LIST OF TABLES

Table 1.1:	Seizures of drugs in kilogram equivalent according to regions in 2009	6
Table 2.1:	Specific purposes or reasons of adulterants or cutting agents in heroin	43
Table 2.2:	Pharmacological effects of heroin in human body	49
Table 3.1:	Color changes upon reacting with various opium-based alkaloids in Marquis, Mecke and Frohde tests	62
Table 3.2:	Common types of compounds found in illicit heroin	76
Table 3.3:	Comparison of two procedures involved in the intelligence process	96
Table 4.1:	Instruments employed for the profiling of heroin	121
Table 4.2:	Police information and case background of a single heroin case	124
Table 4.3:	Color categories for the description of heroin substance	127
Table 4.4:	Texture categories for the description of heroin substance	128
Table 4.5:	General morphology of plastic wrapping styles defined by seal, margin and portion	129
Table 4.6:	Contents (%) of eight target components in eight pre-cut samples	143
Table 4.7:	Composition of post-cut samples generated from eight pre-cut samples	144
Table 4.8:	Proportions of pre-cut sample and cutting agents for five simulated links using the sample weight equivalent 15 mg heroin base approach	153
Table 4.9:	Proportions of pre-cut sample and caffeine for five simulated links using the constant 650 mg weight approach	154
Table 4.10:	Operating parameters for the ICP-MS	155
Table 5.1:	Examples of substance color varieties encountered in 311 heroin cases	170
Table 5.2:	Frequency of seal patterns and seal clarity according to the number of seals	178

Table 5.3:	Reproducibility of a batch of 12 empty plastic packets	182
Table 5.4:	Polymer types distinguished by ATR-FTIR	191
Table 5.5:	Normalized data and original peak intensities in parentheses of four selected peaks obtained from Spots 1 and 2 of specimen marked 'A'	198
Table 5.6:	RSD (%) of original peak intensities and normalized peaks for specimens B	200
Table 5.7:	GC-FID parameters for quantitative determination of eight target compounds	210
Table 5.8:	RSD (%) of area ratios (peak relative to IS) for eight target compounds, each at approximately 0.1 mg/mL in different solvent combinations (n = 6)	213
Table 5.9:	RSD (%) of peak areas and area ratios (peak relative to IS) for a standard mixture injected on the same day, within 28 hours and on ten different days	215
Table 5.10:	Linearity of the study range and LOD of the instrument	216
Table 5.11:	Recovery (%) for eight target compounds	217
Table 5.12:	Total % analyte content ± standard deviation for three samples prepared in PTs and VFs	218
Table 5.13:	Cumulative RSD (%) of area ratios of eight major components obtained within a month	220
Table 5.14:	Description of case samples considered for analysis	221
Table 5.15:	Validation results for Option 2 (NCM)	226
Table 5.16:	Cutting efficiency shown by the regression line between % acetycodeine quantified versus % pre-cut sample added	236
Table 5.17:	Compositional comparison of post-cut samples	237
Table 5.18:	Intra-sample RSD (%) based on the analyte content for n-number of uncolored and colored post-cut samples	239
Table 5.19:	Intra-sample RSD (%) based on the analyte content for two similar cutting processes	240
Table 5.20:	Pretreatment methods for GC-FID data (N_{sum} and $N_{selected}$ respectively are the individual variable-*i*, SD_i = standard deviation of that variable-*i*)	242

Table 5.21:	Loadings of the first three principal components of 11 $N_{selected}$ + S data of 216 simulated samples	244
Table 5.22:	Summary of classification with cross-validation for 216 simulated samples	245
Table 5.23:	Number of samples erroneously clustered and the d_m value in parenthesis obtained with 216 simulated samples analyzed by HCA	247
Table 5.24:	GC-MS parameters for qualitative determination of eight target compounds	253
Table 5.25:	RSD (%) of RRT obtained from a mixed standard and ten different spiked samples	254
Table 5.26:	A comparison between the LODs obtained with GC-MS and GC-FID	255
Table 5.27:	Statistical parameters for the % analytes of eight target components in the heroin case samples, excluding zero values (absence)	260
Table 5.28:	Pearson correlation, r^2 of five opium-based alkaloids	261
Table 5.29:	Area differences or the degrees of dissimilarity expressed by BC1, BC2 and BC3	269
Table 5.30:	Parameters of 9 heroin samples	272
Table 5.31:	Differences in the total areas/degrees of dissimilarity between 9 samples	273
Table 5.32:	Tentative identities of 12 significant impurity peaks	283
Table 5.33:	RSD (%) of area ratios (peak relative to IS) for 12 impurities found in Samples B and C and a control sample analyzed at six injection volumes (n = 4)	286
Table 5.34:	RSD (%) of area ratios (peak relative to IS) for 12 impurities found in Samples A, B and C analyzed at four injector temperatures (n = 4)	288
Table 5.35:	Comparison of the mean recoveries (%) between four different normality strengths of sulfuric acid calculated from three validation sample extracts	292
Table 5.36:	Recovery (%) in the first and second extracts of Sample B with 2 N sulfuric acid	292
Table 5.37:	Repeatability and reproducibility in RSD (%) and r^2 value for the linearity obtained from Samples A, B and C	296

