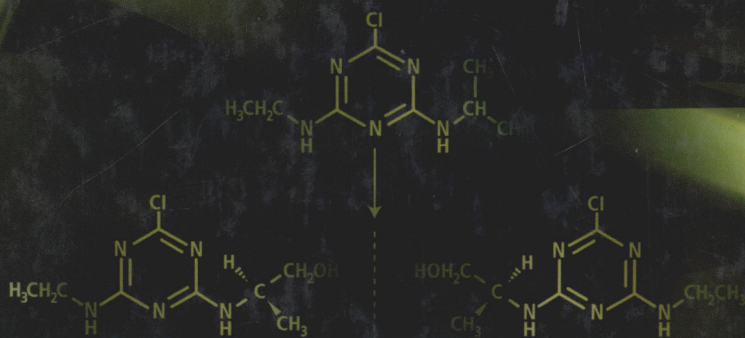


Imran Ali  
Hassan Y Aboul-Enein

# Chiral [C<sub>10</sub>H<sub>12</sub>N<sub>4</sub>Cl] Pollutants

DISTRIBUTION, TOXICITY AND ANALYSIS  
BY CHROMATOGRAPHY  
AND CAPILLARY ELECTROPHORESIS



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# Chiral Pollutants: Distribution, Toxicity and Analysis by Chromatography and Capillary Electrophoresis

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and Capillary  
Electrophoresis

# Dedication

Dedicated to the memories of my late parents:  
Basheer Ahmed and Mehmudan Begum

*Imran Ali*

To my loving family:  
Nagla, Youssef, Faisal and Basil  
for their support and encouragement

*Hassan Y. Aboul-Enein*

# Preface

One of the two enantiomers of a chiral pollutant may be more toxic than the other, and about 25 % of agrochemicals are chiral in nature – including pesticides, which are applied in agricultural and forestry activities in the form of their racemates. The biological transformation of chiral pollutants can be stereoselective, such that the uptake, metabolism and excretion of the enantiomers may be very different. Therefore, the enantiomeric composition of chiral pollutants may be changed during these processes. The metabolites of chiral compounds are often chiral. Therefore, to predict the exact toxicities of pollutants, determination of the concentrations of both enantiomers is essential, and hence environmental scientists are eagerly seeking techniques for their analysis. Moreover, diverse groups of people – ranging from regulators to the materials industries, clinicians and nutritional experts, agriculturalists and environmentalists – are also now demanding data on the ratio of pollutant enantiomers, rather than their total concentrations.

Various approaches to chiral resolution have been developed for the analysis of pharmaceuticals and drugs but, unfortunately, few reports and monographs are available on the chiral separation of pollutants. Therefore, we have set out to write this book, which deals with the distribution, toxicities and art of analysis of chiral pollutants by gas chromatography and liquid chromatography; that is, by high performance liquid chromatography (HPLC), sub- and supercritical fluid chromatography (SFC),

capillary electrochromatography (CEC) and thin layer chromatography (TLC). Additionally, a chapter has been included on the chiral analysis of pollutants by capillary electrophoresis. This book also describes the types, structures and properties of chiral stationary phases, and the applications and future scope of chiral resolution. Moreover, we have attempted to explain the optimization of chiral analysis, which will be helpful in the design of future experiments in this area. Attempts have also been made to explain chiral recognition mechanisms in detail. We very much hope that this book will be a useful source of information for scientists, researchers, academics and graduate students who are working in the field of the chiral analysis of pollutants.

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I must also pay my sincere and respectful thanks to Professor Vinod K. Gupta, Department of Chemistry, Indian Institute of Technology, Roorkee, India, who helped me to complete this book. Moreover, his moral support, which I received continuously, has been the biggest help and the most memorable event in my life. Finally, the administration of the National Institute of Hydrology, Roorkee, India is also acknowledged for allowing me to write this book.

*Imran Ali*

I would like to express my thanks to the administration of the King Faisal Specialist Hospital and Research Centre for their support of this work. Special thanks are extended to Ms Jennifer Cossham and the editorial staff of John Wiley & Sons, Ltd, for their assistance in publishing this book. I am particularly grateful to my wife, Nagla El-Mogaddady, for her forbearance and support throughout the preparation of this book, and it is to her that I extend my deepest gratitude.

