

## Subject Index

Numbers in front of the page numbers refer to Volume 1 and 2: e.g., 2: 282 refers to page 282 in volume 2

### a

- A. niger* CBX-209, levoglucosan fermentation 1: 229
- A. rhizogenes* 2: 275
- absorption, acoustic 2: 242
- acetaldehyde, glucose product family 1: 21
- acetate, biorefinery concept 2: 210
- acetic acid, glucose product family 1: 21
- Acetobacterium woodii* 1: 235
- acidogenic bacteria, metabolic pathways 1: 234
- acetogens 1: 233
- acetoin, biomass building blocks 1: 22
- acetone, glucose product family 1: 21
- acetyl-CoA 1: 233, 236
- acetylated starches 2: 80
- acid addition, lactic acid 2: 386
- acid-catalyzed dehydration 1: 91
- acid-catalyzed hydrolysis, cellulose 1: 133
- acid-catalyzed stages, biofine process 1: 144
- acid conversion, cellulose 1: 129
- acid cooking, straw 1: 193
- acid-forming anaerobes 1: 235
- acid hydrolysis, carbohydrate polysaccharides 1: 144
- acid hydrolysis of polysaccharides 1: 140
- acid hydrolysis process 1: 130–133, 199
- acid-insoluble ligneous components, feedstock 1: 146
- acid prehydrolysis 1: 200
- acidification, lactic acid 2: 386
- acidogenic anaerobes 1: 235
- acids
- dilute 1: 362
  - sugar-derived 2: 5
- aconitic acid, glucose product family 1: 21
- acoustic absorption, elastic protein-based polymer 2: 242
- acrylic acid, glucose product family 1: 21
- acyclic sugar derivatives 2: 48
- acyl glutamate, synthesis 2: 305
- acylated proteins 2: 304
- addition
- cationic 2: 264–265
  - copper-initiated 2: 262–263
  - perfluoroalkyl iodides 2: 263–264
- additive chemicals 1: 91
- additive replacement, ethanol 1: 357
- adhesions prevention, post-surgical 2: 238
- adhesive films 1: 282
- adhesive tack 2: 186
- adhesives 2: 86
- advanced materials, protein-based polymeric materials 2: 220
- aerobic storage, potato juice 1: 300, 309
- agarose gel gene ladder 2: 229
- age of sustainability, modeling tools 1: 57–60
- agribusiness, integrated production 1: 8
- agricultural applications, lignin 2: 192
- agricultural crop residues 1: 117
- agricultural ecosystem modeling 1: 57–60
- agricultural land, net requirement 1: 54–55
- agricultural varieties, oil qualities 2: 276
- agricultural waste 1: 68
- agriculture residue collection 1: 317–344
- agrification 1: 96
- Agrobacterium tumefaciens* 2: 275
- agroindustry, sugar 1: 209–211
- agrosector, dutch 1: 96
- air-blown gasification 1: 232
- air classification 1: 176
- oat grain 1: 183
- Alcaligenes eutrophus*, PHB accumulation 2: 424
- alcell demonstration plant 2: 180
- alcell process 2: 179
- alcohol commodities, sugar-based 2: 36–37

- alcohols
  - microbial conversion 2: 32–34
  - microbial fermentation 2: 33
  - production 1: 235–236
  - sugar-based 2: 42
  - sugar-derived 2: 5
- alfalfa 1: 254
  - chlorophyll extraction 2: 329
  - cultivation 1: 260
- Alfalfa New Products Initiative *see* ANPI
- alfaprox procedure 1: 257
- algal fungi, chitin occurrence 2: 415
- aliphatic diols, high molecular weight 2: 298
- alkali pretreatments 1: 200
- alkaloids 1: 268
- alkanes 1: 268
  - thermal addition 2: 264
- alkyl polyglycoside carboxylate 2: 307
- alkyl polyglycosides 2: 272, 305
  - emulsifiers 2: 308
  - manufacturing processes 2: 306
  - synthesis 2: 306
  - *see also* APG
- allylic C–H Bonds, oxidation 2: 269–270
- alternative life, GJ Drinks 1: 275–277
- American Society for the Testing of Materials *see* ASTM
- american straw, chemical composition 2: 107
- amino acid-based product family trees 2: 201–216
- amino acid composition, lucerne 1: 275
- amino acid production, microbial 2: 201–216
- amino acid residues, hydrophobicity scale 2: 234–235
- amino acid units, proteins 1: 122
- amino acids 1: 267, 2: 304
  - analysis 1: 299
  - brown juice content 1: 305
  - fermentation 2: 203
  - markets 2: 207
- $\delta$ -aminolevulinic acid *see* DALA
- ammonia fiber explosion, pretreatment 1: 362
- ammonium lactate 2: 387
- amphiphilic drugs, controlled release devices 2: 240
- amylases 1: 197
- amylopectin
  - physical structure 1: 140
  - starch synthesis 2: 71
- amylose
  - physical structure 1: 140
  - starch synthesis 2: 71
- anaerobe bacteria, lactic acid fermentation 1: 298
- anaerobes, acidogenic 1: 235
- anaerobic fermentations, succinic acid 2: 35
- anaerobic production, succinic acid 2: 369
- anaerobic storage, potato juice 1: 300, 310
- analytical assays, antioxidant activities 1: 186
- analytical methods, lactic acid fermentation 1: 299
- 1,6-anhydro- $\beta$ -D-glucose, chemical structure 1: 245
- D-anhydroglucopyranose units 1: 140
- anhydrosugar 1: 229, 243, 245
- animal bedding, stover 1: 325
- animal feed, nutrient-enriched 1: 170
- animal feed supplements
  - antioxidants 2: 188
  - lignin 2: 196
- animal health 2: 195–196
- anions of fatty acids, oxidative coupling 2: 266
- anodic coupling, fatty acids 2: 267–269
- ANPI 1: 260
- anthracenes 1: 118
- antibiotic-resistant bacterial strains 2: 195
- antibiotics 2: 15
- antidiarrheic effects, dietary lignin 2: 195
- antifeedants 1: 277
- antifreeze protein 1: 269
- antimutagenic effects, chlorophyll 2: 336
- antioxidant activity, oat bran-rich fractions 1: 186
- antioxidants 1: 186
  - animal feed supplements 2: 188
  - ferulic acid 1: 179
  - lignin 2: 187–189
  - lubricants industry 2: 188
  - rubber industry 2: 188
  - synthetic 2: 188
- antisense RNA approach 2: 275
- APG 2: 11–12, 272
  - synthesis 2: 13
- apolar groups, exothermic hydration 2: 218
- apolar–polar repulsive free energy of hydration 2: 218
- apple-peel wax 2: 430–432
  - components 2: 434

- market launch 2: 436–437
  - natural 2: 429–437
  - production 2: 432–433
  - skin protection 2: 434
  - aquatic biomass 1: 91
  - aqueous media, proteins 2: 218
  - aqueous phase hydrogenation 2: 375
  - arabinanes 2: 109
  - arabinose, reaction 1: 199
  - arabinoxylans 1: 178
  - Arachis hypogaea* 2: 277
  - aromatic chemicals, sugar-based 2: 29
  - aromatic compounds 1: 118
  - renewable raw materials 2: 259
  - transition metal-catalyzed syntheses 2: 259
  - aromatic functionality, char 1: 156
  - Arthrobacter* 1: 398
  - arthropods, chitin occurrence 2: 416
  - arylglycerol units 2: 156
  - ascorbic acid, D-sorbitol 2: 9
  - ash components, feedstock 1: 146
  - asparagine residues, biodegradable thermo-plastics 2: 241
  - aspartic acid (ASP) 2: 34
  - basic biobased chemicals 1: 22
  - Aspergilli* 1: 181
  - Aspergillus* 1: 202
  - Aspergillus itaconicus*, IA 2: 36
  - Aspergillus oryzae* 2: 20
  - cellulase development 1: 366
  - thermostabilization 1: 370
  - Aspergillus succinoproducens* 2: 35
  - Aspergillus terreus*, IA 2: 36
  - asphalt emulsifiers, lignin-based 2: 192–193
  - ASTM, tests 2: 232
  - austria-wide concept, biomass usage 1: 284
  - austrian-concept, biorefinery 1: 273
  - autoadhesive tack 2: 186
  - autotrophic acetogens, syngas fermentation 1: 233
  - autotrophic bacterium
  - AVGVP, biocompatibility 2: 232
  - axioms, phenomenological 2: 232–234
- b**
- B-starch 2: 68
  - Bacillus megaterium* 2: 424
  - bacteria, biodegradation 1: 363
  - bacteria cellulosome 1: 365
  - bacteria destruction, lignin 2: 196
  - bacteriochlorophylls 2: 326
  - bagasse 1: 91
  - brazil production 1: 210
  - energy source 1: 222
  - world production 1: 51
  - bagasse storage, case study 1: 321
  - bale storage 1: 322
  - corn stover 1: 320
  - bale transport, Iowa Corn Stover Collection Project 1: 319
  - baling 1: 333
  - dry material 1: 332
  - BAS 1: 268
  - basic chemicals
  - cellulose 1: 17
  - glucose 1: 17
  - starch 1: 17
  - basic principles, biotechnology 2: 349–351
  - basic substances, biorefinery 1: 18
  - batch fermentation, brown juice 1: 299–300
  - BBI 2: 322
  - 14-BDO 2: 373, 375
  - beer streams 1: 134
  - benzene 1: 87
  - benzene derivatives 1: 118
  - cyclotrimerization 2: 259
  - benzene–toluene–xylene *see* BTX
  - Bergius, F. 1: 5
  - Berzelius, J.J. 1: 5
  - Beta vulgaris* 2: 410
  - betaine 2: 410–415
  - chemical properties 2: 411
  - chemical structure 2: 411
  - usage 2: 412–414
  - betaine esters 2: 414–415
  - BG 1: 203, 364
  - BG Supplement 1: 366–367
  - binder, starch 2: 84
  - bio-alcohols, sugar conversion 2: 32
  - bio-based building blocks 2: 453
  - emergence 2: 450
  - biobased consumer products, cosmetics 2: 409–442
  - biobased economy 2: 138
  - 3-pillar model 1: 3
  - existing 1: 43
  - growth 1: 44–45
  - historical outline 1: 42–45
  - Biobased Industrial Products, initiative group 1: 16
  - bio-based industry, transition 1: 93–96
  - bio-based materials 2: 354
  - biobased oleochemicals, industrial development 2: 291–314

- biobased poly(lactic acid) 1: 296
- biobased production, integrated 1: 8–12
- biobased products
  - market opportunity 2: 353
  - markets 2: 348
- biobased technology, current 2: 375–377
- bio-cascade, biorefinery concepts 2: 355
- biocatalysts 1: 68
  - development 1: 108
  - genetically engineered 2: 37
  - improvement, 3-HPA 2: 35
- biocatalytic routes
  - chemicals production 1: 385–406
  - ethanol production 1: 390–393
- biochemical refinery, secondary 1: 104–106
- biochemicals 1: 13
- biocompatibility 2: 230–232
- biocomposites 2: 362
- bioconversion
  - biomass processing 1: 98
  - fermentation 1: 104
  - starch 2: 89–91
- bio-counterpart, petroleum-derived polymers 2: 41
- biocrude 1: 98, 2: 351
- biodegradability
  - general aspects 1: 213
  - intrinsic 2: 348
- biodegradable films, gluten 1: 181
- biodegradable lubricants, european potential market 2: 301
- biodegradable packages 2: 422–423
- biodegradable plastics 1: 182
  - sugar cane 1: 212–216
- biodegradable polymer 1: 91
- biodegradable thermoplastics, programmable 2: 241
- biodegradation
  - definition 1: 213
  - white-rot fungi 2: 160
- biodiesel 1: 116, 152
  - production 1: 126
- bio-ethanol 2: 451–452
- bio-fertilizer, grasses 1: 283
- biofine char 1: 155–158
  - insoluble components 1: 146
- biofine plants
  - byproducts 1: 145
  - costs 1: 159
- biofine process 1: 139–164
  - advantages 1: 146
  - economics 1: 158–161
  - yields 1: 145–146
- biofuel cells 1: 379
- biofuels 1: 182
  - directive 1: 15
  - promotion 1: 94
- biogas 1: 30, 377
- biogenic amorphous silica *see* BAS
- biological inhibitors, fast pyrolysis 1: 249
- biological raw materials, product classes 1: 13
- biomass
  - availability 1: 99–101
  - commercialization 1: 317–344
  - components 1: 22
  - composition 1: 16, 119, 359, 2: 108
  - compositional variety 1: 45
  - conversion 2: 151–163, 350, 455–456
  - definition 1: 12–14
  - depolymerization 1: 123
  - diversification 1: 54–55
  - hydrolysis 1: 129–138
  - hydrolyzate 1: 78
  - industrial 1: 13
  - industrial chemicals 2: 347–365
  - key sugars 2: 3–59
  - lignocellulose 2: 97
  - local 1: 56–57
  - multi-quality 1: 92
  - policy targets 1: 85
  - polysaccharide-containing 1: 105
  - pretreatment 1: 107, 361–363
  - recycling 1: 117
  - refining 1: 41–66, 107, 227–252
  - sustainability 1: 93–97, 106
  - technology 1: 14–16, 93–97
  - thermochemical processing 1: 249
- biomass-based industrial products 1: 87
- biomass-based products, estimated EU potential 1: 89
- biomass carbon resources 1: 116
- biomass chemistry, comparison with petroleum 1: 118–122
- biomass content, classes 2: 4
- biomass feedstocks 1: 45
  - costs 1: 48–50
  - required properties 1: 50
- biomass flux, The Netherlands 1: 99
- biomass fuels 1: 103
- biomass gasifiers, types 1: 231
- biomass industry, chemical production numbers 1: 284
- biomass-nylon-process 1: 26
- Biomass Research and Development Technical Advisory Committee 1: 135

- biomass streams 1: 100
- biomass substitution volume 1: 85
- biomass suppliers 1: 118
- Biomass Technical Advisory Committee *see* BTAC
- biomass value 1: 324–328
- biomaterials 1: 13
- bionics 2: 410
- bio-oil
  - characteristics 1: 243
  - fermentation 1: 229, 244
  - yield 1: 241
- Biopol 2: 44, 422–424
  - biodegradability 2: 424
  - future 2: 428–429
- biopolyesters, synthetic 2: 41
- biopolymers 2: 40–47
  - cellulose 2: 104
- bioprocessing, consolidated 1: 56
- bioproduct opportunities, industrial 1: 379
- bioproduction
  - highlights 2: 223
  - mechanistic foundations 2: 217–251
  - protein-based polymers 2: 223–227
- bioproducts, classification 2: 356–357
- bioreactor engineering 1: 108
- biorefineries
  - basic principles 1: 17
  - bio-oil based 1: 229
  - Brazil 1: 71
  - building-block concept 2: 202–204
  - cellulosic 1: 55–56
  - chlorophyll disregard 2: 338
  - conceptual schematic diagram 1: 239
  - definition 1: 19–22, 116, 227, 358
  - development 1: 67–83
  - disadvantage 1: 46
  - fuel-oriented 1: 193
  - future integration 1: 380
  - generations 1: 19–20
  - green *see* green biorefinery
  - integration 2: 201–216
  - lignin 2: 177
  - lignocelluloses 2: 110–115
  - lignocellulosic 1: 115–128
  - lignocellulosic feedstock 1: 24–26, 129–138
  - MAAP 2: 209
  - near future production 1: 317
  - oats based 1: 183–187
  - phase III 1: 19
  - plant juice 1: 295–314
  - possible products 1: 45–47
  - primary research areas 1: 101–103
  - principles 1: 16
  - raw material 1: 45–47, 253
  - sugar-based 1: 209
  - supply 1: 45–52
  - technological development 1: 53–56
  - wet mill-based 1: 28
  - wheat based 1: 167–183
  - whole-crop 1: 24, 26–29
- biorefinery complex, cost estimates 1: 118–122
- biorefinery concepts 1: 98–99, 2: 355–356
  - definition 1: 166
  - elements 1: 81
- biorefinery context 2: 315–324
- biorefinery evolution 1: 69
- biorefinery I, sucrose-based 1: 68
- biorefinery II, starch-based 1: 69
- biorefinery III 1: 69
- biorefinery lignin, substitution 2: 182
- biorefinery model 1: 68
- biorefinery process, integrated 1: 102
- biorefinery products 1: 11
- biorefinery research, current 1: 11
- biorefinery supply, transport options 1: 338
- biorefinery systems 1: 3–40, 23
  - history 1: 4–16
  - sustainability 1: 56–65, 60–65
  - whole crop 1: 165–191
- biorefinery technology developments, milling industries 1: 345–353
- biorefinery two platforms concept 1: 24
- biorefinery wastes 1: 56
- biosyngas 1: 98
- biosynthesis, poly(3-hydroxybutyric acid) 1: 224
- biosynthesis genes, *Escherichia coli* 2: 44
- bio-synthetics, car production 1: 9
- biotech, industrial 2: 445–462
- biotech adoption 2: 447
- biotech development, pace 2: 447
- biotech strategy 2: 457
- biotechnological processes, typical problems 1: 388–389
- biotechnology, predictions 2: 32
- biphenyl units, lignin 2: 158
- 1,5-biphosphatecarboxylase/oxygenase 1: 255
- bisphenol A *see* BPA
- black liquors
  - Kraft pulping 2: 170
  - soda pulping 2: 171

