Index

AA-poly(a-amino acid)s 332
acetaldehyde-rich stream 8
acetaldehyde 10
acetalized carbohydrates
– aromatic polyesters, comparison 297
– biodegradability 297
– co-polyesters 295
– derived from sugars 294
– gluco- and galacto-derived monomers 294
– Glux moieties 295
– Mannitol derivatives 296
– manno-derived monomers (Manx) 294
5-(acetoxymethyl)furfural (AMF) 200
acid-catalyzed dehydration 13
acid catalyzed mechanism 434
acid solid catalysts 437
acrolein 222
acryl-CoA to propionyl-CoA 238
adipic acid 334, 511
– benzene 157
– bio-based chemicals production 154
– biological processes 153
– bio- vs. petro-based 170
– chemical feedstocks 153
– conventional and fermentation-based 158
– oleochemicals 153
– price volatility 153
– Rennova’s development 153, 157
aeration and gas systems
– optimal oxygen uptake rate (OUR) 185
– reverse TCA cycle 185
– yeast systems 185
aldol condensation
– acid catalyzed mechanism 434
– acid solid catalysts 437
– base catalyzed mechanism 434
– basic solid catalysts 436
– catalysts 437, 438
– cyclopentanone upgrading strategy 467, 468
– description 433
– enolate formation mechanism 433
– enol formation mechanism 434
– furfural and acetone over dolomite 435
– of furfural and HMF with cyclopentanone 469
– homogeneous catalysts 436
– upgrading process 439
– aldose and ketose sugars 250
– algae biomass harvesting 650
– algal oils
– downstream processes 651
– heterotrophic cultivation technology 652
– industrial development 651
– microalgae 648
– photoautotrophic cultivation technology 649
– upgrading to fuels 653
– alkaline cleavage process 537
– 5-(alkoxycarbonyl)furan-2-carboxylic acid (ACFC) 200
– alkyl-5-formylfuran-2-carboxylate (AFC) 200
– alkyl furan-2-carboxylate (AFC) 200
– alkylphenols, deoxygenation of 407
– alumina-based catalysts 5
– aluminium phosphate (AlPO4) 230
– Amberlyst 15 catalysts 508
– Amoco Mid-Century (MC) catalyst 198
– amphiphilic conetworks applications (APCNs) 343
– Anellotech technology
– CFP 36
– lignocellulosic biomass 38
– solid biomass 36
– zeolite catalysts 36
animal oils and fats
  – fatty acids composition 117
  – triglycerides 117
APR. See aqueous phase reforming (APR)
aquatic biomass
  – growing and processing 497
aquatic (marine) biorefinery 501
aqueous phase processes 108
aqueous phase reforming (APR)
  – advantages 94
  – alkanes production from xylitol over
    bifunctional metal-acid catalyst 100, 102
  – biomass fractions see biomass fractions, APR
  – biorefinery 107
  – catalysts 97, 98
  – closed-vessel reactors 98
  – description 79
  – diluted oxygenated hydrocarbon solutions 98, 99
  – Gibbs free energy change with temperature 95
  – glucose and glycerol 100
  – green fuels and bio-platform molecules 94
  – highly reactive compounds 100
  – parallel reactions, ethylene glycol 96
  – pressure conditions 98
  – process 406, 420
  – solid arrows pathways 100, 101
  – sugars and polyols 98
Archer Daniels Midland (ADM) 200
Arkema’s plant-based factories 535
  – Blooming Prairie (USA) 538
  – Feuchy (France) 539
  – Hengshui (China) 537
  – Marseille Saint-Menet (France) 536
  – Parentis (France) 539
aromatics
  – p-xylene. see p-xylene
  – bio-aromatics 33, 34
ATR. See autothermal reforming (ATR)
Au-Cu bimetallic catalysts 195
Au nanoclusters 195
Au-Pd nanoparticles 196
Au-Pt bimetallic catalyst 225
Augeo™ family 619
Augeo™ family
  – chemistry and applications 619
  – autothermal reforming (ATR) 89
azelaic acid 331, 536
benzofuran, deoxygenation of 412
5-benzylxy-trimethylene carbonate 343
Bergius-Rheinau and the Scholler-Tornesch
  process 248
beta zeolite 71
bi(2,5-hydroxymethyl)-furan 211
bi-functional catalysts 439
bi-functional catalysts for C8+production 454
BiMo mixed oxide catalyst 217
Bio Diesel international (BDI) technology 673
bio synthetic natural gas (BSNG) 86
bio-acrylic acid (Bio-AA)
  – academic and industrial researchers 218
  – acrylonitrile 217
  – BiMo mixed oxide catalyst 217
  – biochemical routes 238
  – bio-propylene 237
  – dehydration 239
  – enzymatic reactivity 239
  – glacial acrylic acid 218
  – glycerol 218, 220–224
  – 3-hydroxypropanaldehyde 239
  – lactic acid. see Lactic acid (LA)
  – propene-based processes 217
  – 2-propenoic acid 217
bio-alcohols
  – C3 -alcohols to olefins 13–15
  – C4 -alcohols to olefins 15–18
  – ethanol to butadiene 6, 7, 8, 10, 12, 13
  – ethanol to ethylene 4–46
BioAmber Yeast Process 184
bio-based chemicals, raw materials 554
bio-based economy 532
biobased 1,2-ethanediol 339
biobased poly(butylenesuccinate-
  co-butyleneazelate 331
bio-based process
  – reliability 558
bio-based products 550, 559
bio-butadiene route 587
bio-butadiene, synthesis 28
Biochemtex MOGHI process
  – hydrodeoxygenation 44
  – lignin transformation 44, 45
  – process integration 43, 44
  – soaking 43
biodiesel 653
  – production from waste sources 675
Bio Diesel international (BDI) technology 673
biodiesel mandatory 528
bio-economy 504
– legal and regulatory background 531
– oleochemistry in 532
bioengineering 578
bioethanol 366
bioethanol 582
biofactories 499
– CO₂ usage 514
– models 503
BioFormate™ 34
BioForming® 34
biofuels
– expansion and production 498
– FSCW 672
– lipid based feedstock conversion 653
– projects overview 576
bioliq® process 405
biological processes
– development of 530
biomass 549, 643
– constituent parts of 574
– European Union power consumption 403
– German electric power consumption 403
– lignocellulosic 536, 576
– production 573
– technologies 569, 571
biomass derivatives 361
biomass fractions APR
– cellulose fraction 103
– drawbacks 103
– gaseous and liquid products TOC percentage 104
– H₂ selectivity 103
– lignocellulosic fractions 103
– pilot plants and patents. see pilot plants and patents
– recondensation reactions 104
biomass gasification, see also reforming
– APR 79
– biomass transformation 80
– CGE 82
– CH₄ and light hydrocarbons 80
– CO CO₂ and H₂ and H₂O 80
– densification and high-temperature gasification 82, 84
– direct gasification 85, 86
– fluid bed gasifiers 81
– fuel production costs 93
– full-chain BTL process 80
– integrated electrolysis 93, 94
– low-to-medium temperature 82
– oxidizing agent 79
– total energy share gas products 81, 82
– Varnamo and Gussing plants composition of 8
– water-gas shift 81
biomass transformation
– algal oils 648
– bio-oils upgrading 657, 659
– hydrothermal liquefaction 658
– lipids 644
– metabolic yields 646
– microbial oils 644
– microorganism 644
– Neste Oil 648
– phospholipids membrane-bound lipids 648
– product distribution 655
– pyrolysis 655, 656
– solvent extraction 648
– technologies for 644
– vegetable oils and fats 644
Bionolle® 330
bio-oil hydrotreating process 660
bio-oil stability 657
bio-oils
– from fast pyrolysis 413
– from hydrothermal liquefaction 413
– hydrotreatment 432
bio-oil stability 657
bio-oils chemical composition of 407
bio-oils upgrading 657, 659
biorefineries 535
– agricultural feedstocks 52
– APR process 107, 108
– aquatic (marine) biorefinery 501
– bio-based chemical production 52
– bioethanol 497
– in Brazil 581
– butanol production 594
– biomasses/residues and their costs 573
– CO₂ use and solar energy integration 512
– competing technologies/products 575
– concept of 500, 519, 550
– crop breeding technology 53
– crude oil 603
– definition 500, 572, 603
– development 500
– driving forces 497
– ethanol production 593
– future ideas 499
– gasification 604
– green biorefinery 501, 502
– guayule-based biorefinery 606, 609
– hydrocarbon-rich chemicals 53
– innovation 498
– lignocellulosic biorefinery 501
– models of 499, 502, 503
biorefineries (contd.)
- flexible production of chemicals and fuels 508
- olefin biorefinery 505
- oilseed biorefinery 501, 502
- oleochemistry 53
- raw material 603
- raw sugar production 593
- saccharification 604
- schematic representation 571
- sector requirements/geographical constraints 500
- socio-political drivers 497
- starch biorefinery 501
- succinic acid production 593
- sugar biorefinery 501
- synthetic biology 577
- technology options 500
- transformation 52
- transitional economy 498
- types 500, 547, 549
- value chain 577
- World Economic Forum 571
biorefining
- cost analysis 676
bio-olefins
- catalytic cracking 18–21
- field of 28
- metathesis 21–24, 26
Bio-PDO™ production 565
bio-PE 582
bio-poly(trimethylene terephthalate) (PTT) 341
bio-products
- drop in 580
- not drop in 580
bio-propylene production 237
bio synthetic natural gas (BSNG) 86
biotechnologies 504
2,5-bishydroxymethylfuran (BHMF) 56
Bis-(isostearic acid amidoethyl)-N-polyethoxy-N-methyl ammonium methosulfate 66
bismaleimides (BMI) 325
black liquor 416, 417
Blooming Prairie (USA) 538
Brottsted acid 136
branched fatty acids/alcohols 530
Branched unsaturated fatty acids (BUFA) 69
Braskem methodology 585
Braskem's Technology Roadmapping 584, 585
BSNG. See bio synthetic natural gas (BSNG)
BtO® process 405

