 - separation techniques 547
 - crystallization 547
 - distillation 547
 - drying 547
 - SEVIN preparation 15
 - shell higher olefin process (SHOP) 79, 84, 85, 86, 118, 401
 - scheme 86
 - side-chain alkylation 125
 - Sigma-Aldrich catalogue 559
 - silica alumina catalysts 542
 - silicalite-1 136
 - silylation treatment, beta zeolite 133
 - single enzyme nanoparticles (SENs) 116
 - single-pot catalytic carboxylation 402
 - slip-blind plates 19
 - slurry processes 564
 - Snamprogetti high conversion etherification unit 473
 - Snamprogetti water cooled tubular reactor, *see* water cooled tubular reactor (WCTR)
 - Sn-Beta 173, 174, 186
 - SNPA-DEA process 450
 - social indicators 294
 - social performance indicators 295
 - socio-political metrics 285
 - solar cells 62
 - solid acid alkylation catalysts 494
 - solid acid catalyst (SAC) process 125, 140, 488
 - alkylation 125–130
 - classes 120
 - mesoporous materials 140
 - zeolite 140
 - solid-base catalysts 144–158
 - advantages 144, 150
 - characteristics 157
 - classes 120
 - solid bed technologies 267
 - solid catalysts 180, 484, 530
 - multifunctionality 180
 - types 484, 530
 - soluble supports, dendrimers 87
 - solutia process 514–516
 - block scheme 515
 - material balance 515
 - solvent recovery energy 304
 - solvent recovery system 392
 - solvent recycle stream 339
 - sonochemical reactors 241
 - optimum operating conditions 241
 - sonochemistry, *see* ultrasound

- sour gas composition 454
- sour gas processing, introduction 449
- Soxhlet extraction 535
- soybean
 - composition 430
 - palm vs. rapeseed 430
 - properties 430
- space velocity (SV) 353
- spectroscopic methods 154
 - FTIR/UV 154
- Spheripol process 567
 - block diagram of 567
 - bulk polymerization reactor 567
 - refinement of 567
- Spherizone process 574, 576
 - catalyst feeding 568
 - features of 576
 - gas-phase polymerization 568
 - modular technology 568
 - multi-zone circulating reactor 568
 - product characteristics 575
 - simplified process flow diagram 569
- Spherizone technology 572
- spinning disc reactor (SDR) 201, 231
 - centrifugal forces 201
 - heat transfer coefficient 203
 - high gravity technology 201
 - mass transfer characteristics 231
 - multifunction device 201
 - packing bed 202
 - phase-transfer-catalyzed 231
 - Darzens reaction 231
 - polycondensations 231
 - polymerizations 231
 - Ramshaw's group 201
 - separation processes 202
 - rotating-bed equipment 202
 - simplified scheme of 201
 - thin liquid film 201
- spinning disc tests 204
- SPREX process 459, 460
 - acid gas extraction performance 459
 - capital cost 460
 - energy balance comparison 460
 - gas removal process 458
 - performance 459, 460
- stainless-steel standard reactor 534
- steam importers, *see* oxo process
- steam reforming of methane (SRM) 271
- stereo-configuration, importance 162
- Strategic Approach to International Chemicals Management (SAICM) 44, 46
 - global plan of action 46
 - objectives 44
- Strategic Research Agenda (SRA) document 58
- structure-property relationships 66
- styrene-based sulfonic acids 123
- sublimation curve 95
- sulfonic acid
 - resin, use of 407
- sulfuric acid 477
 - alkylation 477
 - minimum operating temperature 477
 - operating dilution range 477
 - system 477
 - units, operating costs 484
- Sulzer SMR static mixer 206
- Sumitomo process 135, 136, 325–328
 - flow-sheet 327, 328
 - PO production summary 325
 - steps 325
- super-acids 98
 - 1,1,2,2-tetrafluoroethanesulfonic acid (TFESA) 98
- supercritical carbon dioxide (scCO₂) 96, 103, 395
 - applications 96
 - biphasic systems 97
 - properties 96
 - use of 395
- supercritical fluids (SCFs) 95, 96, 162
- supercritical solvents 95–97
- supersonic gas-liquid reactor 243
- supported aqueous-phase catalysis (SAPCs) 100
- supported ionic liquid phase (SILP) catalysis 98, 99
- supported liquid films 97–102
- supported liquid membranes (SLMs), advantage 99
- supported liquid phase catalysts (SLPC) 97
- supported molten metal catalysis (SMMC) 101
- supported phosphoric acid (SPA) 130
- supported salt melts 101
- SusChem visionary project 66
- sustainability 6, 7, 8, 20, 43, 58, 60, 172, 279, 308
 - accounting 292–296
 - G3 guidelines 293, 294
 - global hectare (gha) 282
 - system boundary 295
 - case studies 60
 - concept 279, 308
 - critical enabling factors 8
 - improvement directions 172

