

Index

A

- Aerobic reactor/digester
 - biofilm growth, 327
 - biohydrogen production, 326
 - classification, 324
 - configuration, 325
 - CSTR, 324, 326
 - EGSB, 327
 - mesophilic temperature, 323
 - operation temperature, 324
 - psychrophilic temperature, 323
 - solid retention, 326
 - solid wastes and wastewaters, 327
 - thermophilic temperature, 323
 - UASB, 327
- Acetic acid, 334, 380, 382, 401, 470, 483
- Acetic acid pulping
 - acetocell process, 161
 - acetosolv system, 160
 - biodyne processes, 161
- Aceticlastic methanogenesis, 495
- Acetogenesis, 319, 320
- Acetone-butanol-ethanol (ABE), 212, 220–222, 287, 288, 376, 503
- Acidogenesis, 414, 424
 - acetic acid, 380
 - acetyl-CoA, 379, 380
 - acrylate/succinate pathway, 379
 - amino acids, 317–319
 - anaerobic oxidizing organisms, 377
 - butyric acid synthesis, 380
 - catabolic pathways, 378
 - cofactors, 378
 - dark fermentation metabolic models, 378
 - environmental changes, 378
 - equivalents, 378
 - formic acid, 380
 - glycolysis, 379
 - LCFA, 317
 - metabolism, 378
 - monosaccharides, 319
 - oxidation-reduction reactions, 378
- Acidogenic mixed culture fermentation, 376
- Acrylate pathway, 379
- Activated carbons (ACs), 97–99
- Adaptive evolution, 286
- Aeration pretreatment, 482, 487, 488
- Aerobic dynamic feeding (ADF), 619
- Agitated-granular-sludge-bed reactor (AGSBR), 425–427
- Agricultural residues
 - high value products, 39–43
 - primary resources
 - ecological functions, 40
 - intensive agriculture, 40
 - theoretical potential, 40
 - production and usage, 42, 43
 - resources usage, 42
 - secondary resources, 41
 - tertiary resources
 - animal/household waste, 42
 - food supply chain, 42
- Agricultural waste (ACW)
 - AIW (*see* Agro-industrial waste (AIW))
 - description, 235
- AGRIFORVALOR project, 269
- Agro-industrial waste (AIW)
 - biorefinery, 247, 248
 - fruit processing industry, 235
 - valorization (*see* Valorization approaches)

- Aikan® system, 392, 463
- Alcohols
 butanol, 286–288, 290
 ethanol, 284–286
- Aldehyde dehydrogenase, 380
- Algal biomass, 419, 420
- Algenol, 17
- Aliphatic-aromatic polyesters
 aliphatic diacid ethyl esters, 565
 alkane- α,ω -aliphatic linear diols, 565
 applications, 565
 bicyclic diacetals, 567
 biodegradable oligoesters, 566
 macromolecular monomer, 566
 melt polycondensation, 567
 polytransesterification, 565
 substitution pattern effect, 566
- Aliphatic polyesters
 array, 559
 bulk reactions, 557
 CaLB affinity, 559
 co-polyesters, 560
 degradation, 557
 enzymatic cyclocondensation, 560
 factorial design approach, 558
 immobilization
 iCaLB and iCut1, 557, 558
 renewable solid support, 558
 Lewatit VPOC 1600, 557
 MWe, 560
 N435 catalyst, 558
 Novozyme 435, 557
 polycondensation reactions, 557
 polymeric nano-carriers, 559
 protein binding, 558
 reaction cycles, 559
 reaction rates, 559
 serine hydrolases class, 557
- Alkylammonium, 188
- Allothermal gasification, 80
- Allyltriphenylphosphonium, 200
- Amino acids, 315, 317, 377
- Ammonium persulfate (APS), 641
- Amorphadiene synthase (ADS), 293
- Amorphous silicates, 121
- Amylolytic lactic acid bacteria (ALAB), 294
- Anabolism, 378
- Anaerobic biodegradability, 314
- Anaerobic contact process, 326
- Anaerobic digestion (AD)
 acetogenesis, 319, 320
 acidogenesis, 317–319
 biogas (*see* Biogas)
 chemical equilibria, 314
 CHP, 540
 COD, 314, 316
 digestate and odours, fertilizer value, 331
 disintegration and hydrolysis, 315 (*see also*
 Dry anaerobic digestion)
 electricity, 537, 539
 energy production method, 314
 GHG, 330, 331
 history, 313
 investment and operational cost, 540
 methane to grid, 537, 539
 methanogenesis, 320
 microbiological process, 314
 nutrient recovery processes
 ammonia recovery, hydrophobic
 membranes, 333
 ammonia recovery, stripping and
 absorption, 333
 phosphorous recovery as struvite, 332,
 333
 thermal concentration, vacuum
 evaporation, 334
 VFA, 334, 335
 renewable energy production, 329, 330
 sanitation, 332
 scientific and technological knowledge,
 314
 SCOPUS data base, 314, 315
 waste treatment to resources processing,
 327, 328 (*see also* Wet anaerobic
 digestion)
- Anaerobic Digestion Model number 1
 (ADM1), 315
- Anaerobic fermentation, 491
- Anaerobic filter (AF), 327, 448
- Anaerobic membrane bioreactor (AnMBR),
 326
- Anaerobic sequencing batch reactor (ASBR),
 326, 414
- Anaerobiospirillum succiniciproducens*, 297
- Analysis of Variance (ANVOA), 701, 709
- Analytical methods
 COD, 465
 HPLC, 466
 organic acids, 466
 RID detector, 466
 spectrophotometric tests, 465
- Animal by-products, 261
- Anode-respiring bacteria (ARB), 511
- Anoxic conditions, 617
- Aquaculture, 665
- Archer Daniels Midland Company (ADM), 20
- Arrhenius equation, 722
- Arrhenius kinetic parameters, 716

- Artemisinic acid, 293
- Artisanal fishery
- chitin and chitosan, 243
 - pharmaceuticals/nutraceuticals, 242
 - polyunsaturated fatty acids, 242
 - seashell waste, 242
- Ashes
- ACs, 97–99
 - biochar, 90
 - in carbon content, 90
 - and chars, 90, 92
 - direct (on-site) valorization of char, 90, 92
 - feedstock, 90
 - pyrolysis and gasification processes, 90
 - thermal biorefinery processes, 93–97
- Avantium, 23
- Avicennia marina*, 658
- anaerobic digestion, 673
 - bioenergy production, 672
 - biomass composition, 673
 - biomass samples, 670, 674
 - biomethane potential, 671, 675
 - chemical composition, 675
 - environmental benefits, 669
 - material characterization, 671
 - seawater, 675
 - total solids, 671, 672
 - volatile solid, 671, 672
- Azeotrope, 223
- B**
- Bacterial nanocellulose (BNC), 605, 606
- advantages, 606
 - applications, 606
 - bacterial genera, 606
 - biosynthesis, 609
 - dietary foods, 606
 - Gluconacetobacter*, 606
 - pellicles, 608
- Basfia succiniciproducens*, 297
- Benzene, toluene and xylenes (BTX), 112
- Bioactive compounds
- AIW, 236
 - biorefinery and circular economy, 247
 - rice bran, 241
 - SSF, 246
 - technologies, 236
 - valorization, 238
- BioAmber technology, 298
- Bio-based catalysts
- enzyme, 175
 - hydrophilic glycerol, 175
 - immobilization, 176
 - lipase, 175
 - methanol, 175
- Bio-based economy, 595
- Bio-based feedstocks
- biofilm systems, 174
 - microalgae, 174
 - open ponds, 174
 - and photobioreactors, 174
- Bio-based fuels, 169
- Biobutanol, 395
- Biochar, 81, 355
- Biochemical building blocks
- bio-isobutene, 25, 26
 - FDCA (*see* Furan dicarboxylic acid (FDCA))
 - glutamic acid, 21
 - lignocellulosic feedstock, 21
 - LVA, 23–24
 - National Renewable Energy Laboratory, 22
 - production of, 22
 - succinic acid, 25
 - 3-HP (*see* 3-Hydroxybutyrolactone (3-HP))
 - the U.S. Department of Energy, 21
- Biochemical conversion processes
- anaerobic digestion
 - acidogenesis, 358
 - digestate, 358
 - mesophilic range, 358
 - methanogenesis, 358
 - natural process, 358
 - psychrophilic system, 358
 - thermophilic range, 358
 - biodegradable waste, 357
 - composting
 - aerated windrow composting, 363
 - aerobic biological decomposition, 363
 - anaerobic digestion process, 363
 - composting process, 363
 - decomposing organic waste, 364
 - in-vessel composting, 364
 - leachate, 364
 - non-optimal operating conditions, 363
 - nutrient recovery, 365
 - stages of, 363
 - thermophilic stage, 364
 - vermicomposting, 364
 - incineration, 357
 - nutrient recovery
 - acidic/enzymatic reactions, 362
 - bioethanol production, 362
 - biomethanation, 362
 - crystallization/precipitation, 361
 - CSTR, 362