- product composition 405
- butadiene 507, 611
- 1,3-Butadiene 10, 611
- butadiene, renewable 610
- 1,4-butanediol, 1,4-BDO 55, 209
- 1,4-butanediol (BDO) 41
- 2,3-butanediol (2,3-BDO) 09
- 1-butanol 2
- butanol
- production 594
- butyric acid 674

C
C-starch 560
C_{16}-C_{17} branched primary alcohols 61
C_{20}-chain fatty acids 59, 60
C_{3}-olefins
- chemicals and biological routes 14
- dicarboxylic acid 331
C_{2}-C_{4} olefins 3
C_{3} -C_{5} olefins 3
C_{3}-olefins and C_{2} oxygenated species 14
- direct conversion 14
- direct cracking approach 14
- ethylene selectivity 14
- FCC approach 14
- GTO 13
- product prices 15
- synthesis 13
C_{4} -alcohols
- acetone/butanol/ethanol (ABE) process 16
- BD synthesis 15
- BDOs 17, 18
- 1,4-BDO dehydration 17
- (butane)diol(s) dehydration 17
- n-butanol 15, 16
- chemical and biotechnological processes 15
- and diols 16
- methyl ethyl ketone (MEK) 17
- MgO 15
- non-linear C_{4} olefins 16
- scandium-oxide (Sc_{2}O_{3}) 17
- zeolite catalysts 16
capital demand
- co-location model 557
Capital Expenditure (CAPEX) 576, 586, 603
caprolactam 511
Carbo-V® process 83
cash flow, co-location model 556
castor oil 535, 536
- to amino-undecanoic acid plant 537
- industrial use of 536
Index

685

– sebacic acid from 621
catalysis
– key-lock 69
– van der Waals interactions 69
– zeolite 69
catalytic cracking route 406
Catalytic fast pyrolysis (CFP) 36
catalytic gasification
– ceramic candles 88
– dolomite 86
– entrained flow gasifiers 86
– Fe and Cu-based materials 88
– hydrocarbon hydrocracking and phenol
diodeoxidation 88
– low-temperature and "dry"
  high-temperature cleaning 88
– MgO 87
– Ni-based catalysts 87
– pretreated olive 87
catalytic hydrotreatment 406
Catalytic partial oxidation (CPO) process 89
catalytic transfer hydrogenation 422
cationization 637
CatLiq® process 423
cello-oligomers 256
cellobiose 248
cellulose 404, 431
– acetic acid 386
– bi/multi-functional catalysts 380
– catalyst and polarity, reaction medium 380
– FA. see formic acid (FA)
– gluconic and glycolic acids 383, 384
– L.A. see levulinic acid (LA)
– plant cell walls, component 380
– structure 380
– succinic acid 385
– valuable chemical products 381
Cellulose acetate (CA)
– applications 632
– cellulose to 630
– definition 629
– films 633
– filter tow 632
– history 631
– markets and applications 631
– plastic applications 633
– present and future business development 633
– textile fibers 631
– well-documented monograph on 630
cellulose and hemicellulose 245
cellulose diacetate (CDA) 629, 631
cellulose triacetate (CTA) 629
cereal grains, wet milling 551
– bio-based chemicals 554
– maize 551
– starch slurry 553
– wheat 552
CFB. See catalytic fast pyrolysis (CFP)
CGE. See cold gas efficiency (CGE)
chemical activation process 539
circular economy 532
citric acid 562
clay-catalysed polymerisation 57
Clostridium Propionicum 238
Clostridium tyrobutyricum 674
co-location model
– COGS 555
– corn wet mill 560
– DCF analysis 555
– increased cash flow 556
– reduced capital demand 557
– reduced manufacturing risk 557
– starch biorefineries 555
– starch-based chemicals 565
– value creation 554
Cobalt(II)-meso-tetra(4-pyridyl)-porphyrin 198
Cold gas efficiency (CGE) 82
Common Agricultural Policy (CAP) 543
contamination-free monoseptic culture 650
CoO nanoparticles 197
copolymerizations 273
copper and metal catalysts
– C5 and C6 monosaccharides and sugar
  alcohols 263
– coriander seed 675
corn wet mill
– co-location 560
corn wet mill ethanol 559
Cost of goods sold (COGS) 555
CPO. See catalytic partial oxidation (CPO)
process
cross metathesis vegetable oil plant
– legislators, lessons for 547
– preliminary economic analysis 542
– Rapeseed Oil to Palm Kernel/Coconut oil 540
– R&D program, lessons for 545
– risks analysis 543
crotonaldehyde 12
Crude and refined palm oil 116
crude oils/fats
– biorefinery 603
– extraction of 520
– refining of 521
Cyamopsis tetragonaolobus 634
cycloaddition. See Diels-Alder reaction (contd.)
cycloaddition. See Diels-Alder reaction

