

## Index

### **a**

acid-assisted condensation, of diamines 24

acid–base properties, MPAs 3

acridine-functionalized cyclen  $\text{Zn}^{2+}$  complex 165

Ag(I)-responsive chemosensors 151–153

aliphatic macrocyclic polyamines 1  
Schiff bases 20

alkylation of sulphonamide salts 15, 16

alkyl chain length 88

amide-containing macrocycles 26

amino acids 156–159

5-aminomethyl-furan-2-carboxylic acid 32

[24]ane- $\text{N}_6\text{O}_2$  modified CEC 195, 196

anthracene-cyclen conjugate 163

anthracene-derivatized dioxocyclam 150  
polyamine 149

anthrylmethyl-aminoethyl cyclen conjugate 142

antiport system 178, 188, 190

arginine residues 52

armed cyclens 142

aromatic-containing macrocyclic polyamines 1

aromatic dicarbonyl compounds 24

aromatic polyazamacrocycle preparation, *see* alkylation of sulphonamide salts

aromatic subunit-containing polyazamacrocycles alkylation of sulphonamide salts 15–16  
metal-catalysed N-arylation 16–18

artificial chemosensors 154

atom transfer radical polymerization (ATRP) 101

$\text{Au}^{\text{III}}$ -cyclam 180

Azacrown lanthanide complexes 50

Azacrown macrocycles 47

Aza cryptand 37

Aza-macrocycles 159

### **b**

benzoic acid derivatives 205

benzylated cyclic polyamines 181

$\beta$ -galactose-responsive MRI contrast agent 123

$\beta$ -trimethylsilylethanesulfonyl (SES)-protected amines 12

BINOL–cyclen conjugate 147

binuclear Cu(II) complex 54

binuclear macrocycle-Zn(II) complex 57

binuclear Zn(II) complex 55, 59  
2,6-bis(1-methyl-1,4,7-triazacyclonon-1-yl)pyridine 58

$3_{10}$ -helix-forming heptapeptide 59

quinoxaline-bridged ligand 58

- bioimaging, multi-functional materials
  - for
  - <sup>64</sup>Cu complexes, 103–104
  - description 109
  - Gd complexes 100–103
  - <sup>111</sup>indium isotope 104
- biotin 95
- bipyridine-containing cryptand 33
- bis(nitrophenyl)phosphate (BNPP)
  - hydrolysis 51
- bis- $\alpha$ -chloroamides 26, 27
- bis-amidine-involved approach 14
- blood-pool distribution contrast agents 111
- bolalipids 91
- boronic acid-armed cyclen conjugate 142
- bovine serum albumin (BSA) adsorption 86
- butanedione 13
- C**
- calix[4]arene functionalized polyamine cages 169
- capillary electrochromatography (CEC) 194
- capillary electrophoresis (CE) 190–194
- carbamate-containing lipids 95
- carbonyls condensation
  - with aliphatic diamines 23–25
  - with aromatic diamines 25–26
- carrier-mediated transport systems
  - amino acid derivatives 185–190
  - metal cations 177–185
- cationic lipids
  - bolalipids 91
  - classic head-tail type 91
  - Gemini 91
  - for gene delivery 90
  - hydrophobic tails 91
- cationic liposomes
  - hydrophilic/hydrophobic properties 90
  - description 90
- cationic polymers 85–90
- CEST effect 129
- cFLFLFK peptide 133, 134
- chemical sensors, *see* sensors
- chiral hexaaza-macrocyclic polyamine receptors 158
- cholesterol ester-armed cyclen-metal complexes 171, 172
- classic head-tail type cationic lipids 91
- click chemistry 134
- condensation, *see also* carbonyls condensation
  - of diesters containing  $\beta$ -heteroatoms 30, 31
  - of malonate diesters with amines 31
  - reagent-assisted cyclization 32
- coordination property, MPAs 3–4
- copper-MPA complexes 91
- crab-like cyclization reaction
  - bis- $\alpha$ -chloroamides synthesis 27
  - cyclen/cyclam derivatives 27
  - primary amines 29
  - tetraaza macrocycles synthesis 27
- cryptands 2
  - direct organic synthesis 35–37
  - preformed macrocycles, coupling of 33–35
  - spherical 37–38
  - tripodal aldehydes and amines, coupling of 35
  - tripodal esters with amines, coupling of 35
  - unprotected amines, alkylation of 35
- <sup>64</sup>Cu complexes 103–104
- <sup>64</sup>Cu metal radiotracers 133
- Cu(II) complexes, of macrocyclic ligands 51–54
- Cu<sup>II</sup> ion transport 179
- Cu(II)-responsive chemosensors 147–148
- cyclam(s) 180
- cyclam-based clickates 143
- cyclen 85
  - 1,7-di-Boc-protection 87
  - vs.* TACN 86
- cyclen-based bi-macrocyclic ligands 154
- cyclen-based cationic lipids
  - double-tailed, advantages of 97

