

Cambridge University Press

0521675499 - Acid-base Cements: Their Biomedical and Industrial Applications

Alan D. Wilson and John W. Nicholson

Table of Contents

[More information](#)

# Contents

<i>Preface</i>	xvii
<i>Acknowledgements</i>	xix
1 Introduction	1
References	4
2 Theory of acid–base cements	5
2.1 General	5
2.2 The formation of cements	7
2.2.1 Classification	7
2.2.2 Requirements for cementitious bonding	8
2.2.3 Gelation	10
2.3 Acid–base concepts	12
2.3.1 General	12
2.3.2 History of acid–base concepts	12
2.3.3 Acid–base concepts in AB cement chemistry	14
2.3.4 Relevance of acid–base theories to AB cements	19
2.3.5 Acid–base strength	20
2.3.6 Acid–base classification	22
2.3.7 Hard and soft acids and bases (HSAB)	24
References	26
3 Water and acid–base cements	30
3.1 Introduction	30
3.1.1 Water as a solvent	30
3.1.2 Water as a component	30
3.2 Water	31
3.2.1 Constitution	31
3.2.2 Water compared with other hydrides	33
3.3 The structure of water	34
3.3.1 The concept of structure in the liquid state	34
3.3.2 The structures of ice	35
3.3.3 Liquid water	36
3.4 Water as a solvent	40
	ix

Cambridge University Press

0521675499 - Acid-base Cements: Their Biomedical and Industrial Applications

Alan D. Wilson and John W. Nicholson

Table of Contents

[More information](#)*Contents*

3.4.1	Hydrophobic interactions	40
3.4.2	Dissolution of salts	41
3.4.3	Ion–ion interactions in water	44
3.4.4	Dissolution of polymers	45
3.5	Hydration in the solid state	47
3.5.1	Coordination of water to ions	47
3.6	The role of water in acid–base cements	48
3.6.1	Water as a solvent in AB cements	48
3.6.2	Water as a component of AB cements	48
3.6.3	Water as plasticizer	51
	References	52
4	Polyelectrolytes, ion binding and gelation	56
4.1	Polyelectrolytes	56
4.1.1	General	56
4.1.2	Polyion conformation	58
4.2	Ion binding	59
4.2.1	Counterion binding	59
4.2.2	The distribution of counterions	59
4.2.3	Counterion condensation	63
4.2.4	Effect of valence and size on counterion binding	65
4.2.5	Site binding – general considerations	67
4.2.6	Effect of complex formation	69
4.2.7	Effect of the polymer characteristics on ion binding	70
4.2.8	Solvation (hydration) effects	72
4.2.9	Hydration of the polyion	73
4.2.10	Hydration and ion binding	76
4.2.11	Desolvation and precipitation	77
4.2.12	Conformational changes in polyions	79
4.2.13	Interactions between polyions	82
4.2.14	Polyion extensions, interactions and precipitation	82
4.3	Gelation	83
	References	85
5	Polyalkenoate cements	90
5.1	Introduction	90
5.2	Adhesion	92
5.2.1	New attitudes	92
5.2.2	The need for adhesive materials	92
5.2.3	Acid-etching	93
5.2.4	Obstacles to adhesion	93
5.2.5	The nature of the adhesion of polyalkenoates to tooth material	94
5.3	Preparation of poly(alkenoic acid)s	97
5.4	Setting reactions	98