d
DA. See Diels-Alder (DA) couplings
decarboxylation mechanism 252, 412
decarboxylation/decarbonylation of triglycerides 418
dehydrochlorination 617
dehydrocyclisation 41
densification and high-temperature gasification
  – Bioliq Pilot Plant in Karlsruhe 83, 84
  – Carbo-V® process 83
  – feedstocks 84
  – full-scale plant 84
  – low-temperature pyrolysis 83
  – MWth capacity 83
  – reaction after pyrolysis 83
  – SPG technology 84
  – torrefaction 83
  – Velocys Fischer–Tropsch technology 84
deoxygenation
  – guaiacol and substituted guaiacols 409
  – of benzo furan 412
  – of bio-oil from hydrothermal liquefaction 413
  – of free fatty acids 412
  – of furans 412
  – of furfural 412
  – of guaiacol 409
  – in hydrogen absence 417
  – of lignin derived molecules 410
  – of phenol and alklyphenols 407
  – of phenolic dimers 411
  – of phenols 408
  – of short-chain carboxylic acids 410
deoxygenation, of liquid/liquefied biomass
  – black liquor 416, 417
  – catalytic cracking 406
  – catalytic hydrotreating 406
  – triglycerides 412
deoxygenation, sulfided catalysts
  – CO and CO2 129
  – decarboxylation 127
  – HDO contribution 127, 132
  – metals 127
  – palmitic acid 127
  – paraffins yields and hydrogen consumption 128
  – reaction mechanism 127
  – saturated triglycerides 129
  – vegetable oils 128
depolymerization 636

1,4-3,6-dianhydrohexitols
  – bio-based AB monomers 93, 294
  – biodegradable co-polyesters 90, 291
  – diastereomeric compounds 90
  – fully biobased thermoplastic polyurethanes 92
  – isosorbide, isomannide, isoidide 89, 90
  – new bio-based monomers synthesis 93
  – polymerization partners 90
  – powder coating applications 91, 292
  – synthetic pathway 90
2,3-dichloro-1-propanol 16, 617
di(2-ethylhexyl)furan-2,5-dicarboxylate 206
di(2-ethylhexyl)phthalate 206
di(2-ethylhexyl)phthalate (DEHP) 205
2,5-diformylfuran (DFF) 93, 99, 196, 365
di(2-octyl)furan-2,5-dicarboxylate 206
dialkyl-furan-2,5-dicarboxylate (DAFD) 200
dibutyl furan-2,5-dicarboxylate 206
dibutyltin oxide (DBTO) 343
dicarboxylic acid upgrading strategy, polymerization 478
dichloropropanol
  – isomeric mixture of 616, 617
1,3-dichloro-2-propanol 16, 617
Diels-Alder (DA) couplings 307
Diels-Alder (DA) reaction
  – aromatics production 458
  – bis(hydroxymethyl)furan with succinic acid 325
  – BMI cross-linked materials 325
  – C-C bond formation 455
  – concerted/stepwise mechanism 454
  – cross-linked polymers 324
  – cyclopentadiene 457
  – cyclopentadienone self-coupling 456
  – density functional theory 457
  – dienic character 323
  – DMF and acrolein 456
  – DMF and ethylene 456
  – endo and exo DA stereoisomers 323
  – exploitation 323
  – furan and ethylene 455
  – furan and olefin 455
  – furfurylmethacrylate (FMA) 326
  – furyl-telechelic poly(lactic acid) 325
  – hydrogels 327
  – 2-hydroxy ethylcellulose with
    2-furoylchloride 327
  – inverse demand 455
  – Lewis acid catalyst 456
  – lignocellulosic biomass upgrading strategy 459
  – maleimides 323
– mendability 325
– methyl methacrylate (MMA) 326
– molecular orbital theory 455
– p-xylene production 456
– remendability 326
– thermoreversible characterization 323
diethylene glycol (DEG) residue 209
Differential Scanning Calorimetry (DSC) studies 206
diformylfuran (DFF) 198
diheptyl furan-2,5-dicarboxylate 207
dihexyl furan-2,5-dicarboxylate 206
disononyl esters 206
dimerization, of furfural 478
dimethyl ester of FDCA (DMFDCA) 203
dimethylacetamid (DMAc) 202
dimethylstylene (DMS) 304
dipentyl furan-2,5-dicarboxylate 206, 207
direct C-C coupling reaction, of furfural-HMF 480
direct gasification
  – allothermal fluidized bed process 85
  – BSNG, methanation 86
  – double-bed dehydrogenation process 86
  – gasification, cleaning and upgrading unit 85
  – steam/oxygen CFB gasification 85
  – unconverted hydrocarbon 85
  – wet biomasses 86
direct hydrogen transfer 355, 356
direct selective oxidation
  – biomass valorization 379
  – E factor 380
  – cellulose. see cellulose
  – lignin. see lignin
  – multiple reactive positions 380
  – oxygen functionalities 379
  – renewable resources 379
  – starch. see starch
  – transformations 380
Discounted cash flow (DCF) analysis 554, 555
DMS. See dimethylstylene (DMS)
Downstream process 540
  – crystalline succinic acid product 186
  – crystallization process 187
  – desalting electrodialysis 186
  – large-by-product streams 186
  – liquid–liquid extraction 186
  – microfiltration/centrifugation 186
  – of starch slurry 553
  – stoichiometry 186
Dried distillers grains with solubles (DDGS) 560
DRIFTS analyses 12
“drop in” products 80, 580
Dry distillers grains (DDGs) 155
dry extraction process 651
Dynamotive Energy Systems 658
e
E factor 380
E. coli systems 182, 183
ecofining process 654
Ecofining™
  – gasoil mode 123
  – isomerization reaction 122
Economic drivers (ED) 505
economic opportunity analysis 156
Economies of scale 555
Energy & Environmental Research Center (EERC) 20
energy consumption 403
engine test 142, 143
Eni/UOP Ecofining™ 121
enol/keto tautomerization 253
Environmental and sustainability drivers (ESD) 505
Epicerol® 617, 618
epichlorohydrin 616
  – from glycerol 617
  – from propylene 616
erucic acid 536
ESCR resistance 622
essential oil 675
ethanol
  – acetaldehyde 12
  – 1,3-butadiene 11
  – dehydration 5
  – corn wet mill 559
  – dehydration 5
  – large-scale conventional sugarcane mill 589
  – minimum selling prices 591, 592, 594–597
  – production 593
  – production of 558
  – wheat wet mill 560
ethoxy- and hydroxy-species 6
5-(ethoxymethyl)furfural (EMF) 200
ethylene
  – MgO and CaO 6
  – steam cracking 5
ethylene and propylene glycol
  – advantages 248
  – biodiesel production 245
  – cellulose 248
  – cellulosic material 246
  – decarbonylation, hexitols 252
Index

ethylene and propylene glycol (contd.)
- decarbonylation mechanism 252
- glycol production. see glycol production
- hemicellulose and lignin 245
- lignocellulose 263, 264
- polysaccharides 245, 247
- retro-aldol reaction 251
- selective formation 249
- technical application 264–266
- transformations of polysaccharides 247
ethylene glycol (EG) 209, 258
2-ethylhexanoic acid 62
2-ethylhexyl ester 206
European Food and Safety Authority (EFSA) 54
Evonik process 514