- Biochemical conversion processes (*cont.*)
 - digestion process, 361
 - distillation process, 362
 - electrodialysis, 362
 - gas stripping and absorption, 361
 - lignocellulosic biomass, 362
 - NRTs, 361
 - PFR, 362
 - reverse osmosis, 361
- Biodegradability, 639
- Bio-derived Synthetic Paraffinic Kerosene (Bio-SPK), 660
- Biodiesel
 - bio-based catalysts, 175–176
 - bio-based feedstocks, 174–175
 - catalysts
 - alkaline-based, 172
 - chemical-based, 173
 - FFA, 173
 - supercritical production, 172
 - transesterification, 172
 - type and concentration, 172
 - fatty acid composition, 171
 - feedstocks
 - microalgae, 171
 - non-edible oils, 171
 - oil composition, 170
 - FFA, 192
 - fossil fuel, 169
 - fuel economy of, 187
 - green solvents, 176–177
 - history and properties
 - CO₂ emission, 170
 - oil-rich feedstocks, 170
 - transesterification, 170
 - Novozym lipase, 194
 - production, 187
 - purification
 - approaches, 188
 - glycerol and leftovers, 202
 - synthesis, 192
 - soybean oil, 193, 194
 - synthesis, 187
- Biodiversity, 727
- Bioelectrochemical systems (BES), 376, 511
 - advantages, 514
 - anion and cation exchange membrane, 527, 528
 - applications
 - methane production, 525, 526
 - multicarbon organic compounds, 526, 527
 - concepts, 514, 515
 - ion extraction principle, 528, 529
 - MDC, 527
 - methane production, 526
 - MFCS, 511
- Bioenergy, 618
 - and biofuel area, 46
 - bio-SPK, 660, 662
 - characteristics, biomass, 661
 - enzymatic hydrolysis, 661
 - estimation, 38
 - fermentation, 660
 - gasification, 661
 - lignocellulosic biomass, 660
 - oilseeds, 660, 661
 - pyrolysis, 661
 - resource assessment, 37–39
 - thermochemical pathways, 660, 661
 - transesterification, 660
- Bioenergy with carbon capture and storage technologies (BECCS), 367
- Bioethanol production, 696
 - Algenol, 17
 - Cleanstar, 11
 - cost of, 226
 - feedstock, 11
 - fermentation, 213
 - first-generation, 211
 - lignocellulosic materials, 11
 - MTBE, 11
 - Pannonia ethanol, 11–13
 - Pelagonia project, 16
 - petrochemical fuel lies, 212
 - POET-DSM technology, 16, 17
 - Proesa[®], 13, 14
 - second generation, 211
 - SEKAB technology, 14, 15
 - St1 company, 13
 - third generation, 212
 - the US, 8, 10
 - worldwide, 10
- Biofene[®], 293
- Biofuels, 187
 - first-generation, 640, 657
 - market price, 640
 - renewable energy, 657
 - second-generation, 640, 657
 - third-generation, 640
- Biogas
 - AD (*see* Anaerobic digestion (AD))
 - anaerobic conditions, 732
 - biomethane production cost, 337, 338
 - chromatogram, 733
 - electricity prices, 338
 - electricity production, 335–337
 - energy source, 340

- evolution, 339
 - governmental policies, 339
 - manure processing techniques, 339
 - methane production potentials, 320, 321
 - organic substrates, 322
 - pre-treatments, methane production, 321, 323
- Biohydrocarbons, 22
- Biohydrogen (bio-H₂), 396
 - agricultural residues, 421, 422
 - in Asia, 415–425
 - AGSBR, 426
 - bench-scale bio-H₂ production systems, 425
 - CIGSBR, 425
 - CSABR, 426
 - feedstock pretreatment methods, 414
 - food waste, 420, 421
 - fossil fuel utilization, 430
 - gasification of hydrocarbons, 413
 - hydrogenases and nitrogenases, 414
 - mesophilic and thermophilic microorganisms, 413
 - microalgae processes, 430–431
 - on-site wastewater, 430
 - organic wastes, 413, 429, 430
 - pilot-scale bio-H₂ production (*see* Pilot-scale bio-H₂ production)
 - research, 414, 431
 - solid waste (*see* Solid waste)
 - subdue methanogenesis, 414
 - VFA, 414
 - wastewaters (*see* Wastewaters)
- Biohythane, 376, 400
- Bioleaching, 354
- Biologically active carbon (BAC), 99
- Biological nutrient removal (BNR), 631
- Biomass, 618–621, 627, 629, 630, 642, 695
 - agricultural residues (*see* Agricultural residues)
 - anaerobic digestion, 102, 103
 - ashes (*see* Ashes)
 - biochemical conversion, 284
 - bio-oil production, separation and upgrading, 87, 89
 - bio-oil yield, 80
 - carbohydrate composition, 281
 - char and ash, 90
 - cost
 - absolute, 43
 - feedstock, 44
 - supply and components, 43, 44
 - transport, 44
 - energy consumption, 37
 - free fatty acids, 192, 193
 - fuels and chemicals, 83–88
 - gasification, 80, 81, 104
 - ILs/DESSs, 190–192
 - insufficient resources, 80
 - mobilisation (*see* Mobilisation)
 - mono-/disaccharides, 281
 - original lignin and non-polar, 203
 - PHA, 305
 - pretreatment process, 204
 - pyrolysis (*see* Pyrolysis)
 - SOEC/SOFC, 100
 - solar energy, 38
 - system integration, 99
 - thermal decomposition process, 79
 - thermochemical conversion platform, 103
 - thermochemical conversion processes, 79
 - upstream processing, 281, 283
 - water/steam electrolysis, 100, 101
- Biomass characterization
 - fermentation process, 672
 - thermochemical process, 672
 - yeast fermentation, 672–673
- Biomaterial
 - assumptions
 - cost factors, 644
 - substrates, 644
 - utilities pricing, 644
 - equipment costs, 645
 - materials costs, 646
 - operating costs, 645, 646
 - PEGMA, 646
 - process analysis
 - algae processing, 652
 - challenges, 651
 - cost drivers, 651
 - decomposition approach, 653
 - diverse sensitivity, 651
 - feasibility, 651
 - traditional processes, 651
 - process description
 - centrifugation, 643
 - downstream side, 643
 - drum drying procedure, 643
 - impurities, 643
 - piping installation, 643
 - protein precipitation, 643
 - retention time, 643
 - sensitivity analysis
 - processing techniques, 647–648
 - product formulation, 649–650
 - substrate pricing, 647, 650
 - techno-economic evaluation, 644, 649
- Biomethane, 340, 400

- Bionolix®, 13
- Bio-oil
 - fast and flash pyrolysis processes, 79
 - Fortum Otso® bio-oil plant, 85, 87
 - production, separation and upgrading, 87–89
 - yields, 80
- Bio-oil hydrotreating, 112, 120
 - CFP oils, 123–125
 - hydroprocessing, 122, 123
- Bio-oil integration, *see* Bio-oil upgrading
- Bio-oil upgrading
 - BTX, 112
 - CFP, 111
 - fossil gasoline and diesel fuel, 143
 - FP, 111
 - hydrotreating, 112
 - pyrolysis oil properties, 118
 - refinery integration
 - acidity, 128
 - alkali and alkaline earth metals, 129, 130
 - biomass-derived oxygenates, 138, 139, 142
 - co-processing, 130, 131, 136, 138
 - FCC, 132, 133, 135
 - miscibility, 126
 - organic oxygen, 129
 - pyrolysis oil, 126
 - regulatory and commercial requirements, 140–143
 - stability and aging, 127
 - viscosity, 128
 - water content, 126
 - vapor phase upgrading (*see* Vapor phase upgrading)
- Bioplastics, 615, 617, 632, 633, 639
- Biopolyesters, 396
- Biopolymers, 615, 616
 - black liquor, 609
 - PLA (*see* Polylactic acid (PLA))
 - polyhydroxyalkanoates (*see* Polyhydroxyalkanoates)
- Bio-products, 284
- Bioreactor configuration
 - anaerobic digesters, 390
 - CSTR, 390, 391
 - EPS, 390
 - flocules/granules, 390
 - full-scale technology, 392
 - MBR, 390
 - solid substrates, 391
 - SRT, 390, 391
 - UASB, 391
- Biorefineries
 - biochemical building blocks (*see* Biochemical building blocks)
 - biodiesel (*see* Biodiesel)
 - bioethanol (*see* Bioethanol production)
 - biofertilizer production, 27, 28
 - biological treatment, 3, 28
 - biomass (*see* Biomass)
 - biopolymers (*see* Biopolymers)
 - biorefining, 5
 - chemical, physical and biological treatment, 6
 - classification
 - categories, 7
 - 1st generation, 7
 - 2nd generation, 7
 - 3rd generation, 8
 - conversion processes, 6
 - cosmetic, 27
 - dark fermentation (*see* Dark fermentation)
 - environmental awareness, 3
 - green biorefinery, 6
 - IEA, 6
 - industrial cases, 8, 9
 - manufacturing technologies, 6
 - microalgae production, 26
 - products and chemical compounds, 4
 - renewable source of biomass, 4
 - Spirulina production, 26
 - sustainability, 3
 - traditional petroleum refinery concept, 4
- Biorefinery design, 50
- Biorefinery network
 - building blocks, 60–63
 - intermediate platform, 60–63
 - mathematical framework, 63, 64
 - multi-actor biorefineries (*see* Multi-actor biorefineries)
 - supplier and consumer, 65
- Biorefinery optimization
 - combinatorial, 56
 - and design, 62
 - PNS, 56
- Biorefinery technology
 - economic indicators, 601
 - multi-purpose modular biorefinery layout, 602
 - multi-purpose modular biorefinery structure, 602
 - pilot biorefinery, 598, 599
 - pilot biorefinery plant layout, 600
 - pilot biotechnology plant installation, 601
 - small scale industrial plant, 601

