

Papermaking Science and Technology

a book series
covering the latest
technology and
future trends

Book 4

Papermaking Chemistry

Second Edition

Totally updated version

Book editor

Raimo Alén, Dr.Tech., Professor, University of Jyväskylä, Laboratory of Applied Chemistry, Jyväskylä, Finland

Publisher

Finnish Paper Engineers' Association/Paperi ja Puu Oy



Paperi ja Puu Oy

Table of Contents

1	Introduction to papermaking	15
2	General aspects of papermaking chemistry.....	27
3	Papermaking additives.....	54
4	Internal sizing of paper	122
5	Deposit formation and control	163
6	Paper machine microbiology.....	181
7	Overview of analytical methods in wet-end chemistry	199
	Appendix	229
	Conversion factors.....	237
	Index	239

CHAPTER 1

Introduction to papermaking

1	Historical milestones	16
2	General aspects on pulps	18
3	Common paper grades	20
4	Importance of papermaking chemistry	22
	References	25
	For further reading	26

Chapter 2

General aspects of papermaking chemistry

1	Introduction	28
2	Surface properties of pulps	30
2.1	Surface structure of fibres and fines	30
2.2	Surface chemical composition of pulps	31
2.3	Surface charge of pulps	33
3	Surface properties of fillers	35
4	General properties of papermaking additives	36
4.1	Polymers	36
4.2	Fixing agents	38
4.3	Retention chemicals	38
4.4	Dry- and wet-strength resins	39
4.5	Sizing dispersions and emulsions	41
4.6	Rosin sizing	41
4.7	Neutral sizing	42
5	Factors influencing the adsorption of additives	43
5.1	Polymer properties	43
5.2	Pulp properties	44
5.3	Water phase properties	44
6	Colloidal interactions between papermaking materials	46
7	Hydrodynamic and kinetic effects	49
	References	52

CHAPTER 3

Papermaking additives

1	Introduction.....	56
2	Mineral fillers and pigments	56
2.1	Paper fillers	58
2.2	Coating and specialty pigments	61
2.3	Effects of fillers.....	65
2.4	Techniques for use of minerals.....	71
2.5	Filler retention.....	72
2.6	Current and emerging pigment technology	74
2.7	Need for more strength in filled papers	77
3	Papermaking chemicals	77
4	Functional chemicals.....	79
4.1	Dry-strength chemicals.....	79
4.1.1	Starch.....	79
4.1.2	Other natural strength additives	88
4.1.3	Synthetic dry-strength additives.....	89
4.2	Wet-strength chemicals.....	90
4.2.1	Initial wet web strength.....	90
4.2.2	Re-wetted web strength.....	91
4.2.3	Wet-strength mechanisms	92
4.2.4	Wet-strength resins.....	92
4.2.5	Repulpability	94
4.2.6	New approaches to acquire wet strength and runnability.....	95
4.2.7	Uses of wet-strengthened paper	96
4.2.8	Remarks on wet strength	97
4.3	Sizes	98
4.4	Dyes and optical brighteners.....	98

4.5	Coating colour additives.....	103
4.6	Other functional chemicals.....	105
5	Process chemicals.....	105
5.1	Fixatives	105
5.2	Adsorbents	106
5.3	Retention and drainage polymers.....	106
	5.3.1 Polymer types	106
	5.3.2 Flocculation mechanisms.....	107
5.4	Defoaming agents.....	111
5.5	Biocides and detergent-related agents.....	113
5.6	Other process chemicals.....	113
5.7	Dosing of chemicals.....	114
5.8	Process control of wet-end additives.....	115
6	Economic aspects of additives	115
7	Future perspectives	116
7.1	Nanotechnology	116
7.2	Self-assembly of monomolecular layers.....	116
7.3	REACH	117
	References	118