f
FA. See formic acid (FA)
farnesene 583
fast/flash pyrolysis
- bio-crude/bio-oil manufacture 405
fats
- raw materials for oleochemicals 525
fatty acid biosynthesis 645
fatty acid methyl ester (FAME) 617, 653
- biodiesel 648
- NExBTL process 403
fatty acids 536, 539
- branched 530
- chain modification 524
- chemicals and industrial products 55
- clay-catalysed process 58
- Colgate–Emery Process 55
- distribution 541
- downstream physical processes 56
- to fatty amines 539
- hydrogenation 56
- market for oleochemical products 526
- palm-based import streams 55
- production of 526
- short chain 530
- thermal polymerisation 57
fatty alcohols
- branched 530
- short chain 530
fatty amines
- fatty acids to 539
Faujasite type 227
3,4-FDCA isomer 321
feedstock
- animal oils and fats 116, 117
- FAME 113
- provider 557
- triglycerides, algae 113, 117, 118
- vegetable oil production 113, 114
Fermentation process
- aeration and gas systems 185
- commercial and semi-works processes 182, 183
- Corynebacterium glutamicum systems 183
- E. coli systems 183
- media and pH control 185
- rumen bacteria 183
- yeast systems 184
fermentation technology, novel yeast-based 562
ferulic acid 337
Feuchy (France) 539
Figure of merit (FOM) 155
Fischer–Tropsch (FT) syntheses 61, 405
Fischer–Tropsch to olefin (FTO) reaction 505
Fischer–Tropsch reaction 79
fixed costs 555, 586
Fixed-bed technologies 5
Fluid catalytic cracking (FCC) process 18, 505, 654
food additives
- from FSCW 671
Food crops 549
Food supply chain waste (FSCW)
- biofuels 672
- biorefining cost analysis 676
- chemical processing and the biorefinery 675
- combining chemical- and bio-processing 674
- components derived from 668
- extraction 669
- integrated biorefinery 668
- market, assessing 675
- microwaves 669
- platform chemicals and biopolymers 673
- pre-treatment method 671
- reusing 668
- sustainability transition patterns 676
- technical aspects 675
- valorisation 669
formic acid (FA)
- agriculture, bulk chemistry and pharmaceuticals 381
- catalytic systems, one-pot selective oxidation cellulose 381
- coupling vanadium-polyoxometalate catalysts 383
- formic acid conversion 381, 382
- heteropolyanion PMO_{11}VO_{40}^{4-} 383

54
hydrolyzed monosaccharides 383
Keggin-type vanadium-substituted phosphomolybdic acid catalyst 382
mineral acids 383
oxygen and $H_2PV_2Mo_{10}O_{40}$ 40, 381
pervanadyl species 382
5-formyl-2-furancarboxylic acid (FFCA) 194, 198
fossil fuels
cost of 498
fossil-based polyalkylene terephthalates 338
fossil-derived monomers 273
Free fatty acids (FFAs) 672
FSCW. See food supply chain waste (FSCW)
Fuel Quality Directive 112
Fumaric acid (FA) 474
functional foods
from FSCW 671
furan dicarboxylates 320
furan-2-carboxylic acid (FCA) 200
2,5-furan diacrylate 212
2,5-furan dicarboxylic acid (2,5-FDCA) 331, 510
academic studies 212
applications 191–213
aqueous phase oxidation of HMF 193, 195–198
biomass 212
carbohydrates and furfural 204, 205
decarboxylation 213
FDMC 203–04
furanic polyesters and co-polyesters 210–212
HMF in acetic acid 1981, 200–203
PEF and polyesters 208–210
petrochemicals 191
polymers 207
PTA 191
surfactants and plasticizers 205, 207
and terephthalic acid 192
2,5-furan dicarboxylic acid (PEF) 37
2,5-furan dimethylcarboxylate (FDMC) 213
Au/Co$_2$ 204
desirable feeds 203
diester of 203
EMF 203
furandicarboxylates 203, 204
HMF 203
MMF 203
non-nm size CeO$_2$ support 204
polymerization 203
furanic compounds 432
furanic polymers 207
furanics
upgrade and stabilization 432
upgrading strategy 480, 481
furanics oxidation
in gas phase 470
in liquid phase 471
non-radical mechanism 471, 472
radical based mechanism 471
furans
2,5-furandicarboxylic acid 315
5-methylfurfural 317
academic and industrial researches 315
bifunctional hydroxymethyl furfural 315
catalytic decarboxylation 317
DA reaction 323, 325, 326, 328
dienic character 344
FA synthesis 316
FDCA 344
HMF 317
lignocellulosic material 315
macromolecules 344
monomers and polymers 315
peculiarities 315
pol(ethylene furan dicarboxylate) 344
polymides 321
poly(dihydroferulic acid) 344
polyesters 317–320
polyfunctional monomers 344
polyfurans 328
polyurethanes 322
furans, deoxygenation of 412
furfural/HMF, aldol condensation of See aldol condensation
products 471
to maleic acid (MA) 473
to maleic anhydride (MAH) 475
to succinic acid 474
furfural oxidative coupling mechanism 479
furfural ring rearrangement reaction 461
Bronsted and Lewis acid catalysts 463
conversion to cyclopentanone 462
conversion to cyclopentanone 466
cyclopentanone upgrading strategy 465
hydrogenation to furfuryl alcohol 462
hydrogenation, catalysts for 464
4-hydroxy-2-cyclopentenone 462
Ni-based catalyst 464
Pt and Pd-C catalyst 464
furfural, deoxygenation of 412
g
Genomatica 612
Gevo technology
dehydrocyclisation 41
heterotrophic cultivation technology 652
heulandite (HEU) 68
Hevea brasiliensis 606
hexamethylenediamine (HMD) 620
1,6-hexanediol 11
HG2. see Hoveyda-Grubbs 2nd Generation (HG2)
high molecular weight polyacrylamides (HPAM) 628
HMF-acetone, aldol condensation 436
homogeneous catalysts
- hydrogen transfer process 354
- and Oppenauer oxidation 354
- transfer hydrogenation 355
homogeneous catalysts, for aldol condensation 436
Hoveyda-Grubbs 2nd Generation (HG2) 281
Hoveyda-Grubbs catalyst 338
HPTT reaction pathway 415
HSE profile 619
humins 432
hydric route 355
hydro flex 120
hydroconversion processes
- Ecofining™ see Ecofining™
- FAME 119
- fats and oil 119
- HDS 119
- physical properties 126
- product characteristics and fuel specification 122
- product yields and characteristics 125
- renewable diesel fuel 120
hydrocracking process 531
hydrodeoxygenation 253
- catalysts and conditions 164
- C-OH bonds 164
- C-OH reduction 164
- C1 and C6 carboxylic acid 163
- glucaric acid to adipic acid 164
- hydrohalic (HX) acid 164
- long-term catalyst stability 169
- long-term stable operation 166
- polyhydroxylated substrates 164
- reaction pathways 167
- reaction profile 165
- tartaric acid and malic acid 167
- vicinal diols 168
hydrodeoxygenation (HDO) 18–21, 127, 659
- catalysts for 406
hydrogen transfer mechanism 360
Hydrogenated Vegetable Oil (HVO) 654
hydrogenation
- raw material for 522
hydrogenation mechanism 250
hydroisomerization
- bifunctional catalyst 136
- C–C bond 138
- hydro/dehydrogenating function 135
- hydroconversion catalysts 135
- isomerization reaction 135
- isomerization reactions 137
- PCP 138
- zeolitic materials 136
hydropyrolysis 654
Hydrotalcite (HT) 195
hydrothermal liquefaction 658
hydrothermal process
- biomass/liquified biomass deoxygenation 419
- feature of 420
hydrothermal upgrading process 422
β-hydrox carbonyl 50
hydroxalkylation
- cyclopentanone upgrading strategy 467
hydroxalkylation-alkylation (HAA)
- catalysts for
- 2-methyl furan and carbonyl compounds 445
- 2-methyl furan upgrading strategy 448, 452
- acidic resins 446
- hydrophobicity 448
- liquid inorganic acids 445
- solid acids 445
- solid catalysts 446
- soluble organic acids 445, 446
- strongly acidic zeolites 447
- sulfonic acid-functionalized ion liquid 447
- mechanism 445
hydroxyapatites (HAP) 12, 233, 234
5-hydroxyxylvinic acid (5-HLA) 335
5-hydroxymethyl-2-furancarboxylic acid (HMFCA) 193
5-hydroxymethylfurural (5-HMF) 335, 356, 508, 509
- aqueous phase oxidation 193, 195–198
- catalytic oxidation 191
- furanic building blocks and furfural 207
- oxidation 198, 199, 201–203
- oxidative esterification 203, 204
- para-xylene (PX) 193
4-hydroxypentanoate (4-HPE) 363
3-hydroxypropanaldehyde 240
hydroxypropylation 637
Index

