

TABLE OF CONTENTS

| | |
|---|-----------|
| 1 Introduction | 1 |
| 1.1 Historical developments | 1 |
| 1.2 Expectations from commercial additives | 2 |
| 1.3 Definitions | 4 |
| 1.4 Classification | 5 |
| <i>References</i> | 6 |
| 2 Generic Types | 9 |
| 2.1 Introduction | 9 |
| 2.2 Characteristic properties of commercial additives | 10 |
| 2.2.1 Antiblocking agents | 10 |
| 2.2.2 Mold release agents | 20 |
| 2.2.3 Slip agents | 25 |
| <i>References</i> | 30 |
| 3 Standard Methods of Control | 33 |
| 3.1 Adhesives | 33 |
| 3.2 Floor coverings | 34 |
| 3.3 Footwear and walkway surfaces | 34 |
| 3.4 Geosynthetics | 35 |
| 3.5 Leather and coated fabrics | 35 |
| 3.6 Lubricants | 36 |
| 3.7 Medical | 37 |
| 3.8 Paints and Coatings | 37 |
| 3.9 Paper | 37 |
| 3.10 Plastics and rubber | 38 |
| 3.11 Roads and pavement | 39 |
| 3.12 Sport equipment | 40 |
| 3.13 Textiles | 41 |
| <i>References</i> | 41 |
| 4 Transportation and Storage | 47 |
| 4.1 Transportation | 47 |
| 4.2 Storage | 48 |
| <i>References</i> | 49 |
| 5 Mechanisms of Action | 51 |
| 5.1 Antiblocking agents | 51 |
| 5.2 Slip agents | 57 |
| 5.3 Release agents | 60 |
| <i>References</i> | 65 |

| | |
|---|------------|
| 6 Compatibility and Performance | 67 |
| <i>References</i> | 71 |
| 7 Diffusion and Migration | 73 |
| 7.1 Diffusion | 73 |
| 7.2 Distribution of additive in bulk and on surface | 76 |
| 7.3 How mobility affects additive selection? | 78 |
| 7.4 Additive transfer to material in contact | 79 |
| 7.5 Additive loss | 80 |
| <i>References</i> | 82 |
| 8 Interaction with Other Components of Formulation | 83 |
| 8.1 Fillers | 83 |
| 8.2 Other components of formulation | 85 |
| 8.3 Synergy between surface additives | 86 |
| 8.4 Other properties | 88 |
| <i>References</i> | 88 |
| 9 Processing and Additive Performance | 91 |
| <i>References</i> | 93 |
| 10 Effect on Product Properties | 95 |
| 10.1 Mechanical properties | 95 |
| 10.2 Mar and abrasion | 97 |
| 10.3 Shrinkage and warpage | 98 |
| 10.4 Blocking force | 99 |
| 10.5 Adhesion to mold and demolding | 101 |
| 10.6 Coefficient of friction | 105 |
| 10.7 Residues on molds | 110 |
| 10.8 Residues on molded parts | 111 |
| 10.9 Optical properties | 111 |
| 10.10 Rheological properties | 115 |
| 10.11 Electrical properties | 118 |
| 10.12 Structure and orientation | 118 |
| 10.13 Thermal aging | 119 |
| 10.14 UV radiation | 121 |
| 10.15 Effect on other properties | 121 |
| <i>References</i> | 124 |
| 11 Use in Specific Polymers | 127 |
| 11.1 ABS | 127 |
| 11.2 Acrylics | 129 |
| 11.3 Bromobutyl rubber | 131 |
| 11.4 Cellulose acetate | 132 |
| 11.5 Cellulose, acetate, butyrate and propionate | 133 |
| 11.6 Cellulose nitrate | 134 |
| 11.7 Chlorinated polyvinylchloride | 135 |

