

Table of contents

Part 1 Clinical Applications

Contributing authors (to Volumes 1 and 2)	11
Acknowledgements	13
INTRODUCTION TO PART 1	17
J. P. Schwing	
1. ZERO-CURRENT POTENTIOMETRY	17
1.1 Inert platinum or gold electrodes	17
1.2 Metal-metal oxide electrodes	18
1.3 Ion-selective electrodes	18
1.4 Enzyme electrodes	19
2. ELECTROCHEMICAL TECHNIQUES WITH CURRENT FLOW	19
References	20

CHAPTER 1 — *IN VITRO* DETERMINATIONS

1.1 CONVENTIONAL AND NOVEL ELECTROCHEMICAL DETECTION TECHNIQUES IN CLINICAL ANALYSIS	21
J. C. Viré, J. M. Kauffmann, and G. J. Patriarche	
1 Treatment of the sample	21
2 Electrochemical techniques	23
3 Voltammetric techniques with preconcentration step	27
4 Applications	29
4.1 Psychotropic compounds	29
4.2 Antiseptics, antimicrobial agents, antibiotics	31
4.3 Analgesics, anti-inflammatory drugs	31
4.4 Antitumor drugs	32
4.5 Blood pressure regulators, cardiotonics	33
4.6 Other compounds	34
4.7 Toxic compounds	35
4.8 Naturally occurring compounds	35
5 Metal analysis	36
5.1 Direct voltammetric analysis	37

5.2 Voltammetric stripping analysis	37
5.3 Potentiometric stripping analysis	38
Acknowledgements	38
References	45
1.2 HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY WITH ELECTROCHEMICAL DETECTION	53
M. Porthault	
1 General aspects of HPLC	53
1.1 Main parameters in HPLC	53
1.2 Extra-column peak broadening (or band broadening)	56
1.3 Main modes of separations	57
1.4 Main detection techniques	58
1.5 Micro-HPLC	59
2 General aspects of electrochemical detection techniques in HPLC	60
2.1 Amperometric detectors	61
2.2 Cells with solid working electrodes	61
2.3 Working electrode materials	62
2.4 Noise	62
2.5 Signal	63
2.6 Cell with dropping mercury electrode	65
2.7 Coulometric detectors	66
3 Main improvements in performance	67
3.1 Dual-electrode systems	67
3.2 Electrochemical detector miniaturization	69
3.3 New electrodes	70
3.4 Reaction detectors	71
4 Applications	73
4.1 Catecholamines and derivatives	74
4.2 Tryptophan metabolites	75
4.3 Isoquinolic and morphinic alkaloids	75
4.4 Common analgesics: ring-substituted phenols, substituted naphthols	76
4.5 Phenothiazines	76
4.6 Characterization of quinonoid pterin derivatives	76
4.7 Thiol and disulfide compounds	77
4.8 Other applications	77
5 Conclusion	77
A1 Key words	79
A2 Choice of an appropriate potential for the working electrode	79
References	80
1.3 ION-SELECTIVE ELECTRODES IN CLINICAL CHEMISTRY	85
P. Nabet	
1 Definitions and nomenclature	86
1.1 Principles of ISEs	86
1.2 Ion activity	87
1.3 Notions of direct potentiometry and indirect potentiometry	88
1.4 Plasmatic or seric water	90

2 ISE characteristics	92
2.1 Selectivity coefficient	92
2.2 Precision	93
2.3 Time constants of ISEs	93
2.4 Accuracy and/or fidelity	94
3 Main types of ISEs used in clinical chemistry	95
3.1 Glass electrodes	95
3.2 Liquid or semiliquid membrane electrodes	96
4 Clinical chemistry devices based on ISEs	96
5 Specific problems in the use of these clinical chemistry instruments	99
Acknowledgements	100
References	100