hyperbranched polyesters (HBPE) (contd.) 334
hydropolymerization 616
HZSM-5 zeolite 221, 657

i
immobilized phosphoric acid 5
integrated bio-refineries 528
Internal rate of return (IRR) 588
International Energy Agency (IEA) 498
IPDI. See isophoronediisocyanate (IPDI)
iron oxide-based catalyst systems 371
– anti-static properties 66
– C16-C18 isostearic acids 60
– Emery Industries 69
– hydrogenated derivative 61
– markets and applications 64
– metal and mineral particles 66
– thermal and oxidative stability 62
isobutene 13
isocyclol furan-2,5-dicarboxylate 206
isomerization process 123
isomers and cracking products 138
isophorone diisocyanate 206
iso-paraffins 138
isophorone diisocyanate (IPDI) 284
isopropyl alcohol 367
isosorbide 331
isostearic acid
– bio-lubricants 64, 65
– biodegradability 63
– BUFA 69
– calcination 69, 72
– clay-catalysed process 67
– cosmetic and skin care products 65, 66
– ferrite selectivity 72
– food grade vegetable oils 51
– global production 51
– hydro-isomerisation 69
– liquidity at low temperature 63
– markets and applications 58
– mesoporous sieves 71
– oils and fats 51
– oligomeric fraction 71
– oligomerisation 67
– polymerised fatty acids 59, 67
– properties 62
– Pt/zeolite-based hydro-isomerisation 68
– shape selectivity effects 68
– solubility 63
– thermal and oxidative stability 62

j
vegetable-derived fatty acids 59
itaconic acid 331
jatropha oil 114

k
ketal-ester oligomers 343
Keto-L-gulonic acid 564
keto–enol tautomerism equilibria 133, 335
KIOR 658
Kyoto Protocol 531

l
LA. See levulinic acid (LA)
lactic acid (LA) 249, 384, 561, 674
– acrylic acid 226, 227
– glycerol 224, 225
– hydroxyapatite-based catalysts 230–236
– phosphate-based catalysts 230–233
– zeolites 227–229
lanthanides-impregnated zeolites 228
LanzaTech 507, 612
large-scale conventional sugarcane mill 589
latex 606
Lebedev approach 9
Lebedev process 507
Lebedev reaction 6, 7
levulinic acid 335, 336
levulinic acid (LA) 508
– acid catalysed process 384
– cellobiose conversion 385
– liquid phase direct fragmentation 384
– ZrO2 catalyst 385
Lewis acid catalyst 456
Life cycle analysis (LCA) 187, 618
life cycle assessment (LCA)
– adipic acid 170
– Rennovia’s bio-based adipic acid 170
light olefins 505
lignin 404, 431
– aromatic compounds 387
– aromatic ring 42
– biochemtexMOGHI process 43
– biomass component of 387
– catalytic oxidative cleavage of 387
– deoxygenation 42
– depolymerisation 42
– heterogeneous catalysts 392–394
– homogenous catalysts 387, 389–392
– phenylpropanoid interunits 387
– and primary precursors 387, 388
– typical model compounds 387, 389
– valorization 387
lignin and sugar hydrogenation
- depolymerization 370
- MMP 370
- monomeric building blocks 370
lignin derived molecules, deoxygenation of 410
lignocellulose 246, 263, 550
lignocellulosic biomass 404, 536, 576
- sources of 431
lignocellulosic biorefinery 501
Limonene modification
- DMS 304
- thiol–ene reaction 302, 303
linear 1,3-linked glycerol polymers 342–344
1,3-linked glycerol carbonate exploits 43
linoleic acid 536
lipid bodies 645
lipid synthesis 646
lipids
- biomass transformation 644
- production of microalgae 650
Lipomycetes starkeyi 647
lipophilicity 446
liquefied biomass 405
- upgrading 406

Lobry de Bruin–Alberda van Ekenstein (LBE) 251
long-chain carboxylic acids, deoxygenation of 419
low-carbon footprint production 504
low-temperature pyrolysis. See torrefaction

magnesium oxide 358
maize
- wet milling of 551
- wet-milling process 551
Maleic acid (MA) 473
Maleic anhydride (MAH) 475
- liquid phase production 476
- utilization through Diels–Alder coupling 476
Mannose-derived monomers (Manx) 294
MAO. See methylaluminoxane (MAO) catalyst
Marseille Saint–Menet (France) 536
Matrica biorefinery 606
Meerwein–Ponndorf–Verley (MPV) reaction 12, 611
- heterogeneous catalysts. see heterogeneous catalysts
- homogeneous catalysts. see homogeneous catalysts
- industrial applications 372, 373
melt-polycondensation 209
metabolic engineering 577
metal hydride pathway 356
metal hydroxide species 359
metathesis
- CDIs technology 23
- dimerization of ethylene 22
- double-bond isomerization catalyst 23
- ethylene and butenes 21
- “greener” version 22
- homogeneous/heterogeneous 22
- industrial level 24
- initial carbene formation 24
- lower reaction temperatures 23
- M-Ox species 24
- mechanism 24
- Mo oxide catalysts 23
- Ni/MCM-41 catalyst 24
- OCT 22
- propylene production 25, 27
- pseudo-Wittig reaction 24
- Re oxide catalysts 23
- ReO3/O2/Al2O3 23
- Sc/In2O3 and Y2O3–CeO2 24
- SHOP 24
- tungsten-based catalysts 22
methanized oil
- cost of production 543
Methanesulfonic acid (MSA) 477
methoxyhydroquinone 337
2-methoxy-4-methylphenol (MMP) 370
methylaluminoxane (MAO) catalyst 301
4,4′-methylenedisiphenylisocyanate (MDI) 333
methyl esters of fatty acids (FAME) 113
methylfuran (MeF) 365
microalgae 513, 648
microalgae strains 650
microbial electrolysereaction 579
microbial oils
- biomass transformation 644
- hydrocarbon production 646
- from sugar 647
- upgrading to fuels 653
microorganism
- biomass transformation 644
microporous zirconosilicate molecular sieves 364
microwaves 669
mild pyrolysis. See torrefaction
Mineral oil refineries 549
minimum selling price (MSP) 586
- butanol production 586
- ethanol 591, 592, 594–597
- sugar cane mill 588
modified natural monomers (contd.)
modified natural monomers 273
molybdenum vanadate (Mo₃ VOₓ) 220
monomeric structures (diacids, hydroxyacids and diols)
  – adipic acid and its polymers 334, 335
  – alicyclic/aromatic units 329
  – biobased and non-harmful aromatic monomers 330
  – biomass-derived value-added compound 329
  – classical engineering plastics 329
  – depolymerization 330
  – diols and their polymers 339, 341
  – levulinic acid and its polymers 330, 336
  – succinic acid and its polymers 330
  – lignin 330
  – poly(ester amide)s 332
  – polyesters 330–332
  – polyurethanes 333
  – vanillin, vanillic and ferulic acids and derived polymers 337, 338
monomers and polymers. See also sugar derived monomers and polymers
monomers and polymers. See also Terpenes
  – biomedical applications 278
  – composites/biocomposites 278
  – erucic acid 276
  – fatty acids, vegetable oil compositions 276, 277
  – fossil feedstock 275
  – iodine value 276
  – oils, usage of 275
  – PAs. see polyamides (PAs)
  – polyesters. see polyesters
  – polyurethanes. see polyurethanes
  – polymer synthesis 276
  – triglyceride, generic structure 277
  – USDA 275
Monte Carlo simulation
  – production cost from 546