- blood plasma substitutes, starch 2: 89
  - blue starch 2: 62
  - Boehringer, A. 1: 7
  - bonding patterns 2: 156–159
  - Boudouard reaction, syngas production 1: 230
  - Bowman–Birk inhibitor *see* BBI
  - BPA 1: 148
  - Brabender viskograph 2: 75
  - Braconnot, H. 1: 5
  - bran, wheat milling 1: 170
  - Branched PLA, melt rheology 2: 397
  - branching, rheology control 2: 396
  - branching technology 2: 398
  - Brassica napus* 2: 277
  - Brazil, agroindustry 1: 209–211
  - breeding material, fatty acid variants 2: 279
  - Brevibacterium* 2: 35
  - British gums 2: 62
  - bromination, LA 1: 150
  - Brookfield viscometer 2: 75
  - brown juice (BJ) 1: 271, 274, 300–308
    - average composition 1: 301–302
    - batch fermentation 1: 299–300
    - carbohydrate addition 1: 311
    - composition of nutrients 1: 305
    - fermentation medium 1: 298
    - lactic acid fermentation 1: 305–306
    - lactic acid source 1: 295
    - quality variations 1: 302–305
    - storage alternatives 1: 298
  - BTAC 1: 14
  - BTX 2: 29
  - building-block concept 2: 204
    - biorefinery 2: 202
    - metabolic engineering 2: 204, 206
  - building blocks 1: 22–23, 98
    - biobased 2: 450, 453
    - heterocyclic 2: 26
    - protolignins 2: 152
    - succinic acid 2: 367–379
    - sugar derived chemicals 2: 34
  - building chemistry 2: 87
  - bulk chemicals 1: 386
    - production routes 1: 385–406
  - Burkholderia spp.*, poly(3-hydroxybutyric acid) biosynthesis 1: 224
  - business structure 1: 117–118
  - butadiene
    - 1,4-BDO 2: 373
    - glucose product family 1: 21
  - 1,4-butanediol 1: 149
  - 2,3-butanediol, glucose product family 1: 21
  - 1,2,4-butanetriol 2: 37
  - n*-butanol, glucose product family 1: 21
  - Butyrubacterium methylotrophicum* 1: 228
    - representatives 1: 235
  - $\gamma$ -butyrolactone *see* GBL
  - by-products
    - animal feed 1: 100
    - biorefinery 1: 23
    - brown juice 1: 311
- C**
- C<sub>1</sub> compounds 1: 233
    - syngas fermentation 1: 228
  - C<sub>5</sub>-carbon sugars, product categories 2: 358–360
  - C<sub>6</sub>-carbon sugars, product categories 2: 358
  - C–C coupling, radical 2: 266–269
  - C–C double bonds, oxidative cleavage 2: 258
  - C. glutamicum* 2: 205, 210
    - phosphorus supply 2: 211
  - C–H bonds, functionalization 2: 269–270
  - C. milleri* 2: 212
  - C-nucleosides 2: 25
  - (C-x)-chemicals 1: 21
  - C<sub>2</sub> anions, oxidative coupling 2: 266
  - C<sub>2</sub> building-block chemical, ethanol 2: 132
  - C<sub>3</sub>–C<sub>5</sub> carboxylic acids, microbial fermentation 2: 33
  - C3 plants
    - protein yield 1: 253
    - yield 1: 258
  - C4 plants
    - protein yield 1: 253
    - yield 1: 258
  - C7 plant acids, potential generation 2: 32
  - CAFI 1: 136
  - calcium lactate 1: 106
  - cancer chemopreventive agents 2: 322
  - cancer therapies, DALA 1: 150
  - Candida antarctica*, lipase B 2: 256
  - Candida bombolica* 2: 274
  - Candida tropicalis* 2: 273
  - Candida tropicalis* DSM 3152 2: 274
  - Candida tropicalis* M 25 2: 274
  - capital costs, biorefinery 1: 240
  - carbohydrate-based product lines 2: 3–59
  - carbohydrate-based surfactants 2: 305
  - carbohydrate composition, lignocellulosic feedstock 2: 109
  - carbohydrate content, changes 1: 266
  - carbohydrate esters, lipase-catalyzed syntheses 2: 272
  - carbohydrate homopolysaccharides 1: 139

- carbohydrate polymers, cellulose 1: 55  
 carbohydrate polysaccharides, acid hydrolysis 1: 144  
 carbohydrate refining 1: 351  
 carbohydrate source, addition to brown juice 1: 311–312  
 carbohydrate stream, corn refinery 1: 349  
 carbohydrates 1: 89–90, 2: 108  
 – annually renewable 2: 6  
 – biorefinery 1: 18  
 – catalytic oxidation 1: 403–404  
 – chemical catalytic conversion 1: 402  
 – contained in biomass 2: 3  
 – heating 2: 24  
 carbon  
 – recycling 1: 116  
 – renewable 1: 43  
 carbon-14-labeled *Escherichia coli*, purification 2: 228–229  
 carbon-based plant material, yearly amount 1: 43  
 carbon dioxide  
 – glucose product family 1: 21  
 – recycling 1: 117  
 carbon dioxide sink, PLA 2: 402  
 carbon fibers  
 – annual demand 2: 197  
 – porous 1: 283  
 – vehicle production 2: 196–197  
 carbon-oxygen reaction, syngas production 1: 230  
 carbon-processing industries 1: 42–44  
 carbon sequestration 1: 62  
 carbon sources 2: 209  
 – fermentable 1: 78  
 – industrial 1: 67  
 – reduced cost 2: 204  
 carbon sugars 2: 358  
 carbon-water reaction, syngas production 1: 230  
 carbonate polymerization 2: 398  
 carboxylic acids 2: 34–36  
 – addition 2: 262  
 – chemical conversion 2: 37–40  
 – microbial conversion 2: 32–34  
 – sugar-based 2: 43  
 carboxymethylation 2: 77  
 cardboard, from press cake fibers 1: 282  
 care additives, multifunctional 2: 309  
 carotene 1: 257  
 – industrial production 1: 9  
 carotenoids 2: 320  
 Carothers, W. H. 1: 8  
 carton production 2: 84  
 case studies, sustainable production 2: 448  
 catabolism, chlorophyll 2: 330–331  
 catalysis technology 2: 349  
 catalysts  
 – bio-oil production 1: 244  
 – carbohydrates conversion 1: 403  
 – metal-based 1: 228, 233  
 catalytic decarbonylation, furan 2: 9  
 catalytic hydrogenation  
 – LA 1: 151  
 – sorbitol 2: 130  
 catalytic pulping, wood 2: 118  
 catalytic routes, chemicals production 1: 385–406  
 catalytic transformations 2: 270–272  
 – succinic acid 2: 372–375  
 catechol 2: 30  
 cationic addition, Lewis acid-induced 2: 264–265  
 cationic polymers, hair 2: 419  
 cationic surfactants 2: 412  
 – structure 2: 414  
 CBH 1: 203, 364  
 CBH-EG-BG System, optimization 1: 366–371  
 CBH I 1: 76  
 CBH I (Cel7A) variants, thermal activity 1: 368  
 CBM, cellulase families 1: 364  
 CC 1: 61  
 cell contents 1: 265–269  
 cell-immobilization 1: 392  
 cell removal 2: 388  
 cell wall, structural constituents 1: 260–265  
 cellobiohydrolase *see* CBH  
 cellobiohydrolase I *see* CBH I  
 cellulase development 1: 366–375  
 cellulase enzyme performance 1: 74  
 – improved 1: 76–77  
 cellulase enzyme production 1: 194  
 cellulase enzymes 1: 74, 2: 177–178  
 – costs 1: 72–73  
 – production 1: 201–202  
 – superior 1: 205  
 – thermal stability 1: 76  
 cellulase expression inducers, disaccharide sophorose 1: 76  
 cellulase mix, lignocellulosic conversion 1: 374  
 cellulase production economics, improved 1: 74–77

- cellulase production strain, enhancement 1: 374
- cellulase saccharification, plant development 1: 134
- cellulases
  - biodegradation 1: 364
  - commercial status 1: 202
  - expression 1: 374–375
  - improvements 1: 367
  - novel 1: 367–370
- cellulolyteomics 1: 374
- cellulolytic fungi
  - protein gels 1: 372
  - secretome 1: 371–373
- cellulose 1: 6, 71–73, 90, 121
  - accessibility 1: 55
  - acetate 1: 243
  - acid conversion 1: 129
  - biosynthesis 1: 90
  - chemical composition 1: 359
  - chemical conversion to LA 1: 144
  - chemical structure 2: 418
  - conversion rates 1: 130
  - digestibility 1: 261
  - enzymatic hydrolysis 2: 115
  - fermentation 2: 177–179
  - glucan source 1: 139
  - high-vacuum pyrolysis 2: 23
  - history 2: 100
  - hydrolysis 1: 26, 194, 199, 202–205
  - isolation 2: 127
  - plant content 1: 261
- cellulose-based biorefinery III 1: 69
- cellulose-based product family tree, industrial 2: 129
- cellulose-based product lines 2: 127
- cellulose-binding modules *see* CBM
- cellulose derivatives 2: 357
  - principal 1: 90
- cellulose fiber, pretreatment 1: 72
- cellulose-hydrolyzing enzymes 1: 17
- cellulose saccharification 2: 99
- cellulosic biomass 1: 68, 197
  - conversion to fuel 1: 52
  - ethanol production 1: 193
  - recalcitrance 1: 56
- cellulosic biomass conversion 1: 71
- cellulosic biorefineries, process development 1: 55–56
- cellulosic feedstocks, hydrolysis 1: 140
- cement 2: 87
- CENTURY model 1: 60–65
- cereal fractionation, advanced 1: 173
- cereal fractionation plants, categories 1: 167
- cereal fractionation processes *see* CFP
- cereal grains, baling 1: 333
- cereal waste, LCF biorefinery 2: 111
- cereals 1: 26, 165–191
  - starch sources 2: 63
- ceitol CC 2: 311
- CFP 1: 166
- chain length, cellulose 1: 195
- char 1: 145
  - biofine process residual 1: 155
- chemical composition, apple-peel wax 2: 433
- chemical conversion, sugars 2: 37–40
- chemical degradation, chlorophyll 2: 333
- chemical digestion, intracellular poly(hydroxyalkanoates) 1: 218
- chemical fractions, lignocellulose 1: 24
- chemical industry 1: 97
  - biorefineries 1: 85–111
  - renewable raw materials 2: 253–289
- chemical modification, naturally produced structures 2: 349
- chemical pulping 2: 166
  - environmentally friendly 2: 179
  - LCF 2: 114
- chemical sources, grasses 1: 282–283
- chemical transformation steps, petrochemical industry 1: 88
- chemicals 1: 22–23
  - basic 2: 5
  - biobased 1: 22
  - biomass compounds 1: 119
  - fossil sources 1: 120
  - from biomass 1: 108
  - from renewable resources 2: 367–379
  - glucomannan derived 2: 120
  - lignocellulose-based 2: 97–150
  - low-molecular-weight 2: 160
  - organic 1: 124
  - product family tree 2: 124–126, 132
  - production 1: 386
  - production routes 1: 385–406
  - special 1: 378
- chemo-enzymatic epoxidation 2: 254
- chemo-enzymatic self epoxidation, reaction principle 2: 256
- chemoattractant, peptides 2: 238
- chemopreventive agents, cancer 2: 322
- chemurgy 1: 9
- chiral purity, lactic acid 2: 383
- chitin 1: 182
  - chemical structure 2: 418

- chitosan precursor 2: 415
- deacetylation 2: 417
- occurrence 2: 415–419
- purification 2: 416–417
- chitosan 2: 415–422
  - chemical structure 2: 418
  - production 2: 417
- chitosan derivatives 2: 421
- chitosonium salts, water vapor sorption
  - 2: 421
- chlorophyll 2: 325–343
  - biological catabolism 2: 330–334
  - breakdown 2: 330
  - chemistry 2: 327
  - commercial production 1: 257
  - degradation 2: 331, 333
  - derivatives 2: 335–339
  - fundamentals 2: 326
  - historical outline 2: 325
  - industrial production 1: 9
  - isolation 2: 328
  - new materials 2: 338
  - reactivity 2: 328
  - structure 2: 327
- chlorophyllin 2: 335
- cholesterol level, decrease 1: 180
- cholesterol mediation 1: 277
- cholesterol reduction,  $\beta$ -glucan 1: 185
- chopping, pretreatment 1: 361
- chrisgas-project 1: 103
- Chromatium okenii* 2: 424
- circuit board resins 2: 194–195
- citrates 1: 91
- citric acid, glucose product family 1: 21
- Clostridium ljungdahlii* 1: 228, 235
- Clostridium methoxybenzovorans* SR3 1: 179
- Clostridium thermoaceticum* 1: 235
- Clostridium thermocellum* 1: 365
- clothing, synthetic fibers 2: 190
- CO<sub>2</sub> flux 1: 328
- CO<sub>2</sub> production, MAAP 2: 212
- CO<sub>2</sub> sequestration 1: 173
- co-polymerization, starch 1: 27
- co-products 2: 370
  - sugar fermentation 2: 375
- coconut oil 2: 292
- collection, baling dry material 1: 332
- collection cost, forage harvester 1: 334
- commercial consideration, MAAP
  - 2: 205–209
- comonomers, multi-cyclic 2: 398
- company closures, lignosulfonate produc-
  - ers 2: 173
- competitive prices, biobased products 2: 49
- competitors, external challenges 2: 457
- components, cereals 1: 166
- composite materials, carbon fiber 2: 196
- compositional variety, biomass 1: 45
- concentration, lactic acid 2: 390
- concept, all biomass is local 1: 57
- concrete, self-leveling 2: 88
- concrete admixtures 2: 189–190
- conditioner, sugar beet 2: 410–415
- conditioning agent, natural 2: 436
- coniferyl alcohol, oxidation 2: 158
- consolidated bioprocessing 1: 56
- Consortium for Advanced Fundamentals
  - and Innovation *see* CAFI
- consumer acceptance, external chal-
  - lenges 2: 457
- consumer products 2: 409–442
- continuous cultivation *see* CC
- continuous fermentation 1: 300
- controlled-release devices, design 2: 240
- conversion, chlorin 2: 333
- conversion efficiency 1: 196
- conversion steps
  - biorefinery 1: 23
  - lignocellulosic biorefinery 1: 24
- conversion technologies 1: 108
  - primary 1: 270, 2: 350
- cooking liquors 2: 166
- coordination–insertion mechanism, lactide
  - polymerisation 2: 393
- copolyesters, PHB 1: 215
- copolymer, PHV-PHB 2: 426
- copper-initiated additions 2: 262–263
- corn 1: 26
  - phytochemicals 2: 317
  - wet milling 1: 28
- corn continuous cultivation 1: 61
- corn dry milling, biorefinery example 1: 70
- corn dry milling industry 1: 345–353
- corn grain, export reduction 1: 43
- corn oil, corn refinery products 1: 348
- corn pricing 2: 368
- corn refinery, modern 1: 348
- corn refining 1: 346–347
- corn–soybean rotation 1: 61
- corn starch, pearl 1: 351
- corn-steep liquor 1: 349
- corn stover, world production 1: 51
- corn stover bale storage 1: 320
- corn stover pricing 1: 319
- corn stover structure 1: 74
- corn syrup, carbohydrate refining 1: 351

