

Contents

Chapter 1 Raman Spectroscopic Sensing in Food Safety and Quality Analysis	1
<i>Zhong Zhang</i>	
1.1 Raman spectroscopy	1
1.1.1 Basics of Raman Spectroscopy	1
1.1.2 The Raman Spectrometer	2
1.1.3 Surface Enhanced Raman Spectroscopy (SERS)	3
1.1.4 Statistical Analysis for SERS Methods	4
1.2 Sensing of Food Contaminations by SERS	6
1.2.1 SERS Detection of Chemical Contaminations in Foods	7
1.2.2 SERS Detection of Microbiological Contaminations in Foods	10
1.3 Determination of Food Components and Food Quality by SERS	12
1.3.1 Analysis of Food Proteins by SERS	12
1.3.2 Analysis of Food Lipids by SERS	13
1.3.3 Analysis of Polysaccharides by SERS	13
1.4 Summary	15
References	15

Chapter 2	Quantum Dots in the Analysis of Food Safety and Quality	17
	<i>K. David Wegner, Michael V. Tran, Melissa Massey and W. Russ Algar</i>	
2.1	Introduction	17
2.2	Quantum Dots	21
2.2.1	Overview	21
2.2.2	Advantages in Bioanalysis	24
2.2.3	Synthesis and Functionalization Strategies	24
2.2.4	Bioconjugation Strategies	25
2.3	Applications of QDs in Food Safety and Quality Analysis	27
2.3.1	Foodborne Pathogens	30
2.3.2	Pesticides	42
2.3.3	Antibiotics	47
2.3.4	Genetically Modified Organisms (GMOs)	52
2.4	Summary and Perspective	53
	References	55
Chapter 3	Microfluidic “Lab-on-a-Chip” Sensing in Food Safety and Quality Analysis	61
	<i>Xian Huang, Chongyue Tang, Qingmei Xu, Yicong Zhao and Dachao Li</i>	
3.1	Introduction	61
3.2	Materials, Structures and Fabrication Methods of LOC Devices	62
3.2.1	Major Materials Used in Microfluidic LOC Devices	62
3.2.2	Major Structures and Components	65
3.2.3	Fabrication Approaches	68
3.3	Methods Used in LOC Detection of Food Safety and Quality Analysis	72
3.3.1	PCR and Isothermal Amplification	72
3.3.2	Immunoassay	73
3.3.3	Detection Methods	73
3.4	Applications in Food Safety and Quality Analysis	76
3.4.1	Food Additives	76
3.4.2	Toxins	77
3.4.3	Bacterial and Foodborne Pathogens	78
3.4.4	Antibiotics	80
3.4.5	Heavy Metals	80

3.4.6	Pesticide Residues	82
3.4.7	Migrants from Packaging Materials	83
3.4.8	Biogenic Amines	83
3.4.9	Food Allergens	84
3.4.10	Antioxidants	85
3.4.11	Food Authentication	85
3.5	Conclusions and Perspective	86
	References	87
Chapter 4	Paper-fluidic Based Sensing in Food Safety and Quality Analysis	95
	<i>Yang Lin and Jie Xu</i>	
4.1	Introduction	95
4.2	Fabrication Techniques	96
4.3	Functional Components and Flow Control	100
4.4	Detection Mechanisms	102
4.5	Representative Applications in Food Safety and Quality Analysis	106
4.6	Conclusions and Future Perspectives	116
	References	117
Chapter 5	Colorimetric-based Sensing in Food Safety and Quality Analysis	121
	<i>Azadeh Nilghaz, Evan Trofimchuk and Xiaonan Lu</i>	
5.1	Introduction	121
5.2	Colorimetric Analysis	124
5.2.1	Overview	124
5.2.2	Advantages and Limitations of Colorimetric Sensing in Food Safety and Quality Control	124
5.3	Colorimetric Detection of Food Contaminants Using Gold Nanoparticles	125
5.3.1	General Overview	125
5.3.2	Applications of Using Gold Nanoparticles for Food Safety and Quality Analysis	125
5.4	Colorimetric Detection of Food Contaminants Using Immunological Methods	131
5.4.1	General Overview	131
5.4.2	Applications of Colorimetric Immunological Methods and ELISA for Food Safety and Quality Analysis	132

