

Contents

Preface	xiii
1 Historical Milieu	1
1.1 Organophosphorus Nerve Agents	2
1.2 Blister Agents	5
1.3 Sternutator Agents	11
1.4 Chemical Weapons Convention (CWC)	13
1.4.1 Schedule of Chemicals	14
1.4.2 Destruction of Chemical Weapons	14
References	16
2 Toxicity of Chemical Warfare Agents and their Degradation Products	19
2.1 Organophosphorus Nerve Agent Toxicity	20
2.1.1 Toxicity Mechanism – Acetylcholinesterase Inhibition	20
2.1.2 Exposure	21
2.1.3 Response, Treatment and Prevention	22

2.2	Toxicity of Nerve Agent Degradation Products	24
2.2.1	Toxicity of GA (Tabun) Degradation Products	25
2.2.2	Toxicity of GB (Sarin) Degradation Products	26
2.2.3	Toxicity of GD (Soman) Degradation Products	29
2.2.4	Toxicity of GF (Cyclosarin) Degradation Products	33
2.2.5	Toxicity of VX Degradation Products	33
2.3	Toxicity of Blister Agents	36
2.4	Toxicity of Sternutator Agents	45
2.4.1	Toxicity of Degradation Products of Sternutator Agents	46
	References	48
3	Analysis of Chemical Warfare Agents	59
3.1	Introduction	60
3.2	Minimally Invasive Detection Techniques	61
3.3	Separation and Detection Techniques	68
3.3.1	Capillary Electrophoresis	69
3.3.2	Ion Mobility Spectrometry	75
3.3.3	Gas Chromatography (GC)/Gas Chromatography-Mass Spectrometry (GC-MS)	79
3.3.4	Liquid Chromatography (LC)/Liquid Chromatography-Mass Spectrometry (LC-MS)	88

3.3.5	Desorption Electrospray Ionization and Direct Analysis in Real Time Mass Spectrometry	90
	References	91
4	Chemical Warfare Agent Degradation Products	99
4.1	Analysis of Nerve Agent Degradation Products	100
4.1.1	Sample Preparation	101
4.1.2	Liquid–Liquid Extraction (Pre-concentration)	104
4.1.3	Solid Phase Extraction (SPE)	105
4.1.4	Solid Phase Microextraction (SPME)	106
4.1.5	Stir Bar Sorptive Extraction (SBSE)	106
4.1.6	Derivatization	107
4.2	Analytical Techniques	108
4.2.1	Gas Chromatography (GC)	109
4.2.2	Liquid Chromatography (LC)	110
4.2.3	Elemental Speciation	114
4.2.4	Ion Mobility	115
4.2.5	Capillary Electrophoresis	117
4.3	Analysis of Sulfur Mustard Degradation Products	117
4.4	Analysis of Sternutator Degradation Products	125
	References	131
	Appendix	135
	Index	141