- corn tillage practice 1: 330
  - corn wet milling industry 1: 345–353
  - corn wet milling process 2: 367
  - corncobs 1: 91
  - corporate action, increasing 2: 451
  - corrugating industry, starch usage 2: 83–84
  - Corynebacterium efficiens* 1: 80
  - Corynebacterium* 2: 35
  - cosmetic emulsion, oil-phase components 2: 310
  - cosmetic lipids, occlusion testing 2: 434
  - cosmetics
    - chitosan 2: 419
    - consumer products 2: 409–442
    - history 2: 409–410
    - ilex resin 2: 439
    - starch usage 2: 88–89
  - cost components, ethanol production 1: 73
  - cost disadvantage, cellulose-based ethanol 2: 203
  - cost efficiency 1: 381
  - cost estimates, biorefinery complex 1: 118
  - cost generators, waste 1: 96
  - cost savings, biotechnology 2: 450–451
  - costs
    - antioxidants 2: 188
    - biomass vs. petroleum 1: 48–50
    - feedstock 1: 196
    - MAAP 2: 202
    - processing systems 1: 53
  - cotton 1: 90
  - coupling, oxidative 2: 266
  - cover crops 1: 331
  - crop-drying industry, grass usage 1: 298
  - crop residues 1: 45
    - commercial 1: 318
    - world production 1: 51
  - cropping system 1: 61
  - crops, starch sources 2: 63
  - cross-linking
    - free radical 2: 399
    - starch modifications 2: 81
  - cross-reactions 1: 145
  - crotonaldehyde, glucose product family 1: 21
  - crude drugs, juice fraction 1: 274
  - crude fiber, plant content 1: 261
  - crude oil 2: 292
    - high prices 1: 115
  - crude petroleum, separation 1: 119
  - crude starch milk 2: 66
  - crushing, pretreatment 1: 361
  - crystalline cellulose 1: 195
  - crystalline melting point, control 2: 394
  - crystallinity, starch 2: 72
  - CSL 1: 349
  - cultivation temperature 2: 213
  - curl-retention test 2: 420
  - curled hair, swatches relaxation 2: 419
  - cycle times, PHB 1: 216
  - cyclization, methyl 17-octadecanoate 2: 259
  - cyclodextrins 2: 90
  - cyclotrimerization, benzene derivatives 2: 259
  - Cyprus papyrus* 2: 98
- d**
- Dactylis glomerata* 1: 261
    - alkanes 1: 268
    - amino acid composition 1: 267
    - sugar 1: 265
  - DALA 1: 149–150
  - DDGS 1: 71
  - debranning apparatus 1: 174
  - decomposition methods, primary refinery 1: 271
  - decorative laminates 2: 185
  - deformation energy, recovery 2: 220
  - degradation, chlorophyll 2: 331, 333
    - definition 1: 213
  - degradation resistance, cellulose fibrils 1: 140
  - degree of polymerization, cellulose 1: 195
  - demonstration process, iogen's 1: 193
  - density, bales 1: 335
  - department of energy (DOE) 1: 19, 74
  - depolymerization, biomass 1: 123
  - designer proteins 1: 122
  - development lines, sugar-based chemicals 2: 14
  - development trap, underdeveloped countries 1: 52
  - dextrins 2: 79
  - dextrose 2: 128
    - production 1: 44
    - starch hydrolysis 1: 5
  - dextrose syrup, carbohydrate refining 1: 351
  - DFA III, production 1: 397
  - diacids, replacement 2: 38
    - 1,4-diacids 2: 34
    - basic biobased chemicals 1: 22
  - dialkyl carbonates 2: 311
    - synthesis 2: 311
  - diamines, sugar-based 2: 42

- diammonium succinate 2: 376  
 diastereomeric forms, lignin 2: 157  
 dibenzodioxin structures, lignin 2: 158  
 Diels-Alder reaction, methyl conjugen-  
 ate 2: 260  
 diesel 1: 119  
 – low-smoke formulation 1: 153  
 dietary lignin, antidiarrheic effects 2: 195  
 diethyl ether, glucose product family 1: 21  
 diffraction patterns, starch 2: 73  
 difructose anhydride 1: 397–402  
 digestibility, cellulose 1: 261  
 diglycerides, lipase-catalyzed syntheses  
 2: 270–272  
 dihydropyranones 2: 20  
 – disaccharide-derived 2: 24  
 dilactide, glucose product family 1: 21  
 dilute acid hydrolysis 1: 200  
 dilute acids  
 – pretreatment 1: 362  
 – starch treatment 2: 76  
 dilute sulfuric acid, biofine process 1: 142  
 dilute-sulfuric-acid hydrolysis, cellulose  
 1: 132  
 dimer acid 2: 297–298  
 dimerdiols, dimer acid based 2: 297–298  
 dimerization, radical 2: 267  
 dimethyltetrahydrofuran *see* DMTHF  
 diphenolic acid 1: 148  
 direct distillation 2: 389  
 disaccharide sophorose 1: 76  
 disaccharides, availability 2: 4–7  
 disposal problems, Biopol 2: 428  
 dissociation, of industries from petrochem-  
 ical 1: 94  
 distillation of lactate ester 2: 389  
 distillers dried grains and solubles *see*  
 DDGS  
 DM 1: 261  
 DMTHF 1: 152  
 DOE *see* department of energy  
 door binders 2: 185–186  
 downdraft gasifiers 1: 231  
 downstream processing  
 – grass fiber fraction 1: 281  
 – poly(3-hydroxybutyric acid) 1: 218–220  
 drilling fluids, starch derivatives 2: 91  
 drugs, sugar derived 2: 14  
 dry fractionation, wheat 1: 176–183  
 dry matter 1: 261  
 dry mill refinery 1: 346–347  
 dry milling 1: 27, 70  
 – operations 1: 166  
 dry reactions, starch modifications 2: 77  
 dry storage, bagasse 1: 321  
 DSM, transition process 1: 93  
 Duales System, biodegradable bottle 2: 427  
 Dutch Energy Research Strategy 1: 109  
 dye dispersants 2: 190–192  
 dyes  
 – biorefinery context 2: 315–324  
 – juice fraction 1: 274  
 dyestuff 2: 191
- e**  
*E. coli see Escherichia coli*  
 E10-Fuel 1: 9  
 ECN 1: 109  
 ecological aspects, green biorefinery  
 1: 283–285  
 ecological balance, fermentative produc-  
 tion 2: 207  
 ecological compatibility, biobased oleochem-  
 icals 2: 293  
 economic aspects, green biorefinery  
 1: 283–285  
 economic barriers, biotechnology 1: 381  
 economic benefits 2: 452–454  
 economic clusters, new synthesis 1: 95  
 economic forces 1: 41  
 economic potential  
 – biotechnology 2: 446–451  
 – industrial biotech 2: 445–462  
 economics, biofine process 1: 158–161  
 economies of scale 1: 159  
 – biodiesel plant 1: 127  
 economy, biobased 1: 41–66  
 economy growth 1: 67  
 economy of scale  
 – biorefineries 1: 350  
 – furfural 1: 125  
 ecosystem modeling 1: 57–60  
 edible films, gluten 1: 181  
 efficiencies, biofine process 1: 145–146  
 efficiency improvements, biotechnology  
 2: 454  
 efficient energy conversion, elasticity pro-  
 vides 2: 219  
 EG (endoglucanase) 1: 203, 364, 2: 133  
 – structure–function relationship 1: 370–  
 371  
 Ekman, C. D. 1: 6  
 EL (ethyl levulinat) 1: 152–153  
 elastic consilient mechanism 2: 223  
 – protein-based polymer engineering  
 2: 217

- elastic mechanisms, coupling to hydrophobic mechanism 2: 237–238
- elastic moduli, fibers 2: 241
- elastic protein-based polymers, temporary functional scaffoldings 2: 239
- elasticity, protein-based polymers 2: 219–220
- Elbow washing test, betaine 2: 413
- electricity 1: 46
  - biomass share 1: 14, 16
- electricity generation, biomass 1: 44
- electrodialysis, lactic acid purification 1: 312
- electrophilic substitution, furan 2: 9
- emollients 2: 310
- emulsifiers
  - lecithin 2: 318
  - polyglycerol esters 2: 308
  - vegetable oil 2: 301
- emulsion(co)polymerization process, starch derivatives 2: 90
- endoglucanase *see* EG
- endotoxins, removal 2: 230
- enediol, dehydration 1: 142
- Energie Onderzoeks Strategie *see* EOS
- energy and protein coproduction 1: 55
- energy balance, simultaneous processing of sugars 1: 221
- energy conversion, efficient 2: 219
- energy costs, impacts 1: 115
- energy crops, renewable carbon 1: 44
- energy efficiency, fossil fuels replacement 2: 449
- Energy Research Center of the Netherlands *see* ECN
- energy sources, biomass-based 1: 380
- engine efficiency loss, diesel 1: 153
- engineered organisms 1: 68
- engineering
  - mechanistic foundations 2: 217–251
  - protein-based polymers 2: 219–220, 232–238
- engineering principles
  - fundamental 2: 222
  - protein-based polymers 2: 220
- entire barrel of biomass 1: 54–55
- entropic elastic force, proteins 2: 223
- environmental aspects, biodegradable plastics 1: 212
- environmental benefits 1: 117
- environmental consideration, MAAP 2: 205–209
- environmental impact, production process 1: 92
- environmental improvements 1: 64
- environmentally friendly, biotech 2: 448–450
- enzymatic conversion 1: 130
- enzymatic digestion, poly(3-hydroxybutyrate-co-valerate) 1: 219–221
- enzymatic hydrolysis 1: 79, 147
  - cellulose 2: 115
  - improvements 1: 205
  - reactions 1: 203
- enzymatic hydrolysis process 1: 134
- enzymatic methods, LCF 2: 115
- enzymatic oxidizing systems 1: 178
- enzymatic processes, starch degradation 2: 79
- enzymatic reactions 2: 270–274
- enzymatic synthesis, MAAP 2: 202
- enzymatic transport, improvements 2: 204
- enzyme-based plant development 1: 134
- enzyme broth 1: 201
- enzyme catalysis, economic barriers 1: 381
- enzyme cost reduction, ethanol production 1: 377
- enzyme dosage 1: 366
- enzyme immobilization 1: 399–402
- enzyme performance, cellulase 1: 76–77
- enzyme production 1: 202
  - bran 1: 172
- enzyme recovery 1: 74
- enzyme requirement, increase 2: 178
- enzyme screening 1: 398
- enzyme system, optimisation 1: 74
- enzymes 1: 357–383, 2: 90
  - biodegradation 1: 363
  - biomass conversion 1: 68
  - cellulase 1: 201–202
  - cost reduction 1: 56
  - markets 2: 446
  - nonhydrolytic 1: 365
  - oxidative 1: 213
  - recycling 1: 205
  - superior 1: 205
  - synergism 1: 365–366
  - thermally stable 1: 368
- EOS 1: 109
- epoxidation
  - chemo-enzymatic 2: 254
  - new methods 2: 254–257
- epoxides 2: 254
  - polyols 2: 298–299
  - PVC stabilizers 2: 256
- equilibrium concentration, protonated glycoside 1: 141

erosion 1: 327  
 – cover crops 1: 331  
 – prevention 1: 61  
 ERRMA 1: 89  
 erucic acid, high 2: 280  
 erythro form, lignin 2: 157  
*Escherichia coli* 1: 206, 2: 30  
 – bioengineered 2: 35–37, 44  
 – carbon-14-labeled 2: 228–229  
 – cost of production 2: 242  
 – fermentation 2: 230  
 – inulin production 1: 398  
 – recombinant 1: 399  
 – transformation 2: 227–230  
 esparto grass, xylitol source 1: 283  
 esterification, starch 2: 80  
 esters, lubricant applications 2: 300  
 ETBE 2: 7  
 ethanol 1: 89, 104, 146, 209, 2: 7–8, 132  
 – additive replacement 1: 357  
 – fermentation 1: 11, 2: 120, 351  
 – global market 2: 446  
 – glucose product family 1: 21  
 – lignocellulose transformation 2: 115  
 – predictions 2: 454  
 – vapor pressure 1: 151  
 – wood hydrolyses 1: 5  
 ethanol production 1: 125, 130, 193, 209–210, 389  
 – advantages 1: 197  
 – cellulase 1: 201  
 – costs 1: 72, 246  
 – enzyme cost reduction 1: 377  
 – sucrose 1: 70  
 ethanol production plant, process design 1: 393  
 ethanol recovery 1: 206–207  
 ether structures, lignin 2: 158  
 etherification, starch 1: 27, 2: 80  
 ethyl *t*-butyl ether 2: 7  
 ethyl ester, LA derivatives 2: 10  
 2-ethyl hexanol, glucose product family 1: 21  
 ethyl lactate, glucose product family 1: 21  
 ethyl levulinate (EL), properties 1: 151  
 ethylene, glucose product family 1: 21  
 EU directives 1: 94  
*Eubacterium limosum* 1: 235  
 Europe, biomass conversion 2: 351  
 European grassland, yield 1: 259  
 European Renewable Resources and Materials Association *see* ERRMA  
 excess water, removal 1: 219

exothermic hydration, apolar groups 2: 218  
 expansin, enzymatic hydrolysis 1: 365  
 expressed protein-based polymers 2: 242–245  
 expression vector, gene 2: 227  
 external challenges 2: 456  
 external environment, biotechnology 2: 461  
 extraction, chlorophyll 2: 328  
 extraction methods, chlorophyll 2: 337  
 extraction processes, PHB 1: 218  
 extrusion cooking, starch modifications 2: 77  
 extrusion processes, PHB 1: 216

## f

fabric coloring 2: 191  
 FAME 1: 152  
 farmer value 1: 325–327  
 FAS 2: 303  
 – synthesis 2: 303  
 fast pyrolysis 1: 229, 241  
 – biorefinery 1: 246–248  
 – products 1: 242  
 – reaction pathways 1: 243  
 fast-pyrolysis plant, schematic diagram 1: 244  
 fat hardening 1: 7  
 fats  
 – microbial conversion 2: 274  
 – new syntheses 2: 253–289  
 fatty acid esters, biodegradable 2: 299–301  
 fatty acid methyl esters *see* FAME  
 fatty acid oil seeds variants, commercially available 2: 278  
 fatty acids 1: 90–92  
 – anodic coupling 2: 267–269  
 – apple-peel wax components 2: 433  
 – chain length 2: 292  
 – epoxidation 2: 254–257  
 – juice fraction 1: 274  
 – microbial oxidation 2: 273–274  
 – nucleophilic addition 2: 265  
 – oxidative coupling 2: 266  
 – triglycerides 1: 122  
 – unsaturated 2: 272–273  
 – *vic*-dihydroxy 2: 257–258  
 fatty alcohol sulfate 2: 303  
 fatty alcohols 2: 294  
 fatty compounds  
 – reactions 2: 266–270  
 – unsaturated 2: 254–266