Cambridge University Press

0521675499 - Acid-base Cements: Their Biomedical and Industrial Applications

Alan D. Wilson and John W. Nicholson

Table of Contents

[More information](#)*Contents*

5.5	Molecular structures	99
5.6	Metal oxide polyelectrolyte cements	101
5.7	Zinc polycarboxylate cement	103
5.7.1	Historical	103
5.7.2	Composition	103
5.7.3	Setting and structure	104
5.7.4	Properties	106
5.7.5	Modified materials	112
5.7.6	Conclusions	113
5.8	Mineral ionomer cements	113
5.9	Glass polyalkenoate (glass-ionomer) cement	116
5.9.1	Introduction	116
5.9.2	Glasses	117
5.9.3	Poly(alkenoic acid)s	131
5.9.4	Reaction-controlling additives	133
5.9.5	Setting	134
5.9.6	Structure	143
5.9.7	General characteristics	146
5.9.8	Physical properties	147
5.9.9	Adhesion	152
5.9.10	Erosion, ion release and water absorption	156
5.9.11	Biocompatibility	159
5.9.12	Modified and improved materials	162
5.9.13	Applications	166
5.10	Resin glass polyalkenoate cements	169
5.10.1	General	169
5.10.2	Class I hybrids	170
5.10.3	Class II hybrids	171
5.10.4	Properties	173
	References	175
6	Phosphate bonded cements	197
6.1	General	197
6.1.1	Orthophosphoric acid solutions	197
6.1.2	Cations in phosphoric acid solutions	198
6.1.3	Reactions between oxides and phosphoric acid solutions	201
6.1.4	Effect of cations in phosphoric acid solutions	203
6.1.5	Important cement-formers	204
6.2	Zinc phosphate cement	204
6.2.1	General	204
6.2.2	History	204
6.2.3	Composition	205
6.2.4	Cement-forming reaction	207
6.2.5	Structure	212

Cambridge University Press

0521675499 - Acid-base Cements: Their Biomedical and Industrial Applications

Alan D. Wilson and John W. Nicholson

Table of Contents

[More information](#)*Contents*

6.2.6	Properties	214
6.2.7	Factors affecting properties	218
6.2.8	Biological effects	219
6.2.9	Modified zinc phosphate cements	219
6.2.10	Hydrophosphate cements	220
6.3	Transition-metal phosphate cements	220
6.4	Magnesium phosphate cements	222
6.4.1	General	222
6.4.2	Composition	222
6.4.3	Types	222
6.4.4	Cement formation and properties	223
6.4.5	Cement formation with phosphoric acid	223
6.4.6	Cement formation with ammonium dihydrogen phosphate	223
6.4.7	Cement formation with diammonium hydrogen phosphate	231
6.4.8	Cement formation with ammonium polyphosphate	232
6.4.9	Cement formation with aluminium acid phosphate	232
6.4.10	Cements formed from magnesium titanates	235
6.5	Dental silicate cement	235
6.5.1	Historical	235
6.5.2	Glasses	237
6.5.3	Liquid	241
6.5.4	Cement-forming reaction	243
6.5.5	Structure	249
6.5.6	Physical properties	253
6.5.7	Dissolution and ion release	255
6.5.8	Biological aspects	260
6.5.9	Conclusions	261
6.5.10	Modified materials	262
6.6	Silicophosphate cement	263
6.7	Mineral phosphate cements	265
	References	265
7	Oxysalt bonded cements	283
7.1	Introduction	283
7.1.1	Components of oxysalt bonded cements	284
7.1.2	Setting of oxysalt bonded cements	284
7.2	Zinc oxychloride cements	285
7.2.1	History	285
7.2.2	Recent studies	286
7.3	Magnesium oxychloride cements	290
7.3.1	Uses	290
7.3.2	Calcination of oxide	290
7.3.3	Setting chemistry	291

