THE ANALYSIS OF CONTROLLED SUBSTANCES

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For Mum, Dad and Ania, for all of their love, support and encouragement

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Series Preface

There has been a rapid expansion in the provision of further education in recent years, which has brought with it the need to provide more flexible methods of teaching in order to satisfy the requirements of an increasingly more diverse type of student. In this respect, the *open learning* approach has proved to be a valuable and effective teaching method, in particular for those students who for a variety of reasons cannot pursue full-time traditional courses. As a result, John Wiley & Sons, Ltd first published the Analytical Chemistry by Open Learning (ACOL) series of textbooks in the late 1980s. This series, which covers all of the major analytical techniques, rapidly established itself as a valuable teaching resource, providing a convenient and flexible means of studying for those people who, on account of their individual circumstances, were not able to take advantage of more conventional methods of education in this particular subject area.

Following upon the success of the ACOL series, which by its very name is predominately concerned with Analytical *Chemistry*, the *Analytical Techniques in the Sciences* (AnTS) series of open learning texts has been introduced with the aim of providing a broader coverage of the many areas of science in which analytical techniques and methods are now increasingly applied. With this in mind, the AnTS series of texts seeks to provide a range of books which will cover not only the actual techniques themselves, but *also* those scientific disciplines which have a necessary requirement for analytical characterization methods.

Analytical instrumentation continues to increase in sophistication, and as a consequence, the range of materials that can now be almost routinely analysed has increased accordingly. Books in this series which are concerned with the *techniques* themselves will reflect such advances in analytical instrumentation, while at the same time providing full and detailed discussions of the fundamental concepts and theories of the particular analytical method being considered. Such books will cover a variety of techniques, including general instrumental analysis, spectroscopy, chromatography, electrophoresis, tandem techniques,

electroanalytical methods, X-ray analysis and other significant topics. In addition, books in the series will include the *application* of analytical techniques in areas such as environmental science, the life sciences, clinical analysis, food science, forensic analysis, pharmaceutical science, conservation and archaeology, polymer science and general solid-state materials science.

Written by experts in their own particular fields, the books are presented in an easy-to-read, user-friendly style, with each chapter including both learning objectives and summaries of the subject matter being covered. The progress of the reader can be assessed by the use of frequent self-assessment questions (SAQs) and discussion questions (DQs), along with their corresponding reinforcing or remedial responses, which appear regularly throughout the texts. The books are thus eminently suitable both for self-study applications and for forming the basis of industrial company in-house training schemes. Each text also contains a large amount of supplementary material, including bibliographies, lists of acronyms and abbreviations, and tables of SI Units and important physical constants, plus where appropriate, glossaries and references to literature sources.

It is therefore hoped that this present series of textbooks will prove to be a useful and valuable source of teaching material, both for individual students and for teachers of science courses.

Dave Ando
Dartford, UK

Preface

The control of drugs is an emotive issue and has been, and will continue to be, the subject of much debate. Many drugs have medical uses and these, and others, are also used for 'recreational' purposes. A large number are also subject to control at both national and international levels. Many are addictive and their use can sometimes result in antisocial behaviour. Furthermore, their use is often associated with significant health risks, where these are known. It is not the intention of this present book to debate the 'rights and wrongs' of drug control and use. While drugs remain controlled, it will be necessary, within the legal context, for the forensic scientist to carry out a number of types of analyses, including the following:

1. Determine whether or not a controlled substance is present.
2. Determine how much of the substance is present.
3. Determine, on occasion, the relationship of drug samples to each other.

Drug analysis is one of the areas of forensic science where it is necessary to carry out an analytical investigation, in this case to prove whether a controlled substance is present or otherwise. In order to achieve this, a number of analyses are required, which must conform to the highest scientific standards. It is the aim of this text to illustrate the analyses that must be undertaken and why, to explain the processes and their underlying chemistry, and to give the reader an insight into why each of the analyses is performed. The book is not exhaustive in describing all of the methods that are available – there is a huge body of scientific literature available, including research methods that have not yet found casework applications. The choice of method will depend upon the resources and equipment available to the analyst, the legislative system in which the analyst is working and the questions being asked. The first chapter outlines the legal context of the analyses, while each of the subsequent chapters describe methods which

can be applied to individual classes of drugs. The methods that are described in this book have, however, been used by the present author and in many examples the data are taken from casework materials, with the methods being known to work. By applying the principles described, the analyst should arrive at sound findings in terms of a particular analysis.

It would not have been possible to write this book without the support and encouragement of a great number of people, including colleagues and friends from around the world, and my family. For this, I thank them all.

Mike Cole
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Acronyms, Abbreviations and Symbols

General

AU	absorbance unit
CNS	central nervous system
DNA	deoxyribonucleic acid
ENFSI	European Network of Forensic Science Institutes
FTIR	Fourier-transform infrared (spectroscopy)
GC-ECD	gas chromatography, employing electron-capture detection
GC-FID	gas chromatography, employing flame-ionization detection
GC–MS	gas chromatography–mass spectrometry
HIV	human immunodeficiency virus
HPLC	high performance liquid chromatography
i.d.	internal diameter
IR	infrared
LLE	liquid–liquid extraction
PPE	personal protective equipment
QA	quality assurance
SIM	selected-ion monitoring
SPE	solid-phase extraction
TIC	total ion current
TLC	thin layer chromatography
UNDCP	United Nations Drug Control Programme
UV	ultraviolet

d_f	film thickness (of chromatography column)
M_r	relative molecular weight

m/z	mass-to-charge ratio
R	correlation coefficient
R^2	coefficient of determination
R_f	retardation factor (or relative front value)
t_R	retention time (chromatography)
λ_{max}	wavelength of maximum absorption in a UV spectrum