- FDCA (furan-2,5-dicarboxylic acid) 2: 38, 133
  - basic biobased chemicals 1: 22
  - synthesis 2: 134
- feedstocks 1: 100, 105
  - alternative 2: 452
  - composition 1: 195
  - conversion 1: 68–73
  - fibrous 1: 239
  - insoluble components 1: 146
  - pretreatment 2: 167, 178
  - pricing 1: 327
  - production 1: 181
  - quality 1: 196, 334
  - selection 1: 194–198
  - sucrose-based 1: 197
  - supply 1: 317, 2: 368–369
  - thermogravimetric analyses 1: 156
- fermentable-carbon-cost 1: 68
- fermentable carbon source 1: 78
- fermentable sugars 1: 67–73
- fermentation 1: 74, 85, 123, 146, 2: 356
  - *E. coli* 1: 399
  - *Escherichia coli* transformation 2: 227
  - amino acids 2: 203
  - biomass processing 1: 98
  - bio-oils 1: 229
  - cellulose 2: 177–179
  - commercial lactic acid production 2: 384
  - continuous 1: 300
  - economics 2: 369
  - ethanol 1: 390–391, 2: 351
  - fungal 1: 181
  - glucose 1: 31
  - guidelines 1: 21–22
  - lactic acid 1: 298, 2: 383
  - microbial 1: 181
  - PHB production 1: 217
  - rhizopus-based 2: 388
  - succinic acid 2: 369
  - syngas 1: 233–239
- fermentation broth, no processing 1: 75
- fermentation by-products 2: 388
- fermentation ethanol 2: 7
- fermentation industry, starch 2: 89
- fermentation inhibitors, bio-oil 1: 245
- fermentation medium
  - brown juice 1: 298
  - pearled grain flour 1: 176
  - plant juice 1: 295–314
  - potato juice 1: 309–310
- fermentation organisms 1: 77–81
- fermentation process 1: 104–106
  - inhibitors 1: 78
  - performance 1: 78
  - PLA 1: 296–297
- fermenters, ethanol production 1: 201
- fertilizer
  - ash 1: 161
  - nitrogen 1: 325
- ferulic acid 1: 178–179
- Festuca arundinacea* 1: 261
  - alkaloid production 1: 277
  - fructans 1: 267
  - sugars 1: 266
- Festuca pratensis* 1: 261
  - amino acid composition 1: 267
  - sugar 1: 265
- Festuca spp.*, proteins 1: 277
- fiber fraction 1: 278–285
  - corn 2: 369
  - grass 1: 281
- fibers
  - biodegradable 2: 10
  - corn refinery products 1: 348
  - high-performance 2: 41
  - improved 2: 241
  - Kraft lignin 2: 197–198
  - paper 2: 84
  - press-cake components 1: 280–282
- fibrous biomass, fast pyrolysis 1: 246
- film-forming agents, chitosan 2: 419
- films, water-retentive properties 2: 420
- filter aids, purified biogenic silica 1: 278
- fine chemicals 1: 386
  - production routes 1: 385–406
- finishing agents 2: 86
- Fischer glycosidation, APG synthesis 2: 12
- Fischer–Tropsch process 1: 158
- flocculants, starch derivatives 2: 91
- flow dynamics, agricultural ecosystems 1: 60
- fluidized bed gasifiers 1: 231
- foams, production 2: 9
- follow-up chemicals, ethanol 2: 7
- follow-up products, biorefinery 1: 24
- food 1: 13
- food preservative, ferulic acid 1: 179
- forage crops 1: 45
- forestry ecosystem modeling 1: 57–60
- forestry waste, furfural hydrolysis 2: 8
- formic acid 1: 153–154, 2: 39
  - production 1: 139–164
- formulation 1: 74
- forward extraction, lactic acid 2: 389
- fossil-based raw material substitution 1: 85

- fossil carbon-processing industries  
1: 42–44
- fossil fuel substitution 1: 85
- fossil fuels replacement, energy efficiency 2: 449
- fossil organic raw materials 2: 347
- fossil resources, dependence 1: 92
- foundry, starch derivatives 2: 91
- foundry resins 2: 184–185
- Fownes, G. 1: 6
- fraction-I protein 1: 274  
– economic interest 1: 255
- fraction-II protein 1: 275
- fractionation, green crops 1: 272
- fractionation process, oats based  
1: 183–187
- free energy of hydration, repulsive 2: 218
- free radical cross-linking 2: 399
- friction materials 2: 184
- Friedel-Crafts acylation 2: 265
- fructans 1: 267  
– enzymatic decomposition 1: 302
- fructose 2: 131  
D-fructose, synthesis 2: 132
- frying oil, byproducts 1: 100
- fuel additives 1: 150  
– ethanol 1: 26
- fuel alcohol, production 1: 193
- fuel cells 1: 378
- fuel ethanol, legislative support 2: 453
- fuel ethanol program, Brazil 1: 210
- fuel gas 1: 102
- fuel-oriented biorefineries 1: 193–208
- fuel production 1: 53  
– starch 1: 181
- fuel source, sustainable 1: 115–128
- fuels 1: 13  
– biobased products 1: 376  
– biofine char 1: 155
- fumaric acid 2: 35
- functional foods 1: 180
- functional group transformations, side chains 2: 333
- functional groups 2: 156–159  
– addition to hydrocarbons 1: 119  
– LA 1: 147
- functionalization, C–H bonds 2: 269–270
- fungal cellulolytic system 1: 365
- fungal fermentations 1: 181
- fungal genes, schematic representation  
1: 373
- fungi, cellulolytic 1: 371–373
- fungicides, lignin-based dispersants 2: 193
- fungus, wood-rotting 1: 201
- fungus Z proteins 1: 373
- furan 2: 19  
– hydrophilic 2: 20  
– polyesters 2: 44
- furan commodity chemicals 2: 8
- furan compounds 2: 16
- furan derivatives 2: 98
- furan-2,5-dicarboxylic acid (FDCA) 2: 38,  
133  
– basic biobased chemicals 1: 22  
– synthesis 2: 134
- furan polyamides 2: 46
- furan resins 1: 154
- furanoid sugar derivatives 2: 48
- furfural 1: 6, 78, 91, 124–125, 154, 199,  
2: 8, 121–127  
– biomass building blocks 1: 22  
– chemical structure 1: 143  
– formation 2: 123  
– history 2: 101  
– lignocellulosic products 1: 25  
– mass yield 1: 145  
– production 1: 142  
– yields 2: 102
- furfural production 1: 125, 133, 139–164
- furfuryl alcohol 1: 154
- furfurylamines, conversion 2: 28
- future biorefineries, lignocellulosic materials  
processing 2: 166
- future development lines, sugars 2: 3–59
- g**
- galactanes 2: 108
- gas-phase chlorination, photochemical  
2: 269
- gas to liquids *see* GTL
- gasification 1: 31, 85, 101, 123, 227, 2: 350  
– air-blown 1: 232  
– bioproducts 2: 361  
– bran 1: 172  
– coal 1: 157  
– fundamentals 1: 230  
– separation of value components 1: 103
- gasification-based systems, hybrid processing  
1: 230–241
- gasifier temperatures 1: 232
- gasoline 1: 119  
– replacement 1: 49
- gasoline market, USA 1: 71
- GBL 1: 149, 2: 373, 375
- GEGVP, repulsive free energy 2: 237
- gelatinization, starch 2: 78

- gelatinization temperature 2: 75  
 gene constructions 2: 225–227  
 – expressed protein-based polymers  
 2: 242–245  
 gene ladder 2: 229  
 – GVGVP 2: 226  
 gene technology, plant breeding 2: 275,  
 281  
 Genencor International 1: 74, 77  
 generation-I biorefinery 1: 19  
 generation-II biorefinery 1: 19  
 generation-III biorefinery 1: 19–20  
 genetic engineering 1: 374, 398  
 – ethanol production 1: 391  
 genetically engineered organisms, fermenta-  
 tion 2: 7  
 genetically modified crops 1: 96  
 geographical distribution, refineries 1: 57  
 geoporphyrins 2: 331  
 germ, corn refinery products 1: 348  
 GGAP, biocompatibility 2: 232  
 GH 1: 364  
 GH families, *Trichoderma reesei* 1: 373  
 Gibbs free energy, change 2: 218, 222, 232  
 – phase transition 2: 234  
 GJ *see* green juice  
 glass fiber, resins 2: 185  
 GLNC, juice fraction 1: 274  
 global warming 1: 94  
 GLU *see* glutamic acid (GLU)  
 glucan 1: 139, 2: 108  
 $\beta$ -glucan 1: 175–176, 185  
 glucanases, biodegradation 1: 364  
 glucaric acid 2: 38  
 – basic biobased chemicals 1: 22  
 D-glucitol 2: 9  
 gluconic acid 1: 402  
 – biomass building blocks 1: 22  
*Gluconobacter oxydans* 1: 80  
 glucosamine 1: 182  
 D-glucosamine, pyrroles synthesis 2: 25  
 glucose 1: 17, 2: 128–128  
 – electrolytic reduction 2: 130  
 – microbial conversion 2: 274  
 – nitric acid oxidation product 2: 38  
 – wood saccharification 1: 5  
 D-glucose  
 – derivatives 2: 22  
 – one-pot conversions 2: 20  
 – reductive amination 2: 12  
 glucose fermentation, plant develop-  
 ment 1: 134  
 glucose-product family tree 1: 21–22  
 D-glucose residues, *Lolium perenne* 1: 264  
 glucose yields 2: 177  
 $\beta$ -glucosidase *see* BG  
 glucosides 2: 130–133  
 5-(glucosyloxymethyl)furfural 2: 16  
 glutamate, markets 2: 207  
 glutamic acid (GLU) 2: 34, 304  
 – basic biobased chemicals 1: 22  
 gluten, corn refinery products 1: 348  
 glycanes 2: 108  
 glycerol 2: 271  
 – basic biobased chemicals 1: 22  
 – biocatalytic route 1: 393–397  
 glycine, chemical structure 2: 411  
*Glycine max* 2: 277  
 glycolipids, microbial conversion 2: 274  
 glycoside hydrolase family classification sys-  
 tem *see* GH  
 glycosidic bonds 1: 140  
 GMF 2: 17, 25  
 gold catalysts 1: 403  
 grain 1: 45  
 grain wet-milling, biorefinery example  
 1: 70  
 grass  
 – composition 1: 262–263  
 – key components 1: 260–269  
 – production costs 1: 284  
 grass fibers  
 – basic properties 1: 281  
 – downstream processing 1: 281  
 – products 1: 282  
 grass press cake, major components 1: 279  
 grass silage juice, physicochemical charac-  
 teristics 1: 276  
 grassland feedstocks, availability 1: 259–  
 260  
 gravity separator, acid hydrolysis 1: 145  
 green biorefiner concept 1: 253–294  
 green biorefineries 1: 19, 24, 29–31  
 – concept 1: 269–273, 296–297  
 – ecological aspects 1: 283–285  
 – economic aspects 1: 283–285  
 – products 1: 31  
 – raw materials 1: 258–269  
 green chemistry, chlorophyll 2: 325–343  
 green crop-drying plant 1: 270  
 green crops, industrial use 1: 9  
 green cycle, sugar cane industry 1: 210–211  
 green harvesting residue material 1: 258  
 green house gases 2: 402  
 green juice (GJ) 1: 30, 269, 271, 273–277  
 green leaf nutrient concentrate 1: 274

green natural gas 1: 103  
 green pellets, production amount 1: 260  
 green plant material, composition 1: 258  
 green plant parts, fractionation 1: 256  
 greenhouse gas reduction 1: 62  
 greenhouse gases, emission 1: 197  
 gross visualization, phase separated product 2: 229  
 ground water pollution, brown juice 1: 298  
 growth, biorefining industry's 1: 317  
 growth phase, fermentation 1: 218  
 GTL technology 1: 158  
 guerbet alcohols 2: 311  
 – synthesis 2: 312  
 guinea-pig, protein-based polymer injection 2: 231  
 gum arabic, substitute 2: 62  
 GVGIP 2: 240  
 – patches 2: 241  
 GVGVP 2: 223  
 – adhesions prevention 2: 238  
 – biocompatibility 2: 232  
 GVL 1: 151  
 gypsum 1: 106, 2: 87, 386

## h

Haarmann, W. 1: 7  
 hair, protection 2: 429–437  
 hair care 2: 434–436  
 – ilex resin 2: 439–440  
 hair conditioners, betaine derivatives 2: 414  
 hair-setting agent 2: 415–422  
 hair surface, cationic compound deposition 2: 413  
 hair swatches, standardized 2: 435  
 Hale, W.J. 1: 9  
 half esters, homocoupling 2: 268  
*Halobacterium sp NRC-1* 1: 80  
 2-halocarboxylates, copper-initiated additions 2: 262–263  
 hammer mill 1: 176  
 hardwood, composition 2: 106  
 hardwood lignins 2: 154, 157  
 harvest cost 1: 333  
 harvest transport 1: 338–339  
 3-HBL *see* 3-hydroxybutyrolactone  
 heating value, biofine char 1: 155  
*Helianthus annuus* 2: 277  
 heliogerme 1: 179  
 hemicellulases 1: 364  
 hemicellulose 1: 72, 121, 198, 2: 104  
 – accessibility 1: 55  
 – chemical composition 1: 360  
 – feedstock content 1: 359  
 – history 2: 101  
 – hydrolysis 1: 362  
 – isolation 2: 119  
 – plant content 1: 261  
 – quantities 1: 264  
 – removal 1: 199  
 hemicellulose removal, advantages 2: 177–179  
 hemicellulose-based product lines 2: 119  
 hemicellulose concentrations, forage grasses 1: 264  
 hemicellulose content, stem tissue 1: 265  
 hemicellulose polysaccharides, hydrolysis 1: 141  
 herbaceous species 1: 50  
 herbicidal treatment, highly selective 1: 150  
 herbicides 1: 149  
 – lignin-based dispersants 2: 193–194  
 heterocoupling, fatty acids 2: 267–269  
 heteropolymeric sugars, hemicellulose 1: 360  
 hexadecanedioic acid, yield 2: 274  
 hexose sugars 1: 78  
 HFCS 1: 351  
 HFRR 1: 153  
 high frequency reciprocating ring test *see* HFRR  
 high-performance fiber 2: 41  
 high-value-added products, sugar-derived 2: 14–15  
 high value pharmaceuticals 2: 40  
 higher-value products, levulinic acid 2: 39  
 HMF (hydroxymethylfurfural) 1: 130, 133, 142, 2: 16, 133  
 – levulinic acid process 2: 100  
 – manufacture 2: 131  
 HMF based family tree 2: 135  
 Holly 2: 437–438  
 holocellulose change, wet storage 1: 336  
 homocoupling, fatty acids 2: 267–269  
 homofermentative strain, *Lactobacillus salivarius* 1: 307  
 hot-wash, pretreatment 1: 362  
 3-HPA 2: 34–35  
 HTU process, liquid biofuels 2: 351  
*Humicola grisea var thermoidea* 1: 77  
*Humicola insolens* 1: 375  
*Humicola* 1: 202  
 hybrid processing, biomass 1: 227  
 hybrid thermochemical-biological processing 1: 227–252

