

Index

- acceptable daily intakes 123
- acetan 34
- acetate 8, 32, 59
- Acetobacter xylinum* 21, 32, 100
- acetyl
 - CoA 59
 - groups carried on D-mannuronosyl residues 25, 67
- acylated alditols or aldonitriles 14
- acetylation 27, 60, 95, 113
- Achromobacter georgopolitanum* 59
- Acinetobacter calcoaceticus* 26, 52
- acyl
 - precursors 59, 62, 73
 - substituents on alternate repeat units 6, 113
- acylated pentasaccharide repeat unit of xanthan 62
- acylation 6, 66, 73, 113
- aeration of culture medium 72
- agar 120, 137
- Agrobacterium, Rhizobium and Zoogloea* polysaccharides 35
- Agrobacterium* species 6, 21, 92
 - A. radiobacter* 36, 72, 80
 - A. tumefaciens* 92
- air-lift fermenters 81
- Alcaligenes faecalis* var. *myxogenes* 21, 77
- algal alginate 86, 118, 135
- alginateases 49
- alginate 5–8, 20, 24, 66–67, 70–71, 80, 86, 94, 106, 108, 111, 118, 120, 135, 137–138
 - epimerase 96
 - gels 108, 119, 135
 - lyases 49
 - production by *Azotobacter vinelandii* under phosphate limitation 80
 - production by *Pseudomonas aeruginosa* 89
 - synthesis 66, 73, 94–95
- alternating structural sequences 67
- amino acids 6, 60
 - in bacterial exopolysaccharides 6
- amino sugars 4, 12–17
- anabolism of glucose 55
- analysis of polysaccharide composition 12
- antibody response to polysaccharide antigens 142
- antimicrobial agents 86
- antitumour and antiviral activity 141, 145–6
- apoemulsan 139
- Arthrobacter luteus* 39
- Aspergillus*
 - A. niger* 22, 43, 45, 136
 - A. oryzae* 45
- assembly and polymerisation of repeat units 62–3
- availability of plant and algal products 126
- Azotobacter*
 - A. chroococcum* 25
 - A. vinelandii* 25, 50, 67, 71, 81, 86, 135
- Azotobacteriaceae* 2
- microcysts and vegetative cells 2
- bacterial alginate 6, 20, 66, 71, 86, 135
- bacterial cellulose 7, 35, 100
 - synthesis 100
- bacteriophages 38, 50
- bactoprenol 61
- batch culture and growth phase 73
- biocides 127, 129
- biodegradability of exopolysaccharides 126
- biofilms 2
- biopolymer, use in the Oil Industry 126, 132
- biosurfactants 79, 139
- biosynthesis 54ff, 90ff
- block structures 25
- branching of the dextran molecule 68–9
- Butyrivibrio fibrisolvens* 5
- Caesalpinia pulcherrima* 114
- calcium alginate fibre 142
- calcium ions in alginate epimerisation 67
- capsule 2
- carbohydrate precursors 54
- carbohydrates as carbon and energy source 70
- carboxyl reduction, prior to analysis 15
- carrageenan 109, 120, 135, 145
- cation-binding sites 102
- cell-free systems 54

