

Contents

1	A brief introduction	15
2	Water-borne resins and coatings: history, markets and definitions	19
2.1	History of water-borne coatings and resins	19
2.1.1	The past	19
2.1.2	The present: from polymer science to resins	21
2.1.3	The present: water-borne resins and coatings	23
2.1.4	The future	25
2.2	Markets and applications	25
2.2.1	The market for water-borne coating resins	25
2.2.2	Coatings market definitions	31
2.3	Definitions	35
2.3.1	Definitions of water-borne paints	35
2.3.2	Definitions of water-borne resins	37
2.3.3	Volatile Organic Compounds	37
2.3.4	Polymer dispersion terminologies	39
2.4	References	39
3	Polymer dispersions and emulsions	41
3.1	General introduction	41
3.2	Preparation of polymer dispersions	42
3.2.1	Stability of polymer dispersions	42
3.2.2	Free radical (co)polymerization mechanism	46
3.2.3	Free radical emulsion (co)polymerization	49
3.2.4	Raw materials: emulsion polymerization	59
3.2.5	Process variation and morphology control	65
3.2.6	Crosslinking of polymer dispersions	68
3.2.7	Polymer dispersions made by other processes	75
3.3	Parameters and mechanisms of polymer dispersions	89
3.3.1	Particle size and particle morphology	89
3.3.2	Glass transition temperature	89
3.3.3	Film formation – coalescence	93
3.3.4	Minimum film formation temperature (MFFT)	94
3.3.5	Coalescing aids, cosolvents and plasticizers	95
3.3.6	Stabilization mechanism	99
3.3.7	Rheology of polymer dispersions and paints	99
3.3.8	Guideline formulations and performance	99
3.4	Coating applications and formulations of polymer dispersions	100

3.4.1	Paint formulation with polymer dispersion resins	100
3.4.2	Styrene copolymer dispersions	106
3.4.3	Styrene acrylic dispersions	110
3.4.4	Pure acrylic dispersions	115
3.4.5	Poly vinyl acetate and vinyl acetate copolymer dispersions	152
3.4.6	Poly butadiene dispersions	159
3.4.7	Cationic polymer dispersions	161
3.5	References	165
4	Alkyd resins	171
4.1	Water-soluble alkyds	171
4.1.1	Molecular structure of the alkyd resins	171
4.1.2	Cosolvents	176
4.1.3	Applications	176
4.1.4	Examples	177
4.2	Externally emulsified alkyds	177
4.2.1	Molecular structure of the alkyd resins	177
4.2.2	Anionic and non-ionic modification	180
4.2.3	Surfactants	180
4.2.4	Technology	186
4.2.5	Emulsification in theory and practice	187
4.2.6	Applications	189
4.2.7	Examples	191
4.3	Internally emulsified alkyds	191
4.3.1	Anionic and non-ionic modification	192
4.3.2	Molecular structure	192
4.3.3	Applications	195
4.3.4	Examples	196
4.4	References	196
5	Epoxy resins	197
5.1	Historical background	197
5.2	Basics	198
5.3	Reaction and crosslinking	200
5.4	Epoxy dispersions	203
5.5	Application	207
5.6	Trends	209
5.6.1	Epoxy hybrids	209
5.6.2	BPA substitutes, biobased epoxy resins	210
5.7	References	212

6	Polyurethane resins and coatings	215
6.1	One-component polyurethane coatings	216
6.1.1	Synthesis of polyurethane dispersions	216
6.1.2	Raw materials for the production of polyurethane dispersions	218
6.1.3	Production process	223
6.1.4	PUD producers	228
6.1.5	Applications and formulations of polyurethane dispersions	228
6.1.6	Automotive OEM applications/ formulations	230
6.1.7	Industrial wood applications	234
6.1.8	Architectural: deco/DIY applications/formulations	241
6.1.9	Automotive plastics applications/formulations	245
6.1.10	Teletronics – industrial plastics	248
6.1.11	Vehicle refinishing	248
6.1.12	Metal applications/ formulations	248
6.2	Two-component polyurethane coatings	251
6.2.1	Polyols and polyisocyanates	251
6.2.2	Coating applications of two-com- ponent polyurethanes	257
6.2.3	Coatings formulation with acrylic emulsion resins	260
6.2.4	Coatings formulation with polyester emulsions	285
6.3	References	295

