



ThermoFisher
S C I E N T I F I C

Single Quadrupole Mass Spectrometry: A Must-Have in the Chromatography Lab

The world leader in serving science

- Mass Spectrometry: Another Dimension in Separation
- Ion Chromatography with the new Thermo Scientific™ ISQ™ EC single quadrupole mass spectrometer
- The ISQ EC mass spectrometer as an LC-MS

Mass Spectrometry: Another Dimension in Separation

- **Near-universal** detector
- **More selective** detector — at the same time
 - TIC Full Scan → SIM → SRM → HRAM (for all ionization techniques)
- Identification and structural information for each analyte
- Orthogonal dimension of species separation
- Alternative to 2D (IC × IC, LC × LC) techniques
- Opens up the door to ion mobility separation dimension (e.g. FAIMS) etc.

Increasing Selectivity from Single Quad to HRAM Mass Spectrometry



ISQ EC Single Quad MS



Thermo Scientific™
Quantis™ Triple Quadrupole MS



Thermo Scientific™
TSQ Altis™ Triple Quadrupole MS



Thermo Scientific™
Q Exactive™ MS Family

Benefits of Ion Chromatography-Mass Spectrometry

- IC compared to LC
 - Greater specificity and selectivity for ionic compounds
 - Metal-free flow path reduces fouling of ion-exchange columns
- MS vs. Conductivity Detection (CD)
 - Increased sensitivity and selectivity
 - Identification and quantification of small polar analytes that have the same retention times using single ion monitoring (SIM) or selective reaction monitoring (SRM) for MS/MS
- On-Line desalting for high ionic strength matrices
 - Reduces MS signal suppression and possible detector damage
- Analyte Confirmation
 - Combines the confirmation of analyte identification into one method
- Total Integrated Solution: IC, MS and Data Management

Ion Chromatography is Ideal for Mass Spectrometry (MS)

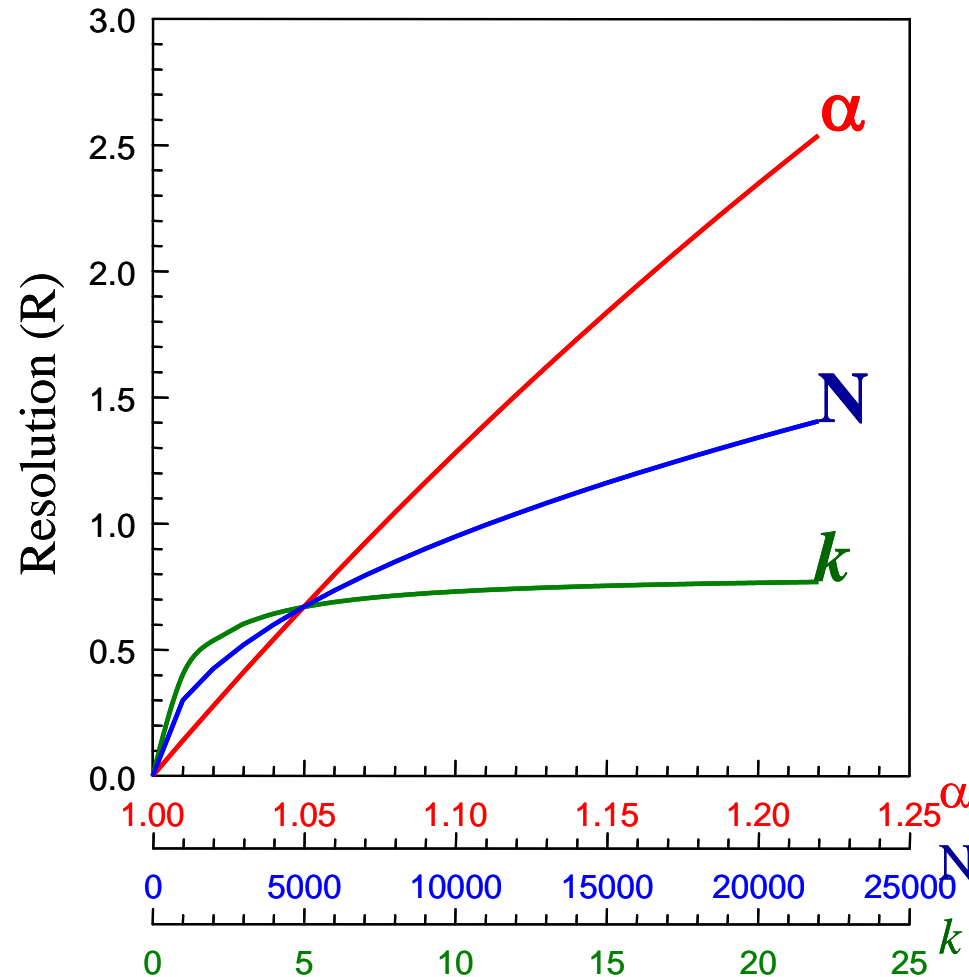
- Analytes are provided already in the **ionic form** needed for MS detection
- Thermo Scientific Dionex **suppressors** allow the use of standard IC eluents and methods and improve MS sensitivity, signal stability and salt/matrix tolerance
- IC-MS may use existing methods from **stand-alone IC**
- **Eluent generators** allow fast, clean switching between anions and cations in IC-MS
- Only need a stainless steel grounding union to couple the IC to the MS source while maintaining a totally **metal-free flow path** otherwise