- hydration
    - microbial 2: 272–273
    - repulsive free energy 2: 237–238
  - hydrocarbons
    - apple-peel wax components 2: 433
    - fossil 2: 6
    - linear 1: 118
  - hydrochloric acid, carbon hydrolysis 1: 131
  - hydrogen bonding, cellulose 1: 360
  - hydrogenation reaction, syngas production 1: 230
  - hydrolases 1: 373–375
  - hydrolysability, biopol 2: 425
  - hydrolysis
    - biomass 1: 129–138
    - furfural 2: 8
    - hemicellulose 1: 362
    - starch 1: 5
  - hydrolysis reactors, novel 1: 205
  - hydrolytic enzymes, costs 1: 105
  - hydrolytic liquefaction 1: 123
  - hydrolyzate, biomass 1: 78
  - hydrophilic imidazoles, D-fructose-derived 2: 27
  - hydrophilic side-chains 2: 24
  - hydrophilic/hydrophobic balance, sorbitan esters 2: 11
  - hydrophobic association, Gibbs free energy 2: 218, 232
    - input energy 2: 219
    - inverse temperature transition 2: 219
  - hydrophobic coating 2: 434
  - hydrophobic consilient mechanism 2: 222
  - hydrophobic effect, comprehensive 2: 237
  - hydrophobic hydration 2: 218
  - hydrophobic mechanism, protein-based polymer engineering 2: 217
  - hydrophobicity scale
    - Gibbs free energy 2: 234–235
    - prosthetic groups 2: 235–236
  - hydrothermal conditioning, granular starch 2: 78
  - hydrothermolysis 2: 351
  - hydroxy cyclic ester 2: 398
  - hydroxyalkylation, starch 2: 80
  - 3-hydroxybutyrolactone (3-HBL) 2: 38, 40
    - basic biobased chemicals 1: 22
  - hydroxymethylfurfural (HMF) 1: 78, 2: 16, 133
    - formation 1: 143
    - hydration 1: 143
    - lignocellulosic products 1: 25
  - 3-hydroxypropionic acid (3-HPA) 2: 34–35
    - basic biobased chemicals 1: 22
  - hydroxypropylation 2: 77
  - 3-hydroxyvalerate *see* PHV
- i**
- IA *see* itaconic acid
  - ideal elasticity 2: 219
    - mechanism 2: 220
  - ift gene 1: 398
  - IgG 2: 230
  - Ilex aquifolium* 2: 437–438
  - Ilex paraguariensis* 2: 438
  - Ilex resin 2: 437
  - Ilex* species 2: 437
  - imidazoles 2: 27
    - hydrophilic 2: 27
  - immobilization 1: 389
    - enzyme 1: 399–402
    - lipase B 2: 256
  - immobilization technology 1: 392
  - immunoblot technique, western 2: 230–231
  - immunoglobulin G 2: 230
  - income generator 1: 96
  - inducing sugar 1: 201
  - industrial biobased products 2: 359
  - industrial biomass 1: 13
  - industrial bioproducts, opportunities 2: 357
  - industrial biotech 2: 445–462
  - industrial chemicals
    - biomass-derived 1: 124, 2: 347–365
    - fossil sources 1: 120
    - sustainable 1: 115–128
  - industrial concepts
    - biobased materials 2: 354–362
    - biomass 2: 347–365
  - industrial feedstock, baling 1: 333
  - industrial product family, development 1: 18
  - industrial products, biomass-based 1: 87
  - industrial resources, historical 1: 4–8
  - industrial starch platform 2: 61–95
  - industrial uses, sugars 2: 7–14
  - industries, fossil carbon-processing 1: 42–44
  - infection, natural 2: 275
  - infrastructure investment 1: 340
  - inhibitors, enzyme activity 2: 322–323
  - initiators 2: 398
  - injection processes, PHB 1: 216
  - injections, histological sections 2: 231
  - innovation potential, fossil-based building blocks 2: 450

insulation materials, resins 2: 185  
 integrated biorefinery applications 1: 125  
 integrated biorefinery process, detailed  
   view 1: 102  
 integrated biorefining systems, sustainabil-  
   ity 1: 56–65, 60–65  
 integrated process chain approach, biomass  
   processing 1: 98  
 integrated processing facility 1: 45  
 integrated production, sugar 1: 209  
 intergeneric hybridization, plant breed-  
   ing 2: 276  
 intermediate chemicals, HMF derived  
   2: 16  
 intermediate products, biorefineries 1: 46  
 intermediates 1: 386  
   – biofine process 1: 145  
 intermolecular order, proteins 2: 221  
 internal obstacles 2: 456  
 intracellular poly(3-hydroxybutyric acid)  
   1: 218–219  
 intracellular reserve material, PHB 2: 424  
 intramolecular cyclization, addition 2: 263  
 inulase II gene 1: 398  
 inulin 1: 267  
   – biocatalytic route 1: 397–402  
   – fructose source 2: 131  
 inulinase II, immobilization 1: 399  
 inverse temperature transition  
   – hydrophobic association 2: 219  
   – protein-based polymers 2: 227  
   – purification 2: 228–229  
 investment costs, poly(3-hydroxybutyric  
   acid) 1: 222–223  
 investments, biomass supplies 1: 318  
 Iogen's demonstration process 1: 193  
   – schematic 1: 194  
 Iowa corn stover collection project 1: 319–  
   321  
 isoamyl alcohol, extraction of PHB 1: 219  
 isoascorbic acid, glucose product fami-  
   ly 1: 21  
 isolation, lignin 2: 116  
 isomaltulose, industrial production 2: 17  
 isosorbide dinitrate 2: 14  
 itaconic acid (IA) 2: 34, 36  
   – basic biobased chemicals 1: 22  
   – glucose product family 1: 21

## j

jet milling 1: 176  
 jetcutting 1: 401  
 juice fraction 1: 273–285

## k

Kevlar 2: 46  
 key chemicals, cellulose-based 2: 128  
 key intermediates  
   – chlorophyll chemistry 2: 338  
   – HMF 2: 133  
 key sugars 2: 3–59  
   – exploitation 2: 14  
 Kirchhoff, G.S.C. 1: 5  
 Kirchhoff 2: 62  
*Klebsiella pneumoniae* 2: 36  
*Klebsiella* 1: 206  
 kojic acid 2: 20  
   – glucose product family 1: 21  
 Kolbe electrolysis 2: 267–269  
 Kraft black liquor 2: 175  
 Kraft lignin, producers 2: 175  
 Kraft lignin recovery 2: 175  
 Kraft pulping 2: 175  
 Kraft pulping industry, lignin 2: 169–170  
 Kyoto objectives, dutch 1: 85

## l

LA *see* lactic acid, levulinic acid  
 lactate ester, distillation 2: 389  
 lactic acid (LA) 1: 7, 11, 91, 2: 10–11, 382  
   – biomass building blocks 1: 22  
   – composition 1: 308  
   – fermentation 1: 11, 298, 303–305, 305–  
     306, 378  
   – glucose product family 1: 21  
   – manufacturers 2: 383  
   – production 1: 306, 312, 2: 382  
   – sources 1: 296  
   – usage 2: 10  
 lactide, polymerization 2: 392–396  
*Lactobacillus buchneri*, 1,2-propanediol  
   2: 37  
*Lactobacillus delbrueckii* 2: 210  
*Lactobacillus paracasei subspecies paracasei*  
   1: 302  
*Lactobacillus plantarum* 1: 302, 2: 273  
*Lactobacillus salivarius* 1: 305  
*Lactococcus lactus* 2: 210  
 laundry starches 2: 89–91  
 lauric oils 2: 292  
*Lb salivarius* BC 1001, fermentation  
   1: 299–300  
 LCA, polylactic acid 1: 284  
 LCF *see* lignocellulosic feedstock  
 LCF-mannan 2: 120  
 LCI, PLA 2: 402  
 leaf dyes, first production 1: 257–258

- leaf nutrient concentrate 1: 274
- leaf protein concentrate 1: 254
- learning from nature, bionics 2: 410
- leaves, Ilex resin 2: 437
- Leblanc, N. 1: 7
- lecithin 2: 318
- levoglucosan 1: 229, 243, 247
- levoglucosan hydrolysis, alternative 1: 245
- levoglucosenone 2: 21
- levoglucosan, biomass building blocks 1: 22
- levulinate esters 1: 153
- levulinic acid (LA) 1: 6–7, 143–144, 2: 38–39, 134, 361
  - basic biobased chemicals 1: 22
  - bromination 1: 150
  - catalytic hydrogenation 1: 151
  - history 2: 100
  - maximum theoretical yield 1: 145
  - oxidation 1: 149
  - production 1: 139–164, 2: 111
  - reaction to diphenolic acid 1: 148
- levulinic acid-based family tree 2: 135
- Lewis acid-induced cationic addition 2: 264–265
- life cycle analysis 1: 57
- life cycle assessment *see* LCA
- life-cycle inventory 2: 402
- lignin 1: 7, 72, 121, 195, 2: 104
  - antioxidant 2: 187–189
  - approximate composition 2: 154
  - biodegradation 2: 160
  - cell wall constituents 2: 151
  - chemical composition 1: 360
  - chemical linkages 2: 182
  - commercially available 2: 176
  - emerging markets 2: 194–198
  - feedstock content 1: 359
  - gasification 2: 118
  - history 2: 101
  - hydrolysis 2: 118
  - Kraft pulping industry 2: 169–170
  - markets 2: 166, 175, 181, 198
  - organosolv biorefinery 2: 179–181
  - plant content 1: 261
  - press cake component 1: 279
  - purified 2: 167
  - pyrolytic 1: 241
  - soda pulping industry 2: 170–172
  - structural units 2: 105
  - structure 2: 152–159
  - utilization 2: 117
  - water-soluble 2: 189–194
- lignin-based product lines 2: 116–118
- lignin chemistry, biomass conversion 2: 151–163
- lignin content 1: 265
- lignin isolation 2: 116
- lignin polymer 2: 155
  - growth 2: 154
- lignin precipitation system 2: 171
- lignin processing 1: 194, 205–206
- lignin production
  - historical outline 2: 168–172
  - industrial 2: 165–200
- lignin products 2: 152
  - existing 2: 172–177
- lignin recovery process 2: 171
- lignin removal, advantages 2: 177–179
- lignin unit, different types 2: 156–159
- lignocellulose 1: 74
  - biorefinery 2: 111
  - enzymatic sequence 2: 210
  - history 2: 102
- lignocellulose-based chemical products 2: 97–150
- lignocellulose chemistry, historical outline 2: 98–99
- lignocellulose structure 1: 121
- lignocellulose utilization
  - industrial 2: 102
  - technical aspects 2: 98
- lignocelluloses 1: 10
  - carbohydrates 2: 108
- lignocellulosic, raw material 2: 103
- lignocellulosic biomass, pretreatment 1: 361
- lignocellulosic biorefineries, PLA 2: 403
- lignocellulosic biorefinery 1: 115–128
  - chemistry 1: 122–125
- lignocellulosic feedstock (LCF) 1: 24, 125, 139–164
  - biorefinery 1: 24–26, 129–138, 2: 111–113
  - chemical composition 2: 106–108
  - conversion methods 2: 113–115
  - definition 2: 103
  - major groups 2: 103
  - sources 2: 105
- lignocellulosic fractionation 1: 139–144
- lignocellulosic materials 1: 45, 105
- lignocellulosic technology, conventional 1: 146–147
- lignosulfonate, dye dispersants 2: 191
- lignosulfonate producers 2: 173–174
- lignosulfonates 2: 168–169, 172–175
  - markets 2: 174

- lignosulfonic acid, vanillin production 1: 7  
 linear hydrocarbons 1: 118  
 linear PLA, melt rheology 2: 397  
 linear polymer, idealized structure 2: 49  
 $\beta$ -1 linkage, phenylpropane units 2: 159  
 $\beta$ - $\beta$  linkage, phenylpropane units 2: 157  
 $\beta$ -O-4 linkage, arylglycerol units 2: 156  
 linseed 2: 281  
*Linum usitatissimum* 2: 277  
 lipase-catalyzed syntheses 2: 270–272  
   – carbohydrate esters 2: 272  
 lipase-catalyzed transformations 2: 270–272  
 lipid based bioproducts 2: 361  
 lipid layer enhancing effect, evaluation 2: 310  
 lipids 1: 7  
   – chemical composition 1: 361  
 lipotropic factor, betaine 2: 411  
 liquefaction 1: 123, 126  
 liquid biofuels 1: 49  
 liquid epoxy polyol esters 2: 298  
 liquid fuel production, missing part 1: 55  
 liquid transportation fuels 1: 46  
 LNC, composition 1: 274  
 load-and-go wagon 1: 320  
 local ownership, biorefinery 1: 56  
*Lolium hybridum*, press cake fibers 1: 281  
*Lolium multiflorum*  
   – alkanes 1: 268  
   – silica 1: 268  
*Lolium perenne* 1: 261, 264  
   – alkaloid production 1: 277  
   – alkanes 1: 268  
   – amino acid composition 1: 267  
   – antifreeze protein 1: 269  
   – fructans 1: 267  
   – minerals 1: 268  
   – silica 1: 268  
   – sugar 1: 265  
   – water-soluble carbohydrate 1: 266  
 low-cost production 2: 242  
 low nutrient conditions, succinate fermentation 2: 370  
 LPC 1: 268  
   – first industrial process 1: 256  
   – first production 1: 254–257  
   – quality 1: 258  
 LPS process 2: 171  
 lubricants, fatty acid esters 2: 299–301  
 lubricants industry, antioxidants 2: 188  
 lucerne, protein fractions 1: 275  
 lyocell 1: 90  
 lyondell propylene oxide, 1,4-BDO 2: 373  
 lysine  
   – biomass building blocks 1: 22  
   – markets 2: 207  
 lysine fermentation 1: 11  
 lysine preparations, commercially available 2: 208  
 lysine yield, *C. glutamicum* 2: 210
- m**  
 MAAP 2: 201–202  
   – ecological impact 2: 207  
   – environmental and commercial consideration 2: 205–209  
   – technical constraints 2: 209  
 MAAP processes  
   – cultivation temperature 2: 213  
   – major steps 2: 208  
   – nitrogen source 2: 211  
 macrocycle 2: 334  
 macrocyclic ring system, reactions 2: 333  
 Madison-Scholler process 1: 132  
 Maillard reaction 2: 24  
 maize starch production 2: 66, 67  
 MALDI-TOF, polymer size 2: 229  
 maleic acid, conversion 2: 375  
 malic acid 2: 35  
   – glucose product family 1: 21  
 malonic acid, biomass building blocks 1: 22  
 maltol, glucose product family 1: 21  
 managing uncertainties, biotechnology 2: 459  
 mannan 2: 108  
 mannan/mannose product lines 2: 119  
 D-mannitol 1: 267  
 margarine 1: 7  
 Marggraf, A. S. 1: 5  
 market development, biotechnology 2: 460  
 market launch  
   – apple-peel wax 2: 436–437  
   – biodegradable bottle 2: 427–428  
 market potential 2: 446  
   – LA 1: 147  
   – succinic acid 1: 149  
 market price, furfural 1: 154  
 markets, lignin 2: 198  
 mass spectra, polymer size 2: 229–230  
 material sources  
   – biomass-based 1: 380  
   – renewable 2: 355  
 materials design 1: 108  
 matrices, natural fibers 2: 295

- matrix assisted laser desorption time-of-flight spectrometry 2: 229
- MBTE 1: 357
- MDI 2: 299
- mechanical pulping 1: 280
- mechanical separation, cereals 1: 26
- mechanistic foundations 2: 217–251
- media cost 2: 370
- Medicago sativa* L 1: 255
- press cake fibers 1: 281
- medical grade purity 2: 230
- Mellier, M. A. C. 1: 6
- Melsens, G. F. 1: 5
- melt, polylactic acid synthesis 2: 391
- melt rheology
- branched PLA 2: 397
- linear PLA 2: 397
- melt stability, PLA 2: 399
- melting enthalpy, PLA 2: 401
- membrane electrodialysis 1: 106
- membrane process, lactic acid purification 1: 312
- metabolic engineering 2: 204
- metabolic flux distributions, *C. glutamicum* 2: 205
- metabolic pathways
- optimize 2: 212
- PHB synthesis 1: 238
- syngas fermentation 1: 234
- metal-based catalysts 1: 228, 233
- metal catalysts, aqueous phase hydrogenation 2: 375
- metal complexes, chlorophyllin 2: 335
- methanation, syngas production 1: 231
- methane, glucose product family 1: 21
- methanol, glucose product family 1: 21
- methanol synthesis, syngas 1: 158
- methyl 17-octadecanoate, cyclization 2: 259
- methyl 2-iodopetroselinate, radical cyclization 2: 263
- methyl conjugate, Diels-Alder reaction 2: 260–261
- methyl elaidate, enantioselective oxidation 2: 258
- methyl epiminooctadecanoate, synthesis 2: 257
- methyl oleate
- co-metathesis 2: 260
- oxidative cleavage 2: 258
- methyl tertiary butyl ether 1: 357
- 1-methylamino-1-deoxy-D-glucitol 2: 11
- methylene di(phenylisocyanate) 2: 299
- methylglucoside, synthesis 2: 131
- methyltetrahydrofuran *see* MTHF
- Michael addition 2: 81
- Michaelis-Menten constant 1: 77
- Michaelis-Menten kinetics, enzymatic hydrolysis 1: 204
- microbial activity, wet storage 1: 334
- microbial amino acid production *see* MAAP
- microbial bioconversions, milling byproducts 1: 172
- microbial biomass 1: 106
- microbial biosynthesis 1: 104
- microbial conversions
- oils/fats and glucose 2: 274
- six-carbon sugars 2: 32–34
- sugar 2: 30
- sugar-based 2: 36–37
- microbial fermentation, drying bales 1: 321
- microbial oxidation, fatty acids 2: 273–274
- microbial polyesters 2: 44–45
- microbial transformations 2: 272–274
- microfibril 1: 195
- microorganisms
- acetyl-coa forming 1: 233
- commercial lactic acid production 2: 384–385
- important 1: 80
- usage 1: 146
- middlings 1: 170
- mill water 1: 348
- milled wood lignin 2: 155
- milling
- industries 1: 345–353
- pretreatment 1: 361
- process flow diagrams 1: 347
- milling byproducts, wheat flour 1: 169–173
- milling efficiency, increase 1: 173
- milling operations 1: 166
- minerals 1: 268
- analysis 1: 299
- brown juice content 1: 304
- Mitscherlich, A. 1: 8
- mix-polymerization, starch 1: 27
- mixed sugars 1: 98
- model building block, succinic acid 2: 367–379
- modeling, ecosystem 1: 57–60
- modern corn refinery 1: 348–350
- molasses 1: 222
- molasses fermentation 1: 131
- mold temperature, PHB 1: 216
- molecular weight, rheology control 2: 396