7	Silicone resins	299
7.1	Silicone chemistry	299
7.1.1	Structure of silicones	300
7.1.2	Silicone resins	300
7.1.3	Silanes, siloxanes and siliconates	301
7.2	Silicone resin-based binders for coatings	302
7.2.1	Silicone resin emulsions	302
7.2.2	Performance profile of a binder	304
7.3	Other silicone ingredients for water-borne coatings	306
7.3.1	Hydrophobic primers	306
7.3.2	Hydrophobic additives	307
7.3.3	Special effect additives	309
7.3.4	Silicone-based pH adjuster	310
7.4	Silicone resin emulsion paints and plasters	311
7.4.1	Definition of silicone resin emulsion paints and plasters	311
7.4.2	Properties of silicone resin paints and plasters	312
7.4.3	Ingredients and formulation principles	315
7.4.4	Selected formulations and properties	316
7.5	Summary and outlook	319
7.6	References	320
8	Alkali silicates	321
8.1	Historical background	321
8.2	Chemical compositions	322
8.3	Molecular structure of water-borne alkali silicates	323
8.4	Production of alkali silicates	324
8.5	Water-borne silicates	326
8.5.1	Classification according to EU Regulations	326
8.5.2	Sodium silicates	327
8.5.3	Potassium silicates	328
8.5.4	Lithium silicates	328
8.6	Curing or hardening processes of alkali silicates	329
8.6.1	Dehydration	329
8.6.2	Reaction with alkali taking substances	330
8.6.3	Reaction with mineral acids and acidic salts	330
8.6.4	Reaction by increasing molar ratio	330
8.6.5	Reaction with CO ₂	330
8.6.6	Reaction with esters	331

8.6.7	Gel formation by reaction with polyvalent metal ion containing compounds or base metals	331
8.6.8	Reaction with base metal powders	331
8.6.9	Reaction with the constituents of the substrate	332
8.6.10	Reaction with water soluble polyvalent metal salts	332
8.6.11	Reactions with alkaline solutions of salts from polyvalent amphoteric metals	333
8.7	Water-borne alkali silicate containing surface coatings	333
8.7.1	Silicate emulsion paint	335
8.8	Organic-silicate paint	340
8.9	Various applications of soluble silicates	340
8.10	References	346
9	Amino resins as hardeners	347
9.1	Structure of amino resins	347
9.2	Types and properties of amino resins	350
9.2.1	Melamine resins	350
9.3	Combination partners for amino resins	353
9.3.1	Crosslinking reactions	354
9.4	Water-borne stoving enamels based on amino resins	356
9.4.1	Selecting amino resins	356
9.4.2	Combination resins for water-borne stoving enamels	357
9.4.3	Hybrid systems	358
9.4.4	Neutralization agents	358
9.4.5	Cosolvents for water-borne stoving enamels	359

9.4.6	Mixing ratios and crosslinking	360
9.4.7	Acid catalysts	360
9.4.8	Film properties	360
9.4.9	Pigmentation	361
9.4.10	Additives	361
9.5	Formaldehyde free melamine-based resins	362
9.6	Formulation examples	363
9.7	Conclusion and comparison water-borne to solvent-based stoving enamels	372
9.8	References	373
10	REACH and other regulations	375
10.1	Legislation on volatile organic compounds	375
10.2	Legislation on chemical substances 'REACH' and 'CLP'	376
10.3	Conclusions	379
11	Outlook	381
	Authors	385
	Index	388