Selectivity Has the Most «depth» in the Parametric Space

Efficiency	Retention	Selectivity
$R = \frac{\sqrt{N}}{4}$	$\frac{k'}{k'+1}$	$\frac{\alpha-1}{\alpha}$

$$\alpha = \frac{k_2}{k_1}$$

- Selectivity (α) has the greatest impact on improving resolution.



Electrospray Ionization (ESI)

Advantages

- Soft ionization = Preserves analyte's molecular ion
- Sensitive, rugged, well-established
- Compatible with a broad range of analytes and eluents

Disadvantages

- High-aqueous mobile phase lower volatility requires Heated ESI (HESI)
 - Requires elevated ESI Probe temperature and post-column solvent*
- Non-volatile buffers may precipitate inside ESI capillary
- Works best at low flow rates (2 mm i.d. columns)
- Ionization is inhibited by high salt/matrix concentrations

* not required on the new ISQ EC mass spectrometer, but some methods may still benefit from it

Components of the “IC” in IC-MS

- Standard suppressed IC chemistries
 - Does not require special unit or extensive modification
- Eluent Generator
 - Cleaner backgrounds, easy switch-over between anions and cations
- Electrical grounding union
- External water for suppressors

Thermo Scientific ISQ EC Single Quadrupole Mass Spectrometer

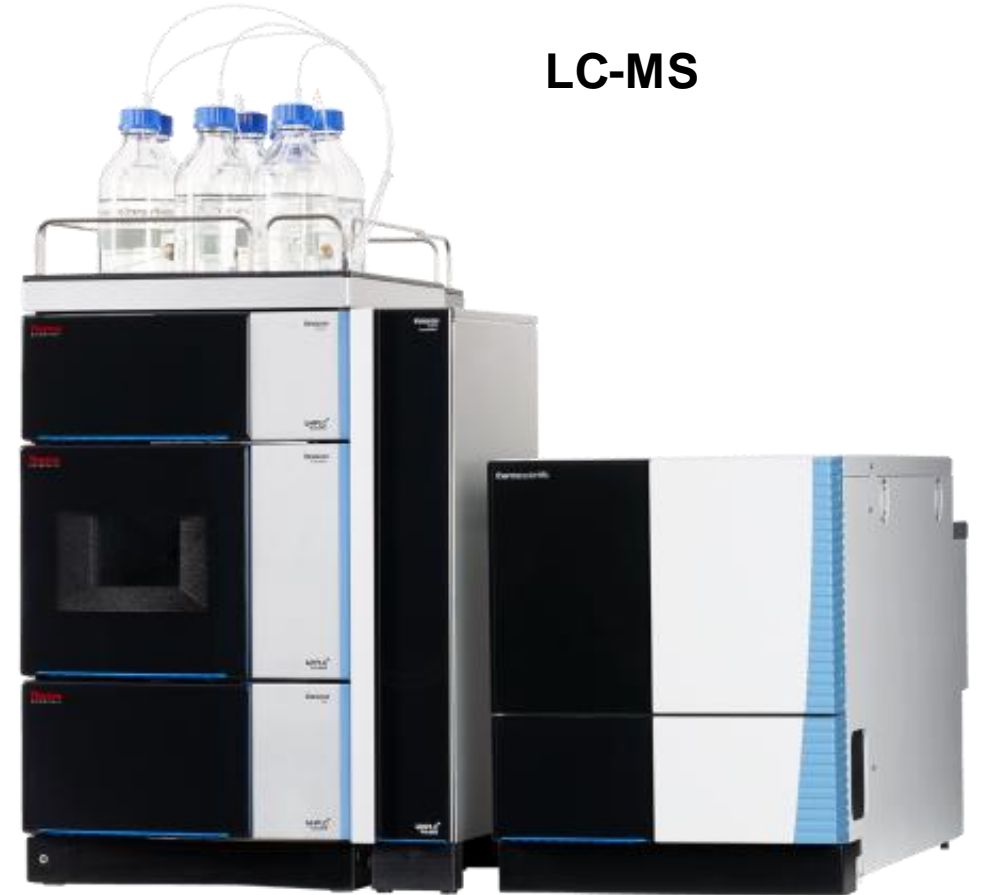
Coupled to Thermo Scientific™ Dionex™
Integrion™ HPIC™

IC-MS



Coupled to Thermo Scientific™
Vanquish™ HPLC system

LC-MS



Combining the Best of Our Triple Quad MS Technologies

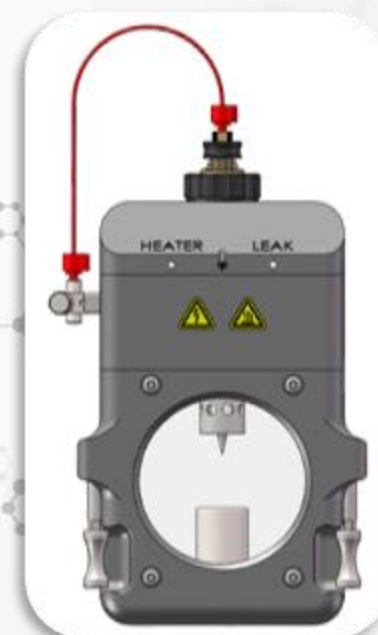
Thermo Scientific™
TSQ™ 8000 Evo Triple
Quadrupole GC-MS/MS



