

REVIEW

Miniature Mass Spectrometry for VOCs Analysis: Recent Developments in Instrumentation and Applications

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ABSTRACT

Rationale: Volatile organic compounds (VOCs) are critical indicators of environmental and biological processes and their analysis is essential for various applications, including environmental monitoring, food safety and clinical diagnostics.

Methods: Traditional mass spectrometry (MS) techniques, such as gas chromatography–mass spectrometry (GC–MS), are widely regarded as gold standards for VOCs detection. However, their lack of portability and limited real-time analytical capabilities hinder their widespread use in on-site and rapid detection applications. Miniature mass spectrometry has emerged as a promising solution by integrating compact instrumentation with innovative ionization techniques, including ultraviolet-based, plasma-based and electron ionization methods.

Results: Recent advancements in mini-MS have focused on enhancing portability, sensitivity and adaptability to complex sample matrices. These developments include the integration of novel sampling interfaces, such as membrane inlet and atmospheric pressure interfaces. Despite these advances, challenges remain in optimizing sensitivity, selectivity and compatibility with real-world samples.

Conclusions: This review synthesizes recent progress in the field of miniature mass spectrometry for VOCs analysis, emphasizing key technological innovations, such as ionization and sampling improvements, portable platform development. The review also explores mini-MS applications in food authenticity, clinical diagnostics, highlighting the growing potential of these technologies to revolutionize on-site, real-time VOCs detection across diverse fields.

1 | Introduction

Volatile organic compounds (VOCs) are key components of biomarkers [1] and environmental pollutants that impact air quality [2], human health [3] and industrial processes [4]. For trace VOC analysis, a variety of analytical techniques have been developed, including gas chromatography (GC), ion mobility spectrometry (IMS), electronic nose (E-nose) and Raman spectroscopy [4–8]. Among them, GC–MS remains one of the most recognized method due to its sensitivity and accuracy. Despite the excellent performance of lab-scale GC–MS, its limited portability, lack of real-time analysis capabilities and poor adaptability to complex matrices restrict its application in fields such as environmental

monitoring, food safety and clinical diagnostics, where rapid, on-site detection is essential.

In recent years, the development of mini-MS has overcome these challenges by integrating novel ionization techniques and compact instrumentation. Significant efforts have been dedicated to the miniaturization of MS for VOC analysis [9], focusing on sampling interfaces, ion sources, mass analyzers and integrated platforms to enhance portability, real-time detection and adaptability in diverse applications. The development of sampling interfaces for miniature mass spectrometers began with membrane inlet (MI) systems, which commercialized by various companies and are widely used for in situ

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**Swati Joshi,Ashok Pandey,Ranjna
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Italy in June 1986 The meeting was organized by the Institute of Forensic Medicine and the Laboratory of Medical Research of the University in cooperation with the Italian Group for Mass Spectrometry in Biochemistry and Medicine The aim of the symposium was bringing together people working in different branches of the wide field of modern analytical sciences for promoting interdisciplinary discussions and exchange of experiences Actually it was felt that most of the analytical problems that very often have to be faced in quite different fields chemistry pharmacology medicine biology have similar solutions that could be made much easier by closer contacts among researchers of these disciplines Original papers and invited reviews presented during the 3 days of the conference by leading experts gave an up to date outline of the modern analytical methods applied in pharmaceutical biomedical and forensic sciences and a glimpse of the future perspectives **Advances in**

Protein Molecular and Structural Biology Methods Timir Tripathi, Vikash Kumar Dubey, 2022-01-14 **Advances in Protein Molecular and Structural Biology Methods** offers a complete overview of the latest tools and methods applicable to the study of proteins at the molecular and structural level The book begins with sections exploring tools to optimize recombinant protein expression and biophysical techniques such as fluorescence spectroscopy NMR mass spectrometry cryo electron microscopy and X ray crystallography It then moves towards computational approaches considering structural bioinformatics molecular dynamics simulations and deep machine learning technologies The book also covers methods applied to intrinsically disordered proteins IDPs followed by chapters on protein interaction networks protein function and protein design and engineering It provides researchers with an extensive toolkit of methods and techniques to draw from when conducting their own experimental work taking them from foundational concepts to practical application Presents a thorough overview of the latest and emerging methods and technologies for protein study Explores biophysical techniques including nuclear magnetic resonance X ray crystallography and cryo electron microscopy Includes computational and machine learning methods Features a section dedicated to tools and techniques specific to studying intrinsically disordered proteins

Recent Advances in the Analysis of Marine Toxins, 2017-09-18 **Recent Advances in the Analysis of Marine Toxins** Volume 78 the newest release in the Comprehensive Analytical Chemistry series presents chapters from the best authors in the field making it an essential resource Updated sections in this new volume include topics such as The importance of toxin detection and quantification environmental issues public health food safety animal health bioterrorism bioactive compounds medical approach an LC MS MS analysis of marine toxins Animal bioassays identification of toxins and mechanism of action Receptor binding assays for the analysis of marine toxins Immunoassays and optical biosensors visual SPR fluorescence for marine toxins and Electrochemical biosensors for marine toxins Chapters in this ongoing series contain practical and useful information describing real advantages and limitations Experts in this field contribute based on their research and personal point of view Contains contributions from the best authors in the field Provides an essential resource for marine monitoring managers and scientific community **Analysis of Food Toxins and Toxicants, 2 Volume Set** Yiu-Chung Wong, Richard J.

