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## EDITORIAL

# A Special Issue of Mass Spectrometry Reviews to Honor Professor Renato Zenobi: A Lifetime of Mentorship and Innovation in Mass Spectrometry

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When Richard Cole (Editor in Chief *Mass Spectrometry Reviews*) reached out to us about coordinating a special issue to honor Renato Zenobi's remarkable career in mass spectrometry (MS), we did not hesitate for a moment. In hindsight, it has been both an honor and a pleasure to contribute to this well-deserved tribute, celebrating an exceptional career and its lasting impact on the field.

After earning his MSc degree at the ETH Zurich, Renato went overseas for a PhD at the Stanford University. After another few years of postdoctoral research in the United States, he finally returned to Switzerland to become a Werner Fellow at the EPFL Lausanne. In 1995, he began his role at the ETH Zurich as an assistant professor, marking the start of an impressive career. Not long after, he was promoted to full professor at ETH Zurich, where his research spanned a wide range of analytical topics, reflecting his extraordinary capacity. Beyond his numerous significant contributions to MS, including the exploration of ion formation mechanisms in matrix-assisted laser desorption/ionization MS and pioneering work in single-cell MS, he was also a pioneer in nanoscale analysis, notably through his invention of tip-enhanced Raman spectroscopy. This has profoundly shaped analytical chemistry, which is reflected in numerous prestigious awards, including the Ružička Prize (ETH Zurich), the Heinrich Emanuel Merck Award for Analytical Chemistry, the Thomson Medal (International Mass Spectrometry Foundation), the Rusnano Prize, and the Fresenius Prize (GDCh). However, Renato has also always served the broader scientific community, as a referee, mentor, or as associate editor for *Analytical Chemistry*.

Beyond his professional accomplishments, we have come to know Renato as an adventurous traveler, a loving family man, a

gifted violinist, and an enthusiastic hiker and skier with a deep love for the Swiss mountains. It's no surprise that he is also a polyglot, even by Swiss standards!

Renato was always a committed mentor, making time available for students discussing research, and returning drafts of manuscripts within days, so that they could be submitted to journals without delay. He always encouraged young researchers to share their work, whether at scientific conferences or with journalists. The collaborations he initiated often grew into lasting friendships and strong professional networks among his former group members. Our experience in Renato's lab has been truly inspiring and became a model for how we approach our own research and lead our own labs. Not least, we will always cherish the group retreats in the Swiss Alps and the tradition of celebrating our achievements with wine and cheese, fond memories that will stay with us!

To celebrate his career, we put together a special issue covering a wide range of MS-related topics. These articles were contributed by many of Renato's colleagues, friends, and former group members, several of whom have worked closely with him over the years.

Mayorga-Martino et al. review MS-based strategies for analyzing insect chemical signaling, which influences survival, reproduction, and ecological interactions. They highlight how MS provides insight into communication, mating, and adaptation mechanisms, revealing chemicals that shape insect behavior.

Lin et al. discuss MS-based proteomic methods for diagnostics and studies related to cancer. This article highlights recent

advancements in MS-based proteomic tools that address the limitations of genome-based analysis, offering insights into cancer biology, biomarker discovery, and therapeutic target identification. It also covers the selection of MS techniques throughout the biomarker discovery pipeline, discusses AI integration, and examines regulatory considerations for advancing precision oncology.

Schmidtke et al. explore MS-based techniques for food, beverage, and agricultural analysis, focusing on ambient ionization and rapid analysis. The review covers multivariate data processing for metabolomics and presents key examples of ambient ionization applications.

Bertrand and Gabelica reviewed internal energy and fragmentation in electrospray ionization sources. The article discusses various thermometer ions, factors affecting internal energies in electrospray ionization, and includes a comparison with atmospheric pressure ionization methods.

Liao et al. examine SESI and EESI ionization mechanisms, enabling real-time trace analysis in gases and aerosols. The review highlights applications of these ionization techniques in diagnostics, drug detection, food safety, and environmental monitoring, along with advancements in sensitivity and future developments.

Manicke et al. explore electrokinetic techniques that integrate sample preparation and separation directly with MS ionization, addressing bottlenecks in traditional methods. Highlighted approaches, such as paper spray and nanoelectrospray-based techniques, enhance efficiency by combining extraction and ionization in a single step.

Van Ede et al. present a comprehensive review of cutting-edge mass spectrometric methods dedicated to the identification and the quantification of monosaccharide building blocks—with a focus on the highly diverse microbial world. The review includes an introduction to monosaccharide chemistry, methods based on liquid and gas chromatography, capillary electrophoresis, matrix-assisted laser desorption/ionization, flow-injection analysis, and ion-mobility spectrometry. It discusses the choice of mass analyzer and bioinformatic approaches.

Luo et al. review and summarize the discovery, ionization mechanisms, and advantages of SESI and EESI. The paper highlights applications of these ionization techniques in breath analysis, contraband detection, food safety, aerosols, and real-time chemical monitoring. Additionally, it provides a retrospective overview and future prospects of both technologies.

Okyem and Sweedler discuss the challenges in the analysis of peptides with modifications that are not associated with any mass shift. The review describes various analytical strategies, including those based on MS, ion-mobility separations, chromatographic separations, enzymatic enrichment, and labeling.

Dryahina et al. present a comprehensive review of dielectric barrier discharge ionization for MS, covering its historical

development, fundamental principles and ionization mechanisms, configurations and ion chemistry, sample introduction methods, commercial implementations, applications, current challenges, and future research directions.

Elpa and Urban review the use of bubbles as an alternative, yet powerful analyte extraction approach, providing a faster and greener solution to mass spectrometric sample preparation. They provide an overview of novel bubble-assisted sample preparation methods, offering practical guidance for integrating them into MS workflows, including traditional, offline, online, and unconventional bubbling techniques. Albeit, the exact extraction mechanism requires further exploration, advancements in automation and miniaturization are expected to drive the development of bubble-assisted sample preparation techniques, integrating them into routine analytical practice.

Guan et al. provided a comprehensive review of postionization techniques, which are applicable to MS imaging. This approach addresses the challenge in MS imaging, which is related to sensitivity limit caused by the minimization of the desorption area in the pursuit of high spatial resolution.

*Photos of Renato Zenobi*



Renato at one of his many ski mountaineering trips in the Swiss Alps (February 2025).



Renato on the way to the New Year's Eve gala at Sydney Opera House, in Sydney, Australia (December 2023).



On a boat trip to Turtle Island, Taiwan (July 2023).