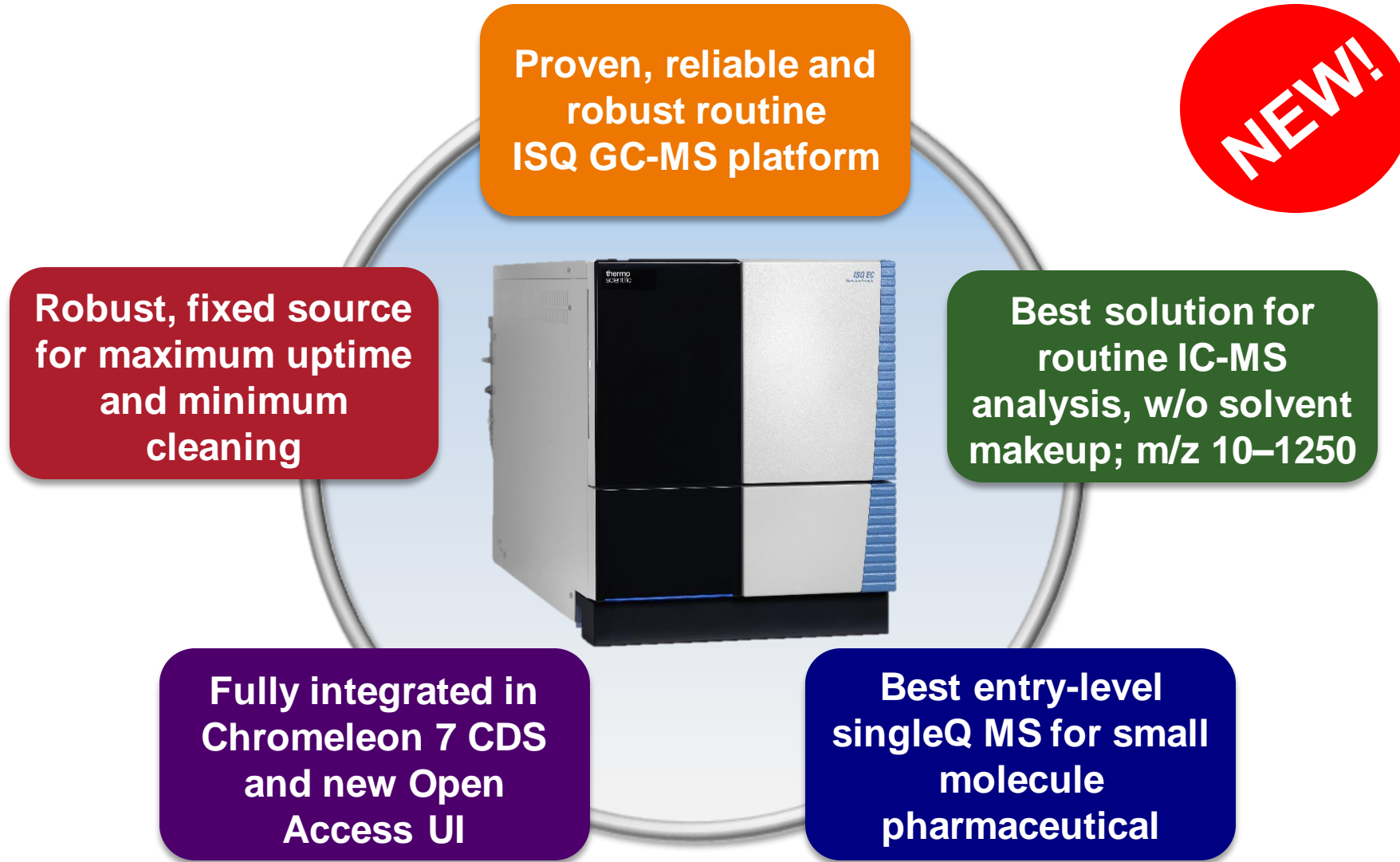
Thermo Scientific™
Chromeleon™ CDS Software



TSQ Altis Triple Quad MS



Thermo Scientific ISQ EC MS – Single Quadrupole MS for IC and LC



Gain Greater Insights From Your Sample

- Unmatched low mass sensitivity
- Chromatographic peak confirmation

Resolve Complexity

- Analyze complex sample matrices
- Hassle-free maintenance

Easily Mastered

- **Integrated tools to help master MS**
- Hassle-free, seamless integration with IC or LC systems
- Embedded control by Chromeleon CDS software

ESI Method Creation & Optimization Challenges

The screenshot displays the 'ICMD-Mass Detector' configuration window. It includes a 'Use this detector' checkbox (checked), radio buttons for 'Easy' and 'Advanced' (Advanced selected), and a 'Source settings' section with input fields for Vaporizer temperature (550 °C), Ion transfer tube temperature (400 °C), Source voltage positive ions (8000 V), Source voltage negative ions (-8000 V), Sheath gas pressure (80.0 psig), Aux gas pressure (15.0 psig), and Sweep gas pressure (0.1 psig). Below this is a 'Method type' dropdown set to 'Component mode' and a 'Transfer scans' button. The 'Scans' section features a toolbar with icons for sorting, zooming, and navigation, along with 'Ion Tables', 'Import', and 'Export' buttons. A table below lists scan parameters for a 'Perchlorate' peak.

Name	Start Time (min)	End Time (min)	Mass	Ion Polarity	Dwell Time Priority	Source CID Voltage	Tube Lens Voltage
Perchlorate	4.50	5.10	99	Negative	Normal	20.0	Last Tune
*							Last Tune

- ESI IC/LC-MS is inherently NOT like EI GC-MS
- What method parameters' set does a newbie start from?
- How do you optimize the whole multi-parametric method?
- Are method parameters inter-dependent?