n
N,N'-diisopropylcarbodiimide 319
N,N-dimethyl formamide 212
Na-ZSM-5 zeolite 228
naphtha cracking 6
natural polymers 273
natural rubber
  – Hevea brasiliensis 606
  – non-tire market sectors 609
  – Parthenium argentatum 607
NaY zeolites 227, 235
Nazarov cyclization 462
neopentanoic acid 60
Neste Oil 141, 648, 654
Net present value (NPV) 554, 588
NExBTL process 404
Ni/Mo ratio 132
nickel based catalysts
  – C₅ and C₆ monosaccharides and sugar alcohols 260
  – polysaccharides 261, 262
nitrous oxide (N₂O) 157
“not drop in” products 80
novelyeast-based fermentation technology 562
n-paraffin son bifunctional catalyst 137

o
oil refineries 535
oils
  – raw materials for oleochemicals 525
  – oilseed biorefinery 501, 502
  – oleaginous microorganisms 644, 645, 647
  – lipid accumulation and fatty acid profiles 645
  – oleaginous waste 672
  – to valuable products 673
  – olefin biorefinery 505
  – companies 507
  – economic drivers 505
  – environmental and sustainability drivers 505
  – fluid catalytic cracking process 505
  – socio-political drivers 505
  – technological and strategic drivers 505
  – olefins
  – automotive industry 3
  – BDO 4
  – bio-olefins. see bio-olefins
  – from bio-alcohols. see Bio-alcohols
  – C₂–C₄ synthesis 3
  – light 3
  – MTO 4
  – petrochemical processes 3
  – primarily ethane 3
  – propylene 3
  – renewable sources 4
  – oleic acid 536
  – oleochemical products
  – applications 523
  – fatty acid market for 526
  – glycerine market 527
  – oleochemicals
  – raw materials for 525
  – substances 523
  – oleochemistry
Index 695

- definition 528
- EU sources 526
- fossil-derived chemicals 73
- in bioeconomy 532
- interest for 519
- oilseed varieties 53
- oleochemical products 53
- overview 519
- potentials for 529
- renaissance 53
- value chain for. see value chain for oleochemistry
- vegetable oil sources 525
open culture systems 649
Operational Expenditures (OPEX) 586, 603
Ostromisslenski reaction 7
Ostromisslenski two-step approach 10
5,5′-[oxy-bis(methylene)]bis-2-furfural (OBMF) 201
oxygenated compounds, classification of 406

p
p-toluenesulphonic acid 446
p-xylene
  – BioForming® 34, 35
  – bio-terephthalic acid 46
  – economic and environmental assessment 47
  – lignin. see lignin
  – PET 33
  – Virent technology 34
Paal–Knoor reaction 326
palladium and rhodium 259
palladium catalyzed-oxidative coupling 478
palladium-supported catalyst 372
palm and coconut oils 114
palm oil
  – global production 525
para-xylene (PX) 193
paraffins 123
paraffins and isoparaffins 124
Parentis (France) 539
Parthenium argentatum 607
particulate matter (PM) 141
PAs. See polyamides (PAs)
peak oil 403
PET. See polyethylene terephthalate (PET)
petro- and bio-based adipic acid 169
petrochemicals
  – branched alcohols 60
  – branched-chain alcohols 61
  – Friedel-Crafts alkylations 62
  – Guerbet alcohols 61
  – vs. isostearic acid 60
  – neoacids 60
  – paraffin waxes 61
  – Versatic™ acid 60
phenolic acids 337
phenols, deoxygenation of 407, 408
PHLA-diol destroys 336
phosphomolybdic acid 473
phosphoric acid-modified niobium-tungsten-vanadium mixed oxide 239
photoautotrophic cultivation technology 649
Phthalic anhydride (PA) production 476
Piancatelli rearrangement. See furfural ring rearrangement reaction
picolinyl esters 72
pilot plants and patents
  – advantages 107
  – Aqueous Phase Reforming reaction 106
  – bimetallic catalysts 106
  – UTRC 105
  – Virent APR pilot plant 105, 106
pine nes
  – cationic polymerization, β-pinene 301
  – isobutylene tertiary carbocation 301
  – MAO activator 301
  – methyl group/electron-donating groups 300
plasticizer 206
plastisols 206
platinum catalysts
  – ethyleneglycol 258
  – isosorbide 258
  – polysaccharides 259
  – xylitol 258
poly(2,5-furandiy carbonyloxymethylene (cis-tetrahydro-2,5-furandiy) methyl enoxy carbonyl) 211
poly(2,5-furandiy carbonyloxymethylene-2,5-furandiy methylenoxy carbonyl) 211
poly(2-furylene vinylene) based on 5-methyl furfural 328
poly(alkylene succinate) backbone 332
poly(bisphenol-A carbonate) 329
poly(butylene
  2,5-furandicarboxylate-co-buthylene adipate) 319
poly(butylene
  2,5-furandicarboxylate-co-buthylene succinate) 319
poly(butylene adipate) (PBA) 211
poly(butylene adipate-co-terephthalate) 334
poly(butylene succinate) (PBS) 330
poly(butylene succinate-co-butylene terephthalate) (PBST) 331
<table>
<thead>
<tr>
<th>Polycondensation Reactions</th>
<th>332</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester–polyurethane Markets</td>
<td>175, 176</td>
</tr>
<tr>
<td>Polyesters</td>
<td></td>
</tr>
<tr>
<td>– aliphatic acidic/ester functions</td>
<td>278</td>
</tr>
<tr>
<td>– BHMF and 2,5-furandicarboxyl chloride</td>
<td>319</td>
</tr>
<tr>
<td>– 2,3-butane diol</td>
<td>318</td>
</tr>
<tr>
<td>– commercial furan polymers</td>
<td>318</td>
</tr>
<tr>
<td>– copolymers</td>
<td>318</td>
</tr>
<tr>
<td>– crosslinked and hyperbranched polymers</td>
<td>279</td>
</tr>
<tr>
<td>– delocalization energy</td>
<td>317</td>
</tr>
<tr>
<td>– dipolarity of heterocycle</td>
<td>319</td>
</tr>
<tr>
<td>– enzyme-catalyzed polymerization reactions</td>
<td>279</td>
</tr>
<tr>
<td>– FDCA vs. 1,4-butanediol directly influences</td>
<td>317, 319</td>
</tr>
<tr>
<td>– FDCA-based</td>
<td>318</td>
</tr>
<tr>
<td>– 2,5-furanedicarboxyl chloride with diols</td>
<td>317</td>
</tr>
<tr>
<td>– HG</td>
<td>2, 281</td>
</tr>
<tr>
<td>– hydrolysable and degradable</td>
<td>278</td>
</tr>
<tr>
<td>– jojoba oil</td>
<td>280, 281</td>
</tr>
<tr>
<td>– melt polymerization reactions</td>
<td>278</td>
</tr>
<tr>
<td>– metathesis reaction</td>
<td>279</td>
</tr>
<tr>
<td>– N,N’-diisopropylcarbodiimide</td>
<td>319</td>
</tr>
<tr>
<td>– PEF vs. PET</td>
<td>320</td>
</tr>
<tr>
<td>– polycondensation reaction, epoxidized oleic acid</td>
<td>279, 280</td>
</tr>
<tr>
<td>– polyfunctional isocyanate</td>
<td>318</td>
</tr>
<tr>
<td>– 1,3-propane glycol (PFP)</td>
<td>318</td>
</tr>
<tr>
<td>– PSAs</td>
<td>279</td>
</tr>
<tr>
<td>– terephthalic acid</td>
<td>318</td>
</tr>
<tr>
<td>– thermal and mechanical data, furan dicarboxylates</td>
<td>320</td>
</tr>
<tr>
<td>– titanium tetrabutoxide</td>
<td>318</td>
</tr>
<tr>
<td>– unsaturated fatty acids</td>
<td>278</td>
</tr>
<tr>
<td>– VSHA, synthesis and polymerization</td>
<td>279, 280</td>
</tr>
</tbody>
</table>

