

## Index

### a

age-old pottery techniques 137  
 agricultural fertilizers 9  
 $\alpha$ -tricalcium phosphate ( $\alpha$ -TCP), ( $\alpha$ -Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>) 26  
 amorphous calcium phosphates (ACPs) 27–29  
 antimicrobial effect, CaPO<sub>4</sub> 38  
 arachidic acid Langmuir monolayer system 101

### b

BCP formulations  
 – biphasic TCP (BTCP) 37  
 – *in vitro* properties 37  
 – multiphasic formulations, biomedical properties 38  
 – triphasic formulations 38  
 $\beta$ -tricalcium phosphate ( $\beta$ -TCP), ( $\beta$ -Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>) 25  
 bioactivity and biodegradation, CaPO<sub>4</sub>  
 – angiogenesis and vascularization 396  
 – bone-resembling hierarchical organization 396  
 – cell attachment and proliferation 392  
 – hydrolysis reactions 391  
 – polymer dispersion and solutions 400  
 – stress-shielding atrophy prevention 391  
 – tissue engineering 395  
 – trabecular bone bonding 393  
 bioceramics, CaPO<sub>4</sub>  
 – bone defects 136  
 – chemical composition and preparation 135, 136  
 – electric/dielectric and piezoelectric properties 162  
 – forming and shaping 137  
 – history 135

– mechanical properties 142, 159–161  
 – microporosity 166  
 – porosity 164, 165, 169, 170  
 – preparation techniques 136  
 – sintering/firing procedure 139, 140, 142  
 – thermal stability 142  
 – transparency 163  
 biocomposites and hybrid biomaterials  
 –  $\alpha$ -TCP and  $\beta$ -TCP-based formulations 296, 297  
 – apatite-based formulations 292, 293, 295, 296  
 – biochemical composition, bones 263  
 – bioorganic and inorganic domains 271  
 – bioorganic compounds and/or biological macromolecules 309, 310, 312  
 – biosensor 321, 322  
 – CaPO<sub>4</sub>-based IBS 312, 314  
 – ceramic-plastic material 287  
 – ceramic/polymer powder mixture 290  
 – with collagen 304–309  
 – co-precipitation and electrochemical co-deposition 290  
 – filling and augmentation 298  
 – glasses, inorganic compounds, carbon and metals 313, 315–320  
 – hydrophilic PEG/vancomycin composite 298  
 – inorganic self-setting CaPO<sub>4</sub> formulations (cements) hardening 299–301  
 – *in situ* formation 290  
 – material processing strategies 292  
 – nanodimensional and nanophasic materials formulations 301–304  
 – natural bone tissue repairment 298  
 – with polymers 287–289  
 bioglass<sup>®</sup> 280  
 biological apatite 10