- Biosurfactants
 biochemical conversion, 299
 first generation, 299
 glycolipid, 299
 MEL, 302
 microorganisms, 299
 multinational companies, 299–300
 petrochemical resources, 299
 RL, 302
 second generation, 299
 solvent-intensive recovery, 302
 sophorolipids, 299, 302
- Biosyngas, 400
- Biotechnology, 617, 619, 633
- Bipolar membrane ED (BMED), 452
- Bitter apple oil (BAO), 197
- Brønsted acidic ILs, 197, 198
- Brønsted basic ILs, 198, 199
- Buswell's formula, 735
- 1,4-Butanediol, 296
- Butanol
 ABE process, 287
 acidogenic phase, 287
 applications, 287
 carbohydrates, 288
 Clostridia strains, 287
 Ehrlich pathway, 290
 evolutionary engineering, 288
 genome shuffling, 288
 isomeric structures, 286
 2-keto-acid, 290
 limitations, 287
 metabolic engineering, 287
 S. cerevisiae, 289
 solventogenic phase, 287
 yeast, 289, 290
- Butyl-methylimidazolium methyl sulfate
 [BMIM][CH₃SO₄], 203
- 1-Butyl-3-methylimidazolium
 bis(trifluoromethylsulfonyl)imide,
 191
- 1-Butyl-3-methylimidazolium dicyanamide, 192
- 1-Butyl-3-methyl imidazolium
 hexafluorophosphate, [BMIM][PF₆],
 194
- 1-Butyl-3-methylimidazolium imidazolide
 ([BMIM]Im) IL, 198
- Butyl-3-methylimidazolium hydrogen sulfate,
 192
- 1-Butyl-3-methylimidazolium tetrachloro-
 indate ([BMIM][InCl₄]) IL, 193
- 1-Butyl-3-methylimidazolium
 trifluoromethanesulfonate, 191
- Butyric acid, 384
- C**
- Cadoxen, 159
- Capital and operational costs vs. route/
 sub-route, 537, 538
- Capital expenditure (CapEx), 212
- Capital investment, 645
- Caproic acid, 380, 384
- Carbohydrates, 670, 680
- Carbon capture and storage (CCS), 367
- Carbon capture technologies
 BECCS, 367
 biogas/LFG, 367
 biogeochemical cycle, 366
 biological carbon cycle, 366
 CCS, 367
 electrochemical conversion, 368
 emissions, 367
 geological carbon cycle, 366
 incineration, 366
- Carbon flux, 285
- Carbon monoxide dehydrogenase/acetyl-CoA
 synthase (CODH/ACS), 494
- Carbon recovery, 366
- Carboxylates, 340
- Carboxylic acid
 aerobic pretreated vs. non-pretreated waste,
 488
 dark fermentation, 479
 esterification, 480
 food waste, 479, 480, 485
 purification and esterification, 480
 TS content, 480
- Carboxylic acid number (CAN), 131
- Carrier-induced granular sludge bed reactor
 (CIGSBR), 414, 425
- Catabolism, 378
- Catalytic fast pyrolysis (CFP), 111, 118, 134, 135
- Catalytic hydrocarbon synthesis, 376
- Cation exchange membranes (CEM), 514
- Cellular metabolism, 681
- Cellulose nanofibrils (CNF), 609
- Cellunolix[®], 13
- Centrifugation, 643, 652
- Cheese whey wastewater, 423
- Chemical catalysis vs. enzymatic synthesis, 561
- Chemical oxygen demand (COD), 314, 448, 465
- Chlorella*
 algae strains, 681
 composition, 691
 flow diagram, 683
 salinity test, 688
 SuperPro Designer, 690, 691
 temperature test, 686, 687
 ultrafiltration/microfiltration, 684

- Chlorophyll, 680, 683, 685, 691
 Choline chloride (ChCl), 189, 191, 194–196, 199–202
 Cleavage of ether bonds, 159
Clostridium acetobutylicum, 220
Clostridium kluyveri, 492
 Co-fermentation, 462
Colpomenia sinuosa
 ash content, 735
 carbohydrates and residue content, 735
 chemical characterization, 734
 EFM, 736
 elemental compositions, 736
 methane production, 738
 raw materials, 729
 Combined heat and power (CHP), 46, 329, 540
 Commodity supply system, 44
 Composting process, 363
 Compound annual growth rate (CAGR), 291, 299
 Concurrent alcohol recovery and fermentation (CARAF), 213
 Conducted a life cycle assessment (LCA), 516
 Content determination
 corrected amount, 731
 NREL protocol, 730
 recovery factor, 731
 sugar degradation, 731
 Continuous stirred-tank reactor (CSTR), 324, 362, 390, 414, 420, 448, 449, 492
 Conventional supply system, 44
 CO partial pressure (P_{CO}), 500
 Co-polymerization reaction, 581
 Cosmetic, 27
 Coulombic efficiency (CE), 512
 Coupling technologies, 492
 Crucibles, 729
 Crude oil, 639
 Crystallinity
 first mechanism, 704
 glucan content, 703, 704
 glycosidic linkages, 704, 705
 pretreatment, 704
 second mechanism, 705
 Crystallisation, 616
 Crystallite size, 698
 Cyclohexanes, 125
- D**
 Dark fermentation (DF), 479, 480, 484, 488
 acetic acid, 382
 acidogenesis (*see* Acidogenesis)
 acidogenesis fermentation metabolism, 378–380
 algae, cyanobacteria and phototrophic bacteria cultivation, 398, 399
 biobased economy, 382
 biohythane, 400
 biomass technologies, 376
 biomethane, 400
 bioprocesses, 376, 382, 384, 388, 394, 396, 400, 402
 bioreactor configuration, 390–392
 biorefinery, 394
 bio-society, 395
 biosyngas, 400
 butyric acid, 384
 caproic acid, 384
 carbon dioxide, 386
 concentration and productivities, 383
 dissolved gas concentration, 389
 economics, 392, 393, 398
 energy generation, 375
 ethanol, 385
 fine chemical production, 396, 397
 formic acid, 385
 fossil resources, 375
 head space partial pressure, 389
 hydrogen, 376, 385
 hydrogen to grid, 537, 539, 541, 542
 hydrolysis, 377
 inocula sources, 387
 lactic acid, 384
 liquid fuels production, 394–396
 metabolic pathways, 376, 379
 methane to grid, 537, 539, 541, 542
 microbial population, 386, 387
 minimal selling price, 392–394
 petrochemical reforming, 376
 petroleum-based chemical synthesis, 382
 pH, 389
 photofermentative systems, 394
 product yields and prices, 381, 382
 propionic acid, 384
 revenues, 394, 396
 substrates and nutrients, 387, 388
 syngas, 400–402
 temperature, 389
 Date palm residues, 695, 696, 701, 704–706, 709
 Deep eutectic solvents (DESs)
 in biochemical reactions, 196
 biocompatibility and biodegradability, 189
 catalysts, 199, 201
 ChCl and MTPPB, 202
 ChCl with HBD, 191
 IL (*see* Ionic liquids (ILs))
 organic salt, 188
 solvents, 194, 196, 197

- Defatted soybean meal, 239
- Degree of polymerization (DP), 578, 705
- Deionized water, 697
- 1,3-Dialkylimidazolium cations, 188
- Dibenzothiophene (DBT), 203
- Dibutyl tin oxide (DBTO), 561
- Diglycerides, 190, 202
- Dimethylallyl diphosphate (DMAPP), 291
- Dimethyl carbonate (DMC), 191
- Diversified Natural Products (DNP), 25
- Docosahexaenoic acid algae, 191
- DONG Energy facility, 157
- Downflow stationary fixed film (DSFF), 327
- Dry anaerobic digestion
 - digestors, 359
 - disadvantages, 359
 - feedstocks, 359
 - silos/garage, 359
- Dry process ash, 353

- E**
- Economic assessment, 542–544
- Economic evaluation
 - high resistance, 689
 - payback time, 690
 - purchasing prices, 689
 - SuperPro Designer, 689
- Economic sensitivity analysis, 544, 545
- Effective hydrogen index (EHI), 134
- Electroactive bacteria (EAB), 511
- Electrodialysis (ED), 335, 451, 452, 454, 503
- Electro-fermentation (EF), 521
 - arcB/arcA* redox-sensing cascade, 523
 - bioelectrosynthesis, 522, 523
 - electroactive microorganisms, 523
 - electroactive species, 524
 - limitations, 524
 - optimization, 524
 - Propionibacterium freudenreichii*, 521–523
 - redox-related process, 521
- Electron paramagnetic resonance spectroscopy (EPR), 580
- Electrostatic precipitator (ESP), 88
- Embden-Meyerhof (EM) pathway, 441
- Embden-Meyerhof-Parnas pathway, 378
- Energy saving company (ESCO), 429
- Enerkem Alberta biofuels, 86–88
- Entner-Doudoroff (ED) pathway, 439, 441, 447, 451, 452
- Enzymatic biodiesel, 176
- Enzymatic catalysis, 397
- Enzymatic coupling
 - functional groups, 582–586
 - hydrophilic derivatives, 584
 - lignosulfonates, 582
 - reactivity of lignin, 584
- Enzymatic hydrolysis, 706
 - cellulose, 155, 159
 - steam explosion, 158
 - yields, 157, 158, 160
- Enzymatic pretreatment, 482, 485–488
- Enzymatic synthesis, polyesters
 - aliphatic (*see* Aliphatic polyesters)
 - polycondensation, 556
 - polymerization, 557
 - ROP, 556
- Epichlorohydrin, 267
- 9,10-Epoxy-18-hydroxyoctadecanoic acid (EHDA), 561
- Etanolix®, 13
- Ethanol, 385, 468
 - ABE fermentation, 212
 - C6/C5 yeasts, 286
 - chemical and thermal stability, 220
 - dehydration, 215, 225, 226
 - dehydrogenase, 380
 - distillation process, 213
 - fed-batch reactors, 220
 - fermentation, 218, 221, 227
 - first generation (1G) bioethanol
 - biorefineries, 284
 - hydrophobicity, 220
 - isomerase pathway, 286
 - permeation, 219
 - pervaporation, 217, 223, 224
 - physical mixture, ethanol-water, 222
 - PPP, 285
 - PTMSP, 222
 - S. cerevisiae*, 212
 - second generation (2G) bioethanol
 - biorefineries, 284
 - sugar-based feedstocks, 211
 - xylose, 284
 - yield, 699, 703, 707
 - zeolite, 225
- 1-Ethyl-3-methylimidazolium trifluoromethanesulfonate ([EMIM][TfO]) IL, 193
- Euglena*
 - algae strains, 681
 - salinity test, 688
 - temperature test, 686, 687
- European Biogas Association (EBA), 339
- Exothermic process, 352
- Expanded granular sludge blanket (EGSB), 327
- Expanded polytetrafluoroethylene (e-PTFE), 333
- Extracellular electron transfer (EET), 512

