DEVELOPMENT OF THE TIME-OF-FLIGHT MASS SPECTROMETRY TECHNIQUE, AND ITS APPLICATIONS

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Abstract

Development of instrumentation to enhance the mass resolution and the ion separation capabilities of plasma desorption mass spectrometers (PDMS) and matrix assisted laser desorption/ionization (MALDI) mass spectrometer are presented in this thesis. As an introduction to the thesis, the historical development of different mass spectrometry techniques are briefly summarized in first two chapters. Although the time-of-flight mass spectrometry technique was introduced in late forties, the interest within the mass spectrometry community was quite poor until the development of new ionization techniques such as fast heavy ion bombardment, laser desorption ionization, and electrospray ionization.

The first part of the thesis is devoted to describe the construction and some preliminary characteristics of newly built PDMS TOF mass spectrometer with an ion mirror. As the experience in building mass spectrometers at Colombo University is limited, the description of the design and construction work of the new PDMS system is somewhat detailed with the aim that this work could be used as a source-book for future building projects. The main difficulties encountered in the construction have been the high cost and the scarcity of suitable materials, and this was partly overcome by employing used stainless steel materials and other available materials in the local market. The standard of performance of the mass spectrometer is found to be comparable to similar instruments operating at any laboratory. The experiments performed with the mirror and the related simulations studies suggest that some of the ions with non zero initial axial kinetic energies are particularly responsible for the delayed ion formation in the plasma desorption process.

As a part of an instrument development, an electrostatic deflector has also been designed and constructed that can be used in any MALDI time-of-flight mass spectrometer with delayed extraction and an ion mirror to select ions of a particular mass. The deflector consists of an interleaved set of parallel deflection electrodes. As a new concept, thin metal ribbons instead of wires or plates have been used for the deflection electrodes. Properly timed reversing electric field was used for the operation of the device. In the operation, a resolving power of approximately 5200 (FWHM) was obtained for an isotopomer of PEG 6000 (m/z ~ 6000) which is far better than that could be obtained with a commercial instrument.

Another instrumental development presented in the thesis is a construction of high resolution multiple reflection time-of-flight mass spectrometer which was designed using two electrostatic mirrors, mounted symmetrically on the same optical axis facing each other. Mirrors used in the non-compensating mode, were located between a MALDI ion source and a stop detector. The ions produced in the MALDI source have been pulsed into the region between the two mirrors using delayed extraction technique and trapped by successive reflections of opposite electric fields in the mirrors for a pre-determined period of time before being detected. The extension of the flight path due to multiple reflections has been used to increase the mass resolution in time-of-flight spectra. Mass resolutions of 55,000 for substance-P and 31,000 for bovine insulin were obtained for single laser shot spectra. The stability of protonated, sodiated and potassiated substance-P ions have also been investigated.