

Executive Summary

Mass spectrometry is a highly sophisticated instrumentation technology which has emerged as the premier method for the analytical definition of biomolecules. This newly defined role has been the result of significant improvements in these instruments, combined with the introduction of a number of new approaches to preparation and separation of the target molecules.

During the early years following its discovery, mass spectrometry was used in the analysis of isotopes, to determine their relative abundance and their atomic masses to within a precision of 1 part in a million or better. Today it is used mainly to analyze organic molecules, yet the principles of mass spectrometry are broadly applicable to include analyses of inorganic substances.

Here we focus on the role that mass spectrometry has played in the advance of biotechnology. In recent years, it has morphed from a costly and cumbersome machine, sequestered within the domain of analytical chemistry, to an amiable companion, accessible both financially and technically to laboratories that are not specialized in its many uses and applications.

We then briefly review the history of mass spectrometry, pointing out early discoveries in physics that led to its initial uses. We consider, in a

non-mathematical framework, the underlying physical principles that dictate the construction and limitation of mass spectrometers.

Today mass spectrometry is characterized by rapid advances in technology, driven by manufacturers' engineering applications. It is acknowledged to be the third most powerful spectral technique in the structural elucidation of unknown organic compounds, trumped only by X-ray diffraction and NMR spectroscopy. But it offers the unsurpassed features of easy coupling to gas-phase and liquid-phase separation techniques, in addition to its extremely high sensitivity and low sample consumption.

In reviewing mass spectrometry instrumentation, we consider hardware designed to move fragile molecules into a gaseous ionized state, where they can be subsequently analyzed. These include electrospray ionization, matrix-assisted laser desorption/ionization (MALDI), and surface-enhanced laser desorption/ionization (SELDI). Following the vaporization/ionization procedure, the sample is introduced into the mass analyzer, of which there are many types. Analyzers are numerous and designed for a variety of applications. A range of devices can be adapted to the separation of molecules before they enter the mass spectrometer, including 2D gel electrophoresis, gas and liquid chromatography.

The more significant applications of mass spec technology are reviewed, including –omics applications, forensics, environmental monitoring and data analysis.

Finally, we discuss conclusions over the future prospects of the industry. Mass spectrometry, as the leading technology for the characterization of macromolecules, is likely in the coming years to produce breakthrough advances in the diagnosis and understanding of a host of recalcitrant diseases.