

PSB 127 Dual-Pressure Linear Ion Trap Technology

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The Thermo Scientific LTQ Velos mass spectrometer incorporates a revolutionary dual-pressure linear ion trap design (Figure 1). Prior to the LTQ Velos™ dual-pressure design, ion traps were operated at a single pressure that was a compromise between the optimum pressures for ion manipulation (trapping, isolating, fragmenting) and detection (mass analysis). The unique dual-pressure linear ion trap technology features two discrete pressure regions (cells) that allow the decoupling of ion manipulation and detection. A high-pressure cell (HPC) is used for trapping injected ions, isolating precursor ions, and fragmenting precursor ions. A low-pressure cell (LPC) is used for scanning ions out to the detectors, i.e. mass analysis.

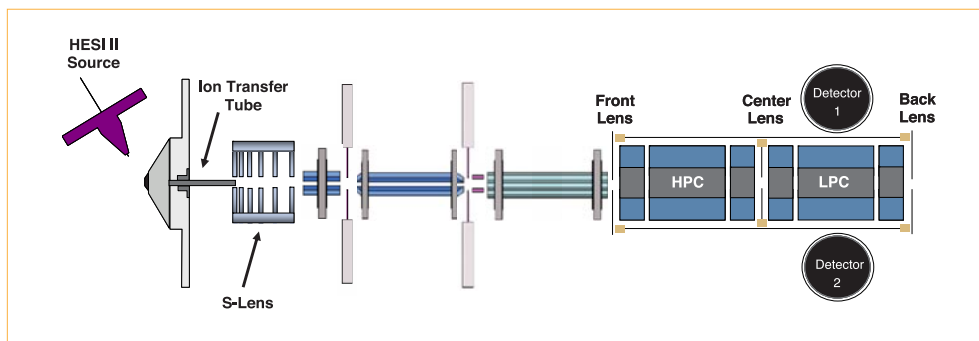


Figure 1: Ion source, ion optics, and dual-pressure linear ion trap in the LTQ Velos ion trap mass spectrometer

High-Pressure Cell

Typically, single-pressure linear ion traps use about 2-3 mTorr of helium buffer gas as good compromise between what is optimum for trapping and fragmentation efficiencies and for mass resolution / scan rate. At this pressure, ion trapping efficiency is approximately 60%; up to 40% of the ions that are sent to the trap can be lost. By increasing the pressure in the trap, trapping efficiency can be increased to greater than 90% (Figure 2). This translates directly into time saved in filling the trap with a desired number of ions, thus shortening cycle times and improving limits of detection.

Increasing pressure in the ion trap also has a positive impact on efficiency of collision-induced efficiency (fragmentation). As can be seen in Figure 3, increasing the pressure from 2.5 to 5 mTorr raises fragmentation efficiency from 68% to more than 80%. This further enhances sensitivity in MSⁿ mode.

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Low-Pressure Cell

As the pressure in an ion trap decreases, the resolution increases (peak widths decrease). The LPC in the LTQ Velos ion trap operates at <1 mTorr, significantly lower than the 2.5 mTorr used in a single-pressure ion trap. This increases mass resolution by decreasing the widths of the peaks from 0.7 u FWHM to about 0.45 u FWHM at the same scan speed. In the LTQ Velos mass spectrometer, part of this resolution gain is traded back for increased scan speed. The scan speed in the LTQ Velos instrument is increased by a factor of 2—to 33,300 u/s—over the previous LTQ ion traps (Figure 4). At the same time, the LTQ Velos maintains peak widths <0.6 u FWHM, a 0.1 u improvement over previous LTQ ion traps.

Conclusion

Decoupling the pressure regions used for ion manipulation and mass analysis allows significant improvements to be made in both processes. The efficiency of ion trapping and ion fragmentation have been enhanced, while scan speed has been doubled at increased resolution, making the LTQ Velos the fastest and most sensitive ion trap commercially available.

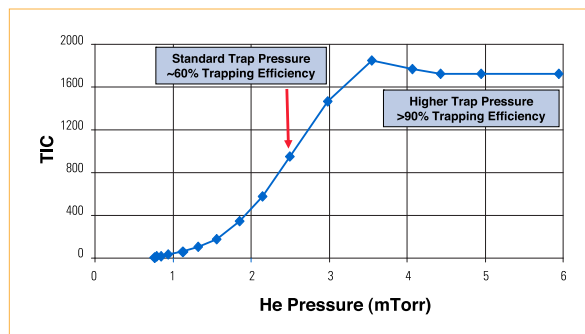


Figure 2: Ion abundance and ion trapping efficiency as a function of pressure in the ion trap.

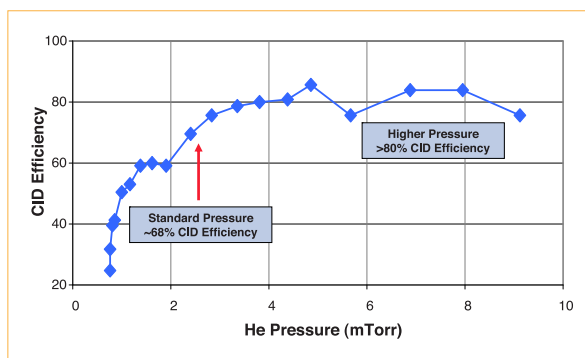


Figure 3: Collision-induced dissociation (CID) efficiency as a function of ion trap pressure.

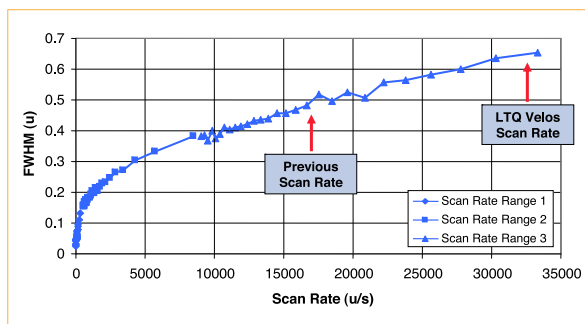


Figure 4: Peak width/mass resolution as a function of scan rate.

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