5.4.3	Colorimetric Detection of Food Contaminants on Paper as a Low-cost Substrate	134
5.5	Summary and Perspective	136
	References	136
Chapter 6	ELISA-based Sensing in Food Safety and Quality Analysis	141
	<i>Yang Lu, Wei Sheng, Bing Liu and Shuo Wang</i>	
6.1	Introduction	141
6.2	Principle and Practice of Hapten Design	143
6.3	Antibodies	147
	6.3.1 Polyclonal Antibodies	149
	6.3.2 Monoclonal Antibodies	151
6.4	Tracers for ELISA: Enzymes and Beyond	154
6.5	Sample Preparation	154
6.6	Assay Format	155
	6.6.1 Direct and Sandwich ELISAs	156
	6.6.2 Indirect and Direct Competitive ELISAs	156
	6.6.3 Homogeneous and Heterogeneous ELISAs	156
6.7	Lateral-flow Immunochromatographic Assays	157
6.8	Application of ELISA on Food Safety Detection	157
	6.8.1 Pesticides	157
	6.8.2 Veterinary Drugs	159
	6.8.3 Plasticizer	160
6.9	Concluding Remarks	161
	References	162
Chapter 7	Molecularly Imprinted Polymers-based Sensing in Food Safety and Quality Analysis	164
	<i>Yiwei Tang, Hong Zhang and Yuchen Zhang</i>	
7.1	Introduction	164
7.2	Materials	166
	7.2.1 Molecularly Imprinted Polymers	166
	7.2.2 Polymerization Techniques	168
7.3	Molecularly Imprinted Polymers-based Sensors in Food Safety and Quality Analysis	168
	7.3.1 Electrochemical Sensors	168
	7.3.2 Quartz Crystal Microbalance Sensors	171
	7.3.3 Fluorescence Sensors	176
	7.3.4 Surface Enhanced Raman Scattering Sensors	181

7.3.5	Surface Plasmon Resonance Sensors	185
7.3.6	MIPs-based Enzyme-linked Immunoassays	191
7.4	Conclusion	194
	References	195
Chapter 8	Aptamer-based Sensing Techniques for Food Safety and Quality	200
	<i>D. N. Goudreau, M. Smith, E. M. McConnell, A. Ruscito, R. Velu, J. Callahan and M. C. DeRosa</i>	
8.1	Introduction	200
8.2	Aptasensors in Food Safety	202
8.2.1	Small Molecule and Protein-based Targets	203
8.2.2	Bacterial Toxins	212
8.2.3	Antibiotics, Drugs and Other Residues	218
8.2.4	Heavy Metals	229
8.3	Cellular Targets	239
8.3.1	Bacteria	239
8.3.2	Viruses	240
8.4	Aptasensors for Food Quality: Adulterants, Additives and Allergens	249
8.5	Conclusions and Future Directions	253
	References	253
Chapter 9	Carbon Nanotube Sensing in Food Safety and Quality Analysis	272
	<i>Raghid Najjar, Joseph R. Nalbach and Wei Xue</i>	
9.1	Introduction	272
9.2	Materials	274
9.2.1	Carbon Nanotubes	274
9.2.2	Sensing Properties of Carbon Nanotubes	276
9.3	Carbon Nanotube Sensors in Food Safety and Quality Analysis	276
9.3.1	Sensors in Food Safety and Quality Analysis	278
9.3.2	Summary of CNT Sensors in Recent Literature	292
9.4	Conclusion	294
	References	295

Chapter 10 Graphene-electrochemical Sensing in Food Safety and Quality Analysis	299
<i>Xian Zhang</i>	
10.1 Introduction	299
10.2 Nanomaterials	304
10.3 Graphene	307
10.3.1 Discovery and Synthesis	310
10.3.2 Physical Properties of Graphene	311
10.4 Application of Graphene in Sensing Food Safety and Quality	312
10.4.1 Detection of Chemical Contaminants in Agri-food Products	313
10.4.2 Detection and Characterization of Food Compositions	315
10.4.3 Detection of Volatile Organic Compounds	318
10.4.4 Detection of Toxins in Agricultural Food Products	318
10.4.5 Detection of Pesticides in Agricultural and Food Products	320
10.5 Electrochemical Sensing in Foods	322
10.6 Application of Graphene in Detecting Food Safety and Quality by Electrochemical Methods	323
10.7 Conclusion	323
References	323
Chapter 11 Smartphone-based Sensing in Food Safety and Quality Analysis	332
<i>Jane Ru Choi</i>	
11.1 Introduction	332
11.2 Smartphone-based Sensing	333
11.2.1 Overview	333
11.2.2 The Advantages in Food Safety Applications	337
11.3 Application of Smartphone-based Sensing in Food Safety and Quality Control	338
11.3.1 The Integration of Smartphones with Paper-based Assays	338

<i>Contents</i>	xvii
11.3.2 The Integration of Smartphones with Chip-based Assays	343
11.3.3 The Integration of Smartphones with Tube, Microwell or Disk-based Assays	345
11.3.4 Smartphone-based Microscopy	349
11.4 Commercial Smartphone-based Sensors for Potential Food Safety Applications	353
11.5 Conclusion and Future Perspective	353
References	354
Subject Index	359