- monitoring technologies, toxicity 2: 212
  - mono-septic operation 2: 209
  - monocyclic aromatic hydrocarbons, biorefinery by-product 2: 29
  - monoglycerides, lipase-catalyzed syntheses 2: 270–272
  - monomer genes
    - concatenation 2: 226
    - preparation 2: 225
    - production 2: 226
  - monomers 1: 46
    - biorefinery 2: 315
    - quasi-aromatic 2: 46
  - monosaccharide production 1: 180
  - monosaccharides
    - availability 2: 4–7
    - conversion 2: 28
  - MSW Management, coupling with fuel production 1: 126
  - MTBE 1: 71
  - MTHF 1: 150, 2: 135
    - formation from LA 1: 152
  - mulch till 1: 329
  - Mulder, G.J. 1: 6
  - multi-cyclic carbonate comonomers 2: 398
  - multi-cyclic epoxy comonomers 2: 398
  - multi-cyclic ester comonomers 2: 398
  - multi-functional polymerization initiators, branching 2: 398
  - multi-quality biomass 1: 92
  - multifunctional care additives 2: 309
  - multifunctional compounds 2: 135
  - multimer genes 2: 226
  - multiple feedstock capability 1: 68
  - municipal solid waste 1: 116–117
    - management 1: 125
  - mutagenesis 1: 75–77
  - mutated spores, fermentation 1: 75
  - MWL 2: 155
- n**
- N*-heterocycles, sugar-derived 2: 24
  - Naegeli 2: 62
  - naltrexone, controlled-release devices 2: 240
  - naphtha 1: 86
  - naphthalene sulfonate, dye dispersants 2: 191
  - naphthenic compounds 1: 118
  - National Farm Chemurgic Council 1: 9
  - National Renewable Energy Laboratory process *see* NREL
  - natural lignin, recovery 2: 179
  - natural fibers 1: 90
  - natural oils
    - formaldehyde additions 2: 264
    - improvements 2: 275–281
    - industrial processing 2: 295
    - polymer building blocks 2: 296
  - natural substance, definition 2: 422
  - natural vector transformation systems 2: 275
  - NatureWorks 2: 10
  - near ideal elasticity 2: 219
    - mechanism 2: 220
  - net corn cost 1: 50
  - network polymer, lignin 1: 121
  - neutralizing agent, lactic acid 2: 385
  - nitrocellulose, history 2: 69
  - nitrogen leaching 1: 63
  - nitrogen source 2: 211
  - NMGA 2: 11–12
  - NMP 2: 373, 375–376
    - rhodium catalytic production 2: 377
  - NMR, purity 2: 229
  - Nocardia cholesteriolicum* 2: 273
  - non-carbohydrate natural products, synthesis 2: 20
  - non-food products
    - manufacture 1: 165–191
    - renewable resources 1: 11
  - non-food uses, sugars 2: 3–59
  - non-recyclable organic solid waste materials *see* NROSW
  - non-starch polysaccharides 1: 175
  - non-wood fibers 1: 280
  - nonactivated C–H bonds, oxidation 2: 269
  - nonhydrolytic proteins 1: 374
  - nontraditional microorganisms 1: 80
  - Normann, W. 1: 7
  - novel fatty acids synthesis, starting materials 2: 255
  - novel plastics, 1,3-propanediol 1: 182
  - novolacs 2: 181
  - novozym 435 2: 256
  - novozymes 1: 77
  - NREL 1: 19, 22, 72, 74, 150
  - NROSW 1: 126
  - NSP 1: 175
  - nuclear magnetic resonance 2: 229
  - nucleophilic addition, unsaturated fatty acids 2: 265
  - nucleus exchange method, lignin 2: 154
  - nutrient replacement 1: 324–325
  - nutrients 2: 388
    - lactic acid 2: 385

- oat 1: 183
  - replenishment 1: 327
  - wheat 1: 168
  - nutritional value, re-growth 1: 261
  - nylon 6, markets 2: 113
  - nylon-6,6 2: 45
  - nylon process, furfural-based 2: 123
- o**
- oat based biorefinery, schematic 1: 184
  - oat bran-rich fractions, value-added byproducts 1: 185–187
  - oat composition 1: 183
  - oat gum 1: 185
  - occurrence, betaine 2: 410–411
  - OFP 1: 151
  - oil 1: 98
    - microbial conversion 2: 274
    - new syntheses 2: 253–289
    - thermochemical conversion 2: 361
  - oil and lipid-based bioproducts 2: 356
  - oil-based surfactants 1: 90
  - oil crisis 2: 348
  - oil fruits, FAS 2: 304
  - oil industry, sections 1: 86
  - oil-like proteins, repulsion 2: 218
  - oil production, permanent decline 1: 42
  - oil qualities 2: 276–277
  - oils and fats, world production 2: 292
  - oilseeds 1: 45
  - olefin, metathesis 2: 259–260
  - olefinic polymers, sugar-based 2: 47
  - olefins, monosaccharide-derived 2: 47
  - oleic acid 2: 254
  - oleochemical base materials 2: 294
  - oleochemical-based dicarboxylic acids 2: 296
  - oleochemical industry 1: 122
  - oleochemicals
    - biobased 2: 291–314
    - polymer applications 2: 295
  - one-pass collection 1: 333–335
  - one-pass harvest 1: 332
  - one step biochemical modification, naturally produced structures 2: 349
  - one-way cycle, oil and gas feedstock 2: 449
  - OP 2: 395
    - PLA 2: 401
  - operating costs
    - biofine plants 1: 160
    - biorefinery 1: 240
  - optical purity 2: 395
  - organic acids 1: 78
    - analysis 1: 299
    - brown juice content 1: 304
    - commercially important 1: 79
    - production 1: 234–235
  - organic chemicals
    - bioproduction 1: 182
    - fossil sources 1: 120
    - industrial 1: 115–128, 124
    - levulinic acid 2: 134
    - renewable carbon 1: 44
  - organisms, engineered 1: 68
  - organization infrastructure 1: 340
  - organosolv biorefinery, lignin 2: 179–181
  - organosolv lignin, products 2: 183
  - organosolv pretreatment, lignin 2: 178
  - oseltamir phosphate, synthesis 2: 30
  - oxalic acid 2: 99
  - oxidation 2: 254–258
    - enantioselective 2: 258
    - fatty compounds 2: 257–258
    - selective 2: 38
    - starch 2: 79
  - $\beta$ -oxidation, fatty acids 2: 273–274
  - $\omega$ -oxidation, fatty acids 2: 273–274
  - oxidation technology, development 2: 38
  - oxidative cleavage 2: 258
    - transition metal-catalyzed 2: 258
  - oxidative coupling 2: 266
  - oxidative enzymes, biodegradable plastics 1: 213
  - oxidative metabolism, phosphorus supply 2: 211
  - oxidative polymerization, lignin polymerization 2: 153
  - oxidative states, changes 2: 236
  - 4-oxopentanoic acid 1: 6
  - oxygen supply 2: 212
  - ozone, cleavage of fatty compounds 2: 258
  - ozone-forming potential, P-Series fuels *see* OFP
- p**
- P-Series fuels 1: 151
  - Pachysolen tannophilus* 1: 147
  - Pacific Northwest Laboratory *see* PNL
  - Pacific Northwest National Laboratory *see* PNNL
  - palm kernel oil 2: 292
  - panel binders 2: 185
  - panelboard adhesives 2: 183–184
  - paper
    - adhesion 2: 87
    - from press cake fibers 1: 282

- paper industries, starch usage 2: 83
- paper mill waste 1: 134
- parasorbic acid, glucose product family 1: 21
- partial glycerides 2: 270
- particle size, feedstock materials 1: 144
- paste reactions, starch modifications 2: 77
- pasture lands 1: 52
- patents
  - protein-based polymers 2: 245–249
  - reexamination request 2: 245–249
- Payen, A. 1: 6
- PC 1: 30, 269, 271
  - downstream processing 1: 281
- PCB, lignin containing 2: 194
- PCR technique 2: 225
- PCS-hydrolyzing cellulases, improvements 1: 367
- PD 1: 393–397
- PDLA 2: 395
- PDO 1: 11
- peanut 2: 281
- pearl corn starch, carbohydrate refining 1: 351
- pearling 1: 173–176
  - oat grain 1: 183
- pectin substances 1: 265
- Penicillium* 1: 202
- pentaerythritol esters 2: 308
- 2,3-pentane dione, glucose product family 1: 21
- “pentanes-plus” 1: 151
- pentosan change, wet storage 1: 336
- pentosans, conversion 2: 28
- pentose fermentation 1: 206
- pentose sugars 1: 78
- pentoses 1: 91
  - conversion 2: 28
- peptide sequences, repeating 2: 217
- Peptostreptococcus productus* 1: 235
- perfluoroalkyl iodides, addition 2: 263–264
- perfluoroalkylated products, synthesis 2: 263
- performic acid procedure 2: 254
- pericarp 1: 183
  - wheat 1: 167
- pericyclic reactions 2: 260–261
- pesticides, lignin-based dispersants 2: 193
- PET 2: 133
- petrochemical industry 1: 86
  - transformation steps 1: 88
- petrochemical technology 2: 373
- petroleum
  - dependence 1: 115
  - structural shift 1: 116
- petroleum-based pathways, polyamides 2: 45
- petroleum chemistry, comparison with biomass 1: 118–122
- petroleum costs 1: 48–50
- petroleum dependence, reduction 1: 71
- petroleum feedstocks 1: 45
- petroleum refineries 1: 16
- petroleum refining industry, development 1: 41
- petroleum reserves, prognoses 1: 387
- petroporphyrin formation 2: 332
- petroporphyrins 2: 331–332
- PF 2: 181
- PF resins, markets 2: 183
- pH adjustment 1: 79
- PHA 1: 182, 214, 236, 239, 2: 44
  - accumulation 1: 236
- pharmaceuticals 1: 13, 2: 14–15
  - intermediate 2: 40
  - preparation 2: 26
  - purification target level 2: 230
  - starch usage 2: 88–89
- phase III-biorefineries 1: 19–20
- phase separated product, gross visualization 2: 229
- phase separation, purification 2: 228
- phase transition, Gibbs free energy 2: 234
- PHB 1: 209, 238
  - chemical structure 1: 214
  - copolyesters 1: 215
  - intracellular reserve material 2: 423
  - lifetime of products 1: 214
  - synthesis 1: 237–238
  - yield determination 1: 238
- PHB-PHV copolymer, brittleness 2: 426
- phenol–formaldehyde resin 2: 181
- phenol–formaldehyde resin markets, lignin 2: 187
- phenolic acids 1: 178
- phenolic–carbohydrate complexes, *Lolium perenne* 1: 264
- phenolic molding compound market 2: 184
- phenolic resins 2: 16, 181, 185
  - biorefinery lignin 2: 181–183
- phenomenological axioms, engineering protein-based polymers 2: 232–234
- phenyl-propanoid units, crosslinked 2: 181
- phenylpropane units 2: 157, 159
  - bonding 2: 153–156

- phloroglucinol, biosynthesis 2: 30
- phospholipids 1: 361
- phosphorus source 2: 211
- phosphorylation, changes 2: 236
- photochemical gas-phase chlorination 2: 269
- photodynamic therapy, chlorophyll derivatives 2: 336
- photosensitizer, chlorophyll 2: 334
- photosynthesis 1: 12, 42
- photosynthesis enzyme, plant content 1: 255
- photosynthetic bacteria 1: 229
- photosynthetic pigments 1: 257, 2: 326
- phthalo green 2: 338
- PHV 1: 237, 2: 426
- phylogenetic tree, gene sequences 1: 367
- phytic acid 1: 170
- phytochemicals, biorefinery context 2: 315–324
- phytoestrogens 2: 321–322
- phytosterols 2: 317–318
- Pichia* yeast 1: 206
- Picrophilus torridus* 1: 80
- pigments
  - biorefinery context 2: 315–324
  - carotenoids 2: 320
  - chlorophyll 2: 336
- pilot plants, biomass fermentation 1: 135
- Pirie, N.W. 1: 9
- PLA 2: 10–11, 41, 381
  - biobased 1: 296–299
  - high polymer 2: 391
  - melt rheology 2: 397
  - production 2: 390–396
  - properties 2: 400
  - resins 2: 400
  - semi-crystalline 2: 394
  - stereocomplex 2: 401
- plant breeding, oil improvement 2: 275–281
- plant cuticle, schematic 2: 431
- plant development, biomass hydrolysis 1: 129–138
- plant infection, fungal endophytes 1: 277
- plant material
  - usage 1: 90
  - yearly amount 1: 43
- plant resources 2: 353
- plant usage, historical 1: 254
- plasma cholesterol, reduction 2: 317–318, 321
- plasticization, starch 1: 27
- plasticizer, biodegradable bottle 2: 427
- plastics
  - biodegradable 1: 182, 212–216
  - novel 1: 182
- platform chemical 1: 147
- platform molecules 1: 182
- PLLA 2: 395
- plug-flow reactor 1: 144
- PNL process 1: 151–152
- PNNL 1: 22
- poly(3-hydroxybutyric acid) polymer 1: 214–216
- poly(hydroxyalkanoate) production, future milestone 1: 224
- poly(hydroxyalkanoates) 1: 238, 2: 44
- poly(3-hydroxybutyrate-co-valerate), enzymatic digestion 1: 219
- poly(hydroxybutyrate)
  - monomer 1: 237
  - processing 1: 215–216
  - switchgrass 1: 283
- poly(3-hydroxybutyric acid-co-3-hydroxyvaleric acid) 1: 214–215
- poly(3-hydroxybutyric acid) 1: 212–213
  - biosynthesis 1: 224
  - downstream processing 1: 218–219
  - production process 1: 217–223
  - sugar fermentation 1: 217
- poly- $\beta$ -hydroxy butyric acid 2: 423
- poly(lactic acid) 1: 8, 296
- poly(tetramethylene ether glycol) *see* PTMEG
- poly(vinyl chloride), cements *see* PVC
- polyamides 1: 122, 2: 45–47
- polyesters
  - fiber 2: 36
  - furan containing 2: 44
  - microbial 2: 44–45
  - production 1: 236–239
- polyetherpolyols, biodegradable 2: 9
- polyglucaramides, stereoregular 2: 46
- polyglycerol ester, emulsifier 2: 308
- polylactic acid 2: 10, 41
  - non-solvent process 2: 392
  - polymerization routes 2: 391
  - production capacity 1: 284
  - renewable resources 2: 381–407
- polymer building blocks, natural oils 2: 296
- polymer development, protein-based 2: 221–222
- polymer industry, starch 1: 28
- polymer size, mass spectra 2: 229–230