158 *Index*

- cellulases 39, 45, 82
- cellulose 7, 20, 35, 100
- cellulose synthase 100
- Chlorella pyrenoidosa* 57
- chondroitin and heparin 28, 48
- circular dichroism 102, 106, 109
- Cladosporium resinae* 42
- cluster of genes involved in xanthan production 96
- CMP-sialic acid 57
- colanic acid 89, 94
 - synthesis 89, 92
- colominic acid 144
- combined action of xanthanase and xanthan lyase on xanthan 52
- commercial production of exopolysaccharides 77
- Committee on Toxicity of Chemicals in Food, Consumer Products and Environment 122
- common features
 - of different capsular serotypes 90
 - genetic, in polysaccharide synthesis 89
- completion operations 127
- composition of exopolysaccharide 3
- conformation of polysaccharide in solution 3, 102, 106, 143
- conformational change 103, 109–10
- consistency index, of xanthan 74
- continuous culture 77
- continuous processes 77
- conversion efficiency of carbon source to polysaccharide 78
- conversion
 - of carbon substrate to polysaccharide 96
 - of substrate to extracellular polymer 79
- cooling of fermenter vessel 82
- cross-flow filtration techniques 86
- cross-linked polycationic ferritin 8
- crystallinity in junction zones 112
- curdlan 7, 21, 29, 40, 77, 86, 108–9, 121, 137
 - gels 113
 - in Japan 117
- Cyanobacteria 3, 7, 59
- cyclic guanyl nucleotide 100
- β-D glucanases 39
- α-D-glucans 22
- β-D-glucans 20, 98, 145
- decarboxylation of sugar nucleotides 56
- definition 2, 3
 - of exopolysaccharides 1–2, 124
 - of exopolysaccharides, for legislative purposes 124
- degradation of biopolymers 132
- degradative enzymes 16
- 6-deoxyhexoses 3, 12
- dermatan epimerase 66
- desulphatoheparin 27
- dextran 7, 9, 20, 22, 39, 54, 68, 70, 76, 87, 123, 133, 136, 141
 - production 76
 - synthesis 68
- dextranase 41
 - from *Penicillium luteum* 41
 - from a *Pseudomonas* species 41
- dextranucrase 68
- diamino sugar nucleotide 57
- Dictyostelium discoideum* 60
- differential scanning calorimetry 110
- directive of the Council of Ministers on Emulsifiers, Stabilisers, Thickeners and Gelling Agents for Food Use 123
- dolichol 62
- double helical conformation 103, 109–10
- double-stranded form of xanthan 11, 102
- drilling 127
- drilling fluid with pseudoplastic rheology 127
- drilling mud 127
- duplication of a DNA segment 99
- effect of growth rate 79
- 'egg-box' model of alginate gelation 110
- electron microscopy 1, 4, 10, 102
- eliminative cleavage 48
- β-elimination 15
- elsinan 22, 45, 136
- emulsan 26, 52, 79, 106, 139
- emulsan depolymerase 52
- emulsification 105
- emulsifiers and stabilisers in food
 - regulations 123
- emulsions 119
- endo-β-glucanases 40, 45–6, 52, 132
- endodextranases 41
- endoenzymes, lyases 48
- endoglucanase from mixture of salt-tolerant bacteria 46
- endolyases 47
- endomannolyses 47, 53
- energy-driven export system 100
- energy
 - as proton motive force and/or energy-rich phosphate bonds, for extrusion and release of polymer 64
 - for biosynthesis and excretion of exopolysaccharides 65
 - requirements for 65
- enhanced oil recovery 126 et seq., 149
- Enterobacter aerogenes* 77, 102
- Entner–Doudoroff pathway 72
- environmental control over alginate synthesis 95
- enzyme and cell immobilization 133

