Contents

Preface of second edition — XIII

1 Textiles — 1
1.1 Introduction — 1
1.2 Spinning — 1
1.3 Linear density – yarn count — 3
1.4 Fabric formation — 4
1.5 Textile chemical aspects in spinning and fabric formation — 5
1.5.1 Spin finish — 6
1.5.2 Sizing — 8
1.5.3 Embroidery — 10
1.5.4 Printing/coating — 10
1.5.5 Garment production/assembly/joining — 11
1.5.6 Technical textiles — 11
References — 12

2 Textile fibres — 17
2.1 Fibre production — 17
2.2 Fibre formation — 20
2.2.1 Polymer-dependent fibre properties — 20
2.3 Molecular mass/degree of polymerisation — 24
2.4 Important fibres and their chemistry — 26
2.4.1 Cellulose fibres — 26
2.4.2 Structure of cotton/flax/hemp fibres — 27
2.5 Relevant aspects of cellulose chemistry (chemical reactions, derivatisation and chemical stability) — 32
2.6 Chemical reactions — 35
2.6.1 Derivatisation — 35
2.6.2 Hydrolysis — 35
2.6.3 Oxidation — 36
2.6.4 Esterification — 37
2.6.5 Etherification — 38
2.6.6 Complex formation — 39
2.6.7 The secondary structure of cellulose — 40
2.6.8 Methods of structural characterisation — 41
2.7 Regenerated cellulose fibres — 42
2.7.1 Dissolution of cellulose — 42
2.7.2 The viscose process — 43
2.7.3 Lyocell fibres – the NMMO process — 46
2.7.4 Ionic liquids and other cellulose solvents — 49
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7.5</td>
<td>Cupro fibres – the cuprammonium process</td>
<td>49</td>
</tr>
<tr>
<td>2.7.6</td>
<td>Cellulose diacetate and triacetate</td>
<td>50</td>
</tr>
<tr>
<td>2.8</td>
<td>Protein fibres</td>
<td>51</td>
</tr>
<tr>
<td>2.8.1</td>
<td>General aspects of protein fibres</td>
<td>51</td>
</tr>
<tr>
<td>2.8.2</td>
<td>Protein structure – basic properties</td>
<td>52</td>
</tr>
<tr>
<td>2.8.3</td>
<td>Wool</td>
<td>55</td>
</tr>
<tr>
<td>2.8.4</td>
<td>Silk</td>
<td>57</td>
</tr>
<tr>
<td>2.8.5</td>
<td>Casein fibres</td>
<td>58</td>
</tr>
<tr>
<td>2.9</td>
<td>Synthetic fibres</td>
<td>59</td>
</tr>
<tr>
<td>2.9.1</td>
<td>General</td>
<td>59</td>
</tr>
<tr>
<td>2.9.2</td>
<td>Polyamide</td>
<td>60</td>
</tr>
<tr>
<td>2.9.3</td>
<td>Aminocarboxylic acid-based PAs</td>
<td>61</td>
</tr>
<tr>
<td>2.9.4</td>
<td>Diamine–dicarboxylic acid-based PAs</td>
<td>63</td>
</tr>
<tr>
<td>2.9.5</td>
<td>PES fibres</td>
<td>65</td>
</tr>
<tr>
<td>2.9.6</td>
<td>Polylactic acid and polyhydroxybutyrate</td>
<td>69</td>
</tr>
<tr>
<td>2.9.7</td>
<td>Polyurethanes/elastomer fibres</td>
<td>71</td>
</tr>
<tr>
<td>2.9.8</td>
<td>Polyolefin fibres, PE and PP</td>
<td>74</td>
</tr>
<tr>
<td>2.9.9</td>
<td>Polycrylonitrile fibres</td>
<td>78</td>
</tr>
<tr>
<td>2.9.10</td>
<td>High-performance fibres</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>83</td>
</tr>
</tbody>
</table>