| Polyethylene Furanoate (PEF) | 192, 207, 510 |
| Polyethylene Terephthalate (PET) | 33, 207, 510 |
| – gas barrier properties | 207 |
| – oil-based | 192 |
| – production | 459 |
| – synthesis | 191, 212 |
| – thermal behavior | 211 |

| Polyfurans | |
| – HOMO–LUMO gap | 328 |
| – α-oligofurans | 328 |
| – β-oligofurans | 328 |
| – oligofurans | 328 |
| – opto-electronic devices | 328 |
| – planarity prerequisite | 328 |
– poly(2-furylene vinylene) based on 5-methyl furfural 328
polyglycerol polyricinolate 342
polyglycerols (PG) 342
polyhydroxyalkanoates (PHAs) 207
polyactic acid (PLA) 207, 561
polymerizations 273
polymers
– multi-functional molecules for 530
polymyrcene
– emulsion polymerization 302
– non-cyclic terpenes 302
Polyol Chemical Inc. 507
polypropylene furandicarboxylate (PPF) 208
polyunsaturated fatty acids (PUFA) 673
polyurethanes
– biodiesel-derived crude glycerol 282
– 2,5-bis(hydroxymethyl)furan BHMF 322
– DDI structure 282, 283
– disadvantages 285
– flammability 285
– fossil-based disiocyanates 282
– 2,5-furyldisocianate 322
– glycerol 286
– Jatropha curcas 284
– IPDI 284
– lignin-oleic acid macropolyol 286
– NCO moieties 282
– 5,5′(oxy-bis(methylene))bis-2-furfural OBMF with disiocyanates 322
– palm oil monoglyceride and alkyd diols 283
– polysisocianates 282
– polyols, anionic waterborne polyurethanes 284
– soy oil-based cationic aqueous polyurethane dispersions 285
– versatile materials 281
Porto Torres project 499
potassium-modified zeolites 229
pristine 273
1,3-propanediol (1,3-PDO) 09
propanediol (PDO) 41, 564
propylene 507
– epichlorohydrin from 616
1,2-propylene glycol 53
protonated cyclopropane (PCP) 138
p-xylene
– Anellotech technology. see Anellotech technology
– bio-ethanol 41
– bio-terephthalic acid 46, 47
– lignin. see lignin
– Gevo technology. see Gevo technology
– Virent technology 35, 36
pyrolysis 404, 655
– reactor system 656
pyrolysis oils, hydroprocessing 415, 417
R&D programs
– effort of 545
Race Way Paddle Wheel Ponds 649
Rapid Thermal Processing (RTP) technology 658
raw materials
– correlation matrix for 544
– development of 569
– for oleochemical 525
– value chain for oleochemistry 520
raw sugar
– production 593
reactivity of functional groups 407
reforming
– BTL production process 92
– DME production 92
– gas upgrading
– ATR 89
– CPO process 89
– dual-bed gasifier 91
– Ni/Mg/Al catalyst, hydrotalcite 90, 91
– Ni/Rh-containing catalyst 91
– partial oxidation and ATR upgrading downstream 90
– problems 90
– SR 88
– syngas applications 91
rendered animal fats 525
renewable biomass
– balanced utilization of 550
renewable butadiene 610, 611
renewable chemical evaluation 585
Renewable Fuel Oil (RFO) 658
Renewable raw materials (RRM) 569
– Braskem’s Technology Roadmapping 584
– Braskem’s TRM 583
– chemical chain work 572
– chemical production chain 573
– to chemical products 158
– exploitation of 604
– industrial chemicals 154
– pound-to-pound conversion 154
– sustainable technologies 154
Rennova’s bio-based adipic acid production 158, 159, 169
retro-aldol based hydrogenolysis 251
Return on investment (ROI) \textit{(contd.)}

Return on investment (ROI) 586

Rhodotorula glutinis 646
Rhorosporidium toruloides 647
Rhovanil®Natural 638
ricinoleic acid
– methyl ester of 537
rigid furan diol 2,5-bis(hydroxymethyl furan)(BHMF) 331
Ring-opening metathesis polymerization (ROMP) 305
ROMP. See ring-opening metathesis polymerization (ROMP)
rosin
– conjugated double bond system 307
– hydrogenation and dehydrogenation reactions 307
– linear and cross-linked materials 307
– thermoplastic polymers 308, 309
– thermoset polymers 308
ruthenium catalysts
– bimetallic catalyst 257
– dispersion and electronic effects 254
– lactic acid 256
– sorbitol 255
– xylose 255

Saccharification processes 248, 604
SAIGA company 608
SCW. See supercritical water (SCW) processing
sebacic acid 538
– from castor oil 621
self-aldol condensation, of CPO 465
Separation Zone 2 (SZ2) 8
Separation Zone 3 (SZ3) 8
sesquiterpenes 608
– renewable resources 306
– ROMP of 305, 306
Shell HTU process 422
short chain fatty acids/alkohols 530
short-chain carboxylic acids, deoxygenation of 410
simultaneous condensation-hydrogenation, in
water-oil emulsions
– advantages 440, 442
– ring opening 442
– schematic illustration 440
single cell oil 644
single-reactor process, for sequential aldol-condensation and hydrogenation 439
single-step fuel production process 453
SiO$_2$-SO$_3$ H catalyzed dehydration reaction 204
socio-political drivers (SPD) 505
solar (renewable) energy
– within bio-refinery/-factory scheme 513
Solazyme plant 583, 652
Solena’s Plasma Gasification (SPG) technology 84
solid catalysts 436
solid state fermentation (SSF) 671
solid state polymerization (SSP) 209
SOLVAY technology 618
Solvay’s strategy 615
solvent extraction 648
sorbitan and isosorbide 249
sorbitol 563
SPG. See Solena’s Plasma Gasification (SPG) technology 84
spinel Li$_2$CoMn$_3$O$_8$ 202
splitting process 522
SR. See steam reforming (SR) 88
standalone cellulosic ethanol plant 591, 593
starch
– Ag$_{3.5}$(NH$_4$)$_{1.5}$PMo$_{10}$V$_2$O$_{40}$ 398
– Brønsted acid polyoxometalates 397
– CH$_3$ReO$_5$/H$_2$O$_2$/Br- system 396, 397
– FeSO$_4$ and CuSO$_4$ catalysts 396
– glycosidic bonds. 394
– Na$_4$Co(H$_2$O)$_6$V$_{10}$O$_{28}$.18H$_2$O system 397
– non-degrading starch oxidation 396
– POMs with ionic liquids 397
– selective oxidation 395
– structures of 395
– TEMPO radical 396
starch biorefineries, co-location model 501, 555
starch slurry
– downstream processing of 553
starch-based chemicals, co-location model
– citric acid 562
– ethanol 558
– keto-L-gulonic acid 564
– lactic acid 561
– propanediol 564
– sugar alcohol 563
steam reforming (SR) 88
steeping process 551
straw 575
stress cracking resistance 622
substituted guaiacols, deoxygenation of 409
Succinic acid see also Fermentation process 182
– advancements 177
– applications 174, 175
– biochemical pathway and host microorganism considerations 178–182
– commercial scale acid manufacturing facilities 173, 174
– downstream process 186, 187
– fermentation 177
– host organism 177
– hydrogenation of 174
– 30 KT BioAmber plant in Sarnia, Canada 173, 174
– life cycle analysis 187
– polyester–polyurethane markets 176
– reduction 593
– structure 173, 174
sugar alcohol 563
sugar biorefinery 501
sugar cane
– Brazil 574
– economic importance 575
sugar derived monomers and polymers
– 1,4-3,6-dianhydrohexitols 289–291, 293
– acetalized carbohydrates 294, 296, 297
– carbohydrates 289
– materials displaying interesting properties 289
– polycondensation reactions 289
sugar production 575
sugarcane biorefinery 589
– integrated conventional/cellulosic ethanol factory 591
– large-scale conventional sugarcane mill
– stand-alone cellulosic ethanol plant 591
Sugarcane-based biorefineries in Brazil 581
sulfonic acid-functionalized ion liquid 447
supercritical water (SCW) processing 423
surfactants 625, 627
Syvahn process
– bio-oil upgrading strategy 449
– biomass-derived diesel fuel production 452
– efficiency 449
– HAA. see hydroxalkylation/alkylation (HAA)
– improvements 453
Syndol® catalyst 5
synthetic biology 577–579, 583