Index

159

- enzyme extraction in two-phase systems 133
 enzymes, degrading exopolysaccharides 38ff
 epimerisation 56, 66, 95
 of sugar nucleotide 57
Erwinia stewartii 93
 erythrocytes coated with polysaccharides 18
Escherichia coli 3–8, 23, 27, 57, 59, 69, 89, 92, 124, 144, 147
 ester-linked
 components 5, 12
 glyceryl residues 6
 substituents, reducing structural crystallinity in salt form 113
 exodextranases 41
 exolyase 53
 exopolysaccharides
 structure 15, 20
 as source of flavour components 124–5
 extracellular polysaccharides 1
 use as vaccines 141ff
 export 69, 97, 99
 export systems for exopolysaccharides 97–9
 expression of sialic acid synthesis
 in *Escherichia coli* 94
 in *Salmonella typhimurium* 94
 extent of hydrolysis of dextrans by dextranases 42
 extracellular epimerase 66
 extracellular synthesis 68
 fast atom bombardment spectrometry 6, 15, 39
 fermentation process 77
 fermenter design 80
 fibre diffraction pattern 102
 filtration 83, 85
 financial incentive for use of biopolymers and relatively high cost chemicals for E.O.R. 133
 flocculation 107
 floc-forming bacteria 35
 food additive 123–4
 Food Advisory Committee 122
 Food and Drugs Administration 123
 Food Chemicals Codex 124
 food-grade polysaccharides 85, 124
 food-grade xanthan 124
 food usage of exopolysaccharides 117
 fragmentation by acid or enzymic hydrolysis 12
 fruiting bodies 2
 fungal β-D-glucans 21, 145
 furaneol and its derivatives 125
 furanose forms 3
 fusion zones 64
 galactofuranose 56
 galactoglucose polysaccharides 36
 galactomannan 144
 galactomannan, from *Ceratonia siliqua* 114
 galactomannan, from *Leucaena leucocephala* 115
 galactomannans, in synergistic gelling reactions with xanthan 115
 gas-liquid chromatography 14
 gel permeation chromatography 18, 46
 gel-like texture 119
 gellan 6, 27, 53, 84, 108, 110, 113, 120–1, 132, 135, 149
 gels in presence of monovalent or divalent cations 110
 gelling agents 119
 gels 108, 113, 133, 137
 formation of 117, 131
 gene cluster controlling K antigen (exopolysaccharide) synthesis 90
 gene coding for polysaccharide export 97, 99–100
 Generally Regarded as Safe (GRAS) list 123
 genes
 functioning in translocation of completed polysaccharide 90
 related to synthesis of repeat unit of xanthan 97
 responsible for biosynthesis 90 et seq.
 genetic control and regulation of exopolysaccharide synthesis 89ff
 genetics
 of colanic acid synthesis in *E. coli* 92
 of exopolysaccharide synthesis 89 et seq.
 GLC-mass spectroscopy 15
 α-glucanases 39
 glucoamylase 43
 glucomannans 144
 glucose-binding proteins 72
 glutamic acid in exopolysaccharides 6, 8
 glycerol residues 27, 113
 glycocalyx 1
 glycogen 42, 55
 glycosidases employed to remove and identify terminal sugars 18
 group C streptococcal strain 29
 guar gum 114, 117, 147
 guluronic acid 5, 24, 67, 110
 gum arabic 117
Haemophilus influenzae 99, 144
 heat and oxygen transfer 70, 82
 heat transfer 70
 helix-coil transition temperature of xanthan 114
 heparin 27, 66, 145, 147
 biosynthesis 66

160 *Index*

- heparin, chondroitin and dermatan 61
 heparin intermediates 67
 heparinases 28
 heptoses 12
 heteropolysaccharides 8, 20, 24
 hexosaminuronic acids 5
 high cost of biopolymers 128
 high permeability zone 131
 homologous gene sequences found in genomes of exopolysaccharide-producing *Klebsiella aerogenes* 93
 homology with regard to exopolysaccharide production 93
 homopolymeric substrates 49
 homopolymers 67
 homopolysaccharides 7, 20
 horiticultural and agricultural applications 138
 HPLC 12–3
 hyaluronate lyases 50
 hyaluronic acid 27, 142, 150
 from *Pseudomonas aeruginosa* strains 29
 hyaluronidase 29, 50
 hydrolytic enzymes (polysaccharases) 38 et seq.
 3-hydroxybutanoate 6, 59
 3-hydroxybutyrate 30
 hysteresis 110, 120
 ice crystal formation in frozen foods 117
 iduronic acid 7, 28
 immobilised enzymes 68
 immunological methods 18
 imperfect polysaccharide molecules 63
 increased synthesis of colanic acid 93
 industrial dextran production 22
 industrial substrates 73
 influence of medium composition 70
 inorganic substituents 7, 12, 60
 interaction with cations 106
 intermolecular hydrogen bonds 105
 intracellular accumulation of polysaccharide 90
 intrinsic viscosity measurements 18
 introduction and definition 1
 ions required for polysaccharide synthesis 71
 isomaltose as sole product of enzymic hydrolysis 42
 isomaltose, isomaltotetraose and isomaltopentaose as major digestion products 42
 isopanose 43
 isoprenoid lipid pyrophosphate 63
 isoprenoid lipids 61–5, 67, 73
 isopullulanase from *Aspergillus niger* 43
 junction zones 109
 ketalation 60
 ketals 12, 30–1
 ketodeoxyoctonic acid 5
Klebsiella aerogenes 3–7, 11, 45, 53, 61–2, 72, 90, 93, 113, 143
Klebsiella species which present clinical problems 143
 konjac mannan 114
 L-galactose 57
 L-hexoses 3, 27
 L-iduronic acid 7, 28, 66
Lactobacillus bulgaricus 118
 lactyl groups 6
 laminarin 40
 lectins 18
 legislative acceptability 112
Leucaena leucocephala 114
Leuconostoc mesenteroides 22, 42, 68
 levan 54, 70
 light scattering 19, 103, 105
 limiting factor for capsule synthesis 92
 lipid intermediates 61
 lipid-linked oligosaccharide 60
 lipid-soluble oligosaccharides 61
 lipophilicity of molecule 6
 lipopolysaccharides 1, 5
 synthesis 63
 Loci
 involved in alginate biosynthesis 95
 involved in carbohydrate metabolism 95
 lock and key arrangement between xanthan side-chains and galactomannan backbone 114
 locus linked to serA resembles the kps genes involved in synthesis of several *Escherichia coli* capsular (K) antigens 92
 locust bean gum 114
lon mutants in *Escherichia coli* K12
 overproduce colanic acid 93
 long-term stability of xanthan 119
 loose slime 2
 lyases 47
 acting on microbial exopolysaccharides 47 et seq.
 activity 48
 mannosidase 47, 51
 mannosaminuronic acid 59
 mannosylation methylation 60
 mannuronic acid 4, 8, 24, 67, 110
 marginalin 36
 market share of xanthan for oil usage 133–4
 mass spectroscopy 18
 meat products 120
 mechanism of gelation 108

