

## REVIEW

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

Junhe Cao | Ting Jiang  | Wei Xu 

School of Medical Technology, Beijing Institute of Technology, Beijing, China

Correspondence: Ting Jiang (6120230052@bit.edu.cn) | Wei Xu (weixu@bit.edu.cn)

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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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*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

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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

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**Energy Research Abstracts**, 1987 *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

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