Optimization of the Detection System for Fast Scanning Linear Ion Trap Mass Spectrometers
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Overview
Purpose: A new linear ion trap mass spectrometer ion detection system is developed with greater linear dynamic range and improved precision.
Methods: The detection system was investigated on a Thermo Scientific Velos Pro linear ion trap mass spectrometer.
Results: The improved detection system demonstrated an analytical linear dynamic range of 8 orders of magnitude on the Velos Pro linear ion trap mass spectrometer.

Introduction
The linear dynamic range of the detection system in mass spectrometry can be defined as the ratio of the maximum number to the minimum number of ions which can be quantitatively detected in a given mass spectral peak. An instrument with a higher dynamic range is clearly more useful analytically, as it allows for the quantitation of compounds over a larger range of concentrations and injection volumes. As the scan rate requirements for mass spectrometers increase, the challenge to increase dynamic range becomes even more critical as high scan rates are realized at the same time. Here we describe our analysis into several challenging detection system phenomena that have demonstrated a non-linear dynamic range of up to 10^7. This improvement in the detection system has led to an analytical (chromatographic) linear dynamic range up to 8 orders of magnitude.

Results
Dynamic Range Requirements with Increased Scanning Speed
New Linear Ion Trap Detection System

References

Conclusion
- An optimized detection system for a fast scanning linear ion trap has been designed.
- Discrete dynamic ion trap multipliers used in the system have shown linearity up to 10^6.
- An ion trap detection system has been demonstrated.
- A new detection system is designed with 6 × 10^5 more signal count than the current generation of linear ion traps.
- The new optimized detection system has allowed a 10000-fold increase in scan rate, 500 thousand times faster than the linear ion trap.

Analysis of detection appears shown beyond 10^7 for 6 orders of magnitude.

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FIGURE 1 Linear ion trap detection system

FIGURE 2 Continuous Dynamic Electro-multiplication (D) and discrete dynamic electro-multiplication with an equivalent circuit model (E).

FIGURE 3 Electro-multiplexer design

FIGURE 4 Simulated and measured ion ejection at different scan speeds

FIGURE 5. Calculation of ion time based on prescan (A) and saturated (B) W: 1/X

FIGURE 6. Balanced linear dynamic range on the Velos Pro linear ion trap

FIGURE 7. A: 0.1% formic acid 10 mM NH4OAc in H2O
B: 0.1% formic acid in MeOH 30:70, no internal standard
0.4 3.70 20 1.9840 4.03 100 4.33200 2.03 1000 3.85 6000 3.342000 1.03 50000 3.9850000 0.03

FIGURE 8. Simulated dynamic ion ejection at different scan speeds