Book Review

Measuring Mass: From Positive Rays to Proteins, Michael Grayson, ed. (Chemical Heritage Press, 2002) 149 pp., ISBN: 0941901319, $35.00 (hardcover)

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Most chemists are first introduced to mass spectrometry in their sophomore organic chemistry course where it is used in conjunction with other spectroscopic tools to identify compounds and determine their structure. This limited perspective belies the vast array of applications for which this technique has been utilized and gives no insight into its rich history. For those whose exposure to mass spectrometry is limited to this function, the book Measuring Mass: From Positive Rays to Proteins will hold a number of enlightening surprises. Even those who have taken advantage of the most recently developed methods of mass spectrometry are likely to be unaware of the significant impact that this instrument has had on science and society.

While the first chapter of the book outlines the early history behind measuring the masses of atoms and molecules, the overall organization of the book is not chronological. The majority of the chapters are focused on an area of application. One chapter does lay down the basic theory and describes components of the instrumentation, but the more advanced methodologies are discussed on a "need to know" basis. Each chapter ends with an extensive list of Suggested Readings related to the topic. Short essays that give details of ionization methods or that describe a case in which mass spectral data proved be particularly well suited to solving a problem are set apart from the main text in boxes. Two parallel timelines run along the bottom of the pages, one of which traces major events in world history while the other highlights significant advances in mass spectrometry, so that an overall picture of the chronology is readily available.

Although one of the first names mentioned in the chapter on history is the familiar J. J. Thomson, the average chemist will not recognize many of the other historic figures. Thomson's mass spectrograph was improved upon by his assistant, Francis Aston, who discovered that isotopes exist for stable elements as well as for radioactive elements. One of the first applications of mass spectrometry was to find the isotopes of all the known elements. Alfred Nier is credited with making sector field mass spectrometers, which

were smaller and less expensive than earlier machines, and thus allowed for more widespread use of the technique. A fascinating account of the role that mass spectrometry played in the Manhattan Project is included in this chapter.

The applications covered by the remaining chapters are many and varied. In the fields of geologic and earth sciences, we learn, for instance, that mass spectral data have shed light on prehistoric ocean temperatures. Isotope ratios vary with temperature in aqueous environments; consequently, analysis of these isotopes in fossils allows one to estimate the temperature of the water when the organism was alive. In a similar manner, isotope ratios in the atmosphere vary with latitude, thus mass spectrometry can assist in tracing the migration patterns of animals, birds and insects.

An entire chapter is devoted to the use of mass spectrometry in petroleum chemistry. This significant industrial application encouraged the commercialization of the technique and led to the discovery of new organic species, such as the tropylium ion. Of course, using fragmentation patterns and molecular weight determination to identify organic compounds is most fully exploited in the pharmaceutical industry, to which another chapter is devoted. In addition to elucidating the structures of potential drug candidates, mass spectrometry has been used to analyze metabolites, both to understand the mechanism of action of the drug as well as to detect toxic byproducts. Because sampling with a mass spectrometer can be done at relatively high rates of throughput, it has also been an invaluable tool in combinatorial chemistry.

Other areas of application that are discussed include atmospheric chemistry, planetary science and environmental analysis. Mass spectrometers have been put into orbit in the upper reaches of our atmosphere to detect the presence of small molecules. They have traveled to Venus, Mars and Jupiter where the planet's atmosphere and, in the case of Mars, soil have been sampled. Pollutants in our atmosphere, in bodies of water and in soil have been detected by mass spectrometers. In fact, the creation of the Environmental Protection Agency in the 1970's helped to drive the need for fast, easy-to-use instruments, and soon after, GC-MS became a ubiquitous tool in laboratories. This contribution to the cleanup of our environment is one of the most significant benefits that our society has gained from mass spectrometry.

The latest advances in mass spectrometry have been in the area of novel ionization techniques that have proven to be most valuable in analyzing biological samples. Thermospray and electrospray ionization methods have allowed liquid chromatographs to be interfaced with mass spectrometers; thus, complex biological mixtures can be more effectively analyzed. Fast Atom Bombardment and Matrix-Assisted Laser Desorption Ionization are techniques that can be used with high molecular weight molecules that are not robust. These ionization methods impart less energy to the molecule and can be used

with non-volatile, labile compounds such as proteins. These new techniques have impacted the area of forensic science, where LC- MS facilitates the analysis of biological samples, while lower energy ionization allows for the analysis of the sensitive, volatile compounds used in explosives. Diagrams of the ionization processes and explanations of the principles behind the techniques are included. The whole array of mass spectrometry acronyms, a veritable alphabet soup, is conveniently summarized in a table in Chapter 6. Also included in this chapter is a section describing what lies ahead in the development of even better instrumentation.

Measuring Mass was published by the Chemical Heritage Press in con- junction with the American Society for Mass Spectrometry to commemorate the fiftieth anniversary of the Conference on Mass Spectrometry and Allied Topics. The history of this professional society is outlined in the final chapter of the book. Twelve scientists contributed to the content of the text, and the editor, Michael Grayson, is to be commended for pulling all the information together in a well-organized fashion and with a consistent style of writing. Measuring Mass is a fitting tribute to the accomplishments of mass spectrometrists in the twentieth century.