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Curtiss Hanson, Department of Chemistry, University of Northern Iowa

Student authors: J. Page, Department of Chemistry, University of Northern Iowa

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KINETIC ENERGY ANALYSIS OF METASTABLES AND ION ISOLATION USING A TWO-SECTION ELECTROSTATIC PARTICLE GUIDE IN A TIME-OF-FLIGHT MASS SPECTROMTER

Jason S. Page, Curtiss D. Hanson and Nathan Adams
Department of Chemistry, University of Northern Iowa, Cedar Falls, IA 50614-0423

The continued growth in biomolecular analysis has led to a need for efficient instrumentation[1,2,3]. Most biomolecules are difficult to obtain and laborious to isolate resulting in very small available sample sizes. The ability to obtain as much of information from as little of sample is desired. To address this problem, tandem mass spectrometry experiments are performed to obtain structural information from trace samples. Tandem MS is accomplished by first isolating an ion packet, and then analyzing the ion packet to obtain a mass/charge spectrum of the parent ion and its fragments. From these fragments, the overall structure of the sample molecule is achieved. Time-of-flight Mass spectrometry (TOF-MS) has been a preferred choice in analyzing biomolecules because of its high sensitivity[3,4,5] and, now with advancements in source techniques such as matrix assisted laser desorption ionization (MALDI)[6], electrospray[7] and particle desorption ionization, it has almost an unlimited mass range. However, until now tandem time-of-flight instrumentation can only be done with the use of an added second mass spectrometer.

Use of an electrostatic particle guide has been demonstrated in TOF to be an effective method of both ion isolation and reduction of unwanted matrix background[8]. Furthermore, use of a two section electrostatic particle guide (EPG) in a time-of-flight mass spectrometer can be used to perform tandem MS experiments. An EPG consists of an isolated wire electrode that runs down the center of the flight tube, creating a potential field that only effects the ions perpendicular to the flight axis. These field lines can be used in conjunction with a skimmer orifice as a kinetic energy analyzer for daughter ions while still permitting mass analysis along the flight axis.

Mass spectra were obtained on a prototype MALDI-TOF mass spectrometer built at the University of Northern Iowa. A rear entry stainless steel probe with a single extraction was used. The acceleration voltage was maintained at 14kV. The laser optics were mounted in the vacuum chamber at a 45° angle with respect to the probe. Detection of the ions was accomplished using a Comstock CP625/M microchannel plate detector with chevron geometry at the end of a 2 meter flight tube. The detector current was digitized using a LeCroy 9310 digital sampling oscilloscope (100 megasamples per sec.). Background pressure for the system was maintained at $2x10^{-8}$ torr by a Pfeiffer/Balzers TPU 220 turbomolecular pump.

Ions were generated by laser desorption using a Laser Science VSL-337ND-T nitrogen laser producing a 3nsec. Pulse at 337 nm. The selected matrix was 3,5-dimethoxy-4-hdroxycinnamic acid (sinapinic acid) because of its strong absorbance at 337 nm.

The electrostatic particle guides consisted of a 0.25mm diameter stainless steel wire supported by cross-hair wires and insulated from the tube wall. The first EPG began at 25cm from the source and terminated 50cm from the detector. The second EPG began 5cm from the detector. The second EPG was strung down 10cm where the first EPG and was strung down 10cm where it was terminated at skimmer orifice with a radius of 2 cm.(figure 2).

Ion extraction can be accomplished by a two-section EPG by use of an attractive negative voltage on the first EPG and applying a calculated pulsing sequence on the second EPG. The first EPG focuses the ions down the center of the flight tube allowing the different compounds to separate out depending on their masses. The second EPG, with a repulsive positive voltage, repels the ions towards the wall of the flight tube as they enter the second EPG region. When the ion of interest enters this region, the EPG is switched to an attractive negative voltage. This potential focuses the ion through the skimmer orifice and to the detector. Once the ion has left the second EPG region, the voltage is switched back to a repulsive positive potential to eliminate the rest of the ions traveling down the instrument. This pulsing sequence can be calculated by using the velocity dependent equation of source acceleration, and is successful in repelling the unwanted ions away from detection and focuses the wanted ion to the detector. This axial flight time isolation allows for the complete ion packet extraction. The various mass fragments, caused by unimolecular decay of the parent ion following acceleration will have the same velocity as the parent ion and are therefore are still contained in the isolated ion packet.