Chapter 4

Internal sizing of paper

1	Introduction	124
2	Historical background	125
3	Basic mechanisms involved in sizing	127
3.1	Fibre and paper surfaces	127
3.2	Wetting and spreading	127
3.2.1	Contact angle, wetting, and adhesion	128
3.2.2	Spreading	129
3.2.3	Adsorption	130
3.3	Rough and heterogeneous surfaces	130
3.3.1	Contact angle hysteresis	130
3.3.2	Quantification of roughness and heterogeneity	132
3.3.3	Kinetics of wetting	132
3.4	Capillary penetration	134
4	Extent and mechanisms of sizing	136
4.1	Tests of sizing	137
4.2	Analysis of paper surfaces and sizing mechanisms	138
5	Rosin sizing	139
5.1	Origin and synthesis of rosin sizes	139
5.2	Rosin sizing in acid papermaking	142
5.2.1	Aluminium chemistry	142
5.2.2	Sizing with saponified rosin	143
5.2.3	Sizing using dispersed rosin	144
5.3	Rosin sizing in neutral papermaking	145
6	Sizing with alkenyl succinic anhydride (ASA)	147
6.1	Synthesis of ASA	147
6.2	Preparation of ASA emulsions	147

6.3	Reactions of ASA sizing.....	148
6.4	Spreading and wetting of ASA on paper surfaces	149
7	Sizing with alkyl ketene dimer (AKD)	150
7.1	Preparation of AKD dispersions	150
7.2	Reactions, spreading, and wetting of AKD on paper surfaces.....	151
7.3	Size reversion	154
8	Comparison of sizes	155
	References	156

Chapter 5

Deposit formation and control

1	Introduction.....	164
2	Deposits	166
2.1	Sources	166
2.2	Principles of formation	171
2.3	Effects on process performance.....	172
3	Process control.....	174
3.1	General aspects.....	174
3.2	Deposit-control agents.....	175
3.3	Practical examples.....	176
4	Conclusions.....	178
	References	179

Chapter 6

Paper machine microbiology

1	Introduction.....	182
2	Microorganisms – the enemies.....	183
2.1	Taxonomy of microorganisms.....	183
2.2	Bacteria.....	184
2.3	Functional classification of bacteria.....	185
2.3.1	Aerobic bacteria.....	185
2.3.2	Anaerobic bacteria.....	185
2.3.3	Sulphate-reducing bacteria (SRB).....	185
2.4	Fungi.....	185
2.5	Other microorganisms.....	186
3	Growth of microorganisms in paper mills.....	186
3.1	General aspects.....	186
3.2	Paper machine as an ecosystem.....	187
4	Problems caused by microbes.....	188
4.1	Microbiological deposits (slimes and biofilms).....	188
4.2	Prevention of biofilm formation.....	189
4.3	Other runnability problems.....	190
4.4	Spoilage of raw materials.....	190
4.5	Problems caused by anaerobic microbes.....	191
4.6	Heat-resistant spores.....	191
4.7	Microbially influenced corrosion (MIC).....	191
5	How to avoid microbiological problems.....	191
5.1	Application of biocides (microbicides).....	192
5.2	Different types of biocide.....	192
5.3	Other methods.....	193
5.4	Good housekeeping.....	194
6	Microbiological analytics.....	194
	References.....	197

Chapter 7

Overview of analytical methods in wet-end chemistry

1	Introduction.....	200
2	General aspects on substances in the wet end.....	201
3	Description of analytical methods	203
4	Chemical characterisation of papermaking process waters.....	205
4.1	Wood-derived compounds	206
4.1.1	General approach.....	206
4.1.2	Carbohydrates.....	207
4.1.3	Extractives	209
4.1.4	Lignin.....	212
4.1.5	Miscellaneous organics and inorganics	215
4.2	Papermaking additives.....	215
4.2.1	Sizing agents	215
4.2.2	Other compounds.....	217
5	On-line process methods	218
6	Conclusions and future perspectives.....	220
	References	221