

Contents

Preface.....	v
Executive Summary	vii
Author Biographies.....	xi
Acronyms	xv
Chapter 1 The History of Energetic Materials in China	1
1.1 The Discovery of the Components of Gunpowder	1
1.1.1 The Discovery of Saltpeter	1
1.1.2 The Discovery of Sulfur.....	3
1.1.3 The Discovery of Carbon.....	4
1.1.4 The History of Alchemy	4
1.1.5 The Invention of Gunpowder.....	7
1.1.6 Song Dynasty	10
1.1.7 Yuan Dynasty.....	10
1.1.8 Ming Dynasty.....	11
1.1.9 Modern China	11
1.2 Fireworks.....	12
1.2.1 Han Dynasty.....	12
1.2.2 Tang and Song Dynasties.....	12
1.2.3 Ming Dynasty.....	13
1.2.4 Modern China	13
1.3 Firearms.....	17
1.3.1 Song Dynasty	17
1.3.2 Yuan Dynasty.....	17
1.3.3 Ming Dynasty.....	19
1.3.4 Qing Dynasty	26
1.3.5 Modern China	27

1.4	Solid Propellants	27
1.4.1	Modified Low-signature Double-base Propellants.....	28
1.4.2	Deterred Low-signature Double-base Propellants	28
1.4.3	The Gap between China and the World	28
1.5	Space Solid Rocket Motor.....	30
1.5.1	Sounding Rocket Motor	30
1.5.2	The Third Stage Motor of Launch Vehicle	30
1.5.3	Retro-motor of Returnable Satellite	31
1.5.4	Apogee Motor	31
1.5.5	Perigee Orbit Transfer Motor.....	31
1.6	Latest Research Progress.....	32
1.7	Summary	34
1.8	References	34

Chapter 2 Progress in Technology of Chinese Energetic Materials – An Overview..... 37

2.1	Introduction	37
2.2	The Chinese Black Powders—A Historical Note.....	38
2.3	Industrial Energetic Materials	44
2.3.1	General Application Class (Detonation Velocity between 5000 and 9000 m/s).....	45
2.3.2	High Energy Application Class (Explosion Wave Speed above 9000 m/s)	51
2.4	Results and Discussion.....	54
2.5	Concluding Remarks	55
2.6	Acknowledgement.....	55
2.7	References	55

Chapter 3 Science and Technology Trends..... 61

3.1	Energetics Research	65
3.2	Xi'an Modern Chemistry Research Institute	67
3.2.1	Areas of Research in the Xi'an Modern Chemistry Research Institute and Achievements	68
3.2.2	Research Projects	68
3.2.3	Facilities of the Institute.....	69
3.3	Beijing Institute of Technology	69
3.3.1	Energetics Research in the SKLEST.....	70
3.3.2	Research Capability	71
3.4	Nanjing University of Science and Technology	74
3.4.1	Energetics Research in the School of Chemical Engineering ...	75
3.4.2	Research Capability in the School of Chemical Engineering ...	76
3.4.3	Energetics Research in the NSSPERC	77
3.4.4	Research Capability in the NSSPERC	77
3.5	China Academy of Engineering Physics	79
3.5.1	Energetics Research at the Institute of Chemical Materials	80
3.5.2	Research Capability	80
3.6	North University of China.....	81

3.6.1	Energetics Research in the School of Chemical Engineering and Environment.....	82
3.6.2	Research Capability	82
3.7	National University of Defense Technology	85
3.7.1	Energetics Research in the College of Aerospace and Materials Engineering.....	86
3.7.2	Research Capability	87
3.8	References	88
Chapter 4 Synthesis.....		93
4.1	Energetics Synthesis Research	94
4.2	References	98
Chapter 5 Combustion.....		153
5.1	Research in Combustion.....	156
5.1.1	Detonation and Deflagration	157
5.1.2	Combustion Ignition	160
5.1.3	Combustion Catalyst.....	165
5.1.4	Explosive Combustion	168
5.1.5	Propellant Combustion.....	172
5.1.6	Others.....	184
5.2	References	186
Chapter 6 Modeling and Simulation		209
6.1	Modeling and Simulation Methods in Energetic Field.....	210
6.2	Modeling and Simulation Research in the Energetics Field.....	213
6.2.1	Modeling and Simulation in Phase Transformations of Energetic Materials	213
6.2.2	Modeling and Simulation in Molecular Geometry Optimization	214
6.2.3	Modeling and Simulation in Theoretical Thermodynamics Investigations	215
6.2.4	Modeling and Simulation of Detonation Waves in Energetic Materials	216
6.2.5	Modeling and Simulation in Chemical Reactions of Energetic Materials	216
6.2.6	Modeling and Simulation in Propellants.....	217
6.2.7	Modeling and Simulation in Other Areas of Energetic Materials	218
6.3	References	219
Chapter 7 Nanoenergetics		229
7.1	Research in Energetic Nanomaterials.....	230
7.2	References	232