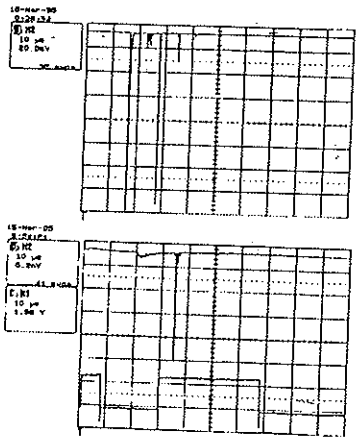

Figure 1
Ion isolation of Cesium Iodide using a pulsing sequence on the 2nd electrostatic particle guide.

The tandem mass spectrometry experiment can be accomplished by kinetic energy analysis of the daughter ions contained in the parent envelope by a two-section EPG. This is done by the use of an attractive negative voltage on the first EPG and then scanning a repulsive positive voltage on the second EPG. The radius of deflection is calculated by equation (1), where L is equal to the length of the EPG and V is the applied voltage. If this radius is greater than the radius of the skimmer orifice, the ion will be eliminated prior to detection. This permits for the elimination of an ion depending on its kinetic energy. The tandem MS experiment is performed by setting the second EPG at zero volts and allowing the entire ion packet through the skimmer orifice to the detector. The voltage of the second EPG is then increased by a desired increment to a higher repulsive positive voltage. Through consecutive increments, the fragments can be eliminated on the basis of their kinetic energy. The fragment elimination is seen by the decrease of the intensity of the ion peak.

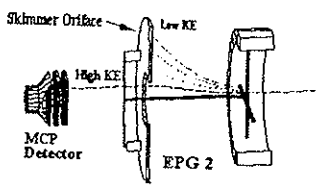

figure 2.
Diagram of 2nd EPG showing ion deflection

$$r = L\sqrt{\frac{V}{KE_{ion}}} \qquad (1)$$

The daughter spectrum is obtained by plotting the intensity of the peak as a function of the voltage applied to the second EPG. A first derivative is then performed on the curve to produce peaks at the corresponding voltages. From the voltage it is possible to calculate the kinetic energy of the fragment, and from this kinetic energy it is possible to calculate the mass. Once the mass of each fragment is known, an overall structure of the sample molecule can be obtained. By the use of this procedure using a two-section EPG, successful tandem MS on a single stage, linear time-of-flight mass spectrometer can be attained.

This improvement, of the addition of a two-section EPG, has led to the ability for successful compound isolation and tandem MS in a single time-of-flight mass spectrometer. This will expand the utility of TOF mass spectrometry for high molecule weight biomolecule analysis.

Literature Cited:

1) Karas, M.; Bahr, U.; Ingendoh, A.; Hillenkamp, F. Agnew. Chem., Int. Ed. Engl., 1989,28,760.
2) Beavis, R.; Chait, B. Rapid Commun. Mass Spectrum., 1989, 3, 233-237.
3) Beavis, R.; Chait, B. Anal. Chem., 1990, 62, 1838.
4) Strobel, F. H.; Solouki, T.; White M. A.; Russel, D. H. J.A.S.M.S 1991, 2, 91-94.
5) Opsal, R.; Owans, K.; Reilly, J. Anal. Chem., 1989, 57, 1884-1889.
6) Karas, M.; Hillenkamp, F. Anal. Chem., 1988, 60, 2299.
7) Kebark, P.; Tang, L. Anal. Chem., 1993, 22, 927A.
8) Just, C.; Hanson, C. D. Rapid Comm. Mass Spectom. 1993, 7, 502-506.