- Extracellular polymeric substances (EPS), 390
- Extractives
- NE, 730
 - ODW, 730
 - soxhlet apparatus, 730
 - TE, 730
 - volatile, 730
- Extractives free biomass (EFB), 736
- Extremophiles, 620
- Extrusion, 247
- F**
- Farnesene
- amorphadiene, 293
 - artemisinin, 292
 - biosynthetic diesel, 290
 - carbon atoms, 290
 - high-purity, 291
 - isoprenoids, 291
 - organic materials, 290
 - prenyl diphosphate precursors, 291
 - S. cerevisiae*, 293
 - squalene, 291
 - yeasts, 292
- β -Farnesene synthase (FS), 293
- Farnesyl diphosphate (FPP), 291
- Fast pyrolysis (FP), 111
- FastQ files, 466
- Fatty acid ethyl esters (FAEE), 259
- Fatty acid methyl esters (FAME), 259
- Fatty acids, 680, 683, 691, 692
- Feed-in tariffs (FITs), 339
- Feedstocks, 44, 153, 157, 158, 162, 616–621, 627–630, 632, 633, 672
- Fibre extraction, 598, 602, 603, 605
- Fibrous bed bioreactor (FBB), 449
- Fischer–Tropsch synthesis, 491
- Fischer–Tropsch Technology, 401
- Flame ionization detector (FID), 733
- Flexible biorefining processes, 593
- Fluidized bed reactor (FBR), 414
- Fluidized/expanded bed (FB), 327
- Flynn-Wall-Ozawa (FWO) model, 716, 718–721, 723
- Food and Agriculture Organization (FAO), 254, 255, 479
- Food waste
- aeration pretreatment, 482, 487, 488
 - Aikan[®] system, 463
 - anaerobic digestion, 535, 537
 - analytical methods, 483
 - bacterial fermentation, 462
 - batch fermentation, 481
 - biorefinery scheme, 475
 - classification, 257
 - co-fermentation, 462
 - dark fermentation, 479, 480, 536, 537
 - downstream processing, 462
 - economic treatment, 461
 - environmental degradation, 479
 - enzymatic pretreatment, 482, 485–487
 - esterification, 480
 - HRT, 463
 - industrial enzymes, 480
 - in situ extraction
 - acetone extraction, 475
 - anaerobic digester, 475
 - bioelectrochemical systems, 475
 - “dirty” fermentation, 474
 - LA yield, 474
 - lactic acid production, 474
 - percolation systems, 473, 475
 - process economics, 473
 - techno-economic analysis, 473
 - industrial enzymes, 480
 - LA production, 475
 - LA yield, 475
 - microbial communities, 462
 - microbial community analysis (*see* Microbial community analysis)
 - mixed culture fermentation, 462
 - mixed culture lactic acid fermentation, 536, 537
 - municipal solid waste, 479
 - percolation (*see* Percolation system)
 - pH, 462, 481
 - practicable system, 475
 - pretreatment methods, 480
 - process and optimization
 - ethanol and acetic acid, 470
 - inoculum, 469
 - LA concentrations and selectivities, 471
 - LA production, 469
 - microbes, 470
 - microorganisms, 471
 - pH controlled experiment, 471
 - protonated acids, 471
 - SEM, 470
 - semi-continuously fed reactors, 469, 470
 - process parameters, 462, 467
 - reactors configurations
 - activated carbon, 465
 - batch experiments, 464
 - mechanical pretreatment, 464
 - percolation system, 465
 - semi-continuously fed reactors, 463

- thermochemical/catalytic down streaming, 465
 - semi-continuous fed reactor (*see* Semi-continuous fed reactor)
 - substrate and inoculum
 - feeding and pH control strategies, 463
 - LA yield, 463
 - pH-controlled, 463
 - sustainable waste management systems, 461
 - synthetic, 481
 - total solid content, 480–485
 - traditional waste management, 461
 - valorization, 488
 - Formic acid, 385
 - Fortum Otso® bio-oil plant, 85, 87
 - Fortum's Joensuu combined heat and power (CHP), 85
 - Fossil polymers, 616
 - Fractionation method, 354
 - France-based Agro-Industrie Recherches et Développements (ARD), 25
 - Free fatty acids (FFAs), 173, 175, 260
 - Fuel Quality Directive (FQD), 38
 - Fumarate, 296
 - Functional polyesters, synthesis
 - bio-based monomers, 564
 - CaLB-catalyzed polymerizations, 561, 562
 - chemo-catalyzed polymerization of IA, 563
 - dimethyl ester vs. itaconic acid, 563
 - DMI/BDO ratio, 563
 - EHDA, 561, 562
 - esterification, 561
 - GLC, 561
 - itaconic acid, 563
 - PHA, 564
 - solvent-free reaction system, 564
 - thermosets, 562
 - Furan dicarboxylic acid (FDCA)
 - Avantium, 23
 - MetGen, 23
 - Futero, 19
- G**
- Galactoglucomannan (GGM), 609
 - Gamma-butyrolactone, 296
 - Gas chromatography (GC), 733
 - Gasification
 - allothermal, 80
 - and anaerobic digestion, 102
 - anion-exchange Resin extractability, 96
 - bio-fuels, 84
 - Enerkem's gasification technology, 86
 - GoBiGas bioSNG production plant, 85, 86
 - K₂CO₃-activated, 98
 - organic secondary resources, 82
 - and pyrolysis, 81, 89, 90, 98, 103
 - solid carbon, 91
 - solid oxide cells, 100
 - steam/carbon dioxide, 80
 - thermal, 80
 - two-stage, 98
 - two-stage downdraft, 94
 - water/steam electrolysis, 99–101
 - Gas stripping, 393
 - Gastroenterology, 384
 - Generally regarded as safe (GRAS), 284
 - Geranyl diphosphate (GPP), 291
 - Geranylgeranyl diphosphate (GGPP), 291
 - Germplasm, 662
 - GFBiochemicals, 23
 - Gibbs free energy, 317, 320
 - GINEXTRA®
 - biomass utilization, 605
 - biorefinery technology, 597
 - community regeneration model, 610
 - environmental biotechnologies, 610
 - enzymatic retting process, 598
 - Ginestra (*see Spartium junceum*)
 - multipurpose modular biorefinery technology, 594
 - rural ecosystems development
 - ATENA consortium, 597, 598
 - community regeneration programme, 597
 - World Cluster Conference, 597
 - side stream valorisation, 605, 606
 - small-scale biorefinery, 598
 - Glasswort of samphire, 661
 - Glucan, 670, 672
 - Glucan-to-glucose conversion, 698, 702, 705–707
 - Glycerol (GLC), 202, 561
 - Glycogen, 617
 - Glycolysis, 378
 - Glyphytes, 657, 660
 - Gothenburg Biomass Gasification (GoBiGas) Project, 84–86
 - Grape pomace valorization, 239
 - Green biorefinery, 4, 5
 - Greengenes Database, 466
 - Greenhouse gases (GHG) emissions, 169, 330, 331, 414
 - Green solvent, 195
 - ILs, 177
 - Mucor miehei* lipase, 176
 - organic, 176
 - SC-CO₂, 176