- indicators 285
 - life-cycle assessment (LCA) tools 20
 - problem 279
 - quality of life 66
 - through chemistry 6
 - bio-based economy 59–61
 - energy 62
 - healthcare 63
 - information and communication technologies 64
 - management strategies 68
 - nanotechnology 65
 - process design 66
 - risk assessment 68
 - sustainable product 66
 - transport priorities 67
 - vision/roadmap 56–68
 - through chemistry 8
 - through F³-factory 6
 - sustainable chemical production 36–43, 108
 - biocatalysis 108–112
 - metrics 306–310
 - sustainable chemistry (SusChem) 5, 11, 42, 47, 58, 73, 75
 - aspects 73
 - European technology platform 75
 - vs. green chemistry 20
 - principles 11–14
 - risk 11
 - sustainable risk 14–20
 - technology platform 58
 - sustainable consumption and production (SCP) 44–46
 - action plan 45
 - green public procurement (GPP) 46
 - integrated product policy (IPP) 46
 - key pillars 46
 - aims 46
 - sustainable development (SD) 257, 295, 296
 - process intensification 257
 - environmental impact 257
 - membrane technologies 257, 258
 - sustainable energy vectors 62
 - sustainable industrial chemistry 1, 10, 40, 66, 69, 199
 - exothermic reactions 203
 - goal 66
 - methods of 199
 - fabrication methods 244
 - measurement/analysis methods 207
 - water removal methods 230
 - nitration 203
 - petrochemicals 207
 - pharmaceuticals 210
 - polymerization 203
 - process intensification (PI) 199
 - areas of 205
 - benefits of 205
 - critical toolbox 204–210
 - development of 199
 - fundamentals of 210–213
 - gas/liquid mass transfer 199
 - heat transfer 199
 - inherently safer processes 203, 204
 - sustainable process design 200–203
 - technologies 206
 - tools of 199
 - critical toolbox for 204–210
 - microengineering 227
 - microreactor-based tools 227
 - microreactor technology 247
 - sustainable materials management 67
 - sustainable process design 102, 200–203
 - multiphase homogeneous catalysis 102, 103
 - opportunities/perspectives for 200
 - Suzuki coupling 84
 - swing reactor 496
 - syngas 218
 - synthetic insecticides, *see* pyrethroids
- t**
- t*-butyl alcohol (TBA) 321, 467
 - t*-butyl cation/olefin condensation 480
 - Takasago process 165
 - TAPO-5 catalyst 405
 - techno-economical assessment 36
 - technology comparison 575, 576
 - investment cost savings 575
 - temperature-programmed desorption (TPD) methods 154
 - temperature swing reactors (TSR) 221
 - templating agents 344
 - polyacrylic acid 344
 - use 344
 - ten-channel microreactor 23
 - tert*-butyl alcohol (TBA) 321, 467
 - tertiary*-methyl-diethanolamine (MDEA) process 450
 - thermal abatement process 383
 - thermal conductivity 210
 - thermal resistance 202
 - thermodynamic metrics 284
 - thermo-sensitive compounds 269
 - thioethers 406
 - HP-based oxidation 406