- with histidine 95
- pH-sensitive group 95
- with single hydrophobic chain 93
- siRNA delivery 98
- cyclen-based clickates 143
- cyclen-containing cryptand 33
- cyclen-functionalized perylenediimides 148
- cyclen-tethered terpyridine ligand, dinuclear zinc(II) complex of 154
- 1 + 1 cyclization 7–8
- 2 + 2 cyclization 8, 9

**d**

- dansylamidoethyl cyclen conjugate 142
- degree of substitution (DS) 88
- di-anthracene armed cyclen compounds 143
- 1,7-di-Boc-protection 87
- diacid-diamine condensation 29–32
- diepoxide linking compounds 89
- diepoxide structure 89
- diethoxyphosphoryl (DEP) protecting group 12
- dihalomethyl arenes 15
- 2,6-diformyl phenols 21
- dioxocyclam (cyclam = 1,4,8,11-tetra-azacyclotetradecane) 178–180
- di-protected cyclen 84
- dipyrenyl cyclams 150
- DNA-binding abilities, of linear TACN-based oligomers 89
- DNA nucleophilic cleavage 46
- DO3A, *see* 1,4,7,10-tetraazacyclododecane-1,4,7-triacetic acid (DO3A)
- DOTA, *see* 1,4,7,10-tetraazacyclododecane-1,4,7,10-tetraacetic acid (DOTA)
- double-tailed cyclen-based lipids 97
- double-tailed lipids 92
- doxorubicin/Gd-loaded nanoparticles 102

- drug delivery, multi-functional materials for 100
- <sup>64</sup>Cu complexes 103–104
- Gd complexes 100–103
- <sup>111</sup>indium isotope 104
- dual-functional star polymers 102

**e**

- electroosmotic flow (EOF) 190–192
- electrophoretic separation, *see* capillary electrophoresis (CE)
- enzyme-responsive MRI contrast agents 117, 123
- extracellular nonspecific contrast agents 111

**f**

- flow cytometry 95
- fluorescent imaging 142
- fluorophores 141
- formyl peptide receptors (FPR) 133
- fused ring-appended cyclen-Zn(II) complexes 168

**g**

- Gadobutrol 131
- gadolinium chelate with 1,4,7,10-tetraazacyclododecane-1,4,7,10-tetrakis(methylene phosphonate) (Gd-DOTP) complex 128
- <sup>68</sup>Ga metal radiotracers 133
- Gd complexes 100–103
- Gd(III) cyclen-based contrast agent 124
- Gd-DOTA complex 100, 101
- Gemini lipids 91, 98

**h**

- hexaaza-cryptands 36, 37
- 4,8,12,18,22,26-hexaaza-1,15-dioxacyclooctaicosane ([28]ane-N<sub>6</sub>O<sub>2</sub>)-modified CEC
- aliphatic acid separation 198
- aromatic acid separation 197
- arsenic and selenium oxyanion separation 197
- nucleoside monophosphate separation 199

- 4,8,12,18,22,26-hexaaza-1,15-dioxacyclooctaicosane ([28]ane-N<sub>6</sub>O<sub>2</sub>)-modified CEC (*contd.*)  
 selenium speciation 201  
 structure 196
- Hg(II)-responsive chemosensors 149–150
- hydrophilicity 130
- hydrophobic modifications, of cationic reagents 88
- hydroxyl-containing lipids 97
- hydroxyl effect 86
- 2-hydroxypropyl p-nitrophenyl phosphate (HPNP) cleavage 53  
 aliphatic acid separation 199  
 aromatic acid separation 198  
 arsenic and selenium oxyanion separation 197  
 nucleoside monophosphate separation 200  
 structure 197
- i**
- imines, *see* Schiff bases
- <sup>111</sup>indium isotope 104
- intracellular targeted contrast agents 111
- intramolecular cyclization 7
- in vitro* transfection experiments 89
- ionophores 177
- l**
- lanthanide(III) complexes, of macrocyclic ligands 48–50
- leaving group activation 46
- Lewis acid activation 46, 58
- Lipofectamine 2000® 92, 95
- lipophilic copper carriers 189
- longitudinal (*T*<sub>1</sub>) relaxation times 100
- m**
- macrobicyclic tris-acridine cryptand 166
- macrocyclic polyamines (MPAs) 2  
 acid–base properties 3  
 additives in running solutions 191–193
- applications 4
- aromatic subunit-containing polyazamacrocycles 14–18
- classification 1
- coordination property 3–4
- crab-like cyclization process 26–29
- features 26
- oxidative DNA cleavage by 70–74
- Schiff bases, *see* Schiff bases
- synthesis saturated, *see* saturated macrocyclic polyamines synthesis
- macrocyclic Schiff bases, *see* Schiff bases
- macrocyclic *vs.* spacer strategy 48
- MAGfect 102
- magnetic resonance imaging (MRI)  
 contrast agents 100  
 developments 109  
 DO3A and derivatives 118–124  
 DOTA and derivatives 111–118  
 features 100  
 ligands with multiamide arms 129–130  
 ligands with multihydroxy arms 130–131  
 PCTA and derivatives 124–126  
 phosphonate macrocyclic ligands 128–129  
 polynuclear Gd(III) chelates 132  
 principle 110  
 NOTA 126–128  
 TETA 126–128
- malonate diesters 30, 31
- melanism contrast agents 111
- metal complex-DNA binder conjugates 64–67
- metal complex, of macrocyclic ligands 46  
 lanthanide(III) complexes 48–50  
 substrate activation 47
- metal-based synthetic hydrolytic catalysts 46
- metal-catalysed N-arylation 16–18
- metal-cation- $\pi$  interactions 152
- metal-free macrocyclic polyamines 67–70  
 oxidative DNA cleavage by 74–75