- biological properties and *in vivo* behavior,  $\text{CaPO}_4$ 
    - bioactivity 211, 212, 214
    - biodegradation 209–211
    - cellular response 215–217
    - dissolution/precipitation phenomena 209
    - fracture healing 207
    - hematoma formation 207
    - inflammation 207
    - neovascularization 207
    - osteoclastic resorption 207
    - osteoinduction 207–209
    - tissues and host responses 205, 206
  - biomedical applications,  $\text{CaPO}_4$ 
    - alveolar ridge augmentation 189
    - coatings, films and layers 196
    - FGMs 197, 200
    - immediate tooth replacement 189
    - ingrowth, fibrous tissue 189
    - maxillofacial reconstruction 189
    - mechanical limitations 189
    - orthopedics and dentistry 189
    - self-setting (self-hardening) formulations 196
    - types 195, 196
  - biomimetics
    - biological process 109
    - bone graft production 110
    - $\text{CaPO}_4$ -based biomaterials and bioceramics 121
    - chemical crystallization 110
    - classical crystallization theory 112
    - *in vitro* crystallization 110
    - of synthetic materials, biomedical applications 109
  - biomineralization,  $\text{CaPO}_4$ 
    - antlers 80, 82
    - biological apatite 59
    - bone/osseous tissue, *see* bone/osseous tissue,  $\text{CaPO}_4$  61
    - chemical composition 59
    - inorganic and bioorganic components 59
    - optical and X-ray analysis of bones 60
    - pathological calcifications 59
    - physico-chemical and crystallographic study, biological apatite 61
    - teeth, *see* teeth,  $\text{CaPO}_4$  73
    - velvet shedding 81
  - biphasic calcium phosphate (BCP) 37
  - bone grafting,  $\text{CaPO}_4$ 
    - chemical similarity 275
    - inflammatory foreign body response 277
    - inorganic materials and compounds
      - – carbon nanotubes 280, 281
      - – ceramics, metal oxide 280
      - – glasses and glass-ceramics 279, 280
      - – metals 279
      - osteoblast adhesion and proliferation 275
      - polymers 275, 276, 278
  - bone hierarchy 65
  - bone/osseous tissue,  $\text{CaPO}_4$ 
    - acid phosphatase 69
      - atomic force microscopy 65
      - bioorganic matrix 68
      - blood cell formation 61
      - bone formation (ossification) and growth 67
      - bone graft substitutes 73
      - calcium balance 69
      - chemical mechanism 69
      - classification, shape 64
      - cortical bone specimens 64
      - electron diffraction studies 67
      - epitaxial growth mechanism 68
      - hierarchical organization 65
      - inorganic and bioorganic phases 62
      - inorganic phases 61
      - *in vivo* stress distribution 68
      - lamellar bones 62
      - locomotion 62
      - maturation mechanism 70
      - mechanical properties 64
      - medullar cavity 62
      - mineral composition 61
      - mineralized organic matrix 63
      - OCP transition phase 67
      - organic matrix-mediated 72
      - organic–inorganic composite nanostructure 66
      - osteoarthritis 68
      - osteocalcin 68
      - precipitated phase 70
      - programmed cell death (apoptosis). 67
      - regenerative medicine 68
      - remodeling process 68
      - SAXS and transmission electron microscopy studies 67
      - sizes and shapes 62
      - types 62
- c**
- calcium-deficient hydroxyapatite (*CDHA/Ca-def HA/CDHAp*),  $(\text{Ca}_{10-x}(\text{HPO}_4)_x(\text{PO}_4)_{6-x}(\text{OH})_{2-x})$  ( $0 < x < 1$ ) 29
  - calcium-deficient hydroxyapatite (*CDHA/Ca-def HA/CDHAp*),  $(\text{Ca}_{10-x}(\text{HPO}_4)_x(\text{PO}_4)_{6-x}(\text{OH})_{2-x})$  ( $0 < x < 1$ ) 30, 31

- calcium dihydrogen orthophosphate
  - anhydrous 22
- calcium dihydrogen orthophosphate monohydrate 18
- calcium hydrogen orthophosphate anhydrate, mineral monetite 23
- calcium hydrogen orthophosphate dihydrate, mineral brushite 22
- calcium orthophosphate bioceramics, medicine
  - biological processes 237
  - and biomaterials, trademarks 190–195
  - biomedical ceramics 132
  - biomimetic materials 132
  - bone augmentation 127
  - CaPO<sub>4</sub>-based formulations 127
  - chemical elements 127
  - clinical applications 131
  - composites 127
  - cranio-maxillofacial reconstruction 127
  - dental fillings and periodontal treatments 127
  - drug-delivery capability 132
  - fracture treatment 127
  - HA bioceramics 169
  - healing of bone defects 127
  - health care 127
  - health care domain 131
  - hierarchical pore size distribution 233
  - implantation, HA surface 214
  - linear shrinkage, ACP powders 141
  - living systems 131
  - materials science and engineering 254
  - material synthesis and processing 131
  - ophthalmology 127
  - orthopedics 127
  - osteoconductive bioceramics 254
  - otolaryngology 127
  - plasma-sprayed HA coating 198
  - pore-graded bioceramics 199
  - porosity 236
  - self-assembling/nanofabrication 255
  - sintering 140
  - spinal surgery 127
  - 3D printing 138
  - tissue replacements 132
  - total joint replacement 127
  - transparent HA bioceramics 163
  - types, ceramic porosity 166
- calcium orthophosphates (CaPO<sub>4</sub>)
  - ACP structure 29
  - adult human calcified tissues 11
  - atomic arrangement 5
  - biological apatite 60
  - biological mineralization, *see* biomineralization, CaPO<sub>4</sub> 59
  - in biological systems (human) 100
  - chemical composition 3
  - chemical elements 3
  - chemical/physical weathering 8
  - classical solubility phase 21
  - crystallographic data 19
  - geological and biological occurrences, *see* geological and biological occurrences, CaPO<sub>4</sub> 7
  - *in vivo* mineralization of a collagen fibril 71
  - mammalian bone 63
  - natural FA 9
  - pathological calcification, *see* pathological calcification, CaPO<sub>4</sub> 99
  - and properties 4
  - surface-directed mineralization 102
  - and technological and scientific uses, apatites 10
  - types 20
- CaPO<sub>4</sub>-based bulk bioceramics 142
- CaPO<sub>4</sub>-containing biocomposites
  - alloplastic/synthetic bone grafts 261
  - biological calcified tissues 262
  - bone growth 263
  - bone tissue repair 262
  - complex composite 270
  - continuous and dispersed phase 269
  - covalent bond formation 375
  - degradation kinetics 263
  - elastic collagen fibers 262
  - fabrication technologies 264
  - FTIR 376
  - graded composite 270
  - healing process 271
  - hierarchical composite 270
  - immunogenicity 261
  - *in vivo* mechanisms, tissue regeneration 264
  - lint-reinforced plaster 264
  - organic-inorganic hybrid biomaterials 264
  - simple composite 270
  - strain shielding 263
  - tissue transplantation 261
  - traumas/natural aging 261
  - xenografts 261
- CaPO<sub>4</sub> tribasic beta/tricalcium bis(orthophosphate) beta) 25
- cellular biodegradation, CaPO<sub>4</sub> bioceramics 216
- clinical implantology 131
- computer-aided design and manufacturing (CAD/CAM) 137