Cambridge University Press

0521675499 - Acid-base Cements: Their Biomedical and Industrial Applications

Alan D. Wilson and John W. Nicholson

Table of Contents

[More information](#)*Contents*

7.3.4	Kinetics of cementation	293
7.3.5	Phase relationships in the MgO–MgCl <sub>2</sub> –H <sub>2</sub> O system	294
7.3.6	Consequences for practical magnesium oxychloride cements	295
7.3.7	Impregnation with sulphur	297
7.4	Magnesium oxysulphate cements	299
7.4.1	Setting chemistry	299
7.4.2	Phase relationships in the MgO–MgSO <sub>4</sub> –H <sub>2</sub> O system	300
7.4.3	Mechanical properties of magnesium oxysulphate cements	302
7.5	Other oxysalt bonded cements	304
	References	305
8	Miscellaneous aqueous cements	307
8.1	General	307
8.2	Miscellaneous aluminosilicate glass cements	307
8.3	Phytic acid cements	309
8.4	Poly(vinylphosphonic acid) cements	310
8.4.1	Metal oxide polyphosphonate cements	311
8.4.2	Glass polyphosphonate cements	314
8.5	Miscellaneous copper oxide and cobalt hydroxide cements	315
	References	316
9	Non-aqueous cements	318
9.1	General	318
9.2	Zinc oxide eugenol (ZOE) cements	320
9.2.1	Introduction and history	320
9.2.2	Eugenol	321
9.2.3	Zinc oxide	321
9.2.4	Cement formation	322
9.2.5	Setting	323
9.2.6	Structure	331
9.2.7	Physical properties	333
9.2.8	Biological properties	334
9.2.9	Modified cements	334
9.2.10	Impression pastes	335
9.2.11	Conclusions	335
9.3	Improved ZOE cements	336
9.3.1	General	336
9.3.2	Reinforced cements	336
9.4	2-ethoxybenzoic acid eugenol (EBA) cements	337
9.4.1	General	337
9.4.2	Development	337
9.4.3	Setting and structure	339

Cambridge University Press

0521675499 - Acid-base Cements: Their Biomedical and Industrial Applications

Alan D. Wilson and John W. Nicholson

Table of Contents

[More information](#)*Contents*

9.4.4	Properties	340
9.5	EBA–methoxyhydroxybenzoate cements	342
9.5.1	EBA–vanillate and EBA–syringate cements	342
9.5.2	EBA–divanillate and polymerized vanillate cements	344
9.5.3	EBA–HV polymer cements	345
9.5.4	Conclusions	346
9.5.5	Other zinc oxide cements	347
9.6	Calcium hydroxide chelate cements	347
9.6.1	Introduction	347
9.6.2	Composition	348
9.6.3	Setting	348
9.6.4	Physical properties	350
9.6.5	Biological properties	350
9.6.6	The calcium hydroxide dimer cement	351
	References	352
10	Experimental techniques for the study of acid–base cements	359
10.1	Introduction	359
10.2	Chemical methods	360
10.2.1	Studies of cement formation	360
10.2.2	Degradative studies	361
10.3	Infrared spectroscopic analysis	361
10.3.1	Basic principles	361
10.3.2	Applications to AB cements	362
10.3.3	Fourier transform infrared spectroscopy	364
10.4	Nuclear magnetic resonance spectroscopy	364
10.4.1	Basic principles	364
10.4.2	Applications to AB cements	365
10.5	Electrical methods	366
10.6	X-ray diffraction	367
10.6.1	Basic principles	367
10.6.2	Applications to AB cements	368
10.7	Electron probe microanalysis	369
10.7.1	Basic principles	369
10.7.2	Applications to dental silicate cements	369
10.7.3	Applications to glass–ionomer cements	369
10.8	Measurement of mechanical properties	370
10.8.1	Compressive strength	371
10.8.2	Diametral compressive strength	372
10.8.3	Flexural strength	372
10.8.4	Fracture toughness	373
10.9	Setting and rheological properties	374
10.9.1	Problems of measurement	375
10.9.2	Methods of measurement	375

Cambridge University Press

0521675499 - Acid-base Cements: Their Biomedical and Industrial Applications

Alan D. Wilson and John W. Nicholson

Table of Contents

[More information](#)*Contents*

10.10	Erosion and leaching	378
10.10.1	Importance in dentistry	378
10.10.2	Studies of erosion	379
10.11	Optical properties	379
10.11.1	Importance in dentistry	379
10.11.2	Measurement of opacity	380
10.12	Temperature measurement	380
10.13	Other test methods	381
	References	382

<i>Index</i>	386
--------------	-----