

Contents

Preface to this 4th English edition — vii

Preface to the 3rd English edition — viii

Preface to the 2nd English edition — ix

Preface to the first English edition — x

Preface to the first German edition — xi

1 Introduction — 1

1.1 Historical Overview — 1

1.2 New Developments — 11

1.2.1 Polymer-Bonded Explosives — 11

1.2.2 New High (Secondary) Explosives — 15

1.2.3 New Primary Explosives — 25

1.2.4 New Oxidizers for Solid Rocket Motors — 34

1.2.5 Initial Characterization of New Energetic Materials — 41

1.3 Definitions — 42

1.4 Combustion, Deflagration, Detonation – A Short Introduction — 48

1.4.1 Fire and Combustion — 48

1.4.2 Deflagration and Detonation — 50

2 Classification of Energetic Materials — 53

2.1 Primary Explosives — 53

2.2 High (Secondary) Explosives — 56

2.3 Propellant Charges — 65

2.4 Rocket Propellants — 68

2.4.1 Chemical Thermal Propulsion (CTP) — 85

2.5 Pyrotechnics — 86

2.5.1 Detonators, Initiators, Delay Compositions and Heat-Generating Pyrotechnics — 86

2.5.2 Light-Generating Pyrotechnics — 91

2.5.3 Decoy Flares — 100

2.5.4 Smoke Munitions — 106

2.5.5 Near-Infrared (NIR) Compositions — 115

3	Detonation, Detonation Velocity and Detonation Pressure — 119
4	Thermodynamics — 127
4.1	Theoretical Basis — 127
4.2	Computational Methods — 133
4.2.1	Thermodynamics — 133
4.2.2	Detonation Parameters — 137
4.2.3	Combustion Parameters — 141
4.2.4	Example: Theoretical Evaluation of New Solid Rocket Propellants — 147
4.2.5	Example: EXPLO5 Calculation of the Gun Propellant Properties of Single, Double and Triple Base Propellants — 154
4.2.6	Semiempirical Calculations (EMDB) — 157
5	Initiation — 161
5.1	Introduction — 161
5.2	Ignition and Initiation of Energetic Materials — 163
5.3	Laser Ignition and Initiation — 165
5.4	Electric Detonators — 171
6	Experimental Characterization of Explosives — 175
6.1	Sensitivities — 175
6.2	Long-Term Stabilities — 180
6.3	Insensitive Munitions — 183
6.4	Gap Test — 184
6.5	Classification — 185
6.6	Trauzl Test — 187
7	Special Aspects of Explosives — 191
7.1	Shaped Charges — 191
7.2	Detonation Velocities — 200
7.3	Gurney Model — 206
7.3.1	Example: Calculation of the Gurney Velocity for a General Purpose Bomb — 211
7.4	Plate Dent Tests vs. Fragment Velocities — 212
7.5	Underwater explosions — 218
8	Correlation between the Electrostatic Potential and the Impact Sensitivity — 225
8.1	Electrostatic Potentials — 225
8.2	Volume-Based Sensitivities — 228

9	Design of Novel Energetic Materials — 231
9.1	Classification — 231
9.2	Polynitrogen Compounds — 233
9.3	High-Nitrogen Compounds — 239
9.3.1	Tetrazole and Dinitramide Chemistry — 240
9.3.2	Tetrazole, Tetrazine and Trinitroethyl Chemistry — 247
9.3.3	Ionic Liquids — 252
9.4	Dinitroguanidine Derivatives — 256
9.5	Co-Crystallization — 258
9.6	Future Energetics — 259
9.7	Detonation Velocities from Laser-induced Air Shock — 271
9.8	Thermally Stable Explosives — 277
10	Synthesis of Energetic Materials — 285
10.1	Molecular Building Blocks — 285
10.2	Nitration Reactions — 286
10.3	Processing — 291
11	Safe Handling of Energetic Materials in the Laboratory — 293
11.1	General — 293
11.2	Protective Equipment — 294
11.3	Laboratory Equipment — 297
12	Energetic Materials of the Future — 299
13	Related Topics — 307
13.1	Thermobaric Weapons — 307
13.2	Agent Defeat Weapons — 309
13.3	Nanothermites — 311
13.3.1	Example: Iron Oxide / Aluminum Thermite — 318
13.3.2	Example: Copper Oxide / Aluminum Thermite — 319
13.3.3	Example: Molybdenum Trioxide / Aluminum Thermite — 320
13.4	Homemade Explosives — 320
13.5	Explosive Welding — 321
14	Study Questions — 323
15	Literature — 327
16	Appendix — 337
	Important reaction types in organic nitrogen chemistry — 337
	Curing of a diol (HTPB) with isocyanate binder — 341

Important reaction types in inorganic nitrogen chemistry — 341
Collection of formulas — 351

Author — 357

Index — 359