- three-column system 434
 - threshold limit value (TLV) 35
 - Ti-based catalytic systems 329
 - Ti silicalite catalyst, use 335
 - Ti-substituted Keggin polyoxometalates 407
 - titanium-silicalite-1 (TS-1) 135, 136, 172, 173, 340, 343, 355, 519
 - activity 519
 - catalysts 341
 - metal-modified 341
 - oxidation reactions 520
 - use 341
 - deactivation 340
 - hybrid 354
 - impregnation 343
 - model 136
 - post-synthesis treatment 520
 - use 354
 - UV/Vis diffuse reflectance spectroscopy (DRS) 521
 - titanium silicalite-2 (TS-2)
 - synthesis 522
 - toluene diisocyanate (TDI) 33
 - toluene oxidation route 507
 - topoisomerase-I inhibitor 185
 - one-pot synthesis 185
 - total cost assessment (TCA) 288
 - toxic feedstocks 35
 - toxicity potential 290
 - toxic reactants 36
 - transalkylation 126, 131
 - catalysts 131
 - Beta 131
 - dealuminated mordenite 131
 - reactor effluent 128
 - transesterification processes 443, 445, 446
 - comparison 446
 - reaction 156, 445
 - transition metal complexes 369
 - transmission electron images 148
 - trans-para*-hydroxycinnamic acid 107
 - transport fuels 439, 463
 - trial-and error approach 47
 - trickle bed reactor 222, 339
 - flow regimes 222
 - schematic diagram of 222
 - triethylbenzene (TEB) 127
 - trifluoroacetic acid (TFA) 402
 - trifluoromethanesulfonic acid (TFMS) 97
 - liquid-phase catalyst 97
 - triglycerides 429
 - chemical structure 429
 - trimethylpentanes (TMPs) 487
 - distribution 487
 - thermodynamic equilibrium 478
 - triphasic system 96
 - trisulfonated triphenylphosphine (TPPTS) ligands 79
 - turnover number (TON) 74
 - catalyst 74, 77, 165
 - two-electron oxidation mechanisms 408
 - two-phase fluid system 395
- u**
- UBE process 29
 - ultrafiltration 87, 258
 - ultra low sulfur diesel (ULSD) 428
 - ultrasound 237
 - reaction time, effect of 237
 - sound 225
 - use of 237
 - United Nations Commission on Sustainable Development 43
 - United Nation's Environmental Program (UNEP) 44, 46
 - International Conference on Chemicals Management (ICCM) 46
 - Strategic Approach to International Chemicals Management (SAICM) declaration 46
 - United Nations Industrial Development Organisation (UNIDO) 43
 - chemical leasing 43
 - α,β -unsaturated aldehydes 100
 - retinal 100
 - selective hydrogenation 100
 - UOP/Eni Ecofining Process 427, 434, 435
 - USA Reformulated Gasoline (RFG) 464
 - US Department of Energy (DoE) 9
 - catalysis science 9
 - US Environmental Protection Agency (EPA) 1
 - design 2
 - green chemistry program 2
 - guiding principles 13
 - toxicity equation 475
 - US Pollution Prevention Act 1
 - US presidential green chemistry challenge awards, recipients of 2
 - UV/Vis diffuse reflectance spectroscopy (DRS) 521
- v**
- V-complexes 402
 - V₂O₅/TiO₂-based catalysts 182
 - vacuum flash drying technique 444

vanadium-based heteropolyacids 408
 vanadyl pyrophosphate 180
 vapor-liquid equilibrium 129
 vapor phase oxidation reactions 171, 172
 vapor pressure curve 95
 vegetable oils 429, 441
 – direct use 441
 – hydroprocessing 430
 vent collection system (VCS) 18
 vent gas scrubber 17
 Vesidryl 149
 vinyl acetate monomer (VAM) 180
 vinyl chloride monomer (VCM) 301
 viscous compounds 269
 vitamin B2 process 108
 – synthesis 292
 – process alternative pathways 292
 vitamin B3 synthesis 112
 – Lonza process 112
 volatile organic compound (VOC) 50,
 221, 513
 – emissions 50

W

Wacker-type ethylene oxidation 97
 waste stream volume 547, 548
 wastewater reclamation 263
 water cooled tubular reactor (WCTR)
 470
 – advantages 470, 472
 – degrees of freedom 472
 – isobutene conversion 470
 – resistance to catalyst 471
 – temperature conversion profiles 471
 water footprint 282
 water-gas shift (WGS) 271
 water washing process 156
 – drawbacks 156
 W-based catalysts 175
 weaker acid sites 121
 World Health Organization 280
 world-scale adipic acid plant 516
 woven wire screens 231
 W-peroxo complex 175

Z

zeolite(s) 120, 121, 130, 132, 413, 485,
 501, 508, 509, 513, 516, 531, 532,
 538, 539
 – alkali-exchanged 155
 – beta 132, 133
 – 12-membered ring 130
 – catalysts 484–488, 508, 509, 513
 – alkylation performance 485, 488
 – BEA-based 542
 – generation 513
 – reaction conditions impact 486
 – destruction 535
 – flow chart 532
 – high-performance use 501
 – industrial application 531
 – large-pore 128, 488
 – membered ring channels 413
 – MFI structure 135
 – micropores 519
 – properties 486
 – recyclability 538
 – use 406
 zeolitic systems 380
 zirconium
 – aluminum catalysts 85
 – titanium Lewis acid sites 174