| | |
|--|------------|
| 11.8 Chlorosulfonated polyethylene | 135 |
| 11.9 Copolymers | 136 |
| 11.10 Cyanoacrylates | 139 |
| 11.11 Ethyl cellulose | 139 |
| 11.12 Ethylene-propylene-diene copolymer, EPDM | 140 |
| 11.13 Ethylene-propylene rubber, EPR | 142 |
| 11.14 Epoxy resin | 143 |
| 11.15 Ethylene-vinyl acetate copolymer, EVA | 144 |
| 11.16 Ionomers | 146 |
| 11.17 Nitrile rubber | 147 |
| 11.18 Polyamide | 147 |
| 11.19 Polybutadiene | 148 |
| 11.20 Polycarbonate | 149 |
| 11.21 Polyester | 151 |
| 11.22 Polyetherimide | 154 |
| 11.23 Polyethylene | 155 |
| 11.24 Polyimide | 162 |
| 11.25 Polylactide | 163 |
| 11.26 Polymethylmethacrylate | 164 |
| 11.27 Polyoxymethylene | 165 |
| 11.28 Poly(N-vinylcarbazole) | 166 |
| 11.29 Poly(phenylene ether) | 167 |
| 11.30 Polypropylene | 168 |
| 11.31 Polystyrene | 171 |
| 11.32 Polysulfone | 173 |
| 11.33 Poly(phenylene sulfide) | 173 |
| 11.34 Polyvinylacetate | 174 |
| 11.35 Polyvinylalcohol | 174 |
| 11.36 Polyvinylbutyral | 175 |
| 11.37 Polyvinylchloride | 176 |
| 11.38 Polyurethanes | 177 |
| 11.39 Proteins | 181 |
| 11.40 Rubber, natural | 181 |
| 11.41 Silicone | 182 |
| 11.42 Styrene-butadiene rubber | 183 |
| 11.43 Styrene-butadiene-styrene | 184 |
| 11.44 Starch | 185 |
| <i>References</i> | <i>185</i> |
| 12 Use in Industrial Products | 195 |
| 12.1 Adhesives and sealants | 195 |
| 12.2 Aerospace | 197 |
| 12.3 Agriculture | 198 |
| 12.4 Automotive applications | 200 |

| | |
|--------------------------------------|------------|
| 12.5 Bottles | 202 |
| 12.6 Ceramic materials | 204 |
| 12.7 Composites | 205 |
| 12.8 Coated fabrics | 205 |
| 12.9 Cosmetics | 207 |
| 12.10 Dental materials | 207 |
| 12.11 Electronics | 208 |
| 12.12 Fibers | 210 |
| 12.13 Film | 211 |
| 12.14 Food | 221 |
| 12.15 Foams | 222 |
| 12.16 Gaskets | 224 |
| 12.17 Inks, varnishes, and lacquers | 225 |
| 12.18 Medical devices | 226 |
| 12.19 Membranes | 226 |
| 12.20 Paints and coatings | 227 |
| 12.21 Pharmaceutical products | 228 |
| 12.22 Photographic materials | 229 |
| 12.23 Pipes | 231 |
| 12.24 Road construction | 232 |
| 12.25 Roofing materials | 232 |
| 12.26 Synthetic paper | 233 |
| 12.27 Tires | 233 |
| 12.28 Toys | 235 |
| 12.29 Wire & cable | 235 |
| <i>References</i> | 236 |
| 13 Various Processing Methods | 243 |
| 13.1 Blow molding | 243 |
| 13.2 Calendering | 245 |
| 13.3 Coextrusion | 245 |
| 13.4 Compression molding | 247 |
| 13.5 Compounding (mixing) | 250 |
| 13.6 Dip coating | 251 |
| 13.7 Dryblending | 253 |
| 13.8 Extrusion | 255 |
| 13.9 Extrusion blow molding | 258 |
| 13.10 Injection molding | 260 |
| 13.11 Lithography | 263 |
| 13.12 Printing | 264 |
| 13.13 Reaction injection molding | 267 |
| 13.14 Rotational molding | 268 |
| 13.15 Rubber processing | 269 |
| 13.16 Slip casting | 271 |

| | |
|---|------------|
| 13.17 Thermoforming | 271 |
| 13.18 Transfer molding | 272 |
| <i>References</i> | 272 |
| 14 Specialized Analytical Methods | 277 |
| 14.1 Identification | 277 |
| 14.2 Determination of concentration | 278 |
| 14.3 Determination of volatility and molecular motion | 280 |
| 14.4 Study of materials containing additives | 281 |
| <i>References</i> | 283 |
| 15 Mathematical Modelling | 287 |
| <i>References</i> | 289 |
| 16 Health, Safety and Environmental Issues | 291 |
| 16.1 Antiblocking agents | 291 |
| 16.1.1 Inorganic | 291 |
| 16.1.2 Organic | 294 |
| 16.2 Release agents | 294 |
| 16.2.1 Fluorocompounds | 294 |
| 16.2.2 Polydimethylsiloxane | 294 |
| 16.2.3 Polymeric waxes | 295 |
| 16.2.4 Other chemical compounds | 295 |
| 16.3 Slip agents | 296 |
| 16.3.1 Acids | 296 |
| 16.3.2 Esters | 296 |
| 16.3.3 Fatty acid amides | 296 |
| 16.3.4 Natural wax | 297 |
| 16.3.5 Salts | 297 |
| 17 Regulations and Data | 299 |
| 17.1 Toxic substance control | 299 |
| 17.2. Carcinogenic effect | 301 |
| 17.3 Workplace exposure limits | 302 |
| 17.4 Food regulatory acts | 304 |
| <i>References</i> | 306 |
| 18 Personal Protection | 307 |
| 18.1 Clothing | 307 |
| 18.2 Gloves | 308 |
| 18.3 Eye protection | 310 |
| 18.4 Respiratory protection | 311 |
| <i>References</i> | 315 |
| Index | 317 |