### 3 Structure of textile fibres

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>General aspects</td>
<td>91</td>
</tr>
<tr>
<td>3.2</td>
<td>Crystallinity versus amorphous regions</td>
<td>91</td>
</tr>
<tr>
<td>3.3</td>
<td>Constitution of a polymer</td>
<td>92</td>
</tr>
<tr>
<td>3.4</td>
<td>High-performance fibres</td>
<td>94</td>
</tr>
<tr>
<td>3.5</td>
<td>Molecular weight distribution</td>
<td>95</td>
</tr>
<tr>
<td>3.6</td>
<td>Consequences of polydispersity</td>
<td>96</td>
</tr>
<tr>
<td>3.7</td>
<td>Configuration</td>
<td>97</td>
</tr>
<tr>
<td>3.8</td>
<td>Conformation</td>
<td>100</td>
</tr>
<tr>
<td>3.8.1</td>
<td>Conformational statistics</td>
<td>101</td>
</tr>
<tr>
<td>3.9</td>
<td>Polymer assemblies</td>
<td>101</td>
</tr>
<tr>
<td>3.10</td>
<td>The thermodynamic non-equilibrium state of polymers</td>
<td>103</td>
</tr>
<tr>
<td>3.11</td>
<td>Models of fibre structure</td>
<td>104</td>
</tr>
<tr>
<td>3.12</td>
<td>Consequences of polymer order in a fibre</td>
<td>107</td>
</tr>
<tr>
<td>3.12.1</td>
<td>Moisture/adsorption/swelling</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>110</td>
</tr>
</tbody>
</table>

### 4 Basic interactions between fibre polymers and sorptives

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>General</td>
<td>113</td>
</tr>
<tr>
<td>4.2</td>
<td>Dipoles</td>
<td>113</td>
</tr>
<tr>
<td>4.3</td>
<td>Polarisability</td>
<td>115</td>
</tr>
</tbody>
</table>
4.4 Molecular interactions — 117
4.4.1 Ion–ion interactions — 117
4.4.2 Van der Waals forces — 119
4.4.3 Hydrogen bonds — 120
4.4.4 Hydrophobic interactions — 121
4.4.5 \(\pi\)-electron interactions — 122
4.5 The polymer–solvent boundary layer — 123
4.6 Zeta potential — 126
4.7 Donnan equilibrium — 131

References — 133

5 Thermodynamics and kinetics in fibre chemistry — 137
5.1 Moisture sorption — 137
5.2 Moisture sorption isotherms — 138
5.2.1 Water activity — 139
5.3 Sorption kinetics for adsorption from the gas phase — 144
5.4 Sorption from the liquid phase — 148
5.4.1 General considerations — 148
5.4.2 The Nernst isotherm — 149
5.4.3 The Freundlich isotherm — 150
5.4.4 Langmuir adsorption isotherm — 152
5.4.5 Special aspects of sorption isotherms — 154
References — 160

6 Kinetics of textile chemical processes — 165
6.1 Elementary steps in polyester dyeing — 165
6.2 Step A – dissolution of dispersed dye — 165
6.3 Infinite and finite dyeing kinetics — 167
6.4 Step B – hydraulic transport in the dyebath — 168
6.5 Step C – diffusion through the boundary layer of the fibre — 169
6.6 Step D – dyestuff sorption in the fibre — 170
6.7 Levelling — 171
6.8 Follow-up reactions – kinetics in reactive dyeing — 172
6.9 Preceding and following reactions – vat dyeing — 174
6.10 Aggregation — 175
References — 176