Thermo Scientific AutoSpray Technology – Patent Application Pending

- Unique Thermo Scientific™ **AutoSpray™** software technology **translates physical properties** of the analyte, mobile-phase and system-wide instrument settings into **optimal method parameters**
- **Easy Mode** for the **novice** user, advanced **tools** for the **MS expert**
- **Auto-tune as part of a sequence**
- **Real-time scanning** for online signal optimization

The screenshot shows the 'Instrument Method Wizard - VMD (Vanquish MS): VMD-Mass Detector' window. The title bar includes the window name and a close button. The main content area is titled 'VMD-Mass Detector for VMD (Vanquish MS)'. It features a checkbox 'Use this detector' which is checked, and two radio buttons for 'Easy' (selected) and 'Advanced'. Below these are three sliders for 'Robust', 'Nonvolatile mobile phase', and 'Stable analyte', all set to 'default'. To the right, a 'Pump flow' field is set to '0.250 mL/min'. Below the sliders are three more sliders for 'Sensitive', 'Volatile mobile phase', and 'Labile analyte'. A 'Method type' dropdown is set to 'Basic mode', and a 'Transfer scans' button is present. A 'Scans' table is visible, with columns for 'Scan Name', 'Mass list or range (amu)', 'Ion Polarity', and 'Source CID Voltage'. The table contains one row with an asterisk in the first column. To the right of the table is an 'Acquisition Rate' section with fields for 'Min. baseline peak width' (3.0 sec), 'Desired scans per peak' (6), and 'Acquisition rate' (2 Hz). At the bottom, there are buttons for '< Back', 'Next >', 'Cancel', and 'Help'.

