Trapping and Analysis of Externally Generated Ions in a Miniature Cylindrical Ion Trap

Craig Cavanaugh, Kenion Blakeman, Mac Gilliland, J Michael Ramsey

University of North Carolina, Chapel Hill, NC

A handheld mass spectrometer would offer unprecedented in-field chemical analysis capability. To achieve this goal, the size, weight, and power (SWaP) of the mass spectrometer must be minimized. By operating the entire mass spectrometer at high buffer gas pressures (> 500 mTorr), turbomolecular pumps are no longer required, greatly reducing SWaP. High pressure mass spectrometry has been demonstrated in our lab using cylindrical ion traps (CITs) with r_o = 500 μm and internal electron impact ionization (EI).

Particular attention needs to be paid to the in-trap path length and mean free path when trapping externally generated ions in a miniature CIT. Due to scaling, the in-trap path length is reduced compared with a traditional scale CIT (r_o = 1 cm). At 1 mTorr buffer gas pressures, typically used for conventional scale ion traps, miniature CITs are unable to trap externally generated ions. However, the reduced mean free path at high pressures aids in trapping by reducing ion kinetic energies in shorter distances, resulting in successful trapping in miniature CITs.

We have demonstrated trapping of externally generated ions in miniature CIT's using custom electron and glow discharge ion sources. Mass spectra have been recorded in helium, nitrogen, and air buffer gases across a broad range of pressures and ion kinetic energies and compared with internal EI signals. The low pressure threshold for external ion injection has been found for mesitylene in helium and nitrogen buffer to be 270 and 20 mTorr, respectively. Externally generated ions were trapped at pressures exceeding 1 Torr buffer gas with signal-to-noise improving with increasing pressure while internal EI signals decreased with increasing pressure.

This work suggests the feasibility of coupling high pressure mass spectrometry with ambient ionization techniques such as ESI and APCI, greatly expanding the scope of chemical detection accessible to a handheld mass spectrometer.