7 Basics of colour development — 179
7.1 The phenomenon of colour – how to approach? — 179
7.2 Physical aspects of colour development — 179
7.3 Additive and subtractive colour — 183
7.4 Development of colour — 184
10.2.2 Reductive cleaning — 253
10.3 Direct dyes — 254
10.4 Reactive dyes — 256
10.4.1 Chemistry of reactive dyes — 256
10.4.2 Important dyeing techniques — 264
10.5 Vat dyes — 268
10.5.1 Oxidation/soaping — 274
10.6 Indigo — 278
10.6.1 Synthesis of indigo — 278
10.6.2 Application of indigo — 279
10.6.3 Chemistry of indigo reduction — 282
10.6.4 Garment wash – fading — 286
10.7 Sulphur dyes — 287
10.8 Acid dyes and metal complex dyes — 291
10.9 Naphthol dyes — 294
10.10 Cationic dyes/basic dyes — 295
10.11 Natural colourants — 297
10.11.1 General aspects — 297
10.11.2 Major classes of natural colourants — 298
10.11.3 Tannin-based dyes — 305
10.12 Pigment dyes — 307
10.13 Textile printing — 308
10.13.1 General aspects of printing — 308
10.13.2 Screen printing — 312
10.13.3 Ink-jet printing — 313
10.13.4 Special printing techniques — 315

References — 316

11 Pre-treatment — 323
11.1 Sizing — 323
11.2 Desizing — 326
11.3 Alkaline extraction — 327
11.4 Prewashing of textiles from synthetic fibres — 328
11.5 Setting of synthetic fibres — 328
11.6 Alkalisation (causticising, mercerisation) — 329
11.7 Alkalisation of polyester fibres — 331
11.8 Bleaching — 332
11.8.1 General aspects — 332
11.8.2 Peroxide compounds — 332
11.8.3 Halogen-based oxidants — 335
11.9 Singing — 337
11.10 Carbonisation — 337
11.11 Reductive bleach — 338
11.12 Wool anti-felt treatment — 339
11.13 Cationisation — 341
11.14 Degumming of silk — 341
11.15 Production of microfibres — 342
References — 342

12 Finishing — 347
12.1 General aspects — 347
12.2 Easy-care/durable press finishing — 347
12.3 Softening — 351
12.4 Hand building finishes — 353
12.5 Water-repellent finishes — 354
12.6 Flame retardant finishes — 356
12.7 Antistatic finishes — 361
12.8 Improvement of colour fastness — 366
12.9 Improving the light fastness — 367
12.10 UV protection — 368
12.11 Antimicrobial finishing — 371
12.12 Insect-resistant finishes – Mite protection — 374
12.13 Enzymatic finishing – biofinishing — 375
12.14 Denim finishing — 376
12.15 Finishes that influence thermal regulation — 379
12.16 Sorption of fragrances and functional substances — 380
12.17 Plasma chemistry in textile treatment/modification — 381
12.17.1 Introduction — 381
12.17.2 Effect of plasma treatment on fibre and textile surfaces — 382
12.17.3 Free radical formation — 383
12.17.4 Etching/cleaning — 383
12.17.5 Surface activation and functionalisation — 384
12.17.6 Surface coating by plasma-induced polymerisation — 384
12.17.7 Industrial plasma technologies and applications on textiles — 385
References — 386

13 Technical approaches in dyestuff/chemical application — 391
13.1 General aspects — 391
13.2 Batchwise operation — 392
13.3 Yarn dyeing apparatus — 392
13.4 Overflow dyeing machines/jet dyeing machines — 394
13.5 Continuous pretreatment — 395
13.6 Continuous dyeing processes – cold-pad-batch dyeing — 400
13.7 Continuous dyeing processes – pad-dry/pad steam plants — 402
16  Circularity, recycling and disposal — 453
16.1  The EU concept of circularity — 453
16.2  Terms and definitions used for assessment of products and processes — 455
16.3  Important steps in a circular concept — 456
16.4  Composition of textile material — 456
16.5  Design for recycling — 457
16.6  Facilitating steps — 457
16.7  Mechanical recycling — 458
16.8  Thermal recycling — 460
16.9  Chemical recycling — 464
16.10  Consumer use — 469
      References — 470

Index — 473