Sensitivity meets Selectivity: Welcome the new level of IMS Performance

Background

The use of a Gas Chromatographic (GC) pre-separation of complex mixtures significantly widened the usability of Ion-Mobility-Spectrometers (IMS). The separation of compounds based on their retention indices (RI) both offers information for identification and suppresses undesired compound interactions during ionization and detection in the IMS.

A major challenge when coupling GC to IMS technologies is a typically poor IMS-signal mapping of compounds eluting from the GC column. Classic IMS design is focussed on maximal sensitivity and IMS-peak resolution rather than compound transient dynamics. These architectures exhibits rather large void volumes when compared to other common GC detectors.

In order to optimize the sample feed time resolution G.A.S. reengineered its high sensitive Time-Of-Flight-IMS. Sophisticated sample- and drift gas flow architectures shape a 'virtual' void volume inside the IMS ionization sphere.

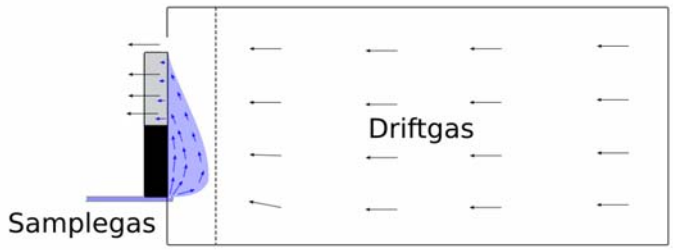

Figure 1: Schematics of the FOCUS-IMS gas flow design

FOCUS-IMS

IMS drift gas flow is guided linearly through the IMS end exhausts passing the radiation source. The later is vertically arranged to preserve optimal IMS resolution. Sample flow -e.g. carrier gas elution from a GC column- is guided on top of the ionization plate via a nozzle. Both flow feeds equilibrate spatially forming a 'gas-bubble'. The size and dwell time of the bubble can be tuned by the ratio of the electronic pressure controlled flows. The bubble can be understand as virtual void volume of the IMS.

Right after ionization the drift flow guides residual sample to the exhaust ensuring high temporal resolution power.

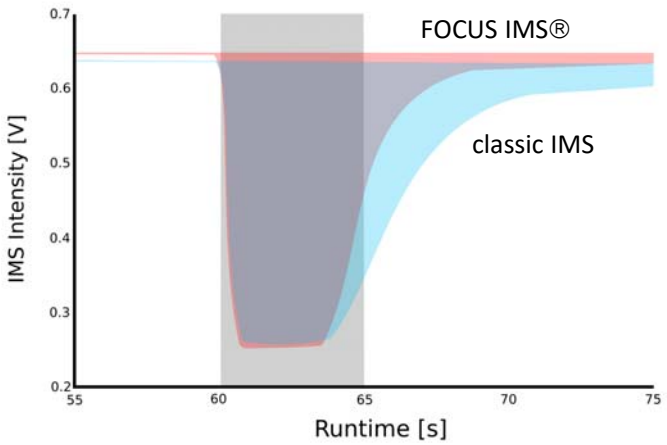

Figure 2: Proton-cluster depletion upon square shaped oxygen feed

The superior washout properties of samples can be observed for square shaped feeds of non retarding compounds. Figure 2 shows the proton-cluster depletion due to oxygen feed. Oxygen quenches the proton-cluster formation, leading to a lowering of the constant ion current (IMS parameter dependent). The oxygen feed was set using a 5 second opening time of a 6-port valve. Regain of base level is significantly faster for FOCUS-IMS® compared to a classic setup. All other settings and parameters were equal in the experiment.

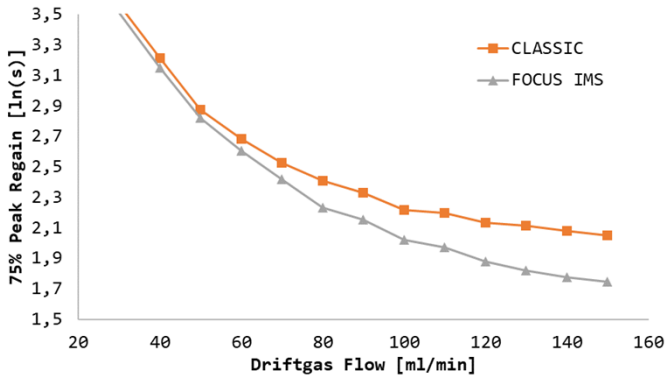

Figure 3: Drift flow dependence of the oxygen washout

Washout performance correlates to drift gas flow rate (constant carrier gas). Higher flows reduce the virtual void volume and accelerates washout.

