

Electronic design and data acquisition system for FAIMS/IMS/MS instrumentation

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Overview

- The FAIMS/IMS implementation presently requires extensive development of custom electronics and data processing algorithms.
- We report here the details of the hardware and software developed at PNNL for FAIMS/IMS instrument control and operation.
- Performance evaluation of the instrument reveals high orthogonality between FAIMS and IMS dimensions.

Introduction

Ion mobility spectrometry (IMS) and field asymmetric waveform IMS (FAIMS) are related gas-phase techniques for rapid separation of complex mixtures and structural characterization of ions.^{1,2} Coupling FAIMS to IMS for enhanced peak capacity requires development of custom electronics and data processing algorithms. We report here on the hardware and software designed for FAIMS/IMS control and operation. We demonstrate the performance of the instrument as it relates to the orthogonality between FAIMS and IMS, as well as the IMS separations using a peptide mixture of moderate complexity.

Methods

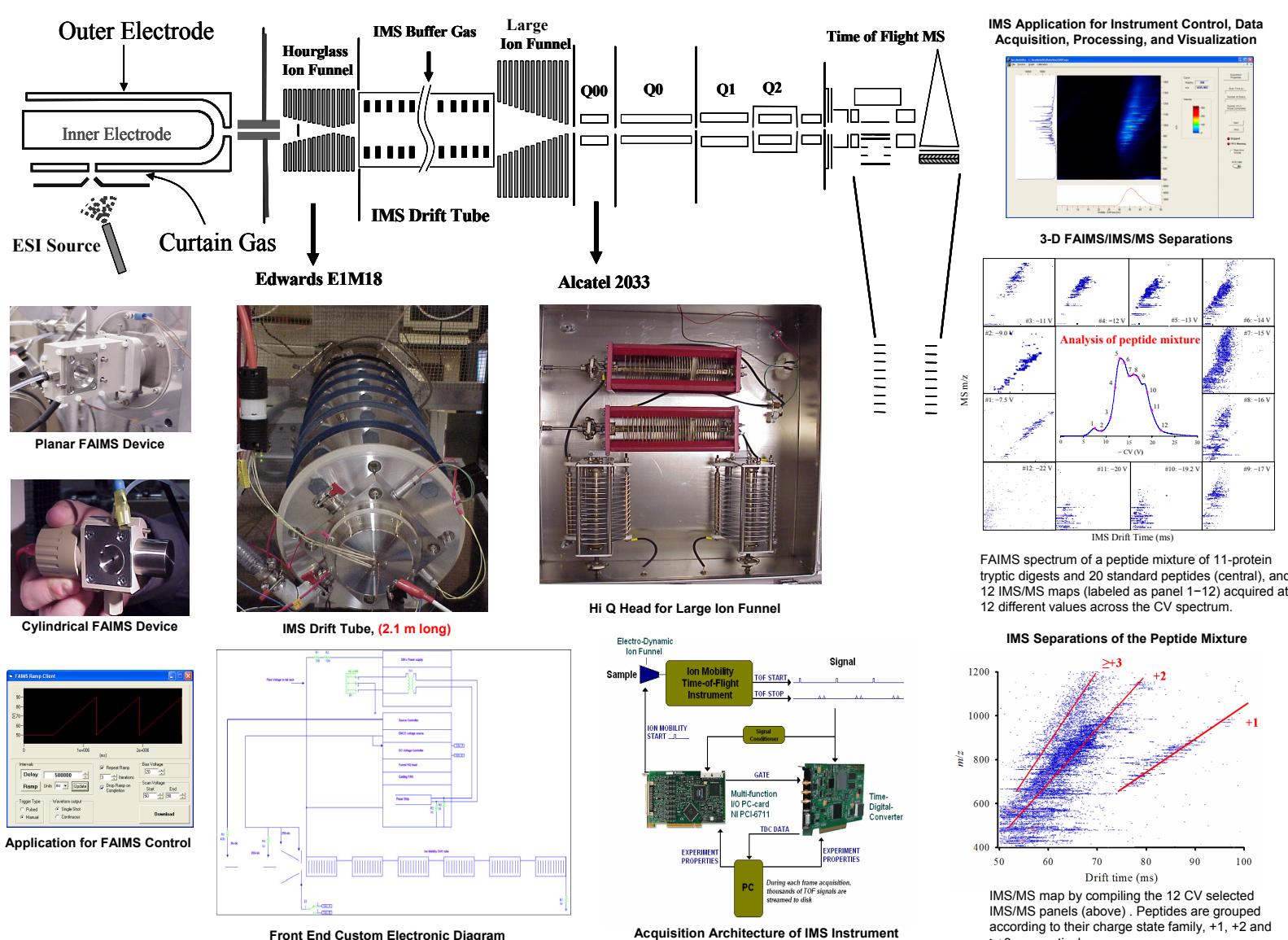
Hardware

The IMS instrument incorporates an electrospray ionization (ESI) source followed by an hourglass ion funnel, a 2-m-long drift tube, a 2" ID ion funnel and a TOF mass spectrometer.¹ All hardware components, including the ESI source, heated capillary interface, and hourglass ion funnel, are electrically floated on the IMS drift tube voltage using a high voltage isolation transformer.

The FAIMS unit is also floated on the IMS drift tube voltage. A PCI-6221 (National Instruments, Austin, TX), installed in a platform server, provides variable analog voltages to a custom-made conditioning circuit. The circuit supplies two high-voltage amplifiers that are coupled to the FAIMS unit to supply all operating voltages. A separate waveform generator is used to supply the asymmetric waveform for FAIMS. To enable user control of FAIMS, a client application running on the data station delivers FAIMS parameters to the server via a fiber optic cable.

Software

A custom software application was developed for instrument control and data acquisition, processing, and visualization. Using a multi-function I/O card (PCI-6711, National Instruments, Austin, TX), the software synchronizes the acquisition of ion mobility spectra to the TOF pusher frequency. In addition, it regulates the introduction of ion packets into the drift tube by pulsing the ion funnel gate through a fiber optic cable that electrically isolates the control and analysis devices from the high-voltage IMS components. A 10-GHz TDC (Model 9353, Ortec, Oak Ridge, TN) acquires and streams the IMS data to hard disk. Upon completion of an acquisition, streamed ion mobility spectra are averaged to generate an intensity map in the ion mobility and TOF domains. The software also permits zooming into features of interest, analysis of the total ion chromatogram (TIC), and examination of individual TOF spectra at selected drift times.



Conclusions

- We have developed an electronic and data acquisition systems for a new ESI-FAIMS/IMS/TOF MS instrument that incorporates electrodynamic ion funnels at both ESI-IMS and IMS-ToF MS interfaces.
- Custom software was developed for instrument control, data acquisition, processing, and visualization. A multi-function I/O card (PCI-6711, National Instruments) was used to synchronize the IMS acquisition with the TOF pusher frequency.
- A platform server using a PCI-6221 (National Instruments) and residing in an electrically floating environment provides variable analog voltages to a custom-made conditioning circuit.
- A client data station delivers the FAIMS operating parameters to the server via a fiber optic cable.
- Initial evaluation of the FAIMS/IMS instrument using a tryptic digest of a pool of 11 common proteins and 20 standard peptides shows substantial orthogonality between the FAIMS and IMS separations.

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IMS/MS map by compiling the 12 CV selected IMS/MS panels (above). Peptides are grouped according to their charge state family, +1, +2 and +3, respectively.

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