



Next-Generation Forensic Pesticide Analysis: Ionic Liquids, Green Chemistry and Computational Intelligence



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*Shakshi Tyagi and Vaishalli contributed equally to this work
and share first authorship*

Book Editor : Shubham Yadav

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Preface

The rapid evolution of forensic analytical chemistry has created an urgent need for innovative, sustainable, and highly selective analytical methodologies capable of addressing emerging chemical challenges. In recent years, the development of third-generation pesticides, advances in green analytical chemistry, and the growing complexity of forensic investigations have collectively reshaped the landscape of modern analytical science. This book has been conceived to provide a comprehensive and forward-looking perspective on the integration of ionic liquid-based technologies into forensic and environmental pesticide analysis, reflecting both current scientific progress and future research directions.

Traditional extraction and analytical approaches, although foundational to forensic science, increasingly face limitations related to selectivity, environmental sustainability, solvent consumption, and matrix complexity. Ionic liquids, often described as “designer solvents,” present a transformative alternative owing to their tunable physicochemical properties, negligible vapor pressure, and potential compatibility with green chemistry principles. By bridging fundamental chemistry with applied analytical methodologies, this book aims to demonstrate how ionic liquid-based systems can enhance extraction efficiency, improve analytical performance, and support environmentally responsible forensic practices.

The chapters are organized to guide readers progressively from foundational concepts toward advanced applications. Beginning with the chemistry, toxicology, and analytical challenges associated with modern pesticides, the text introduces the fundamental principles of ionic liquids, mechanistic insights into extraction processes, and diverse methodologies tailored for complex forensic matrices. Subsequent sections explore the integration of ionic liquid extraction with conventional analytical platforms, evaluation of analytical performance, real-world case studies, sustainability considerations, and the emerging role of automation, artificial intelligence, and computational design in shaping next-generation analytical workflows.

This volume is intended for researchers, forensic scientists, analytical chemists, and graduate students seeking an interdisciplinary understanding of green extraction technologies and their practical implementation in forensic and environmental analysis. By combining theoretical foundations with applied perspectives, the book seeks to serve not only as a reference resource but also as a catalyst for innovation in analytical science.

The editors and contributors hope that this work will encourage the scientific community to embrace sustainable analytical strategies while maintaining the rigor and reliability required for forensic investigations. Ultimately, the vision behind this book is to inspire the development of intelligent, environmentally conscious, and technologically advanced analytical workflows that meet the evolving demands of modern science and society.

Acknowledgement

The authors would like to express their sincere gratitude to all researchers and scientists whose work in forensic chemistry, pesticide analysis, ionic liquids, and green analytical chemistry formed the foundation of this book. We are grateful to our teachers and mentors for their guidance, encouragement, and academic support throughout this journey.

We also thank our colleagues and peers for their valuable discussions and insights, and our families for their patience and unwavering support. Finally, we acknowledge the forensic and analytical science community, whose ongoing efforts toward sustainable and reliable methodologies continue to inspire scientific progress.

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ABOUT THE AUTHORS



Shakshi Tyagi is a forensic science researcher and PhD scholar with academic training in forensic toxicology and analytical chemistry. She holds Bachelor's and Master's degrees in Forensic Science from SGT University. Her research interests include forensic pesticide analysis, environmental toxicology, and advanced analytical techniques. With hands-on experience in chromatographic and spectrometric methods, she actively contributes to research publications and scientific conferences, aiming to integrate green chemistry and modern intelligence into next-generation forensic practices.



Vaishalli is an accomplished forensic science academician and researcher with specialized expertise in analytical toxicology and advanced instrumental techniques. She has earned her PhD with a research focus on new-generation pesticide extraction techniques, demonstrating strong proficiency in modern analytical methodologies and pesticide residue analysis. Currently serving as an Assistant Professor in the Department of Forensic Science, she is actively involved in teaching, research, and academic mentoring at the undergraduate and postgraduate levels. Her academic interests encompass forensic toxicology, analytical chemistry, environmental forensics, and the application of innovative laboratory techniques in forensic investigations. Dr. Vaishalli has contributed to scholarly research through publications in reputed journals, conference presentations, and academic collaborations. Her commitment to scientific rigor, methodological advancement, and skill-based forensic education is reflected in her teaching philosophy and research endeavors. This book represents her continued effort to bridge theoretical knowledge with practical forensic applications and to support capacity building among students, researchers, and forensic professionals.



Vinod Kumar, born on 13 January 1984 in Sultanpur district, Uttar Pradesh, obtained his M.Sc. in Chemistry from Dr. Ram Manohar Lohia Avadh University, Faizabad, in 2006 and his D.Phil. in Chemistry from the University of Allahabad in January 2012, with specialization in analytical chemistry. He worked as a UGC project fellow and later in polymer chemistry with Prof. Pradip K. Dutta at the Department of Chemistry, MNNIT Allahabad (2012–2014). He served as Senior Scientific Assistant at the Forensic Science Laboratory, Government of NCT of Delhi, and as research staff at the All India Institute of Medical Sciences (AIIMS), New Delhi (2014–2016). Since January 2016, he has been working in polymer chemistry at MNNIT Allahabad. He has published 16 research papers in national and international journals and has presented his work at several conferences. E-mail: vinodvishwakarma1984@gmail.com



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