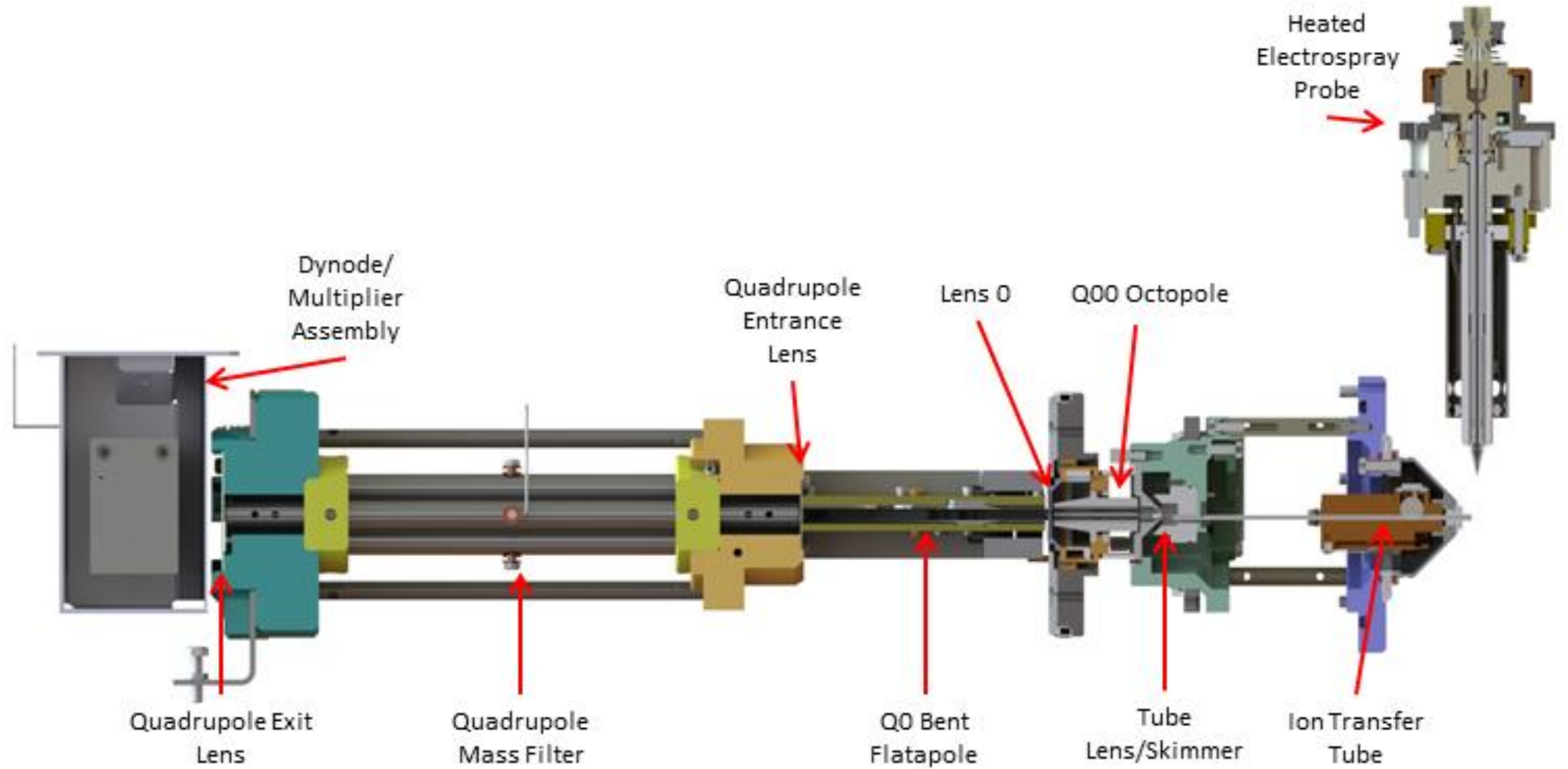
ISQ EC MS is easy to adopt and master

Thermo Scientific AutoSpray Technology Implementation in MS Method Editor GUI

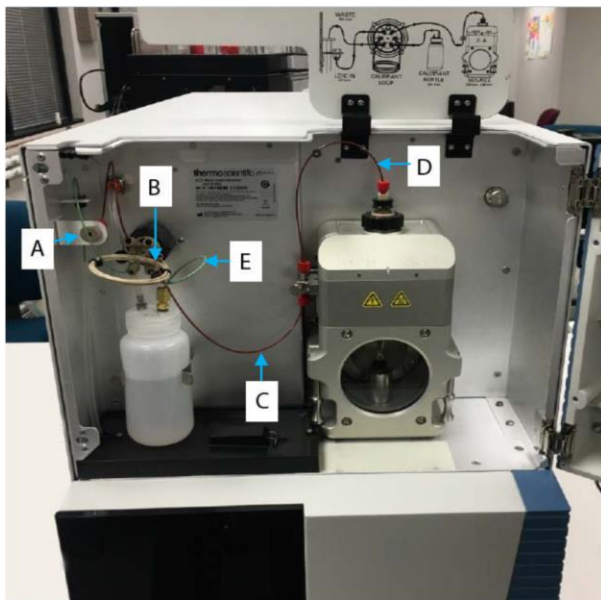
The image displays two screenshots of the VMD-Mass Detector GUI. The top screenshot shows the 'Easy' mode selected, with three sliders for 'Robust', 'Nonvolatile mobile phase', and 'Stable analyte' all set to 'default'. A 'Pump flow' field is highlighted with a red box, showing a value of 0.200 mL/min. The bottom screenshot shows the 'Advanced' mode selected, with a 'Source settings' section containing several numerical input fields: Vaporizer temperature (117 °C), Ion transfer tube temperature (300 °C), Source voltage positive ions (3000 V), Source voltage negative ions (-2000 V), Sheath gas pressure (28.8 psig), Aux gas pressure (3.2 psig), and Sweep gas pressure (0.5 psig). A red arrow points from the 'Easy' mode radio button in the top screenshot to the 'Advanced' mode radio button in the bottom screenshot.