H

- Haber-Bosch process, 328
Halophilic environments, 620
Halophytes
 bioenergy (*see* Bioenergy)
 biofuels (*see* Biofuels)
 climate, 662
 cultivation operation, 665
 definition, 657
 dicots, 659, 663, 664
 greenhouse, 658
 land area, 663, 664
 mangrove species, 658
 monocots, 659
 Phoenix dactylifera (date palms), 715
 products, 659
 salt tolerance, 659
 S. bigelovii (*see* *Salicornia bigelovii*)
 site selection, 662
 species selection, 664
 water source, 663
Hemocytometer, 682
Henry's law coefficients, 450
Herbal wastewater, 424
1-Hexadecyl-3-methylimidazolium
 bis(trifluoromethyl sulfonyl)imide
 [C₁₆MIM][Tf₂N], 194
Hexane, 684
Hexanoic acid, 384
1-Hexylpyridinium bromide (HPyrBr), 193
High density polyethylene (HDPE), 618
High performance liquid chromatography
 (HPLC), 466, 468, 698, 730, 733
Hofmeister series, 706
Holistic approach, 597
Hollow fiber membrane biofilm reactor
 (HfMBR), 492
Homoacetogenesis, 400
Hot compressed water treatment (HCW), 154
Human appropriation of net primary
 production (HANPP), 38
Hydraulic retention time (HRT), 326, 449, 463
Hydrides, 386
Hydrocarbons
 farnesene, 290–293
Hydrodeoxygenation (HDO), 89, 122, 123
Hydrodesulfurization (HDS), 136
Hydrogen, 385
 A. awamori and *A. oryzae*, 420
 A. niger, *E. aerogenes*, and *C. freundii*, 424
 fermentation systems (*see* Biohydrogen
 production)
 G. amansii, 420
 organic waste, 413
 POME-based, 422
 water hyacinth, 419
Hydrogenation, 399
Hydrogen bond donor (HBD), 188, 196,
 200–202
Hydrogenotrophic methanogenesis, 495
Hydrogen partial pressure (P_{H₂}), 500
Hydrogen price vs. natural gas market price, 536
Hydrogen production rate (HPR), 422–428
Hydrolysis, 377
Hydrothermal pretreatment
 principles, 154
 autohydrolysis/hydrothermal processes,
 154
 enzymatic hydrolysis, 155
 HMF, 155
 lignin polymer alteration, 156
 optimal method, 155
 vapocracking, 154
 water properties, 154
 state of the art
 DONG Energy facility, 157
 lignocellulosic feedstocks, 157
 prairie grasses, 157
 steam explosion
 H₂SO₄/CO₂, 158
 RASH, 158
 SSF, 158
 steam temperature, 158
Hydroxy aldehydes, 115
Hydroxy ketones, 115
Hydroxymethylfurfural (HMF), 155, 672
2-Hydroxypropionic acid, 293

I

- Illumina MiSeq, 466
Incineration process, 353
Industrial food waste valorization
 animal by-products, 261
 biodiesel and glycerol, 266, 267
 biofuels, 268
 biorefineries, 269–272
 carbohydrates, 254
 cashew, 264–266
 catering waste and derivatives, 258–260
 chemical composition, 254
 citrus peel, 263, 264
 classification, 256, 257
 cross-industry and public-private
 collaborations, 274
 development, 274
 domestic waste, 262
 FAO, 253, 254

- food supply chain, 274
 - fossil fuels, 253
 - glycerol, 260, 261
 - integrated biorefineries, 272, 273
 - legislation, 255
 - mixed domestic waste and waste packaging, 262
 - non-edible source, 253
 - non-fuel applications, 268, 269
 - organic crop residues, 256–258
 - quality of life, 274
 - regulations, 255, 256
 - statistical study, 254
 - Inflation rate, 644
 - Institute of Biopolymers and Chemical Fibres (IBWCH), 605
 - Intellectual Property Company (IPC), 21
 - Intensive agriculture, 40
 - Intergovernmental Panel on Climate Change (IPCC), 40
 - Intermediate isopentyl diphosphate (IPP), 291
 - Internal return rate (IRR), 337
 - International Energy Agency (IEA), 5, 27
 - International Renewable Energy Agency (IRENA), 40–44
 - Ionic liquids (ILs), 177
 - biochemical and thermochemical processes, 187
 - biodiesel purification (*see* Biodiesel)
 - biofuels, 187
 - biomass lipid extraction, 190–192
 - catalysts
 - Brønsted acidic, 197–199
 - Brønsted basic, 198–200
 - DES, 199, 201
 - drawbacks, 197
 - challenges, 206
 - choline-based DESs, 194, 196, 197
 - dry washing method, 188
 - enzyme-catalysed transesterification, 187
 - ethaline, 188
 - free fatty acids, 192, 193
 - HBA and HBD structures, 190
 - 5-hydroxymethylfurfural, 189
 - ionic solvent system, 188
 - polar and apolar organic substances, 188
 - recovery, regeneration and recycling, 202–204, 206
 - renewable energy, 187
 - solvent, 192–195
 - structures, 189
 - Isocyanates, 640, 653
 - Isoprenoids, 290–292
 - Itaconic acid (IA), 563
- K**
- Kissinger-Akahira-Sunose (KAS) model, 716, 719–721, 723
 - Kolbe electrolysis, 504
 - Kraft lignin, 575
 - Kraft pulping process, 573
- L**
- Laccase mediator system
 - depolymerization/polymerization of lignin, 575, 577
 - effects, treatment of lignins, 576
 - oxidizes lignin, 575, 576
 - redox potential, 575
 - Laccase mediator *vs.* oxygen levels, 577
 - Laccases
 - crosslinking, 573
 - lignin biosynthesis, 573
 - lignosulfonates, 574
 - oxidation of aromatic substrates, 572
 - plants peroxidases, 573
 - trametes versicolor*, 574
 - TVL *vs.* MTL, 575
 - Lactic acid (LA), 384, 462, 465, 467–469, 472, 474, 475
 - asymmetric carbon atom, 293
 - carbohydrates, 294
 - concentration, 483, 485–487
 - food waste, 480
 - genetic modification, 295
 - homo- and hetero fermentative, 294, 295
 - lignocellulosic biomass, 295
 - microbial fermentation processes, 294
 - nutritional requirements, 294
 - petrochemicals, 294
 - PLA, 294
 - and propionic acid, 486
 - Rhizopus*, 295
 - saccharification, 294
 - Lactic acid bacteria (LAB), 294
 - Lactic acid fermentation
 - methane, 537, 539, 541
 - PLA, 537, 539, 541
 - Laminaria japonica*, 393
 - Landfill
 - chemical conversion
 - biochemical conversion processes, 366
 - carbon recovery, 366
 - thermochemical conversion processes, 366
 - transesterification, 365
 - gas capture technologies, 365
 - LFG, 365

- Landfill (*cont.*)
 nutrient recovery, 365
 vertical/horizontal configurations, 365
- Landfill gas (LFG), 365
- Leftovers, 202
- Levulinic acid (LVA)
 bio-on, 24
 GFBiochemicals, 23
- Lewatit VPOC 1600, 557
- Lignin
 applications, 572
 aromatic biopolymer, 571
 depolymerization/polymerization, 575, 577
 Kraft pulping process, 573
 monolignol precursor molecules, 572
 physiological processes, 573
 pulping process, 571, 573
- Lignin based materials, 581
- Lignin fraction, 155, 161
- Lignin modification
 lignosulphonates concentration, 575
 oxidative enzymes, 574, 575
 properties, 574
 TVL vs. MTL, 575
- Lignin peroxidase
 horseradish, 581
 veratryl alcohol, 581
- Lignin polymerization
 applications, 581
 coupling/grafting of functional molecules, 578, 579
 dispersion properties, 581
 EPR, 580
 fractionation/purification, 579
 grass lignins, 580
 laccase reactivity, 577, 578
 organosolv hardwood lignin, 580, 581
 organosolv lignins, 579
 TVL and MTL oxidation, 580
- Lignocellulose, 670, 673–675
 enzymatic digestibility, 162
 organosolv delignification, 161
 pretreatment, 155
- Lignocellulosic biomass, 660, 703, 704, 706, 708, 720, 721
- Lignocellulosic thermochemical pretreatment
 description, 153
 hydrothermal (*see* Hydrothermal pretreatment)
 organosolv (*see* Organosolv pretreatment)
- Lignol process
 solvents, 160
 streams, 160
- Lipase-biodiesel systems
 commercialization, 177
 dimensionless analysis, 178
 transesterification, 177
- Live cycle assessment (LCA), 323
- Long chain fatty acids (LCFA), 315, 317
- Lower calorific value (LCV), 329
- Lowest cost of manufacture (COM), 245
- Low grade crude palm oil (LGCP0), 200
- Low oxygen content (LOC), 131
- Lycopene extraction, 238
- M**
- Macro algae
 bioethanol production, 739
 biomass, 728
 categorization, 728
 chemical analysis methods
 GC, 733
 HPLC, 733
 chemical characterization
 biogas potential, 732, 733
 content determination (*see* Content determination)
 enzymatic digestibility, 732
 extractives (*see* Extractives)
 total solids and ash determination, 729
 chemical composition, 728
C. sinuosa (*see* *Colpomenia sinuosa*)
 elemental analysis, 734
 enzymatic hydrolysis, 736
 feedstock, 728
 fuel and biochemicals, 728
 materials, 729
 methane production (*see* Methane production)
P. boergesenii (*see* *Padina boergesenii*)
 results and discussion
 chemical characterization, 734–735
 elemental analysis, 735, 736
Ulva sp. (*see* *Ulva* sp.)
- Magnetic ILs (MIL), 192
- Malate, 296
- Mangrove
A. marina (*see* *Avicennia marina*)
 arid regions, 669, 670
 gulf coast, 669
 sustainable utilization, 674
 water scarcity, 669
- Mannosylerythritol lipids (MELs), 300, 302, 303
- Marine ecosystems, 616