- metal-responsive MRI contrast agents  
 for calcium 122  
 for copper 123  
 for zinc 121, 122
- metalloradiopharmaceutical 115
- metal template reactions, Schiff bases  
 containing aromatic units 21–22  
 disadvantage 19  
 metal-induced ring contraction/  
 expansion 18, 19  
 ring-closure modes 18  
 without aromatic units 20
- methacrylate-based monolith 205
- methyl acrylates 32
- mono-anthracene armed cyclen  
 compounds 143
- monolithic columns 194, 204–206
- monophosphorylated nucleoside  
 isomers 200
- mono-protected TACN 84
- mono-substituted TACN 88
- MRI contrast agents  
 blood-pool distribution contrast  
 agents 111  
 categories 111  
 conditions 110, 111  
 description 110  
 extracellular nonspecific contrast  
 agents 111  
 gadolinium class 110  
 interaction with esterase 125  
 intracellular targeted contrast agents  
 111  
 paramagnetic ions 111
- multi-armed cyclam 182
- multinuclear lanthanide complexes  
 50
- n**
- N-arylation, *see* metal-catalysed  
 N-arylation
- naphthalene functionalized  
 tetraazamacrocycle 144
- naphthalenedisulfonates (di-NSs) 191
- naphthalenemonosulfonates  
 (mono-NSs) 191
- naphthalenesulfonates (NSs) 191, 192
- negative enhancement contrast agents  
 111
- nitroimidazole–DOTA derivatives  
 135
- noninvasive progesterone-appended  
 MRI contrast agents 117
- non-symmetric cryptands 35
- non-viral gene delivery vectors 83–99  
 cationic lipids 90–93  
 cationic polymers 85–90  
 cyclen-based cationic lipids 93–99  
 MPA [12]aneN3 derivatives 99
- NOTA, *see* 1,4,7-triazacyclononane-  
 1,4,7-triacetic acid (NOTA)
- nuclear magnetic resonance principle  
 110
- nucleic acids  
 polymers hydrolysis of 45–46  
 oxidative cleavage of 70–74
- nucleophile activation 46
- o**
- 1,5,9,13,17,21,25,29-  
 octaazacyclodotriacontane  
 ([32]ane-N<sub>8</sub>) 202
- OFF–ON fluorescent sensors 141, 150,  
 156, 166
- oleyl-containing lipids 92
- ON–OFF fluorescent sensors 141, 166
- open tubular CEC 193–204
- ortho-disubstituted oligomers 89
- oxa-aza macrocycle 146
- oxidative cleavage of nucleic acids  
 70–74
- oxidative damage 70
- oxidative DNA cleavage  
 by macrocyclic polyamine metallic  
 complexes 70–74  
 by metal-free macrocyclic polyamines  
 74–75
- oxygen-containing MPA 164
- p**
- packed column CEC 194
- PARACEST agents 129
- paramagnetic contrast agents 111
- paramagnetic metal chelation 111

