Buffer Gas and q_{eject} Effects on the Performance of an Ion Trap

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The transformation of the ion trap from ion storage device to mass spectrometer was assisted in no small part by the discovery that the addition of a helium buffer gas greatly improved the mass resolution and sensitivity.[1] Ions formed in the ion trap are kinetically cooled to the center of the ion trap by collisions with the helium buffer gas. In the earliest form of the experiment, these ions were then ejected from the trap via a mass instability scan. It was later discovered that the application of a resonant ac voltage could further improve the performance of the ion trap by resonantly ejecting ions as they approached the stability boundary in a process that was named "axial modulation". Until recently, it has been widely held that the ion trap must operate using a helium buffer gas. The development by Bruker-Franzen[2] of the Chemical and Biological Mass Spectrometer (CBMS) and later the Generic Detector (GD) for the US Army has demonstrated that ion traps can be operated without helium, using only air as the buffer gas. Attempts, however, to operate ion traps from Finnigan-MAT using an air buffer gas have not been successful. This research examines the role of the helium buffer gas in an ion trap mass spectrometer and explores the possibility of substituting ambient air as the buffer gas.

The study examines the dependence of resolution and sensitivity on the type (air or helium), pressure, and method of introduction of the buffer gas, as well as on the q_{eject}, the mass, and the sample pressure. It is shown that resolution and intensity depend not only on the pressure of the buffer gas, but also on the q-value used for resonant ejection. Figures 1 and 2 show the results obtained by varying the buffer gas pressure (helium and air, respectively) and the q_{eject}-value on the resolution of m/z 69 from perfluorotributylamine (PFTBA). There is clearly visible in Figure 1, the known resolution valley at a helium buffer gas pressures of ca. 1 millitorr. There is, however a second valley at a q_{eject}-value of ca. 0.85 which shows a significant decrease in peak widths over those obtained at a q_{eject}-value of 0.906 (near the stability boundary). Concurrent with the resolution improvement (but not shown in this abstract) is an increased signal intensity (although the total peak area remains relatively unchanged). Figure 2 demonstrates that by substituting air for helium, similar resolution performance can be obtained although the optimum region of the pressure and q_{eject}-value minimum is much narrower. Signal intensities using both buffer gases were determined using krypton as the sample in order to ensure that the measured mass ion intensities were the result only of ion storage and not skewed to low mass by collisions with the larger air buffer target mass. It was observed that a 50% reduction in signal intensity for m/z 84 from krypton was obtained when substituting air for helium. At higher sample pressures as well as for masses > 200 da., both the improvement in resolution using helium at a q_{eject}-value of 0.85, and the ability to substitute air for helium without performance degradation is diminished.

1. Stafford, G.C., Jr., Kelley, P.E., Syka, J.E.P., Reynolds, W.E., Todd, J.F.J., *Int. J. Mass Spectrom. Ion Processes* **60** (1984) 85-98.
2. Franzen, J., *Int. J. Mass Spectrom. Ion Processes* **130** (1994) 15-40