- polymerase chain reaction 2: 225  
 polymeric materials, protein-based  
   2: 220–221  
 polymeric products, polymeric lignin  
   2: 160  
 polymerizable sugar derivatives 2: 40–47  
 polymerization initiators, multi-functional 2: 398  
 polymers 1: 46  
   – biobased 1: 11  
   – oils and fats 2: 291  
   – oleochemicals 2: 295  
   – PHB 1: 209  
   – protein-based 2: 217–251  
 polyol esters 2: 307  
 polyols, epoxides based 2: 298–299  
 polyoses, history 2: 101  
 polypeptide, protein definition 2: 217  
 polysaccharides 1: 89, 121, 277  
   – acid hydrolysis 1: 141–142  
   – repeating units 2: 4  
 polytrimethyleneterephthalate *see* PTT  
 polyurethane foams, production 2: 9  
 polyurethane stretch fibers 1: 149  
 polyurethanes, oleochemical building  
   blocks 2: 298  
 polyvinylsaccharides 2: 47  
 pomace 2: 432  
 porous carbon fibers 1: 283  
 potato 2: 69–70  
 potato juice 1: 309–310  
   – lactic acid source 1: 295  
   – quality 1: 300  
 potato starch crystals 2: 73  
 potato starch industry, lactic acid producer  
   1: 310  
 potato starch production 2: 69  
 potential future market, formic acid 1: 154  
 potential screening 1: 22–23  
 power technologies, renewable 1: 139  
 precursors, biomass targets 1: 17  
 preprocessing, biomass 1: 46  
 press cake 1: 257, 269  
 press cake fibers, basic properties 1: 281  
 press-cake fraction 1: 278–285  
 press juice 1: 257  
 pressure ulcers, prevention 2: 240  
 pretreatment 1: 135, 198–200  
   – biomass 1: 107  
   – cornstover 1: 245  
   – dilute acid 1: 246  
   – LCF 2: 113  
   – lignocellulosic biomass 1: 361  
   – solvent-based 1: 200  
   – straw 1: 193  
 price changes, external challenges 2: 457  
 price difference, fossil fuel feedstocks  
   2: 446  
 price swings, oil 1: 48, 52  
 prices, renewable carbon feedstock 1: 50  
 primary antioxidants 2: 187  
 primary conversion technologies 1: 270,  
   2: 350  
 primary refinery 1: 269, 272  
   – wet fractionation 1: 271–273  
 primary starch 2: 85  
 primary streams, raw materials 1: 92  
 prime starch 2: 68  
 printed circuit boards 2: 194  
 process economics 1: 53  
 process optimization, lignocellulose-based  
   operation 2: 203  
 process scheme, integrated 1: 127  
 processing technologies, necessary for bio-  
   refineries 1: 46  
 processor value, stover 1: 327  
 product development, biodegradable bot-  
   tle 2: 426–427  
 product diversification, biomass 1: 54–55  
 product family tree 2: 97–150  
   – amino acid-based 2: 201–216  
   – glucose 1: 21–22  
   – hemicellulose-based 2: 121  
   – HMF and levulinic acid-based 2: 136–138  
   – lignin-based 2: 117–118  
   – syngas 1: 33  
 product flow-chart, biobased 1: 23  
 product innovation, biotechnology 2: 450  
 product integrity, verification 2: 229–230  
 product lines  
   – biobased 1: 375  
   – carbohydrate-based 2: 3–59  
   – hemicellulose-based 2: 119  
 product spectrum, chemical compounds  
   1: 105–106  
 product yield 1: 53–54  
 prognoses 1: 387  
 propanediol, glucose product family 1: 21  
 1,2-propanediol, racemic form 2: 37  
 1,3-propanediol 2: 36  
 propionic acid, biomass building blocks  
   1: 22  
 propylene, glucose product family 1: 21  
 prosthetic groups, hydrophobicity scale  
   2: 235  
 protease inhibitors 2: 322

- protective action, hair keratin 2: 436
  - protective film, skin care 2: 439
  - protein-based polymers 2: 217–251
    - charged side chains 2: 240
    - development 2: 221–222
    - elasticity 2: 219–220
    - engineering 2: 217, 232–238
    - expression 2: 227–230
    - gene constructions 2: 242–245
    - materials 2: 220–221
    - order 2: 219
    - patents 2: 245–249
    - purification 2: 227–230
  - protein content, comparison between plants and animals 1: 255
  - protein–fatty acid condensates 2: 304
  - protein gels, cellulolytic fungi 1: 372
  - protein generation, ethanol 2: 133
  - protein-hydrolyzates, extraction 2: 202
  - protein line 2: 201–216
  - protein repulsion 2: 218
  - protein–xanthophylls 1: 271
  - proteins 1: 46, 122, 268, 277, 2: 217
    - acylated 2: 304
    - analysis 1: 299
    - aqueous media 2: 218
    - biomass conversion 1: 371–375
    - brown juice content 1: 305
    - chemical composition 1: 361
    - crude starch milk 2: 66
    - juice fraction 1: 274
    - potato starch production 2: 70
    - thermodynamics 2: 218
  - protolignin 2: 152
  - protonated glycoside, cellulose hydrolysis 1: 141
  - Pseudomonas fluorescens* 2: 30
  - Pseudomonas putida* 1: 245, 2: 37
  - PTMEG 1: 149
  - PTT production 1: 393–396
  - pulp 1: 6
  - pulping
    - environmentally friendly 2: 179
    - mechanical 1: 280
    - semi-chemical 1: 280
  - pure chemicals, xylan derived 2: 122
  - purification 1: 218–219, 2: 388
    - chitin 2: 416–417
    - inverse temperature transition 2: 228–229
    - lactic acid 1: 312
    - phase separation 2: 228
    - PHB 1: 218
    - protein-based polymers 2: 227–230
  - purity
    - evaluation 2: 229
    - medical grade 2: 231
  - PVC 1: 149
  - PVC stabilizers, vegetable oil epoxides 2: 256
  - PX (protein-xanthophylls), production numbers 1: 271
  - pyran, building blocks 2: 21
  - pyranoid, building blocks 2: 23
  - pyranoid sugar derivatives 2: 48
  - pyrazoles 2: 26
  - 3-pyridinols 2: 28
  - pyrogallol 2: 30
  - pyrolysis 1: 123, 230
    - bioproducts 2: 362
    - pyrolysis oil 1: 98
    - production 1: 244
  - pyrolysis products, cornstover 1: 246
  - pyrolytic char 1: 247
  - pyrolytic lignin 1: 241
  - pyrolytic liquid, yield 1: 241
  - pyrones 2: 20
  - pyrroles 2: 24
  - pyrrolidone solvents, manufacture 1: 149
- q**
- quasi-aromatic monomers, sugar-based 2: 46
  - quinoxalines 2: 28
  - sugar derivative 2: 24
- r**
- racemic mixture, lactic acid 2: 382
  - radical additions 2: 261
    - malonic acid 2: 261
    - perfluoroalkyl iodides 2: 263
  - radical C–C coupling 2: 266–269
  - radical cyclization, methyl 2-iodopetroselinate 2: 263
  - rail transport, feedstock 1: 339
  - Ralstonia eutropha* 1: 217, 237
  - ranitidine 2: 14
  - rapeseed 2: 277
  - rapeseed oil, industrial use 2: 280
  - rapid pyrolysis 1: 227
    - cellulose 1: 243
  - rate of biodegradation 1: 213
  - raw material costs 1: 53
  - raw materials
    - appropriate 1: 165
    - aromatic compounds 2: 259

- biomass 1: 12–14
  - biorefineries 1: 45–47
  - costs 2: 110
  - oleochemicals 2: 292–293
  - renewable 2: 253–289
  - sterilization 2: 209
  - world market prices 2: 356
  - RBAEF Project 1: 43, 52
  - reaction system costs 1: 53
  - reactive sites, triglycerides 2: 294
  - recombinant DNA technologies
    - application 2: 204
    - gene construction 2: 225–227
    - protein-based polymers 2: 217
  - recovery 1: 218–219
  - recycling 1: 106
    - plastics 1: 212
  - refined biomass 1: 98
  - refineries
    - hybrid biomass processing 1: 227–252
    - thermochemical 1: 101–103
  - refinery economy 1: 350
  - refining, biomass 1: 41–66, 107
  - reformulated gasoline *see* RFG
  - regioselective syntheses, ricinoleic acid 2: 254
  - re-growth, nutritional value 1: 261
  - regulatory framework, biotechnology 2: 447
  - regulatory situation, external challenges 2: 457
  - reinforcers, lignin 2: 186
  - renewable carbon feedstock prices 1: 50
  - renewable energy law 1: 15
  - renewable material, definition 2: 422
  - renewable-power technologies 1: 139
  - renewable raw materials 2: 355
    - oils and fats 2: 253–289
    - optimized by breeding 2: 277–281
  - renewable resources 2: 347
    - industrial conversion 1: 5
    - integrated utilization 1: 10–11
    - non-food products 1: 11
    - polylactic acid 2: 381–407
    - prognoses 1: 387
    - sources 1: 385
  - repulsive free energy 2: 222
    - apolar–polar 2: 218
    - hydration 2: 237
  - residual biomass, importance 2: 452–457
  - residual sugars, separation 2: 388
  - residue utilization 1: 283–285
  - resin binders 2: 183
  - resin fraction, holly 2: 438–439
  - resin industry 2: 182
  - resins
    - PCB 2: 194
    - thermoset 2: 184
  - resols 2: 181
  - retroaldolization, imidazoles 2: 27
  - retrogradation 2: 75
  - reversed-polarity unsaturated fatty acids, nucleophilic addition 2: 265
  - RFG 1: 151
  - rheological properties
    - $\beta$ -glucan 1: 185
    - NSP 1: 175
  - rheology control 2: 396
  - Rhizomucor miehei* 2: 271
  - Rhizopus arrhizus* 2: 35
  - rhizopus-based fermentation 2: 388
  - rhodium catalyst, NMP production 2: 377
  - Rhodopseudomonas gelatinosa* 1: 237
  - Rhodospirillum rubrum* 1: 237, 239
  - Rhodospirillum rubrum* 1: 229
  - ribulose 1: 255
  - rice, starch production 2: 71
  - rice straw, world production 1: 51
  - ricinoleic acid 2: 254
  - ridge-till 1: 329
  - right opportunities, biotechnology 2: 458
  - ring-opening
    - chlorophyll 2: 330
    - nucleophilic 2: 257
  - ring-opening polymerization 2: 394
  - ring structures, saccharides 1: 121
  - rings, lignin polymer 2: 155
  - Ritter, E. A. 1: 323
  - rocket fuels 2: 37
  - Role of Biomass in America's Energy Future *see* RBAEF Project
  - ROP 2: 394
  - Rothamsted process 1: 256
  - Rouille, H. M. 1: 254
  - rubber industry, antioxidants 2: 188
  - rubber processing, lignin 2: 186
  - rubisco 1: 274
    - plant content 1: 255
  - Rubrivivax gelatinosus* 1: 236–237
  - rye grasses, digestibility 1: 261
  - ryegrass, fiber properties 1: 281
- s**
- saccharides 1: 121
  - saccharification 1: 32, 2: 128, 177–179
    - cellulose 2: 99

- wood 1: 5–6
- Saccharomyces* 1: 194
- Saccharomyces cerevisiae* 1: 7, 146, 2: 209
- Saccharomyces yeast* 1: 206
- saccharose, fructose source 2: 131
- Saccharum officinarum* 1: 210
- salt splitting technology, lactic acid 2: 387
- saponins 2: 321–322
- satake pearling system 1: 174
- saturated fatty compounds, reactions 2: 266–270
- SAXS, lamellar thickness 2: 395
- scaffoldings, temporary functional 2: 239
- scenarios, intgeration of industries 1: 94
- Scholler process 1: 131
- Scholten, W.A. 2: 62
- screening 1: 22–23, 77
- screening methods 1: 75–76
- scutellum, wheat 1: 169
- SDS–PAGE 2: 228
- purification 2: 228
- SEC 2: 72
- second-grade starch 2: 68
- secondary biochemical refinery 1: 104–106
- secondary biorefining processes, thermochemical 1: 103
- secondary starch
- secondary streams, raw materials 1: 92
- secretome, cellulolytic fungi 1: 371–373
- sectoral integration, bio-based industry 1: 93–96
- seed, wheat 1: 167
- selective oxidation, carboxylic acids 2: 38
- self-leveling concrete 2: 87
- semi-chemical pulping, lignin extraction 1: 280
- separation of biomass, technically feasible 1: 17
- separation system costs 1: 53
- sequence integrity, evaluation 2: 229
- sequence verification 2: 226
- sequenced genomes, microorganisms 1: 80
- sequestration, carbon 1: 62
- serine, biomass building blocks 1: 22
- shampoo bottle
  - Biopol 2: 422
  - degradation 2: 425
  - market launch 2: 427
- Shell, transition process 1: 93
- shellfish industry, chitin source 2: 416
- shikimic acid, metabolic engineering 2: 31
- side-chain, oxidativ shortening 2: 25
- side-streams, fermentation 1: 106
- signal peptide effect 1: 375
- silage additive, formic acid 1: 153
- silage juice 1: 276–277
- silage residues, reusage 1: 283
- silage wet-fractionation, primary refinery 1: 271
- silica 1: 268, 277
- silicon carbide, rye grass 1: 278
- simultaneous saccharification and fermentation 1: 134
- sitosterol 2: 317
- six-carbon sugars, microbial conversion 2: 32–34
- sixth framework program, EU 1: 103
- size-exclusion chromatography 2: 72
- sizing agents 2: 85
- skin, protection 2: 429–437
- skin care, ilex resin 2: 439
- skin cosmetics 2: 434
- slaughterhouse wastes, byproducts 1: 100
- slurry process, starch modifications 2: 76–78
- small-angle X-ray scattering 2: 395
- small-scale extractions, chlorophyll 2: 329
- smell, obnoxious 1: 310
- soap 2: 409
- soap production, history 1: 7
- soda process, lignin 2: 176
- soda pulping industry, lignin 2: 170–172
- sodium dodecyl sulfate polyacrylamide gel electrophoresis 2: 228
- sodium lactate, salt splitting 2: 387
- soft tissue augmentation 2: 238
- soft tissue reconstruction 2: 239
- soft tissue restoration 2: 238
- softwood, composition 2: 106
- softwood lignins 2: 157
- soil bioactivators, grass juices 1: 283
- soil carbon equilibrium 1: 325
- soil carbon loss 1: 328
- soil coverage, stover 1: 329
- soil erosion control 1: 329
- soil organic material 1: 328–329
- soil organic matter *see* SOM
- soil quality 1: 324
  - models 1: 324
- solid state bioprocessing *see* SSB
- solubilization, cellulose 1: 359
- solubles removal, wet storage 1: 336
- solvent, selective 2: 9
- solvent extraction 1: 219–221, 2: 388
- SOM, loss 1: 324, 328
- sorbic acid, glucose product family 1: 21