Index

161

- medical applications of exopolysaccharides 141
 megaplasmid, involved in polysaccharide synthesis 98
 melting point, of mixed gel of xanthan and konjac mannan 115
 membrane-bound hyaluronidase 29
 membrane-derived oligosaccharides 54
 meningococcal polysaccharides 143–4
 methane and methanol as substrates 75
 methyl groups 60
 methylation and sequence analysis 12, 15
 methylation followed by hydrolysis,
 identification and quantification of partly methylated sugars 15
 micelles 24
 microcalorimetry 106
Micrococcus luteus 57
 microcysts 2
 microgels 105, 131
 mixed gels 115
 mixing
 of vessel contents 80
 systems 80–1
 modification of exopolysaccharide after polymerisation 90
 molecular mass 11, 18, 63, 105–7
 determination 18, 105
 monoclonal antibodies 18, 124
 mouth feel 117, 121, 141
 mucoid colony morphology 2
Mucor rouxii 60
 multiple acetylation of single sugar residues 6
 multistage process for polysaccharide production 77
 mutan 42, 102
 mutant polymers 32
 mutants
 useful in biosynthetic studies 54
 producing non-acetylated and non-ketalated xanthan 97
Mycobacterium smegmatis 60
 myxobacteriaceae 2
Neisseria meningitidis 23
 NMR spectroscopy 14, 106
 National Formulary 124
 natural occurrence of microbial polysaccharides in foods 118
 negative regulators 92, 98
 negative staining 3
 neopullulanase from *Bacillus stearothermophilus* 43
 networks of polymer chains 108
 neutral gel-forming glucan 21
 nigeran from *Aspergillus niger* 22
 nitrogen-limited continuous culture for xanthan 78
 non-carbohydrate substituents 7–8
 non-food uses of microbial polysaccharides 126
 nucleoside diphosphate sugars 54
 nucleoside monophosphate sugars 54
 nucleotide sugar pyrophosphorylase 57
O-acetyl groups 14
O-acylated residues 14, 16
 oligosaccharides 17
 ordered and disordered states, of polysaccharides 103
 ordered conformation 3, 109, 112, 120, 132
 ordered structure in solution 114–5
 osmolarity-dependent gene action 95
 oxygen transfer 70, 81
 panose 43
 paper and other surface coatings 123, 129
 pasteurisation of fermentation broths 82
 pectin 39, 48, 106, 109, 111, 120, 147
 pectin-, heparin-, chondroitin-, or
 hyaluronate-lyases 48
 pendulon 108
 pentoses 3, 12
 periodate oxidation and Smith degradation 15
 periplasmic polysaccharide 94
 permitted food additives 117
 phage-induced enzymes 38
 pharmacological applications 147
Phormidium sp. 7
 phosphate 7–8, 59
 phosphate groups 7, 61
 phosphoadenylyl sulphate 61
 phosphorylation and dephosphorylation of
 bactoprenyl derivatives 61
 phosphotransferase system 72
 physical properties
 of polysaccharides 71, 86, 102
 of alginate gels 110
 physiology and industrial production 70
 plant gums 113, 126
 poly-D-mannuronic acid 25, 50, 106, 109,
 119
 poly-D-guluronic acid 25, 50, 67, 106, 109,
 119
 polymannuronate epimerase 135
 polymers
 composition 12
 export 164, 94
 polymerase 164, 96
 polymerisation 64, 95, 97
 polymerisation and extrusion of
 polysaccharide, energy requirements 65
 polysaccharases 38ff