- Market price range vs. fermentation-based products, 536, 537
- Masonite process, 158
- Medium-chain-length PHAs (mcl-PHAs), 304
- Medium oxygen content (MOC), 131
- Membrane assisted vapor stripping (MAVS), 214
- Membrane bioreactors (MBR), 390, 414
- Membrane technologies
- asymmetric membrane, 216
 - biorefinery, 212, 213
 - carboxymethyl cellulose membrane, 227
 - conventional distillation process, 226
 - dense polymer film, 215
 - dense thin film, 215
 - ethanol separation, 213, 214
 - ethanol-water mixture, 215
 - film casting method, 215
 - geographical regions, 211
 - hydrophilic membrane dehydration, 223–226
 - inorganic membranes, 217
 - mixed matric membrane, 217
 - nanomaterials, 217
 - organophilic membrane, 215
 - pervaporation, 218–223
 - phase inversion, 215, 216
 - post-fermentation filtration, 227
 - starting material preparation, 227
 - sugar-based feedstocks, 211
 - TFC, 217
 - water treatment, 214
- Mesophilic MCF
- advantages, 437, 438
 - thermophilic lactic acid production, 453
- Metabolic pathway, 438, 441, 445, 447, 453
- Metabolite separation and purification, 451, 454
- Metabolix, 20
- Metal organic framework (MOF), 220
- MetGen, 23
- Methane production
- concentrations, 737
 - cumulative, 736, 737
 - enzymatic convertibility, 738
 - sludge, 738
 - theoretical, 737
- Methanogenesis, 320, 414, 420
- Methanosaeta*, 320
- Methanosarcina*, 320
- Methylerythritol phosphate (MEP), 291
- Methyl tertiary butyl ether (MTBE), 8, 139
- Methyl triphenyl phosphonium bromide (MTPPB), 202
- Mevalonate pathway (MVA), 291
- Microalgae, 191
- biomass production, 174
 - biomaterial (*see* Biomaterials)
 - crucial factor, 653
 - fatty acid profile, 173
 - lipid, 171, 174
 - proteins (*see* Proteins)
- Microalgae biorefinery
- analytical methods
 - concentration, 682
 - dilution factor, 682
 - hemocytometer, 682
 - viable cells, 682
- Chlorella* (*see* *Chlorella*)
- cultivation phase, 679, 684
 - economic evaluation (*see* Economic evaluation)
 - economic viability, 679
- Euglena* (*see* *Euglena*)
- experimental results
- salinity, 689
 - salinity test, 687–688
 - strain, 688
 - temperature test, 686–687
- experimental set up, 681
- extraction phase
- chlorophyll derivative, 685
 - isoelectric region, 685
 - pigment, 685
 - proteins, 684
 - saponification, 685
- feasibility criteria, 683
- harvesting phase, 684
- limitations, 684
- microorganism, 681
- processing, 680, 683
- revenues, 692
- Scenedesmus* (*see* *Scenedesmus*)
- Microalgae production, 26
- Microbial community analysis, 511
- DNA isolation, 466
 - FastQ files, 466
 - Greengenes Database, 466
 - Illumina MiSeq, 466
 - 16S rRNA gene libraries, 466
 - SRA, 466
- Microbial desalination cells (MDC), 514, 527
- Microbial electrochemical technologies (MET), 511
- Microbial electrolysis cells (MECs), 514
- biocathodes, 520
 - carbon-based anodes, 519
 - cathode, 519

- Microbial electrolysis cells (MECs) (*cont.*)
 cation and anion exchange membranes, 519
 disadvantages, 519
 dual-chamber systems, 519
 EAB, 517
 H₂ conversion, 517
 H₂ production, 520
 hydrogenotrophic methanogens, 520
 Nernst equations, 517
 ohmic resistance, 518
 platinum-containing carbon cathode, 519–520
 proton reduction, 517
- Microbial fuel cells (MFC), 493, 511
 advantage, 513
 ARB, 511
 cathodes, 514
 CE, 515
 COD concentration, 516
 EAB, 511
 EET, 512
 electricity, 511
 electrons exchange, 511
 electron transfer mechanisms, 511, 512
 fermentable substrates, 515
Geobacter sulfurreducens, 515
 high current densities, 515
 LCA, 516
 MECS, 514, 516
 MET, 513
 microbial species, 515
 potential application, 515, 516
 principle, 513, 515
 WWTP, 515, 516
- Microbial inhibitors, 283
- Microemulsions, 187
- Microwave energy (MWe), 560
- Microwaves (MW), 191
- Minimum acceptable return on investment (MAR)
 intermediate products, 69
 symmetric, 69
- Miscanthus*, 40
- MixAlco™ process, 392
- Mixed culture fermentation (MCF), 462, 492
 acetic acid, 480
 acetogenesis and homoacetogenesis, 444, 445
 food waste, 480
 hydrolysis and acidogenesis, 439–443 (*see also* Mesophilic MCF)
 methanogenesis, 444
 pretreatment methods, 480
 propionic acid, 480
 thermodynamics, 446 (*see also* Thermophilic MCF)
- Mixed culture fermentation technologies vs. pure culture fermentations, 547
- Mixed integer nonlinear programming (MINLP) problems, 57
- Mixed matrix membrane (MMM), 217, 222, 225
- Mixed microbial cultures (MMC), 620
- Mixotrophy, 399
- Mobilisation
 agricultural residues, 46
 barriers
 economic, 45
 institutional, 45
 technical, 45
 high value products, 45–46
 organisational framework, 46
 policy instruments, 46
- Model food waste, 462, 463, 465
- Monoethylene glycol (MEG), 57
- Monoglycerides, 190, 202
- Monomers, 647
- Monosaccharides, 315, 317, 377
- Mozambique, 11
- Mucor miehei* lipase, 176
- Multi-actor biorefineries
 approaches, 57
 bio-based PTA, 57
 bio-based purified terephthalic acid, 59
 biomass based chemicals value, 73
 biomass-based analogs, 49
 biomass-based feedstocks, 52
 Coca-Cola company, 57
 cyclohexanone and cyclohexanol, 54
 definitions, 50
 fossil based feedstocks, 51
 Intermediate Platform streams, 58, 60–63
 manufacturing processes, 74
 MAR (*see* Minimum acceptable return on investment (MAR))
 Masdar Institute-MIT joint research project, 60
 mathematical framework, 63, 64, 67
 optimal, 54
 petrochemical industries, 50, 53
 PNS, 55, 56
 PTA, 50
 response curves, 66
 ROI (*see* Return on investment (ROI))
 single supplier-single intermediate-single consumer case study, 65, 66
 supplier and consumer, 65

- traditional oil refinery, 50
 - traditional process, 55
- Multi-purpose modular biorefinery, 594, 602
- Municipal solid waste (MSW), 696
- Myriant technology, 298

- N**
- Nanofiltration, 205
- National Renewable Energy Laboratory (NREL), 130, 698
- Net primary production (NPP), 38
- N, N'*-dialkylimidazolium, 188
- N,N*-dimethylcyclohexylamine, 191
- Noncomplex residues, 535
- Nonvolatile extractives (NE), 730
- Novozyme 435 (N435), 557
- Nutrient recovery technologies (NRTs), 361

- O**
- 1-Octadecyl-3-methylimidazolium bis(trifluoromethyl sulfonyl)imide [C₁₈MIM][Tf₂N], 194
- 1-Octyl-3-methylpyridinium tetrafluoroborate ([OMPY][BF₄]), 193
- Oil-rich feedstocks, 170, 171, 173, 178
- Optimal valorisation, 593
- OPX Biotechnologies (OPXBio), 24
- Organic acids
 - LA, 293–295
 - succinic acid, 296–298
- Organic elemental analysis (OEA), 733
- Organic fraction of municipal solid waste (OFMSW), 321
- Organic loading rate (OLR), 326, 463
- Organic residuals, 616
- Organic waste, 413, 426, 429, 430, 535
 - Australian industries, 628
 - biochemical conversion (*see* Biochemical conversion processes)
 - biodegradable, 351
 - carbon recovery, 351
 - conventional feedstock, 633
 - fermentable substrates, 627
 - macronutrients, 352
 - mass flows, 627
 - material flows, 628
 - metabolic processes, 352
 - micronutrients, 352
 - pretreatment
 - deconstruction process, 629
 - hydrothermal processing, 629–630
 - lignocellulosics, 629
 - PHA, 630
 - sugar platform processes, 629
 - VFA production, 629
 - source of nutrients, 351
 - thermochemical conversion (*see* Thermochemical conversion processes)
 - value added products, 351
 - variety of minerals, 351
 - water and waste management services
 - bioplastic formulations, 632
 - BNR, 631
 - commercial-grade PHA, 631
 - feast environments, 631
 - mechanical properties, 632
 - PHA accumulation, 632
 - PHARIO project, 632
 - polymer supply, 631
 - RBCOD, 631
- Organisational framework, 46
- Organosolv lignin, 575
- Organosolv pretreatment principles
 - cleavage of ether bonds, 159
 - lignin, 159
 - solvent applications, 159
- state of the art
 - acetic acid pulping, 160, 161
 - lignol process, 160
 - research, 161, 162
- Oven dry weight (ODW), 730
- Oxaloacetate (OAA), 296
- β-Oxidation process, 317

- P**
- Padina boergesonii*
 - ash content, 735
 - carbohydrates and residue content, 735
 - chemical characterization, 734
 - EFM, 736
 - elemental compositions, 736
 - methane production, 738
 - raw materials, 728
- Palladium-based membrane technology, 503
- Palm-oil mill effluent (POME), 422, 423
- Paraffin, olefin, naphthene, aromatic (PONA), 126, 131, 133
- Payback time, 546, 547, 647, 648, 650
- Pectin extraction, 244
- Pentose phosphate pathway (PPP), 285, 441, 442

