Development of a SLIM SUPER TWIM-MS Application Platform for Multi-Omics

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Overview

- A novel structures for lossless ion manipulations (SLIM) serpentine ultralong path for extended routing (SUPER) traveling wave ion mobility-mass spectrometry (TWIM-MS) module was developed with a goal to enable a wide range of experiment types with applications in multi-omics
- Four independent TW regions allow for simultaneous trapping, cycling, and compression events
- Multiple trapping regions allow for capabilities including pre-scan, large initial ion population accumulation, and mobility-selected accumulation
- Custom software provides user control of experimental design and setup, including precise switching events for rerouting of ions through the module

Introduction

- Traditional IM-MS instrumentation suffers from limitations in small initial ion populations and limited resolution due to relatively short separation length
- SLIM SUPER devices have recently been developed in our group with traveling wave (TW) ion mobility
- These devices allow for initial accumulation of ~10^9 ions
- Multiple passes through the SLIM SUPER module provide ultra-long path separations (>1000 m) for increased resolution of similar mobility species

Methods

- **SLIM SUPER TWIM module coupled with Agilent 6538 QTOF (Figure 1A)**
- **SLIM Module:** 12.3 m path length; 5,4 electrode arrangement; maintained at 4.0 Torr nitrogen gas
- Fabricated with ceramic board material (Rogers RO4000, Rogers Corporation) for reduced off-gassing and improved electrical capabilities for higher RF to allow extended mass/mobility range
- **Trapping Regions:** Pre-trap; 6 m region; post-trap
- **TW Parameters:** Four independent TW regions (Figure 1B); TW Amplitude 25.0 V_{p-p}; TW Speed 160 m/s
- **Sample Introduction:** All samples were infused via syringe pump at 0.1 µL/ min with nESI
- **Software Control:** Custom developed software allows user to design experiments with multiple events, and precisely controls timing of TW parameters for separation and compression, and switches for routing

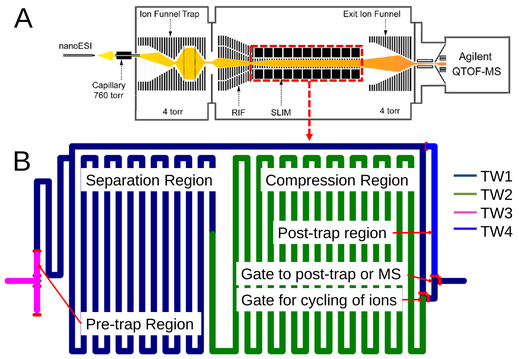

Figure 1. A) Instrument schematic for the SLIM SUPER TWIM-MS system including pre-SLIM optics, SLIM layout, and QTOF-MS. **B)** Layout of SLIM module indicating the various trapping and TW regions.

Results

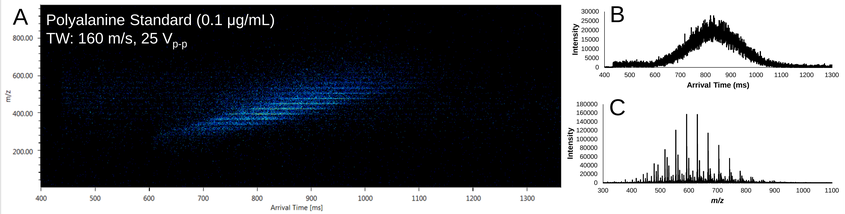

Figure 2. (A) IM-MS spectrum, **(B)** arrival time distribution, and **(C)** mass spectrum of polyalanine standard after single pass separation (12.3 m).

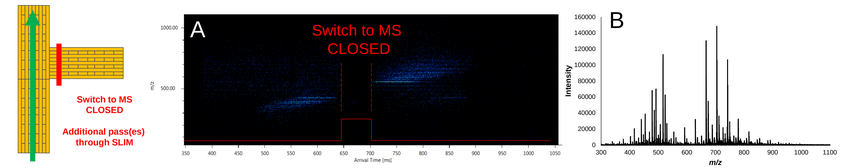

Figure 3. A selected mobility range is rerouted for additional passes through the SLIM module by closing the switch to the MS at 650-700 ms. **(B)** The resulting mass spectrum shows the absence of the masses that were selected.

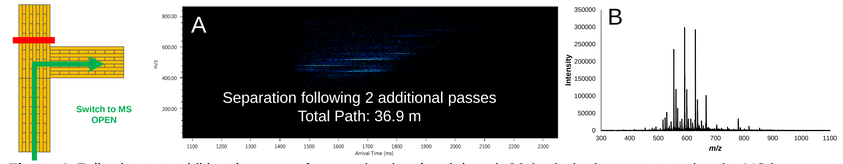

Figure 4. Following two additional passes of separation (total path length 36.9 m), the ions are routed to the MS by opening the switch. **(B)** The resulting mass spectrum shows the selected ions following the additional separation.

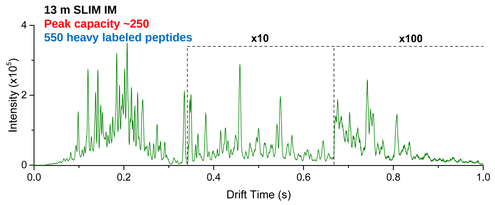

Figure 5. Drift time spectrum for a mixture of 550 heavy labeled peptides, showing increase in peak capacity (~250) on a 13 m SLIM SUPER

Current Directions

- Accumulation of large ion populations (>10^9) using 6-m trapping region
- Post-SLIM separation accumulation of targeted species in post-trap for subsequent long-path separation (i.e., separation of targeted isomers)

Conclusions

- Development of a multi-capability SLIM SUPER TWIM-MS system
- Several trapping regions, including on-board pre-trap region
- Precise control of switch events allows mobility selection for cycling of ions through multiple passes, allowing extended routing for improved separation similar mobility species
- Future experiments will include:
  - Characterization using large initial ion population accumulations
  - Multiple post-trap accumulations for low abundance targeted species in complex matrices
  - Coupling SLIM SUPER TWIM with other online and offline sample preparation techniques for wide application of multi-omic studies

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References

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Career Opportunities: For potential openings in Integrative Omics Group at PNNL please visit http://omics.pnl.gov/careers

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