162 *Index*

- adjunct to chemical methods of structural determination 39
- polysaccharides
 - acylation 7, 80
 - analysis and structural determination 12
 - conformation 102
 - films 136
 - gels 133, 137
 - in the periplasmic space 90
 - lyases 53
 - naturally occurring 117
 - regarded as natural products 117
 - synthesis and excretion 99
 - thickeners used in the printing industry 137
 - use in enzyme technology 133
 - use in paints, printing and textiles 137
 - vaccines 142 et seq.
- polysaccharide-degrading enzymes 39
- polysialic acids 8
- polytetrasaccharide 63, 97
- polytrisaccharide 63, 97
- porin 65
- positive regulator 92
- post column reactions in HPLC analysis 14
- post-polymerisation epimerisation 65
- post-polymerisation modification 77
- precursors 54
- product recovery 70, 82
- product treatment 87
- profile modification 130
- propionyl groups 6, 8
- Pseudomonas aeruginosa* 26, 29, 72–3, 89, 94 et seq.
- Pseudomonas* alginate production 67, 95
- Pseudomonas elodea* 6, 113, 149
- Pseudomonas marginalis* 6, 36
- Pseudomonas* species 7, 25, 70
- Pseudomonas* species which synthesise alginate 25, 70
- pseudoplastic flow 108
- pseudoplastic rheological characteristics 80, 86, 108, 127
- pseudoplasticity index of xanthan 74
- pullulan 7, 18, 23, 77, 108, 133, 136
- pullulanase 43
- pulsed amperometric detection 13
- purification of enzymes and interferon 133
- pyruvate 59
- pyruvate ketals 5, 8, 14, 30–1, 106
- pyruvylated hexose 6
- pyruvylation of xanthan 46, 97
- quaternary ammonium compounds for polysaccharide precipitation 87
- random conformations 112
- recovery 84
- regulation of exopolysaccharide synthesis 92, 98
- regulation of exopolysaccharide molecular mass 63
- regulatory systems 92
- removal of acetate, effect on xanthan transition 104–5
- reverse osmosis 85
- reversed-phase chromatography 13
- rheological properties 107
- rheology of contents of fermentation vessel 82
- Rhizobium* 21, 30, 36, 97
- heteroglycans 29
 - R. leguminosarum* 5, 29, 72
 - R. meliloti* 29, 36, 72, 92, 97
 - R. phaseoli* 5, 29
 - R. trifoli* 5, 29, 59
- S*-adenosylmethionine 60
- Saccharomyces cerevisiae* 136, 147
- salivary α-amylase hydrolysis of pullulan 45
- Salmonella typhimurium* 89, 94
- SAX (strong anion exchange) columns 13
- scanning electron microscopy 3
- schizophyllan 109, 146
- Schizophyllum commune* 21
- scleroglucan 7, 20–1, 40, 84, 109, 113, 128, 130, 145
 - hydrolysis 39
- Sclerotium*
 - S. glucanicum* 21
 - S. roflsii* 21
- SCX (strong cation exchange) materials 13
- secretion and transport 95
- shear thinning 108
- sialic acid 8, 23, 65, 89, 94, 141, 144
- single-stranded and double-stranded chains 11, 102
- size exclusion chromatography 105
- Smith degradation 15
- specific assay procedures for polymers
 - incorporated into foods 124
- specific enzyme assays determine free sugars after hydrolysis 14
- specific enzymes 14, 17
- specific systems of genetic control 92
- spray drying 87
- Staphylococcus aureus* 5
- starch 39
- strain maintenance 80
- strain selection 78
- Streptococcus*
 - S. mutans* 42, 69
 - S. pneumoniae* 51, 57, 89, 144
 - S. salivarus* subsp. *thermophilus* 118