- computer-modeling techniques 35  
 co-precipitation technique 381  
 cryogenic energy-dispersive X-ray spectroscopy 70  
 crystallization, dissolution and phase transformation processes,  $\text{CaPO}_4$  17
- d**  
 decalcium oxide hexakis(phosphate), mineral voelckerite 35  
 deer antlers 80, 81, 83  
 dentine-enamel junction (DEJ) 78  
 diary industry, DCPD 23  
 dicalcium phosphate anhydrous (DCPA/DCP),  $\text{CaHPO}_4$  23  
 dicalcium phosphate dihydrate (DCPD),  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$  22–23  
 Dulbecco's modified Eagle's medium (DMEM) 111
- e**  
 Eagle's minimum essential medium (MEM) 111  
 Earle's balanced salt solution (EBSS) 111  
 enamel formation/amelogenesis 79  
 energy-dispersive X-ray spectroscopy analysis 298  
 European classification of food additives 17  
 $\epsilon$ -caprolactone monomer 295
- f**  
 FDA approved biodegradable polymers 277  
 fluorapatite (FA/FAP),  $(\text{Ca}_5(\text{PO}_4)_3\text{F}/\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2)$  33, 34  
 formation process, enamel 77  
 Fourier-transformed infrared (FTIR) spectra 375, 377  
 freeze-drying method 308  
 functionally gradient materials (FGMs) 197, 200
- g**  
 geological and biological occurrences,  $\text{CaPO}_4$   
 – apatites 7  
 – biological liquids 11  
 – crystallographic defects 8  
 – food industry 17  
 – francolite 7  
 – human bones 10  
 – lattice flexibility 10  
 – morphology of precipitates 9  
 – in primitive organisms 9  
 – solubility isotherms 17  
 – spherulitic clusters 8  
 – triprotic equilibrium 17  
 – types 7
- h**  
 HA bioceramics 32, 38  
 HAPEX™™ 289  
 high resolution elastic modulus mapping 78  
 hydrothermal hot pressing method 142  
 hydroxyapatite *HA/HAp/OHAp*,  $(\text{Ca}_5(\text{PO}_4)_3(\text{OH}))$  31, 32
- i**  
 injectable bone substitutes (IBS) 312  
*in vivo* experiments inflammatory reactions 207  
 ion-substituted  $\text{CaPO}_4$  38
- k**  
 Kramers-Kronig equation 376
- l**  
 low-dose selected-area electron diffraction technique 70
- m**  
 monocalcium phosphate anhydrous (MCPA/MCP),  $(\text{Ca}(\text{H}_2\text{PO}_4)_2)$  22  
 monocalcium phosphate monohydrate (MCPM),  $(\text{Ca}(\text{H}_2\text{PO}_4)_2 \cdot \text{H}_2\text{O})$  18
- n**  
 non-biomedical applications,  $\text{CaPO}_4$   
 – chemical similarity 227  
 – surface acidity/basicity 227  
 noninvasive X-ray microtomography 68
- o**  
 octacalcium bis(hydrogenphosphate) tetrakis(phosphate) pentahydrate 24  
 octacalcium phosphate (OCP),  $(\text{Ca}_8(\text{HPO}_4)_2(\text{PO}_4)_4 \cdot 5\text{H}_2\text{O})$  24  
 orthophosphate-based apatites 32  
 osteogenesis 207  
 osteoinductive  $\text{CaPO}_4$  bioceramics 208  
 oxyapatite (OA/OAp/OXA),  $(\text{Ca}_{10}(\text{PO}_4)_6\text{O})$  35
- p**  
 pathological calcification,  $\text{CaPO}_4$   
 – ageing 99  
 – apatite diseases 100  
 – biochemical processes 101  
 – biological apatite precipitation 101  
 – chronic renal disease 99

