

## Introduction: Frontiers in Mass Spectrometry

The foundations of mass spectrometry were laid more than a century ago by the pioneering research of Sir Joseph John Thomson. In his seminal work, *Rays of Positive Electricity and their Application to Chemical Analysis*,<sup>1</sup> Thomson prophetically notes that "The positive rays thus seem to promise to furnish a method of investigating the structure of the molecule, a subject certainly of no less importance than that of the structure of the atom". This was a bold vision for that era! In the intervening decades, mass spectrometry has become an interdisciplinary research methodology, impacting virtually every area of science, from physics through chemistry and biology. Mass spectrometry is inherently a universal method of analysis: Nature has endowed all molecules with mass, and recent, dramatic developments in ionization methods have allowed essentially all materials to be ionized. This broad applicability is complemented by exceptional sensitivity, high resolution and wide mass range, and unparalleled versatility for coupling with other analytical methods.

At this threshold of a new millennium, the field of mass spectrometry is indeed flourishing, as instrumental innovations and creative applications continue at an accelerating pace. This special thematic issue on mass spectrometry provides an overview of both instrumentation and applications, as well as their natural synergy which has nourished both areas.

The first three articles focus on instrumentation, including methods of ion generation, methods of mass analysis, and the interfacing of mass spectrometry with separation techniques. Marvin Vestal surveys the wide array of ionization methods, from conventional approaches to the emergence of new ionization techniques which have revitalized mass spectrometry for biological applications. Scott McLuckey and Mitch Wells provide a comprehensive review of mass analyzers and tandem mass spectrometry, as well as a critical discussion of performance characteristics. Kenneth Tomer describes advances in the development and application of separation techniques coupled

with mass spectrometry and the enhanced capabilities of these methodologies.

The applications of mass spectrometric methods to elucidating fundamental chemical and physical properties are then highlighted. Scott Gronert provides an overview of three important areas, nucleophilic anion chemistry, electrophilic cation chemistry, and reactions of unusual ionic species, where gas-phase ion studies have deepened our understanding of critical facets of organic reactions. The determination of fundamental thermochemical data for both ions and neutrals through elegant mass spectrometric techniques is then comprehensively and critically reviewed by Kent Ervin.

Applications of mass spectrometry to more complex systems are addressed in two succeeding papers. Susan Richardson provides an exhaustive summary of recent literature on environmental research and discusses both the accurate identification of pollutants as well as the increased understanding of environmental processes enabled by mass spectrometry. Scott Hanton documents the uniquely powerful approach provided by both traditional and recently developed mass spectral techniques in the characterization of bulk polymers and polymer surfaces.

Unquestionably, the most spectacular growth in mass spectrometric applications is in the analysis of biomolecules, and five important areas are highlighted in the remaining articles. Robert Murphy, Jessica Fiedler, and John Hevko review the recent remarkable advances in the analysis of nonvolatile lipid substances. Steven Hofstadler and Richard Griffey summarize key insights, recent experiments, and novel applications of mass spectrometry to the characterization of noncovalent nucleic acid complexes. The fascinating area of mass spectrometry in proteomics is reviewed by Ruedi Aebersold and David Goodlett, and they discuss the enormous potential of future developments. Daniel Kassel documents the analytical challenges associated with the field of combinatorial chemistry and the central role of mass spectrometry in accelerating the discovery of novel therapeutic agents. In the final review, Donald Chace focuses on the innovative utilization of mass spectrometric techniques in the clinical laboratory and

<sup>1</sup> Thomson, J. J. *Rays of Positive Electricity and their Application to Chemical Analysis*; Longmans, Green and Co.: London, 1913.

concludes that mass spectrometry is poised for an increasingly important role in clinical chemistry.

I am most grateful to the authors for investing considerable time and talent in this endeavor and for providing comprehensive, insightful, and richly referenced reviews that will be invaluable to present and future scientists. The last century has witnessed the birth and dramatic growth of mass spectrometry as a methodology of unique capabilities and applica-

tions; the pioneering vision of J. J. Thomson has become reality. As illustrated by the reviews in this thematic issue, the promise of mass spectrometry is even brighter and more exciting as the next century unfolds.

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