Chemical Species

BMK	benzyl methyl ketone
BSTFA	bis(trimethylsilyl)trifluoroacetamide
CBD	cannabidiol
CBN	cannabinol
TMS	trimethylsilyl
THC	tetrahydrocannabinol
LSD	lysergic acid diethylamide
MDA	3,4-methylenedioxyamphetamine
MDEA	3,4-methylenedioxyethylamphetamine
MDMA	3,4-methylenedioxymethylamphetamine
MSTFA	*N*-methyl-*N*-(trimethylsilyl)-2,2,2-trifluoroacetamide
N,O-BSA	*N*,*O*-bis(trimethylsilyl)acetamide
ODS	octadecasilyl
PCP	phencyclidine
HFBA	heptafluorobutyric anhydride

About the Author

Michael D. Cole, B.A. (Hons) Cantab., Ph.D.

Michael Cole graduated from the University of Cambridge in 1986 with a degree in Natural Sciences. From there his career progressed when he obtained a Ph.D. in Natural Product Chemistry from the University of London in 1990, having studied both at this university and The Royal Botanic Gardens, Kew, UK. In 1990, he joined the staff of the Forensic Science Unit at the University of Strathclyde as a short-course tutor, from where he progressed to Director of the Unit in 2000. In July 2001, Michael was appointed Professor of Forensic Science at Anglia Polytechnic University, Cambridge, where he now heads the Department of Forensic Science and Chemistry.

In addition to university duties, Michael was chairman of the European Network of Forensic Science Institutes Working Group on Drugs and Lead Assessor for the Council for the Registration of Forensic Practitioners Drugs Section, and has undertaken drug-related forensic casework in the UK and overseas. He has published a number of papers on drug analysis, particularly in the area of methods of drug identification and profiling.

Teaching and training in forensic science has always interested Michael and he has developed a number of short courses and integrated lecture courses, with a particular emphasis on drug analysis. These have been delivered in the UK, Europe, North and South America and in the Far East. Michael is particularly keen to continue to develop the educational provision in this discipline.

Chapter 1

Introduction to Drug Trends, Control, Legislation and Analysis

Learning Objectives

- To appreciate the problem of increasing drug use.
- To be aware of the international legislation relating to drugs.
- To be aware of the legislation in relation to the control of drugs in the United Kingdom, the United States and Australia.
- To appreciate the role of the drugs chemist in drugs analysis.
- To understand the need for quality assurance in the drugs laboratory.
- To gain an understanding of the ways to facilitate evidence presentation in court.

1.1 Introductory Remarks

The problems associated with psychotropic drugs and controlled substances have been, and continue to be, the subject of much debate. Regardless of one's views, however, there remains the fact that a number of drugs are *controlled substances*. There is now a considerable body of evidence that the number of people using controlled substances for non-medical purposes is increasing. Data from the United Kingdom (Figure 1.1) is mirrored by that collected from the international community.

Within the legal and forensic science context, in order to prove that an offence has been committed, it is necessary to prove that a drug is present, and, if required, to determine the amount of the drug and its relationship to other samples. It is essential for those working in this area to understand how such analyses are

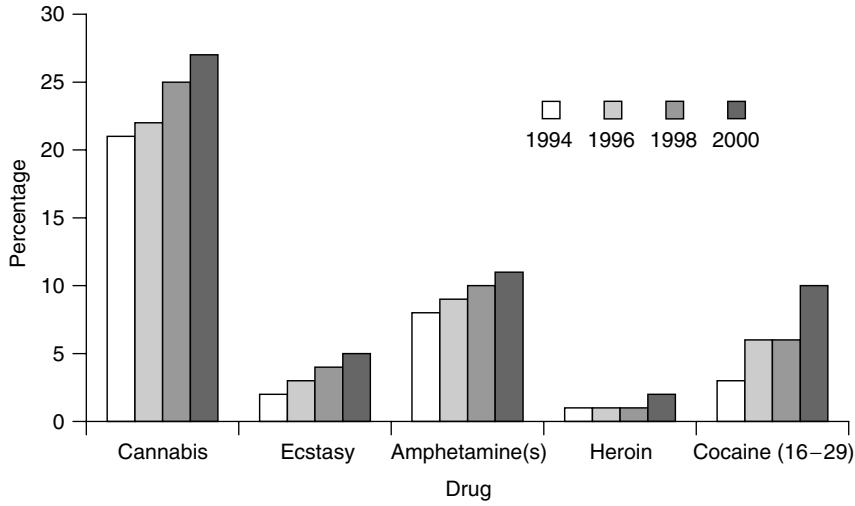

Figure 1.1 Percentage of 16–59 year-olds in the United Kingdom who claim to have used drugs – 'ever' (16–29 year-olds in the case of cocaine) [1].

carried out. In order to select, and critically evaluate, such analyses, it is also necessary to have an overview of the corresponding legislation in the jurisdiction in which one is working.

1.2 International Legislation

Within the international context, controls on drugs are set out in three treaties issued by the United Nations, namely:

1. The Single Convention on Narcotic Drugs, 1961.
2. The Convention on Psychotropic Substances, 1971.
3. The Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, 1988.

Signatories to these treaties implement control through domestic laws. In the United Kingdom, the principle legislative document for drug control is the *Misuse of Drugs Act, 1971*. This has been the subject of 14 modification orders and is accompanied by the *Misuse of Drugs Act (Regulations), 1985*, which was superceded by the *Misuse of Drugs Act (Regulations), 2001*.

Within the United States, the situation is further complicated because drugs are scheduled at the Federal level, but there may also be legislation at the State and County levels.