Comparison to GC-MS

Figure 4 shows the ion currents of a coupled GC-MS/FOCUS-IMS measurement of a homologous series of 2-ketones. Here, the GC separation is identical offering the observability of detector specific features.

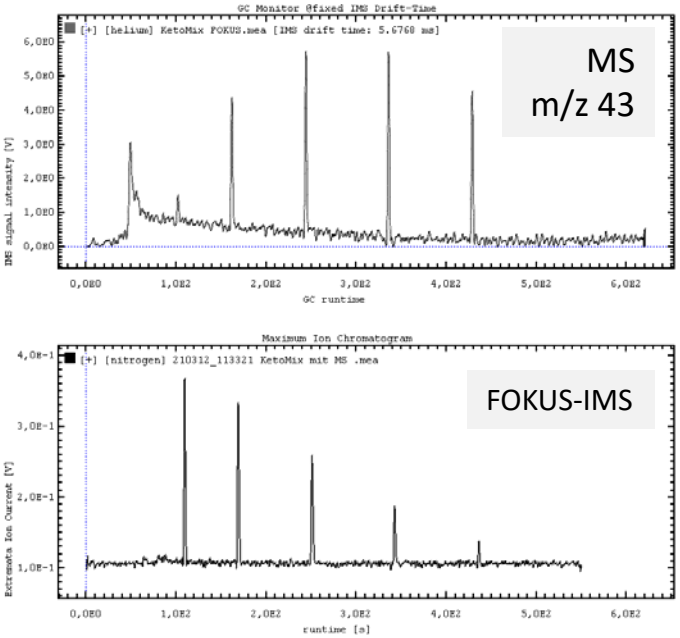

Figure 4: Ion currents of C4-C8 2-ketones measured via a coupled GC-MS/FOCUS-IMS setup

Peak symmetry and FWHM are very comparable between MS and IMS. The shift in absolute retention time is based on to the Y-split restrictors used to transfer the sample to the individual detectors.

Control of sensitivity broadens the Dynamic Range

The ratio of carrier- and drift gas controls the size and dwell time of the sample bubble in the ionization sphere. In classic IMS designs the drift gas flow ratio does not significantly change the sensitivity. Increasing drift gas flows in a FOCUS-IMS® will decrease dwell time and the coverage of the radiation source. Hence it is possible to control the sensitivity of the IMS.

Figure 5 plots the FOCUS-IMS® calibration (semi logarithmic plot) of acetone (Dimer Peak) in a three decade concentration range for two drift gas flows.

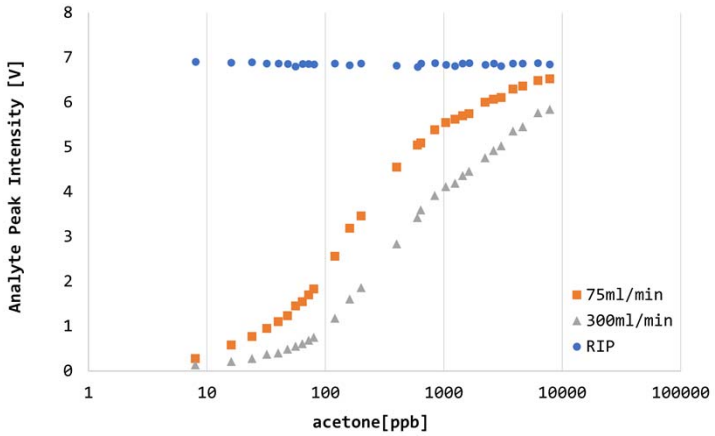

Figure 5: Acetone calibration on a FOCUS-IMS® with 75 and 300SCCM drift gas flow. Alongside the RIP intensity is given.

Elevated drift gas flow lowers the sensitivity throughout the whole concentration range under investigation. Even at highest concentrations the analyte ion peak is >10% below the reactand ion peak (RIP), which represents the level of the assumed theoretic upper limit for IMS response. Extrapolating of the slope indicates a concentration range of approx. 4 decades, which is a significant improvement to typical dynamic ranges of 2 decades seen for classic IMS designs.

G.A.S. IMS device firmware offers control of carrier- and drift gas flows even during a measurement. Thus it is possible to tune sensitivity within a measurement run by switching drift gas flows. This is beneficial for applications where individual concentrations vary extensively.

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