

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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Recent Developments in Mass Spectrometry in Biochemistry and Medicine Alberto Frigerio, 2012-12-06 The Place of Mass Spectrometry in Drug Metabolism Studies In vitro and in Vivo Studies on the Metabolism of Dibenzo c f 1 2 Diazepine Gas Chromatographic Mass Spectrometric Identification of Urinary Metabolites of Propildazine in Rat Mass Spectrometric Characterization of Sydnocarb and its Major Metabolites in Rat Metabolism of an Aryloxy Beta Blocking Drug Isolation and Identification of the Chloroform Soluble Urinary Metabolites of Suloctidil in Man Are Stable Sulfenic Acids Possible Metabolites of Suloctidil The Electron Impact Fragmentation of Products Related to N A Recent Developments in Applied Microbiology and Biochemistry Viswanath Buddolla, 2020-10-15 Recent Developments in Applied Microbiology and Biochemistry Vol 2 provides a comprehensive treatment and understanding on application oriented microbial concepts giving readers insights into recent developments in microbial biotechnology and medical agricultural and environmental microbiology Discusses microbial proteome analyses and their importance in medical microbiology Explores emerging trends in the prevention of current global health problems such as cancer obesity and immunity Shows recent approaches in the production of novel enzymes from environmental samples by enrichment culture and metagenomics approaches Guides readers through the status and recent developments in analytical methods for the detection of foodborne microorganisms

Nuclear Science Abstracts, 1972 **Recent Developments in the Synthesis and Applications of Pyridines**

Parvesh Singh, 2022-09-17 Recent Developments in the Synthesis and Applications of Pyridines is a comprehensive handbook for organic chemists working on innovative approaches to the synthesis of pyridines Written by scientists in both academia and industry and designed to be a standalone reference the book features reviews research results and case studies on synthetic methods and applications of pyridine based chemotypes The book will bridge the gap between industry and academia by presenting recent innovative approaches to the synthesis of pyridines diverse application of pyridines in drug development heterogeneous catalysis and material science as well as benchtop to shelf narratives of pyridine based compounds in the industry The role of computational chemistry in the development of pyridine based bioactive molecules is also included This reference is essential for researchers in organic chemistry both in academic and industrial settings postgraduates in chemistry and medicinal chemistry Includes a detailed review of recent research on the reactivity synthesis and applications of pyridines Features concise accounts of the reactivity synthetic and optimized protocols Discusses the medicinal inorganic and polymer chemistry applications of pyridines **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

Developments in Analytical Methods in Pharmaceutical, Biomedical, and Forensic Sciences G. Piemonte, F. Tagliaro, M. Marigo, 1988-01-31 The papers collected in this volume were presented at an International Conference that with the same heading was held at the Verona University 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 inter disciplinary 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 Developments in Nursing and Midwifery Recep Efe, Behire Sancar, 2018-10-23 This book includes multiple chapters related to themes on nursing and midwifery Some of the topics

explored here are clinical decision improving applications healthy and happy aging house accidents and first aid complementary and alternative medicine sleep quality in paediatric burn patients dyspnoea management in palliative care and personalized chemotherapy It provides essential information on the most important issues in nursing and midwifery including quality of life depression physical restraints and care dependency It offers several suggestions for future research in nursing basing its findings on surveys and scientific literature reviews This book will appeal to professional nurses nursing scientists nursing students scholars in health sciences and nursing medical center staff health sciences students and other healthcare professionals It will also provide a valuable resource for those working in nursing homes as well as researchers in the field

Selected Water Resources Abstracts ,1973 **Current Catalog** National Library of Medicine (U.S.),1982 First multi year cumulation covers six years 1965 70 **Analytical Toxicology for Clinical, Forensic and Pharmaceutical Chemists** Hans Brandenberger,Robert A. A. Maes,1997 No detailed description available for Analytical Toxicology for Clinical Forensic and Pharmaceutical Chemists *Energy Research Abstracts* ,1987 *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 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 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 **New Approaches in Liquid Chromatography** Huba Kalász, 1984 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 Microbial Proteomics: Development in Technologies and Applications Divakar Sharma, 2020-12-31 This volume brings current knowledge of proteomics technologies and related developments with special reference to diseases caused by microbes The editor has compiled chapters written by expert academicians which distill the information about useful methods in microbial proteomics for the benefit of readers Chapters cover several methods used to investigate the microbial proteome and special topics such as antimicrobial drug resistance mechanisms biomarker developments post translational modifications Key Features overview of several biochemical methods in proteomics full color high quality images of the most

frequent technologies and applications concise well organized and didactic format updates in basic applied information bibliographic references information on proteomics for tuberculosis treatment This reference work is intended for researchers seeking information on laboratory techniques applied in proteomics research and microbiology **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

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