1.4 ELECTROCHEMICAL BIOSENSORS IN CLINICAL ANALYSIS. . . 103

J. L. Romette

1 Historical background	103
2 The concept of biosensors	104
2.1 Immobilization techniques	104
2.2 Main electrochemical transducer-biocatalyst combinations	106
2.2.1 pH and ion-selective electrodes	106
2.2.1.1 pH electrodes	106
2.2.1.2 Other ion-selective electrodes	107
2.2.1.3 Field-effect transistors	107
2.2.2 Gas electrodes	110
2.2.2.1 pO_2 (Clark-type) electrode/oxidase activity	110
2.2.2.2 pCO_2 electrode/decarboxylase activity	112
2.2.2.3 NH_3 -sensitive electrode/dehydrogenase activity	114
2.2.3 Metal or carbon electrodes	115
3 Examples of electrochemical biosensor combinations for clinical analysis	120
4 Economic data	120
4.1 Enzymatic analysis	120
4.2 Biosensor market	125
5 Conclusion — new trends	130
References	132

1.5 ELECTROCHEMICAL DETECTION TECHNIQUES IN CLINICAL MICROBIOLOGY 137

G. A. Junter

1 Introduction	137
2 Impedance measurements	139
2.1 Electrical impedance: basic notions	139
2.2 Equipment for impedance measurements	139
2.2.1 Bactometer devices	141
2.2.2 Malthus instruments	142
2.3 Electrical impedance and microbial metabolism	145
2.3.1 Conductance	145
2.3.2 Capacitance	147

2.3.3 Overall impedance	148
2.4 Detection of microbial infections in clinical samples	149
2.4.1 Conventional procedures for detecting bacteremia and bacteriuria	150
2.4.2 Impedance-based procedures	151
2.4.3 Conductance-based Malthus system	152
2.5 Antimicrobial susceptibility testing	153
2.6 Other applications	156
3 Redox potential (ORP) measurements	156
3.1 Introduction	156
3.2 Validity of the concept of ORP in microbial cultures	157
3.3 Redox probes and reference electrodes	158
3.4 Tentative analysis of ORP variations in microbial cultures	160
3.4.1 ORP and dissolved oxygen	160
3.4.2 ORP and specific redox couples	161
3.4.3 ORP and microbial growth	163
3.5 ORP and clinical microbiology	165
3.5.1 Detection of bacteria in biological samples by using ORP measurements	165
3.5.2 ORP and antimicrobial agents	166
3.5.2.1 Historical background	166
3.5.2.2 Application of the lipoic acid technique to the study and evaluation of antimicrobial effects of antibiotics	167
4 Dissolved oxygen and pH measurements	173
4.1 Dissolved oxygen measurements	173
4.2 pH measurements	176
5 Conclusion	178
References	180

CHAPTER 2 — *IN VIVO* DETERMINATIONS

2.1 CARBON FIBRE ELECTRODES	189
J. L. Taboureau and P. Blond	
1 Nerve tissue and neurotransmitters	190
2 Voltammetric techniques and electrodes	191
2.1 Voltammetry	191
2.2 Different voltammetric techniques used <i>in vivo</i>	193
2.3 Electrodes used <i>in vivo</i>	194
2.4 Modification of the electrode surface	194
3 Carbon fibre electrodes	195
3.1 Carbon fibres	195
3.1.1 Origin and use of carbon fibres	195
3.1.2 Structure and state of the surface of carbon fibres	196
3.2 Carbon fibre electrodes	197
3.2.1 Preparation of the electrode	197
3.2.2 Characteristics of the carbon fibre electrode	199
3.3 Chemical and electrochemical treatments of carbon fibre electrodes	200