Lewis, Sr.,2017-09-25 Analysis of Food Toxins and Toxicants consists of five sections providing up to date descriptions of the analytical approaches used to detect a range of food toxins Part I reviews the recent developments in analytical technology including sample pre treatment and food additives Part II covers the novel analysis of microbial and plant toxins including plant pyrrolizidine alkaloids Part III focuses on marine toxins in fish and shellfish Part IV discusses biogenic amines and common food toxicants such as pesticides and heavy metals Part V summarizes quality assurance and the recent developments in regulatory limits for toxins toxicants and allergens including discussions on laboratory accreditation and reference materials

Current Developments in Biotechnology and Bioengineering Swati Joshi,Ashok Pandey,Ranjna Sirohi,Sung Hoon Park,2022-04-29 Designer Microbial Cell Factories Metabolic Engineering and Applications the latest release in the Current Developments in Biotechnology and Bioengineering series provides a detailed overview of the biotechnological approaches and strategies used to generate engineered microbes and to facilitate the acceleration modulation and diversion of metabolic pathways to get desired output such as production of value added compound or biodegradation of xenobiotic pollutant The book also highlights applied aspects of designer microbes in fields as diverse as agriculture pharmaceuticals and bioremediation Designer microbes generated through reprogramming the microbial cell factories MCFs provide an edge over their natural counterparts in terms of increased molecular diversity and selective chemistry These bugs are becoming instrumental in several areas including agriculture environment and human health Engineering microbes through directed evolution not only gives freedom from evolutionary constraints but also allow introduction of regulated and foreseeable functions into MCFs Dedicated to the designing of microbes covering state of the art technological advancements in the field Includes applications of metabolic engineering in the field of agriculture bioremediation value added products therapeutics and more Contains chapters dedicated to innovative approaches surrounding engineered microbial consortia Provides comprehensive details and helps users understand concepts

Energy Research Abstracts ,1987 Current Developments in Biotechnology and Bioengineering Sunita Varjani,Ashok Pandey,R. D. Tyagi,Huu Hao Ngo,Christian Larroche,2020-02-18 Current Developments in Biotechnology and Bioengineering Emerging Organic Micropollutants summarizes the current knowledge of emerging organic micropollutants in wastewater and the possibilities of their removal elimination This book attempts a thorough and exhaustive discussion on ongoing research and future perspectives on advanced treatment methods and future directions to maintain and protect the environment through microbiological nanotechnological application of membrane technology molecular biological and by policymaking means In addition the book includes the latest developments in biotechnology and bioengineering pertaining to various aspects in the field of emerging organic micropollutants including their sources health effects and environmental impacts Includes testing methods for the analysis and characterization of emerging organic micropollutants in wastewater Discusses the environmental impact and health hazards of emerging organic micropollutants in wastewater Provides a useful

guide to identify priority areas of research demand in the remediation removal of emerging organic micropollutants **Drug**

Discovery and Evaluation: Pharmacological Assays Hans G. Vogel, 2002-06-13 Now expanded and updated to include molecular biology and genetic engineering techniques The second edition of this successful reference book contains a comprehensive selection of the most frequently used assays for reliably detecting the pharmacological effects of potential drugs Each of the more than 1000 assays comprises a detailed protocol outlining the purpose and rationale of the method a critical assessment of the results and their pharmacological and clinical relevance The enclosed and fully searchable CD ROM allows easy identification of specific tests An appendix with up to date guidelines and legal regulations for animal experiments in various countries will help the reader to plan experiments more effectively Time-Resolved Mass Spectrometry Pawel L. Urban, Yu-Chie Chen, Yi-Sheng Wang, 2016-03-21 Time is an important factor in physical and natural sciences It characterizes the progress of chemical and biochemical processes Mass spectrometry provides the means to study molecular structures by detecting gas phase ions with the unique mass to charge ratios Time resolved mass spectrometry TRMS allows one to differentiate between chemical states that can be observed sequentially at different time points Real time mass spectrometric monitoring enables recording data continuously with a specified temporal resolution The TRMS approaches introduced during the past few decades have shown temporal resolutions ranging from hours down to microseconds and beyond This text covers the key aspects of TRMS It introduces ion sources mass analyzers and interfaces utilized in time resolved measurements discusses the influence of data acquisition and treatment finally it reviews most prominent applications of TRMS in the studies of reaction kinetics and mechanism physicochemical phenomena protein structure dynamics biocatalysis and metabolic profiling It will assist science and engineering students to gain a basic understanding of the TRMS concept and to recognize its usefulness In addition it may benefit scientists who conduct molecular studies in the areas of chemistry physics and biology **Selected Water Resources Abstracts**, 1973 *Recent Developments in the Synthesis of Fatty Acid Derivatives* Johannes T. P. Derksen, 1999-09-30 Research scientists in both academia and industry will find this book useful An overview of recent synthetic work in the field of fatty acid chemistry is developed and directions for future work are pointed out Diverse derivatives and reactions are considered with a strong representation of epoxidation as a result of its salient position in the field Analysis of Cannabis, 2020-08-27 Analysis of Cannabis Volume 91 contains a wide variety of information on the analysis of cannabis and hemp including cannabinoids terpenes volatile solvents and metals Specific chapters in this new release include the Comprehensive Analytical Testing of Cannabis and Hemp Machine Learning Methods for Inferring Chemotype Profiles in Cannabis Sativa Recent Analytical Methodologies and Strategic Pharmacological Applications of Cannabinoids Analysis of Cannabinoids in Plants Marijuana Products and Biological Tissues LC based UV and MS Analysis of Cannabinoids Testing Cannabis Samples for Heavy Metal Contamination using Microwave Assisted Digestion and ICP MS Techniques Applications of GC MS Techniques for Cannabis

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