FDCA 192, 211
– oil-based 212
– production 477
– synthesis 198
terephthalic acid synthesis
– α-pinene to p-cymene dehydrogenation 304
– limonene via p-cymene 304
– poly(alkylene terephthalate)s 304
terpenes
– adhesive and sealants, resins for 299
– cationic polymerization 300
– copolymers 305, 306
– d-Limonene 299
– isomerization reactions 299, 300
– limonene modification 303
– monoterpenes, chemical structure 298
– “naval stores” 299
– pinenes 300, 301
– polycarbonates and polyurethanes synthesis 304, 305
– polymers, applications of 300
– polymyxene 302
– rosin. see rosin
– rosin components, chemical structure 298
– secondary metabolites 299
– sesquiterpenes 305, 299, 306
– terephthalic acid synthesis 304
– terpenoids 306, 307
– unsaturated cycloaliphatic and/or aromatic structures 297
terpenoids 582
– functional groups 306
– poly(lactide)-poly(δ-lactone)-poly(lactide) triblock copolymers 307
– ring opening polymerization 307
– types 307
tert-butylhydroperoxide (t-BuOOH) 198
1,1,2,2-tetrachloroethane (TCE) 11
tetraethylammonium bromide (TEAB) 205
tetrahydrofuran-2,5-dicarboxylic acid (THFDCA) 200
tetrahydrofuran-2-carboxylic acid (THCA) 200
thermal cleavage process 537
thermal conversion process, products of 432
thermal decomposition
– cellulose 431
– hemicellulose 431
– lignin 431
thermal downstream processes 651
thermo-chemical induced conversion 404
thermo-mechanical pre-processing methods (contd.)
thermo-mechanical pre-processing methods
671
thermochemical conversion process 432
– objective of 432
thermochemical technologies 570
Thermochemical/gasification process 576
thermoplastic co-polyester elastomers (TPEEs) 212
thermoplastic polymers 308, 309
thermoset polymers 308
thiol-ene reaction
– polyester synthesis 302, 303
– terpene-based thiols preparation 302, 303
– thiol-ene click chemistry 302, 303
– unsaturated carbon-carbon double bonds 302
TiO$_2$-supported Pd nanoparticles 197
torrefaction 404
total costs 555
transesterification process 537
transitional economy 498
triglyceride molecule 115
triglycerides 122, 418
– epichlorohydrin 616
triglycerides conversion 128
triglycerides conversion scheme 128, 131
triglycerides hydroconversion
– deoxygenation, sulfided catalysts. see deoxygenation, sulfided catalysts
– hydroisomerization. see hydroisomerization
triphenylphosphine (TPP) 72
triterpenes 608
tropical oils
– vs. metathesized oil 543
tungsten-based heteropolyacids 5

u
undecylenic acid 537
United States Department of Agriculture (USDA) 275
United Technologies Research Center (UTRC) 105
UOP 661
– schematic illustration 439
– simultaneous condensation-hydrogenation, in water-oil emulsions 440
– single-reactor process 439
– steps 439
– upgrading process, of furfural and HMF
urea 512
USDA. See United States Department of Agriculture (USDA)
UTRC. See United Technologies Research Center (UTRC)
v
γ-valerolactone (GVL) 63
value chain
– biorefinery 577
value chain for oleochemistry 520
– applications for products from 523
– processing 522
– raw materials 520
van Krevelen diagram 404
van Krevelen plot 414
vanadium oxide (V$_2$O$_5$) 220
Vanilla planifolia 638
vanillin 638
variable costs 555, 586
Vegan™ 120
vegetable oil
– biofuels market 112
– cross metathesis plant 547
– crude and refined palm oil 116
– economic and agronomic factors 54
– energy costs 111
– environmental price 54
– environmental rules 111
– fatty acid chains 114, 115
– feedstock. see feedstock
– green refinery project 144, 145
– hydroconversion 116
– hydroconversion processes. see hydroconversion processes
– industrial applications 55
– ISCC 54
– isostearic acid 55
– life cycle assessment and emission 138, 141
– oil price 111
– oleochemical companies 54
– RSPO 54
– triglycerides hydroconversion. see : triglycerides hydroconversion
– zero/negative value 55
vegetal oil 675
Verdane 511
Versalis 507
Versalis strategy
– for green chemistry 605
Vinylsulfide-containing hydroxyacid (VSHA) 279, 280
Virent APR pilot plant
– cost breakdown 105
– description 105
– schematic 105
virent’s process 34
viscoelastic surfactants (VES)
– chemistry and synthesis route 627, 628
– micellar structure and rheology 625
– novel applications for 629
– in oil and gas recovery 627
– worm like micelle network 627
VSHA. See vinylsulfide-containing hydroxy acid (VSHA)

w
waste orange peel (WOP) 670
water gas shift and methanation reactions 129
water-oil emulsions 440
wet milling of cereal grains 551
– bio-based chemicals 554
– maize 551
– starch slurry 553
– wheat 552
wet-milling process
– maize 551
– wheat 552
wheat
– wet milling of 552
– wet-milling process 552
wheat solubles 560

Wheat wet mill, for premium grain alcohol 560

winterization 521
wood composition 431
WUR’s Biobased Products laboratory 674

x
xylitol 255
xylose 258

y
Yarrowia lipolytica 646
yeast cell harvesting stage 647
Yeast systems 184

z
zeolites 6
– catalysis 55
– ferrierite and mordenite 72
– hydro-isomerisation 68
– in alkaline medium 69
– multiple-branched fatty acids 71
– OA alkyl isomerisation 70
– petrochemical industry 73
– shape-selective properties 68
– skeletal isomerisation 62
– uni-dimensional channels 61
zeolites nano-cristallites 232
Ziegler–Natta polymerization 607
zinc dimethacrylate (ZDA) 341
ZSM-5 657