- Percolation system, 462, 465
 batch and semi-continuous experiments, 472
 inoculum, 472
 LA concentration, 471
 techno-economic assessment
 metabolic routes, 473
 percolation reactors, 473
 pH-controlled, 473
 practicable system, 472
 research and development, 473
 unpracticable separation technology, 473
 VFA production, 472
- Pervaporation
 ethanol, 217, 224
 ethanol purification, 215
 ethanol-water mixture, 220
 fed-batch ABE fermentation, 220
 MAVS, 214
 membrane filtration, 219
 organophilic and hydrophilic membrane, 227
 PDMS, 222
 PTMSP, 222
 PVA, 224
 TFC membrane, 221
- Petroleum refinery, 680
- PHA, *see* Polyhydroxyalkanoate (PHA)
- PHA accumulation potential (PAP), 631
- pH-controlled, 464
- Phoenix dactylifera*, 695, 697
- Phosphoenolpyruvate (PEP), 296
- Phosphoketolase pathway (PKP), 442
- Photo-bioreactors, 651
- Photosynthesis, 684
- Photosynthetic mixed culture (PMC), 620
- Physisorption, 91
- Pigments, 685, 691, 692
- Pilot-scale bio-H₂ production
 in China, 428
 in India, 428
 in Japan, 428
 in Korea, 427
 in Taiwan, 427
- Ping-pong bi bi kinetic model, 177
- Platanus orientalis* leaves (POL), 421
- Plug flow (PF), 326
- Plug flow reactor (PFR), 362
- POET-DSM technology, 16, 17
- Policy instruments, 46
- Polybutylene succinate (PBS), 296, 304
- Polycondensation reactions, 556
- Polydimethylsiloxane (PDMS), 220–222, 227
- Poly (ether-block-amide) (PEBA), 222
- Polyethylene furanoate (PEF), 23
- Poly(ethylene glycol) methyl ether methacrylate (PEGMA), 641
- Polyethyleneimine-sodium alginate (PEI-SA), 225
- Polygeneration, 81, 84, 99, 104
- Poly[1-(trimethylsilyl)-1-propyne] (PTMSP), 222
- Poly(sodium vinylsulfonate) (PVS), 224
- Polyhydroxyalkanoate (PHA), 418, 564
 bio-on, 21
 bioplastics, 304
 biosynthesis, 305
 commercialisation, 616
 composition, 621
 crystallisation, 622–626
 economic biotechnological polymer production, 306
 feedstock preparation, 618
 mechanical properties, 622–625
 metabolix, 20
 microorganisms, 304
 monosaccharides and disaccharides, 304
 nutrients, 305
 organic waste (*see* Organic waste)
 pentoses, 305
 pilot-scale, 622
 processing window, 626
 production, 304
 feast-famine approach, 619
 generation, 620
 growth and storage yield, 619
 microorganisms, 620
 MMC, 620
 PMC, 620
 two-step process, 618
 reheating cycle, 626
 scl-PHAs vs. mcl-PHAs, 304
 structure, 303, 304
 two-stage syngas utilization system, 504
 waterways, contamination, 615
- Polyhydroxybutyrate (PHB), 384, 451
- Poly(lactic acid) (PLA), 294, 304, 615
 Futero, 19
 NatureWorks/Ingeo, 18–19
 PLAneo, 20
 Sulzer Chemtech, 17
- Polymerization, 556, 557, 643, 647, 648, 651
- Polypropylene (PP), 616
- Polysaccharides, 377
- Polyunsaturated fatty acids (PUFAs), 680
- Polyurethanes, 640
- Polyvinyl alcohol (PVA), 222, 224, 225

- Post-maceration liquid (PML), 605, 606
 chemical composition, 606, 607
 H-S medium, 608
 H-S medium modifications, 606, 607
- Potassium hydroxide (KOH), 172, 196
- Potential electron acceptors, 513
- Powered activated carbon (PAC), 452
- Prairie grasses, 157
- Pressure swing adsorption (PSA), 450
- Proesa[®], 13, 14
- 1,3 Propanediol (PDO), 55
- Propionate, 442
- Propionic acid, 379, 384
- Proteins, 680, 683, 684, 689, 691
 manifestation, 641
 methacrylamide groups, 640, 641
 software, 642
 two-stage reaction, 640
- p*-toluenesulfonic acid (PTSA), 200
- Purification
 biodiesel (*see* Biodiesel)
- Purified terephthalic acid (PTA), 50, 57
- Pyrolysis, 715, 716
 ash and char samples, 83
 biomass types, 81
 fuel characteristics, 82
 Na and Cl rich additives, 83
 organic materials, 81
 palm kernel shells and animal meat and
 bone meal, 83
 palm kernel shells and rice husks, 83
 secondary organic resources, 81, 82
 thermal valorization, 82
- Pyrolysis oil, 112
 actual oxygenate composition, 138
 biomass pyrolysis and composition,
 112–115, 118, 119
 hydrotreating, 123
 physical and chemical properties, 143
 standard refineries, 126, 128–130
- Pyruvate
 ferredoxin oxidoreductase (PFOR)
 pathway, 442
- Pyruvate formate-lyase (PFL) pathway, 442
- R**
- Rapid steam hydrolysis (RASH), 158
- Reactive oxygen species (ROS), 659
- Reactivity of lignins, 581, 584
- Readily biodegradable organic matter
 (RBCOD), 631
- Ready to eat (RTE), 247
- Recyclability, 639
- Refractive index detector (RID), 698
- REnescence process, 392
- Renewable Energy Directive (RED), 38
- Renmatix's Plantrose[®] technology, 293
- Repolymerization process, 155
- Resource density, 46
- Return on investment (ROI), 546, 547
 cost data and product yield data, 72
 demand side actors, 69, 72
 economic profitability, 68
 feasible price of intermediate sugars, 70
 feasible response curves, 70
 feedstocks, 70
 lignocellulosic biorefinery, 69–71
 marketable product, 68
 minimum price of intermediate sugars, 73
 negotiation algorithm, 72
 supply side actors, 69, 71, 72
 theoretical framework, 67
- Reverdia technology, 298
- Reverse TCA (rTCA), 296
- Rhamnolipids (RL), 302
- Rhodamine B, 98
- Rice bran, 241
- Rice mill wastewater, 424
- Rietveld method, 697
- Ring opening polymerization (ROP), 556
- S**
- Saccharification and fermentation (SSF), 158,
 706
- Saccharification process, 706
- Saccharomyces cerevisiae*, 222
- Sago starch-processing wastewater, 424
- Salicornia bigelovii*, 658, 661, 665
 activation energy, 720, 723
 arid-land coastal areas, 715–716
 date palm, 716
 decomposition rates, 716–718
 feedstocks, 721
 FWO method, 718, 723
 heating rate, 716, 718
 isoconversional methods, 722, 723
 KAS method, 719, 720, 723
 kinetic parameters, 720, 721
 Kissinger method, 718, 719, 722
 phases, 716
 pyrolysis, 716
 reaction rate, 718
- Saline lands and water, 658–659
- Saponification process, 685
- Scale-up reactors, 178
- Scandium triflate, Sc(OTf)₃, 561

- Scanning electron microscope (SEM), 155, 156
- Scenedesmus*
- algae strains, 681
 - salinity test, 688
 - temperature test*, 686, 687
- Seashell waste, 242
- Seawater, 659, 663–665
- alkaline hydrolysis, 696
 - by-products, 700
 - cellulose crystallinity, 696
 - chemical composition analysis, 698
 - chloride salts, 696
 - concentrations, 708
 - crystallinity changes (*see* Crystallinity)
 - degradation capacities, 696
 - enzymatic hydrolysis, 698, 699, 705–706
 - fiber direction, 698
 - glucan recovery, 701
 - inhibition, yeast, 707–708
 - lignin recovery, 702
 - pretreatment, 697, 700
 - raw materials, 697
 - saccharification process, 706
 - scaling parameter, 698
 - screening factors, 701, 708, 709
 - SSF, 699
 - temperature, 696
 - t Ratio, 709
 - XRD, 697–698
 - xylan recovery, 702, 703
- Seaweeds, 728
- Semi-continuous fed reactor
- bacterial community structure, 469
 - ethanol, 468
 - HPLC and SCOD, 468
 - LA concentrations, 467
 - LA production, 467–469
 - microbial communities, 468
 - mixed culture fermentation, 469
 - pH controlled experiments, 468
 - pH controlled fermentation, 468
 - product recovery process, 468
- Sequence read archive (SRA), 466
- Sequestration, 640
- Short-chain-length PHAs (scl-PHAs), 304
- Side stream valorisation
- PML, 605
 - solid wastes, 605
- Simulated distillation (SIMDIST) analysis, 125
- Simultaneous saccharification and fermentation (SSF), 295, 699
- Simultaneous saccharification, filtration and fermentation (SSFF), 421
- Sodium hydroxide (NaOH), 172
- Solid and liquid waste valorisation, 603
- Solid oxide electrolysis cells (SOEC), 100, 101
- Solid oxide fuel cells (SOFC), 100, 101
- Solid retention time (SRT), 326, 390
- Solid-state fermentation (SSF), 246, 420
- Solid waste
- algal biomass, 419, 420
 - oilseed cakes, 418
 - water hyacinth, 418, 419
- Soluble chemical oxygen demand (SCOD), 483, 484, 486
- Solvent extraction
- organic, 244
 - pectin, 244
 - physical carrier, 243
- Sophorolipids (SL), 302
- Spartium junceum*
- absorption rate, 604
 - applications, 603
 - characterisation, 603
 - cultivation, 595
 - fibre, 595
 - geographical distribution, 596
 - mechanical properties, 604
 - mediterranean basin, 595
 - pedoclimatic environments, 595
 - perennial shrub, 595
 - pioneer species, 595
 - uses, 595, 596
- Specific surface area (SSA), 705
- Spirulina production, 26
- Sporulation, 387
- Squalane, 291
- Standard error of mean (SEM), 466, 467, 469, 470, 472
- Steam explosion, 158
- Sterilisation, 617
- Sterols, 190
- Stickland scheme, 319
- Stoichiometry, 172
- Straight-run gas oil (SRGO), 136
- Subcritical water extraction (SWE)
- desolventization, 246
 - water reservoir, 245
- Substrate level phosphorylation (SLP), 441
- Succinate pathway, 379
- Succinic acid, 25, 239
- accumulation, 296
 - biodegradable polymer, 296
 - C4-dicarboxylic acid, 296
 - downstream processing, 298
 - E. coli*, 298
 - metabolic pathways, 297