- sorbitan esters 2: 11, 272
- sorbitol 2: 129–130
  - basic biobased chemicals 1: 22
  - D-sorbitol 2: 9
  - dehydration 2: 11
  - Sorghum dochna* 1: 255
  - sorona 2: 41
  - sovermol 2: 299
  - soybean 2: 277
    - phytochemicals 2: 317
    - processing 2: 316
    - saponins 2: 321
  - spandex 1: 149
  - special ingredients 2: 315–324
  - special sugars, juice fraction 1: 274
  - specialties 1: 386
  - specialty chemicals, bio-based 1: 91
  - Spirulina*, chlorophyll extraction 2: 329
  - spores, mutated 1: 75
  - SSB, fungal 1: 172
  - SSF 1: 71, 146, 203
    - process 1: 79
  - starch 1: 27, 67, 70–71, 121, 181, 268
    - acetylated 2: 80
    - bioconversion 2: 89–91
    - chemical composition 1: 360
    - chemical source 1: 50
    - commercial 2: 71–76
    - common sources 2: 62
    - composition 2: 74
    - corn refinery products 1: 348
    - degraded 2: 79
    - ethanol raw material 1: 197–198
    - glucan source 1: 139
    - history 2: 61
    - industrial production 2: 65
    - modification 2: 61–95
    - nitric acid oxidation product 2: 38
    - production 2: 61–95
    - properties changes 2: 78
    - quality 2: 73
    - raw materials composition 2: 65
    - syrups 2: 89
    - tailor-made 2: 92–93
    - total consumption 2: 82
    - world market 2: 64
    - yield 2: 69
  - starch-based biorefinery II 1: 69
  - starch derivatives 2: 82–91
  - starch ethers, building chemistry 2: 87
  - starch–gluten slurry, corn refinery 1: 349
  - starch granules, reshaping 2: 75
  - starch hydrolysis 1: 5
    - starch modification, types 2: 81
    - starch modification technology 2: 76
    - starch platform, industrial 2: 61–95
    - starch saccharification 2: 178
    - starch water, modification 2: 76–81
    - steam 1: 46
    - steam-alkaline pulping, lignocelluloses 2: 114
    - steam explosion 1: 280
      - pretreatment 1: 198
    - steam gasification 1: 156
    - stearic acid, photochemical gas-phase chlorination 2: 269
    - steep liquor 1: 349
    - steeping, corn 1: 348
    - steepwater 1: 349
    - stereoregular polyglucaramides 2: 46
    - stereoselective syntheses, ricinoleic acid 2: 254
    - steric hindrance, enzymatic hydrolysis 1: 147
    - sterigel 1: 178
    - sterols, soybeans 2: 317
    - storage 1: 334
      - bagasse 1: 321
      - baling dry material 1: 332
      - brown juice 1: 298
      - potato juice 1: 335
      - storage area, square bales 1: 335
      - storage investment cost 1: 337
      - storage loss 1: 335
      - storage polymer, PHA 1: 239
      - stover, economic benefit 1: 325
      - stover field value 1: 326
      - stover revenue, farmers income 1: 319
    - strain development 2: 371
    - straw
      - baling 1: 333
      - LCF biorefinery 1: 26
      - world production 1: 51
    - straw species 2: 107
    - straw waste, wood saccharification 1: 10
      - Streptomyces setonii* 1: 179, 245
    - strip till 1: 329
    - strong acid addition, lactic acid 2: 386
    - structural features, lignin 2: 155
    - structure-based design, enzyme improvement 1: 369
    - structure–function relationship, EG 1: 370
    - styling, ilex resin 2: 440
    - substance classes, apple-peel wax 2: 433
    - substrate recalcitrance 1: 204
    - succinate fermentation 2: 369

- succinate strain FZ 21 2: 371
- succinic acid 1: 149, 2: 35
  - catalytic transformations 2: 372
  - conversion 2: 375
  - derivatives 2: 373
  - fermentation 1: 378, 2: 369–372
  - model building block 2: 367–379
  - wheat flour milling byproducts 1: 172
- sucrose 1: 70
  - catalytic oxidation 2: 39
  - conversion 2: 18
  - ethanol raw material 1: 197–198
- sucrose-6,6'-dicarboxylic acid 2: 46
- sucrose-based biorefinery I 1: 68
- sucrose fatty acid monoesters 2: 13
- sugar 1: 209
  - analysis 1: 299
  - bulk-quantity prices 2: 4
  - chemical conversion 2: 37–40
  - contained in biomass 2: 3–59
  - fermentable 1: 68
  - fermentation problems 1: 146
  - increasing demand 1: 67
  - juice fraction 1: 274
  - mixed 1: 98
  - non-food industrial uses 2: 7–14
  - nonionic surfactants raw materials 2: 306
  - plant contents 1: 265
  - simple 2: 5
  - thermochemical conversion 2: 360
  - yield 1: 130
- sugar acids, chemical route 1: 402–405
- sugar and starch bioproducts 2: 356
- sugar-based biorefinery 1: 209
- sugar-based chemicals 2: 14
- sugar-based olefinic polymers 2: 47
- sugar-based surfactants 2: 11–12
- sugar beet 2: 410
- sugar biorefinery 1: 70
- sugar cane industry, Brazil 1: 209–211
- sugar cane processing 1: 211
  - steps 1: 222
- sugar composition, dependence on harvesting time 1: 265
- sugar content, brown juice 1: 303
- sugar conversion, efficiency 1: 136
- sugar crops 1: 45
- sugar derivatives 2: 48
  - polymerizable 2: 40–47
- sugar feedstock, carbohydrate sources 2: 385
- sugar fermentation 1: 194, 206–207
  - poly(3-hydroxybutyric acid) 1: 217
  - sulfite pulp process 1: 8
- sugar mill
  - Brazil 1: 210
  - poly(3-hydroxybutyric acid) production 1: 221
- sugar platform 1: 32
  - intermediate 1: 31
- sugar production 1: 5
- sugar residues, *Lolium perenne* 1: 264
- sugar syrup 1: 222
- sugar transformations, prototype 2: 19
- sugarcane bagasse 1: 74
- sulfite pulp process, historical improvement 1: 8
- sulfite pulping industry 2: 189
  - lignosulfonates 2: 168–169
- sulfite pulping process 2: 172
- Sulfolobus sulfataricus* P2 1: 80
- Sulfolobus tokodaii* strain 7 1: 80
- sulfonated Kraft lignin, dye dispersants 2: 191
- sulfur, lignin structure 2: 171
- sulfur-bearing gases, catalyst poisoning 1: 234
- sulfur-containing components, removal 2: 350
- sulfur emissions, diesel 1: 153
- sulfuric acid, hydrolysis of cellulose 1: 130
- sunflower 2: 280
- surface cover, fields 1: 324
- surfactants
  - carbohydrate-based 2: 305
  - cationic 2: 412
  - classification 2: 301
  - nonionic 2: 272
  - oil-based 1: 90
  - production 2: 302
  - sugar-based 2: 11–12
  - vegetable oil 2: 301
  - worldwide market 2: 303
- sustainability 1: 92, 96
  - biomass 1: 106
  - biorefining systems 1: 56–65
  - economic drivers 1: 381
  - integrated biorefining systems 1: 60–65
- sustainable development 2: 253
- sustainable production 2: 448
- sweet potato, starch production 2: 71
- sweeteners, alternative 2: 62
- switchgrass, polyhydroxybutyrate source 1: 283
- swollenin, enzymatic hydrolysis 1: 365

- syngas 1: 26, 30–31, 46, 98, 126, 157, 2: 361
  - composition 1: 232
  - fermentation 1: 228–229, 233–239, 239–241
  - platform 1: 31–32
  - product family tree 1: 33
  - technology 1: 240–241
- syntheses 1: 123
  - lactic acid 2: 382
  - lipase-catalyzed 2: 270–272
  - petroleum compounds 1: 119
  - with oils and fats 2: 253–289
- synthesis gas 1: 182
- synthesis of structure, petrochemistry 1: 123
- synthetic biofuels 1: 30
- synthetic biopolyesters 2: 41
- synthetic rubber 1: 131
- t**
- tablet coatings 2: 88
- tack 2: 186
- tall oil fatty acid 2: 297
- Tamiflu, synthesis 2: 30
- tapioca 2: 70–71
- tapioca starch production 2: 70
- tar-formation, acid hydrolysis 1: 144
- target chemicals, biobased 1: 14, 16
- target crops, feedstock production 1: 15
- tars, undesirable 1: 231
- technical constraints, MAAP 2: 209
- technical prerequisite, cellulosic biorefineries 1: 55–56
- technoeconomic factor, dominant 1: 53–54
- technological outline, biorefinery systems 1: 4–8
- technological pathways, transformation process 1: 87
- temperature adjustment 1: 79
- temperature transition, inverse 2: 219
- temporary functional scaffoldings 2: 239
- terpenes 1: 91
- terrestrial biomass, content 2: 3
- tetrahydrofuran *see* THF
- tetrahydroxybutyl side-chain, furans 2: 19
- tetrapyrrole structures 2: 328
- TEWL 2: 434
- textile-glass-fiber-industry, starch usage 2: 91
- textile industry, starch usage 2: 85
- The Netherlands, bio-based industry 1: 93–96
- thermal addition of alkanes 2: 264
- Thermatoga maritima* 1: 80
- thermochemical biorefinery concept, ECN 1: 104
- thermochemical conversion 1: 31
  - biomass processing 1: 98
  - catalytic 2: 356
  - oils 2: 361
  - optimization 1: 108
  - sugars 2: 360
- thermochemical liquefaction 1: 123
- thermochemical processing, biomass 1: 249
- thermochemical refinery 1: 101–103
- thermogravimetric analyses, feedstock 1: 156
- Thermoplasma acidophilum*, microorganisms 1: 80
- thermoplastic polymer, PLA 2: 381
- thermoplastics 2: 225
  - adhesive film 1: 282
  - thermoplastic 1: 215
- thermoset resins 2: 184
- THF 1: 149, 2: 373
- thickeners, textile-printing 2: 86
- threonine
  - biomass building blocks 1: 22
  - markets 2: 207
- Tiemann, F. 1: 7
- Tilgham, B.C. 1: 6
- tillage effect, soil carbon loss 1: 328
- tillage practice 1: 330–331
- tin-catalyzed lactide polymerization 2: 391
- tin hydride radical chemistry 2: 261
- tin octoate catalyzed polymerization, lactide 2: 393
- TNPP, melt stability improvement 2: 399
- tocopherols 2: 319–320
- toxicity 2: 212
- TPA, synthesis 2: 134
- traffic congestion 1: 338
- traffic problems, feedstock 1: 338–339
- tragacanth, substitute 2: 62
- transepidermal water loss 2: 434
- transesterification, sucrose fatty acid monoesters production 2: 13
- transition metal-catalyzed syntheses, aromatic compounds 2: 259
- transition metal metathesis, olefins 2: 259
- transport
  - baling dry material 1: 332
  - crops 1: 337
- transportation fuels, biomass share 1: 14, 16
- Treibs's scheme, petroporphyrin formation 2: 332

- triacylglycerides 1: 121–122
  - Trichoderma* 1: 201–202
  - Trichoderma* cellulase 1: 75
    - enzymes 1: 204
  - Trichoderma reesei* 1: 77, 130, 134, 365, 375
    - cellulase development 1: 366
    - enzyme improvement 1: 369
    - GH families 1: 373
    - protein secretion 1: 372
  - Trichoderma viride* 1: 134
  - trichomes 1: 183
  - Trifolium pratense*
    - economic importance 1: 284
    - press cake fibers 1: 281
  - triglyceride oils, hydroxyl-functional 2: 298
  - triglycerides 1: 121–122, 2: 294
  - tris(nonylphenyl) phosphite 2: 399
  - truck transport, feedstock 1: 338
  - tunneling, dry-jet process 2: 88
  - turpentine, crude 1: 91
  - two platforms concept 1: 31
    - biorefinery 1: 24
  - two-use ethic 1: 116
  - two-uses ethics, MSW 1: 126
- u**
- Udic–Rheinau process 1: 131
  - Umbellularia californica* 2: 280
  - unicarbonotroph 1: 239
  - unicarbonotrophic acetogens, syngas fermentation 1: 233
  - United States, biomass conversion 2: 352–353
    - unsaturated fatty acids
      - dimerization 2: 297
      - epoxidation 2: 254–257
      - microbial hydration 2: 272–273
      - nucleophilic addition 2: 265
    - unsaturated fatty compounds, reactions 2: 254–266
    - unsaturated *N*-heterocycles, sugar-derived 2: 24
    - updraft gasifiers 1: 231
    - US patent and trademark office 2: 245–249
    - USPTO 2: 245–249
    - Ustilago maydis* DSM 4500 2: 274
- v**
- $\gamma$ -valerolactone *see* GVL
  - value-added byproducts
    - bran-rich wheat fractions 1: 178
    - oat bran-rich fractions 1: 185–187
  - value-added components, bran-rich wheat fractions 1: 175
  - value-added products 2: 360
  - value chain approach, biomass processing 1: 97
  - vanillin 1: 7, 179, 2: 30
  - vegetable oil
    - emulsifiers 2: 301
    - nonionic surfactants raw materials 2: 306
  - vegetable oil epoxides, PVC stabilizers 2: 256
  - vegetable oils 1: 121, 2: 254, 291
    - chemo-enzymatic epoxidation 2: 256
  - vehicle production, lignin 2: 196–197
  - Vertec 2: 10
  - vic*-dihydroxy fatty acids 2: 257–258
  - vigorous mixing, starch modifications 2: 77
  - vinegar-like proteins, repulsion 2: 218
  - vinyl acetate, glucose product family 1: 21
  - vinylsaccharides 2: 47
  - viscosity, starch 2: 73
  - viskose process, history 2: 102
  - vital wheat gluten 1: 180
  - vitamin A source, carotenoids 2: 320
  - vitamin E source 2: 319
  - vitamins 2: 14–15
    - analysis 1: 299
    - juice fraction 1: 274
    - wheat 1: 169
  - vitriol oil 2: 99
  - von Walden, P. 1: 8
- w**
- wagons, self loading and unloading 1: 319
  - waste biomass 1: 259, 2: 452
    - biorefinery products 1: 11
  - waste-products, processing 1: 8
  - waste streams, cost generator 1: 96
  - waste treatment costs 1: 53
  - waste water treatment 1: 347
  - wastes, biorefinery 1: 56
  - water, enantioselective addition 2: 273
  - water-gas shift reaction, syngas production 1: 230
  - water-retentive properties, chitosonium salts 2: 420
  - water-solubility, chitosan 2: 417
  - water-splitting electrodialysis 2: 387
  - watersoluble carbohydrates *see* WSC
  - wax, isolating 2: 432
  - wax coating, apple 2: 431
  - wax esters, apple-peel wax components 2: 433

waxy maize, starch production 2: 66  
 western immunoblot technique, purity  
 2: 230–231  
 wet fractionation 1: 257, 271–273  
 – green biomass 1: 29–30  
 wet mill-based biorefinery  
 – products 1: 29–31  
 – whole crop 1: 28  
 wet mill refinery 1: 346–347  
 wet-milling 1: 48, 70  
 – corn 2: 367  
 wet oxidation, pretreatment 1: 363  
 wet storage  
 – bagasse 1: 323  
 – silage 1: 334  
 wheat 2: 66  
 – chemical composition 1: 169  
 – composition 1: 167  
 wheat-based biorefinery, schematic 1: 177  
 wheat flour, secondary processing 1: 169–  
 173  
 wheat flour milling byproducts  
 – annual amount 1: 173  
 – biorefinery 1: 171  
 wheat germ 1: 179  
 wheat germ oil, purified 1: 179  
 wheat kernel  
 – exploitation 1: 180–183  
 – morphology 1: 168  
 wheat milling efficiency, increase 1: 173  
 wheat separation processes, advanced  
 1: 173–176  
 wheat starch production 2: 68  
 wheat straw  
 – ethanol production 1: 193  
 – world production 1: 51  
 wheat tillage practice 1: 331  
 wheatfeed 1: 170  
 whey 1: 296  
 white biotechnology 2: 445  
 white-rot fungi 2: 151  
 whole-crop biorefinery 1: 24, 26–29, 165–  
 191  
 – products 1: 27

window of processibility, PHB 1: 216  
 winter cover crop 1: 61  
 wood chemicals 2: 357  
 wood chemistry, origin 1: 10  
 wood hydrolyses 1: 5  
 wood-hydrolysis pilot plant, US 1: 131  
 wood processing, LCF biorefinery 2: 112  
 wood saccharification 1: 5–6  
 woody biomass 1: 245  
 woody crops 1: 45  
 WSC 1: 146  
 – press cake 1: 257

**x**

xanthophylls 1: 257, 2: 321  
 XPS 2: 435  
 X-ray photoelectron spectroscopy 2: 435  
 xylan 1: 129, 2: 108  
 xylan/xylose product line 2: 120  
 xylitol 2: 121  
 xylitol/arabinitol, basic biobased chemi-  
 cals 1: 22  
 xylitol source, esparto grass 1: 283  
 xyloglucan 1: 360  
 xyloidin, history 2: 99  
 xylonic acid, biomass building blocks 1: 22  
 xylose  
 – crystals 2: 121  
 – fermentation problems 1: 146  
 – monomeric 1: 198  
 D-xylose, pyrazole synthesis 2: 26

**y**

yeast  
 – ascomycetous 2: 7  
 – ethanol production 1: 194, 206  
 yeast extract, MAAP processes 2: 211

**z**

*Z. mobilis* see *Zymomonas mobilis*  
 zeolites 1: 278  
 zwitterion, betaine 2: 411  
*Zymomonas* 1: 206  
*Zymomonas mobilis* 1: 133, 2: 7, 108, 210