*Hassan Y. Aboul-Enein*

## About the Book

This book describes the distribution and toxicity of, and analytical techniques for, environmental chiral pollutants. The techniques discussed are gas and liquid chromatography and capillary electrophoresis, the different liquid chromatographic approaches being high performance liquid chromatography (HPLC), sub- and supercritical fluid chromatography (SFC), capillary electrochromatography (CEC) and thin layer chromatography (TLC). This book is divided into ten chapters. The first chapter is an introduction to the principles of chirality. This is followed by Chapters 2–9, which discuss the distribution, toxicity, sample preparation and chiral resolution of environmental pollutants by chromatography and capillary electrophoresis, and include details of the distribution, toxicities, sample preparation and analysis of chiral pollutants. Moreover, optimization of the experimental parameters of chromatographic and capillary electrophoretic techniques is also discussed, and hence this book may be considered as an applied text in the area of chiral pollutant analysis. Discussions have also been included on the types, structures and properties of chiral stationary phases and their applications to the analysis of chiral pollutants. Chiral recognition mechanisms have also been considered, which may be useful in the design of future research in this field of study. The final chapter considers the regulatory framework with regard to chirality around the world, together with perspectives on the large-scale production of pure enantiomers and the impact of chirality on economic growth.

## About the Authors

Dr Imran Ali obtained his M.Sc. (1986) and Ph.D. (1990) degrees from the Indian Institute of Technology, Roorkee, India. At present, he is working as a Scientist in the National Institute of Hydrology, Roorkee, India. His research areas of interest are the chiral analysis of biologically and environmentally active chiral compounds, and metal ion speciation using chromatographic and capillary electrophoresis techniques. He also has expertise in water quality and wastewater treatment methodologies. Dr Ali is the author or co-author of more than 70 journal articles, book and encyclopedia chapters, and of a book entitled *Chiral Separations by Liquid Chromatography and Related Technologies*, published by Marcel Dekker, Inc., in New York. Dr Ali has been awarded a 'Khosla Research Award – 1987' by The Indian Institute of Technology, Roorkee, India, for work on the chiral resolution of amino acids. He is a life member of the Indian Science Congress Association.

Professor Hassan Y. Aboul-Enein is a Principal Scientist and Head of the Pharmaceutical Analysis and Drug Development Laboratory at King Faisal Specialist Hospital and Research Centre, Riyadh, Saudi Arabia. He is the author or co-author of over 500 refereed journal articles, 30 book chapters and 270 conference presentations. He is the author of six books, including *Chiral Separation by Liquid Chromatography and Related Technologies* (Marcel Dekker, Inc.) and *The Impact of Stereochemistry on Drug Development and Use* (John Wiley & Sons, Ltd). He is a member of the

Editorial Board of several journals, including *Talanta*, *Chirality*, *Biomedical Chromatography*, *Analytical Letters*, *Talanta* and *Chromatographia*.

Professor Aboul-Enein is a member of the World Health Organization (WHO) advisory panel on international pharmacopeia and pharmaceutical preparations, and he is a Fellow of the Royal Society of Chemistry (UK). He received his B.Sc. degree (1964) in pharmacy and pharmaceutical chemistry from Cairo University, Cairo, Egypt, and his M.Sc. (1969) and Ph.D. (1971) degrees in pharmaceutical and medicinal chemistry from the University of Mississippi, Oxford, USA. Professor Aboul-Enein's current research interests are in the field of pharmaceutical and biomedical analysis and drug development, with a special emphasis on chiral chromatography, ion-selective electrodes and other separation techniques.

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# Chapter 1

## Introduction

### 1.1 The Importance of the Environment

The growth, health and persistence of human beings and other organisms all depend on the quality of the environment. Therefore, conservation and protection of the environment are essential in the present-day industrialized and developing world. Unfortunately, pollution of the environment is one of the most pressing problems of our age. The problem of the environment has now reached a level that poses a potential threat not only to health but also to entire populations. The quality of our environment is deteriorating day by day, due to the continuous discharge of undesirable constituents. The main sources of the contamination are the geometric increase in the global population, industrialization, domestic and agricultural activities, atomic explosions, and other environmental and global changes. If they are not properly controlled, these activities and changes can destroy the quality of our environment. Broadly, the environment is divided into three parts: the atmosphere, including the air sphere around the Earth; the lithosphere, which consists of the Earth itself; and the hydrosphere – all the water bodies, including the oceans and the surface and ground water. The hydrosphere and atmosphere components of the environment are directly and readily available for contamination by pollutants. Therefore, the quality of these components of the environment is deteriorating continuously, which is a matter of great concern. Again, the notorious pollutants find their way easily through water bodies and reach various levels in the food chain. The