3.3.1 Chemical treatments	200
3.3.2 Electrochemical treatments	201
4 Results obtained <i>in vivo</i>	202
4.1 Implantation techniques	202
4.2 Compounds synthesized by dopaminergic neurones	203
4.2.1 Detection of dopamine	204
4.2.2 Dopac and homovanillic acid	204
4.3 Compounds synthesized by noradrenergic neurones	205
4.4 Compounds synthesized by serotonergic neurones	205
5 Conclusions concerning the detection of monamine derivatives	206
6 Other applications of carbon fibres	207
A1 Metabolism of catecholamines and serotonin	208
References	209
 2.2 ION-SELECTIVE MICROELECTRODES	 215
D. Michel and P. Blond	
1 Introduction	215
2 Li ⁺ -selective microelectrodes	218
3 Mg ²⁺ -selective microelectrodes	220
3.1 Fabrication	221
3.2 Characteristics	221
3.3 Experiments	222
3.4 Conclusion	222
4 Ca ²⁺ -selective microelectrodes	223
4.1 Alkylphosphate sensor	224
4.2 Neutral ligand ETH 1001	226
4.3 Experiments	232
4.4 Discussion and conclusion	233
5 Cl ⁻ -selective microelectrodes	234
5.1 Solid-state chloride microelectrodes	234
5.2 Liquid Cl ⁻ -exchanger microelectrodes	235
5.3 Experiments	240
5.4 Conclusion	240
6 Na ⁺ -selective microelectrodes	241
6.1 Na ⁺ -selective glass microelectrodes	241
6.1.1 Description	241
6.1.2 Characteristics	242
6.1.2.1 Hinke-type electrode	242
6.1.2.2 Inverted-type microelectrode	242
6.1.2.3 Recessed-tip microelectrodes	243
6.1.3 Experiments	244
6.2 Na ⁺ -selective liquid ion exchanger microelectrodes	245
6.2.1 Monensin	245
6.2.2 Tetraphenylborate	246
6.2.3 Neutral ligand ETH 227	247
6.3 Discussion and conclusion	250
7 K ⁺ -selective microelectrodes	252

7.1 K ⁺ -selective glass microelectrodes	252
7.2 K ⁺ -selective microelectrodes based on ionized K ⁺ exchanger	253
7.2.1 Single-barrelled microelectrodes	253
7.2.1.1 Classical single-barrelled microelectrodes	253
7.2.1.2 Side-pore microelectrodes	256
7.2.1.3 Micro ion-selective field effect transistor	257
7.2.2 Double- and triple-barrelled K ⁺ -sensitive microelectrodes	258
7.2.2.1 Double-barrelled microelectrodes	258
7.2.2.2 Coaxial microelectrodes	260
7.2.2.3 Triple-barrelled microelectrodes	261
7.3 K ⁺ -selective microelectrodes based on neutral carriers	262
7.3.1 Valinomycin-based K ⁺ -selective microelectrode	262
7.3.2 Microelectrodes based on a new bis(crown ether)	263
7.4 Conclusion	265
8 pH-selective microelectrodes	266
8.1 Glass pH microelectrodes	266
8.1.1 Recessed-tip glass pH microelectrodes	266
8.1.1.1 Single-barrelled microelectrodes	266
8.1.1.2 Double-barrelled microelectrodes	268
8.1.1.3 Coaxial double-barrelled microelectrodes	269
8.1.2 Spear-type or Hinke-type microelectrodes	270
8.2 Antimony microelectrodes	272
8.3 Liquid ion-exchanger pH microelectrodes	275
8.4 Conclusion	277
9 General conclusion	277
References	278
2.3 HPLC WITH ELECTROCHEMICAL DETECTION	284
P. Blond	284
1 Dialysis procedure	284
1.1 Transcerebral dialysis	284
1.2 The dialysis loop	285
1.3 The dialysis cannula	286
1.4 Dialysis membranes	287
1.5 Perfusion assembly	288
1.6 Histological control	289
1.7 <i>In vitro</i> recovery testing probes	290
2 HPLC assembly	291
2.1 Conventional HPLC-EDT	291
2.2 Perfusion systems connected on-line to analytical systems	292
3 Neurochemical results	292
3.1 Pharmacological investigations	292
3.2 Comparative studies	295
4 Conclusion	297
References	297
Index	300