- Pb(II)-responsive chemosensors 147–148
- Pd-catalysed N-arylation 17 *see also* metal-catalysed N-arylation
- 1,4,10,13,16-pentaazatricycloheicosane-9,17-dione (dioxo[13]aneN<sub>4</sub>) 204, 205
- pH-dependent contrast agent 120
- pH indicators 162–163
- phosphonate macrocyclic ligands 128–129
- phosphorylcholine moiety 90
- pH-responsive contrast agents 120
- polyamine macrocycles 186–188
- polyaza cryptand 33
- polyethylenimine (PEI) 83, 85
- polymer-based monolithic columns 204
- polymer/DNA weight ratio 86
- polymeric non-viral gene vectors, *see* polyethylenimine (PEI)
- poly(GMA-co-EDMA) monolith 205
- polynuclear Gd(III) chelates 132
- positive enhancement contrast agents 111
- positron emission tomography (PET) imaging 133–135
- potassium hydrogenphthalate (KHP) 195
- progesterone receptor 117
- protonated cyclic polyamines 169
- proton sponge effect 84, 85, 95
- Pt<sup>II</sup>-dioxocyclam complex 179, 180
- PTX-Cre (Taxol) 103
- pyridine-based N4O2-donor macrocycle 151
- pyridine-containing dicarbonyls 21
- macrocyclic amides 30
- pyridine-containing cyclen triacetic acid (PCTA) and derivatives 124–126
- q**
- quinolinol-appended cyclen derivative 142
- r**
- rapid phosphate ester hydrolysis 52
- rhodamine-cyclen conjugate 149
- Richman–Atkins method 127
- Richman–Atkins reaction 10, 11
- ring-closure modes
- 1 + 1 cyclization 7–8
- 2 + 2 cyclization 8, 9
- 3 + 3 cyclization 8
- 4 + 4 cyclization 9
- intramolecular cyclization 7
- ring-opening polymerization 86, 88
- RNA hydrolysis 46
- s**
- saturated macrocyclic polyamines synthesis
- protecting groups 12–13
- ring closure using sulfonamides 9–11
- tetraaza macrocyclic compound 13–14
- tosyl protecting groups, removal of 11–12
- Schiff base(s) 18–26
- cryptand 36
- metal template reactions 18–19
- self-condensation reactions 18
- template free cyclization 22–26
- Schiff base-containing macrocycles 48
- sensors 141
- bioactive molecules 164
- fluorescent chemosensors 163
- metal cations 141–153
- serum tolerance 86, 89, 97
- silanol (Si-OH) groups 190
- sodium chromate 195
- sol-gel-derived macrocyclic dioxopolyamine columns 204
- spherical cryptand synthesis 37
- super paramagnetic contrast agents 111
- symport system 178
- t**
- T1 contrast agents 111
- T2 contrast agents 111

- TACN-based lipids 91, 93
- template free cyclization, Schiff bases 22–26
- tetra-armed cyclen bearing crown ethers 153
- 1,4,7,10-tetraazacyclododecane-  
1,4,7,10-tetraacetic acid (DOTA) 111, 133
- backbone-based macrocyclic ligands 48
- and derivatives 111–118
- DOTAGA 112
- DOTApnB 112
- DOTASA 112
- Gd-DOTA 111, 112
- In(III) isotope 104
- [Ln-DOTA]<sup>−</sup> 113
- modification 112
- 1,4,7,10-tetraazacyclododecane-  
1,4,7-triacetic acid (DO3A) and derivatives 118–124
- 1,4,8,11-tetraazacyclotetradecane ([14]aneN<sub>4</sub>) 191, 192
- 1,4,8,11-tetraazacyclotetradecane-  
1,4,8,11-tetraacetic acid (TETA) 126–128
- 1,4,7,10-tetraazacyclotridecane-11,13-dione (dioxo[13]aneN<sub>4</sub>) 192, 193
- tetraaza macrocycles
- crab-like cyclization reaction 27
- compound 13, 14
- zinc complexes 154
- 1,4,7,10-tetrakis(2-hydroxypropyl)-  
1,4,7,10-tetraazacyclododecane 130
- tetranuclear Gd(III) chelate,  
longitudinal relaxivity of 132
- tetraphenyl-ethene (TPE)-based  
cyclen-Zn(II) complexes 155
- theranostics 100
- TPE fluorescence 101
- transition metal complexes, of  
macrocyclic ligands 51
- Cu(II) complexes 51–54
- Zn(II) complexes 55–64
- transversal (T2) relaxation times 100
- TRC105-conjugated unimolecular  
micelles 104
- 1,4,7-triazacyclononane ([9]aneN<sub>3</sub>) 191, 192
- 1,4,7-triazacyclononane (TACN) 85, 86
- 1,4,7-triazacyclononane-1,4,7-triacetic  
acid (NOTA) 126–128
- trifuran-containing hexaaza-cryptand 36
- tri-nuclear Cu(II) complex 54
- trinuclear Zn(II) complex 56
- tripodal units, for cryptand synthesis 35
- two-pyrene-armed cyclen-Zn(II)  
complex 165
- U**
- unsaturated linoleyl-containing lipoplex 95
- unsymmetrical compartmental Schiff  
base ligands 21
- X**
- xylyl-bridged complex 54
- Z**
- Zn(II) complexes, of macrocyclic  
ligands 55–64
- Zn(II)-responsive chemosensors 141–147