Index

163

- Streptomyces* species 51
 structural analysis 12, 14
Structure
 of pullulan 23
 of dextran 22
 of succinoglycan 31
 of scleroglucan 21
 of xanthan 31
 substrate conversion 70
 succinate 6
 succinoglycan 30, 92, 98, 127, 130, 137
 production in *Agrobacterium radiobacter* 72
 succinyl groups 6, 36
 sucrose as carbon substrate 68
 sugar nucleotides 54–5, 59, 62, 69, 73
 for xanthan production 97
 sulphate 7–8, 59
 sulphated cyanobacterial polysaccharides 59, 61
 sulphated heteropolysaccharide 7, 61
 surfactant activity 105
 symbiosis in leguminous plants 97
 synergistic gelling 84, 113, 115, 117
 of galactomannans and xanthan, in foods 121
Synthesis
 of colanic acid 92
 of sialic acid 94
 of xanthan 62–3, 96–7
 taurine in exopolysaccharides 6
 teichoic and teichuronic acids 1, 7, 60
 thermal degradation of the polysaccharide molecule 128
 thermally reversible gelation 115, 121
Thermoactinomyces vulgaris 45
 thermostable and acidophilic pullulanase 43
 thief zones 131
 thixotropy 108
 thixotropic dispersions 119
 three-dimensional network 120
 transcription, unidirectional of *alg* loci 95
 transition 104, 110
 transition temperature of xanthan 104, 132
 translocation and transport 90–1, 94
 transmission electron microscopy 3
 transport
 of exopolysaccharide, from site of synthesis to periplasm 95
 of mature polysaccharide 90
 to bacterial cell surface 95
 treatment prior to recovery 82
Trichoderma viride 39, 45
 triple-helical conformation in aqueous solution 109, 146
 ultrafiltration 85
 undecaprenyl phosphate 61
 unsubstituted regions, of mannan chains 114
 uptake of carbon substrates 72
 uronic acids 4, 12–3
 vaccines, polysaccharide 142ff
 variable side-chain 27
 viscoelasticity 108
 viscosity 73, 103
 of xanthan 74–5
 visualisation of exopolysaccharides 3, 8
 water content of polysaccharide capsules 3
 water-retention capacity of hyaluronic acid 151
 welan gum 111
 wound management 142
 X-ray fibre diffraction 102, 109, 113
Xanthomonas campestris pv. *campestris* 32, 59
 xanthan 6, 9, 31ff, 45, 59, 62–3, 71, 73–5, 79, 82–6, 96ff, 100, 103, 105–6, 108, 113ff, 117, 119, 123, 126ff, 130, 149
 altered in acetylation, pyruvylation and side-chain oligosaccharides 97
 biosynthesis 63
 cross-linked with chromium ions 131
 lyases 49, 51
 lyases active on trisaccharide side-chain of the polysaccharide 51
 molecules lacking side-chain disaccharide and monosaccharide 32, 97
 production 77–8
 solutions for enhanced oil recovery 83
 synthesis 73
 Xanthan-degrading enzymes 45
 Xanthan–galactomannan mixtures 115, 120, 139
 Xanthanase 46, 52
Xanthomonas campestris 3, 7, 32, 62, 73, 75, 79
 XM6 7, 35, 102, 111, 113, 135
 yeast mannans 1
 yoghurts 118
 Zimm plot 19
Zoogloea 35–6, 107
 Z. ramigera 6, 36
Zymomonas mobilis 136