Table 5.38:	Repeatability and reproducibility in RSD (%) and linear range, equation, r^2 value for the linearity, LOD, LOQ and practical LOQ obtained from a control sample	298
Table 5.39:	Extraction reproducibility (n = 6) in RSD (%) for Samples A, B and C	300
Table 5.40:	GC-FID parameters and liquid-liquid extraction for semi-quantitative determination of 12 target impurities	301
Table 5.41:	Variation in RSD (%) encountered in the simulated datasets analyzed by GC-FID using the sample weight equivalent to 15 mg heroin base sample weight approach and the 650 mg constant weight approach	304
Table 5.42:	Pretreatment methods for GC-FID impurity data	305
Table 5.43:	Loadings of the first three principal components of 12 N + S data of 55 simulated samples	307
Table 5.44:	Summary of classification with cross-validation for 55 simulated samples	308
Table 5.45:	Number of samples erroneously clustered and the d_m value in parenthesis obtained with 55 simulated samples analyzed by HCA	309
Table 5.46:	Loadings of the first three principal components of 12 N + S data of 25 simulated samples	312
Table 5.47:	Number of samples erroneously clustered and the d_m value in parenthesis obtained with 25 simulated samples analyzed by HCA	312
Table 5.48:	Number of samples grouped according to the cluster	314
Table 5.49:	Summary of classification with cross-validation for 25 simulated samples	315
Table 5.50:	Statistical parameters for 12 impurity peaks found in 252 heroin case samples, excluding zero values (absence)	319
Table 5.51:	Statistical parameters for 12 impurity peaks found in 46 heroin case samples, excluding zero values (absence)	323
Table 5.52:	RSD (%) for the repeatability and reproducibility of 20 elements in a mixed standard and a QC sample	328
Table 5.53:	Analytical figures of merit (n = 6)	331
Table 5.54:	Recovery (%) for 20 trace elements from the street heroin sample matrix	332

Table 5.55:	Sample precision in RSD (%) and r^2 determined from three random samples	333
Table 5.56:	Concentration differences of the elements from three samples	337
Table 5.57:	Variation in RSD (%) encountered in the dataset containing 6 batches of related samples analyzed by ICP-MS	341
Table 5.58:	Pretreatment methods for ICP-MS data	342
Table 5.59:	Loadings of the first three principal components of 16 N + 4R data of 48 samples	344
Table 5.60:	Number of samples erroneously clustered and the d_m value in parenthesis obtained with 48 samples analyzed by HCA	344
Table 5.61:	Summary of elemental content (ppb) found in 309 street heroin and 103 water samples	350
Table 5.62:	Comparison of elemental content (ppb) between tap water and water from a rusty container	353
Table 5.63:	Pearson correlation coefficients, r^2 between 16 target elements found in 309 street heroin samples	355
Table A1:	Physical and chemical properties of heroin	371
Table A2:	Physical and chemical properties of codeine	372
Table A3:	Physical and chemical properties of morphine	373
Table A4:	Physical and chemical properties of thebaine	374
Table A5:	Physical and chemical properties of papaverine	375
Table A6:	Physical and chemical properties of noscapine	376
Table A7:	Physical and chemical properties of acetylcodeine	377
Table A8:	Physical and chemical properties of 6-monoacetylmorphine	378
Table A9:	Normalized figures for alkaloids and cutting agents	381
Table A10:	Summary of the percentage recovery (%) for the first extracts of three validation samples at four chosen acid strengths	388