- neutralization, 298
 - TCA cycle, 296
 - Succinity technology, 298
 - Sugar-based fermentation processes
 - alcohol (*see* Alcohols)
 - biomass processing, 282
 - bioplastics, 303–306
 - biosurfactants, 299–303
 - cellulose, 282
 - economic feasibility, 306
 - feedstock, 281
 - GHG emissions, 306
 - hemicelluloses, 282, 283
 - hexoses and pentoses, 283
 - hydrocarbon (*see* Hydrocarbons)
 - hydrolytic enzymes, 282
 - lignocellulosic biomass, 281
 - microbial conversion processes, 281, 283
 - organic acid (*see* Organic acids)
 - starch, 282
 - sucrose- and starch-based biomass, 282
 - sustainable biotechnology, 283
 - whole-crop processing, 282
 - Sugar platform, 282, 283
 - 1-(4-Sulfonic acid) butylpyridinium hydrogen sulfate ([SPyr][HSO₄]) IL, 197
 - 1-(4-Sulfonic acid) butylpyridinium trifluoromethanesulfonate ([BSPy][CF₃SO₃]), 197
 - Sulfuric acid (H₂SO₄), 173
 - Supercritical carbon dioxide (scCO₂), 176, 191
 - Supercritical fluid extraction (SFE)
 - advantages, 244
 - COM, 245
 - economic feasibility, 244
 - value-added components, 244
 - SuperPro Designer tool, 651
 - Supply chain, *see* Industrial food waste valorization
 - Sustainable waste management, 461, 616
 - Syngas, 83–86
 - Syngas fermentation, 376
 - acetate, propionate and butyrate, 503
 - acetogenic bacteria, 492
 - bacterial lipid bilayer, 492
 - biochar and bio-oil, 503
 - biopolymers, 504
 - bioreactions and thermodynamics
 - acetate and ethanol production, 494
 - acetyl–CoA, 494
 - caproate production, 494
 - carbon chain molecules, 494
 - energy conservation, 493
 - enzymes, 493
 - Gibbs free energy, 495
 - hydrogen, 494
 - metabolic pathways, 493
 - methanogens, 495
 - water–gas shift reactions, 494
 - biotechnological technique, 491
 - caproate and caprylate, 503
 - carbon chain metabolites, 492
 - CO and H₂ partial pressure, 500, 501
 - CO toxicity, 492
 - cyclones, 502
 - gasification, 491
 - gas stripping and pervaporation, 503
 - impurities, synthesis gas, 502
 - MCF, 492, 504
 - mesophilic conditions, 492
 - metabolites, 495, 497–498, 503
 - microbial community/metabolic pathway, 492
 - microbial electrolysis, 504
 - operating conditions, 495, 497–498
 - organic acids, 492, 503
 - pH, 499, 500
 - reactor configurations, 501, 502
 - temperature, 496
 - Synthetic fuels, 83, 84
 - Syntrophic acetate oxidizing bacteria (SAOB), 319, 326
- ## T
- Technical and economic assessment (TEA), 641
 - Techno-economic production, 392
 - Techno-economics, 246, 414, 429, 430
 - Technology readiness assessment (TRA), 269
 - Technology readiness levels (TRLs), 269, 642
 - Temperature-phased AD (TPAD), 334
 - Terrestrial plants, 727
 - Tetrahydrofurans, 131, 296
 - Tetrahydronaphthalenes, 125
 - Tetramethylethylenediamine (TEMED), 641
 - Textile wastewater, 423
 - Thermal conductivity detector (TCD), 733
 - Thermal cracking, 187
 - Thermal hydrolysis, 630
 - Thermochemical conversion processes
 - advantages and disadvantages, 357
 - combustion, 352
 - gasification
 - biochar, 355
 - chemical leaching treatment, 355
 - heterogeneous waste source, 355
 - process of transforming waste, 355
 - sewage sludge, 355

- Thermochemical conversion processes (*cont.*)
- incineration
 - bioleaching, 354
 - combustion process, 353
 - common leaching method, 354
 - dry process ash, 353
 - electrodialytic separation process, 354
 - environmental and social acceptability, 353
 - exothermic process, 352
 - fractionation method, 354
 - greenhouse, 353
 - incineration process, 353
 - macronutrients, 353
 - multiple dilution-filtration cycles, 354
 - pathogenic waste, 353
 - solid-phase extraction, 354
 - supercritical extraction, 354
 - thermal conversion, 353
 - wet process ash, 353
 - pyrolysis
 - adsorption applications, 356
 - conversion process, 356
 - pyrolyzed ashes, 356
 - pyrolyzed biochar, 356
 - pyrolyzed char, 356
 - torrefaction
 - pyrolysis, 357
- Thermogravimetric analysis (TGA), 421, 716, 721
- Thermophilic anaerobic membrane bioreactor (TAnMBR), 449
- Thermophilic MCF
 - acidic pH, 448
 - advantages, 438
 - alkaline pH, 448
 - bioreactions, 437
 - carboxylic acids production, 439
 - energy recovery, 452
 - environmental biotechnology, 437
 - factors, 447
 - gas stripping technology, 451
 - H₂ and CH₄, 450, 451
 - hydrogen and methane production, 449
 - hydrogenotrophic methanogens, 453
 - metabolic pathways, 453
 - methanogens, 438
 - organic acids, 451, 452
 - reactor type, 448, 449
 - typical biochemical reactions, 438, 439
- Thermophilic microbial fuel cells (TMFC), 439, 452
- Thin film composite (TFC), 217, 221
- 3-Hydroxybutyrolactone (3-HP)
 - joint venture cargill-novozymes, 24
 - OPXBio, 24
- Total acid number (TAN), 131
- Total extractives (TE), 730
- Total fatty acid (TFA), 191
- Total solids (TS), 324
 - effect, 483–485
 - enzymatic and aeration, 488
 - enzymatic hydrolysis, 482
 - food waste fermentation, 481, 482
 - MCF process, 480
- Total volatile solids (TVS), 419
- Traditional waste management, 461
- Transesterification, 187, 188, 193–200, 202, 259, 260
 - catalytic cracking, 172
 - H₂SO₄, 173
 - ILs, 177
 - immobilization, 176
 - lipase-catalyzed, 177
 - Mucor miehei* lipase, 176
 - short-chain alcohols, 170
- Trends, 4
- Tricarboxylic acid (TCA), 296
- Trick biofilm reactor, 492
- Triglycerides, 190, 191, 196
- U**
- Ulva* sp.
 - ash content, 735
 - carbohydrates and residue content, 735
 - chemical characterization, 734
 - EFM, 736
 - elemental compositions, 736
 - methane production, 738
 - potential feedstock, 739
 - raw materials, 729
- Unique rural ecosystems, 594
- Upflow anaerobic sludge blanket (UASB), 327, 391, 414, 448
- Upper calorific value (HCV), 329
- V**
- Vacuum filtration, 697
- Vacuum gas oil (VGO), 130
- Valorization approaches, 540
 - artisanal fishery, 242, 243
 - bioactive compounds, 240, 241
 - bioactive extraction, 240
 - compounds, 237
 - extraction methods, 239
 - extrusion, 247

- grape pomace, 239, 240
 - reuse and recycle, 238
 - SFE, 244
 - solvent extraction, 243, 244
 - SSF, 246
 - SWE, 245
 - Vapocracking, 154
 - Vapor phase upgrading
 - amorphous silicates, 121
 - hydrocarbon fuels, 118
 - HZSM-5, 119, 120
 - metals, 122
 - zeolites, 121
 - Vermicompost, 364
 - Versatile peroxidase, 581
 - Voigt function, 698
 - Volatile fatty acids (VFAs), 334, 335, 392,
 - 414, 423, 439, 441, 444, 448, 449,
 - 451–453, 461, 462, 472, 491, 618,
 - 629, 632
 - Volatile solids (VS), 321
 - Volatile suspended solids (VSS), 448
- W**
- Waste orange peel (WOP), 263
 - Wastewaters
 - cheese, 423
 - herbal wastewater, 424
 - POME, 422
 - rice mills, 424
 - sago starch-processing, 424
 - textile, 423
 - Wastewater treatment process (WWTP), 516
 - Water properties, 154
 - Wet anaerobic digestion operates
 - advantages, 359
 - biological desulfuration, 359
 - complete-mixed digesters, 360
 - energy balance and economic performance,
 - 360
 - fixed-film digesters, 360
 - mesophilic range, 360
 - thermophilic range, 360
 - Wet process ash, 353
 - Wood–Ljungdahl pathway, 492, 494, 504
 - World Cluster Conference, 597
- X**
- X-ray diffraction (XRD), 697
 - Xylan-to-xylose conversions, 702, 705
 - Xylitol dehydrogenase (XDH), 284
 - Xylose isomerase (XI), 285
 - Xylose reductase (XR), 284
 - Xylulokinase (XK), 285
- Z**
- Zeolite cracking, 89
 - Zeolitic imidazolate framework (ZIF-8), 225
 - Zinc dialkyldithiophosphates, 268