- DCPD 101
- hyperparathyroidism 99
- intestinal calcium absorption 100
- massive bone destruction 99
- metastatic 99
- non-osseous viable tissue 99
- nucleation process 101
- occurrence, non-apatite phases 100
- physiological biomineralization 99
- plasma-sprayed coatings of  $\text{CaPO}_4$  35
- poly( $\alpha$ -hydroxyesters) 278
- polydioxanone 276
- polyphosphazenes 276
- preparation techniques of OCP 24
- protein-free acellular simulated body fluid (SBF) 111

**r**

- Raman spectroscopic indications, OCP precursor phase 70
- revised SBF (rSBF) 112
- rheumatoid joint synovitis, HA 38

**s**

- scanning probe microscopy 380
- skeletal tissue regeneration 276
- solid-state pressureless sintering 141
- solid-titration approach 17
- super-phosphate of lime 18
- surface grafting polymerization, ethylene glycol methacrylate phosphate 380
- surface induced nucleation 67

**t**

- teeth,  $\text{CaPO}_4$ 
  - AFM study 76
  - biological apatite 73
  - cellular control 78
  - cementoblasts 77
  - dental abrasion and attrition 79
  - dental enamel 75
  - dental follicle 77
  - dentine and cementum 74
  - fibroblasts 77
  - *in vivo* formation and development 77
  - nano-indentation technique 79
  - osteoblasts 77
  - primary function 73
  - structural hierarchy 75
  - structure 74
  - thermogravimetric studies 78
  - types 73
- template-assisted colloidal processing technique 165

- tetracalcium hydrogen orthophosphate diorthophosphate pentahydrate 24
- tetracalcium oxide bis(orthophosphate), mineral hilgenstockite 36
- tetracalcium phosphate/tetracalcium diorthophosphate monoxide (TTCP/TetCP),  $(\text{Ca}_4(\text{PO}_4))$  36
- tetra-hydrogen calcium phosphate,  $\text{H}_4\text{Ca}(\text{PO}_4)_2$  22
- thermal printing process 137
- thermodynamic properties, HA 32
- thermoplastics 278
- time and energy efficient densification techniques 142
- tissue engineering,  $\text{CaPO}_4$  bioceramics
  - applications 237
  - bioceramic scaffolds 235
  - biochemistry 232
  - bioengineering and clinical research 232
  - bone regeneration 238
  - cell and molecular biology 232
  - clinical application 238
  - grafting 231
  - healthcare technology 231
  - *in situ* regeneration 237
  - manufacturing procedures 167, 168
  - material sciences 232
  - organ transplantation 231
  - osteoinductivity 237
  - scaffolds and their properties 232, 233
  - self-hardening formulations 234
  - synthetic materials 231
  - therapeutic strategies 237
- transmission electron microscopy (TEM) 381
- tricalcium diorthophosphate beta 25
- triclinic structure of OCP 24
- two-step sintering (TSS) 142

**w**

- water inclusions, DCPA 23

**x**

- X-ray absorption spectroscopic data (EXAFS) 29
- X-ray diffraction 380
- X-ray diffraction technique 37
- X-ray photo-electronic spectroscopy (XPS) technique 378, 379

**y**

- Young's (or elastic) modulus, HA 161