- Use the sliders as a teaching tool how settings impact analyte and background
- Use calculated values as a good starting point for method development
- Helpful to novice and expert

Hardware Benefits: Orthogonal Source, Two Offsets, Vacuum Interlock



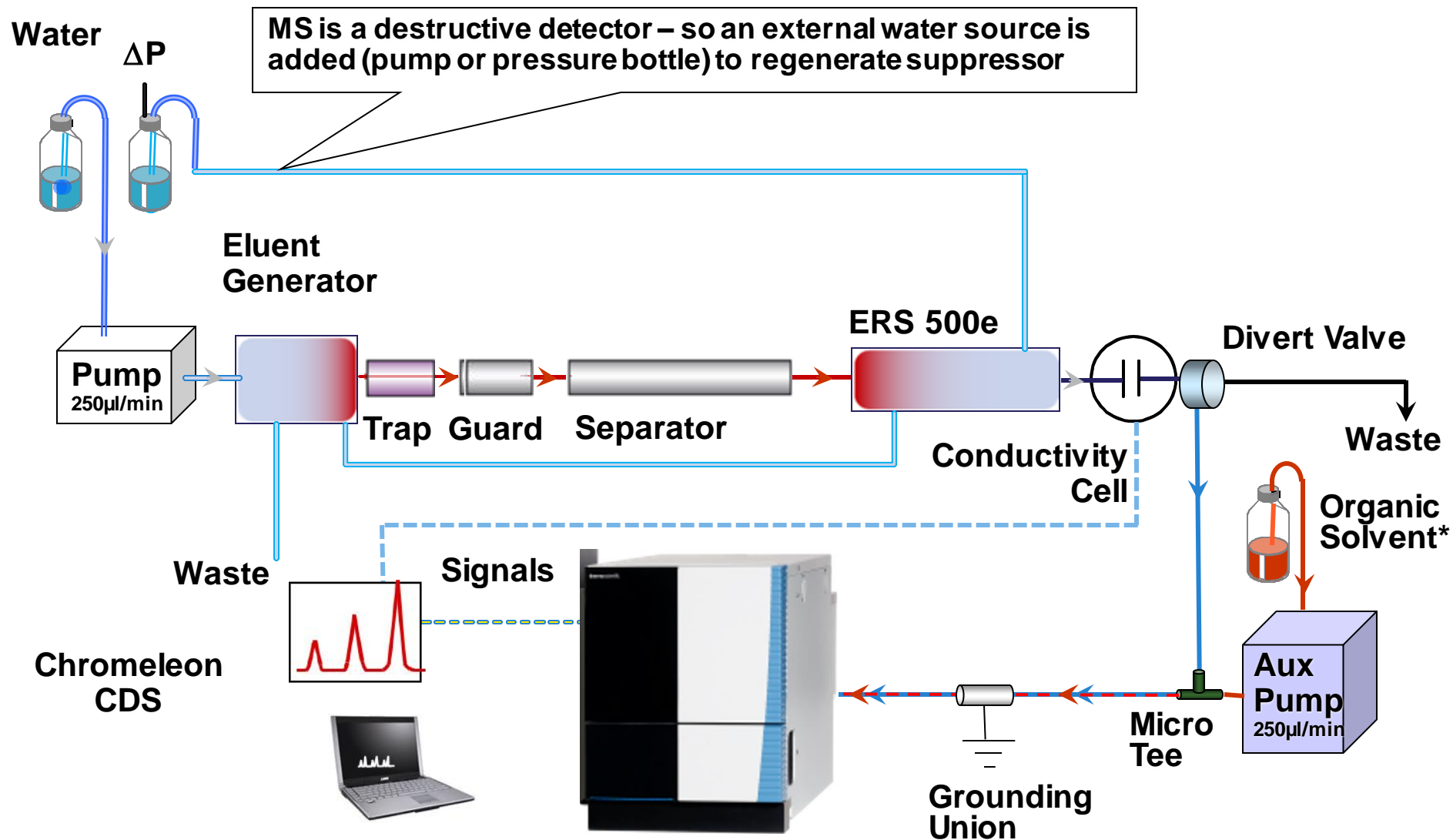
Robustness Design Features



A	Instrument inlet
B	Inlet to valve
C	Valve to grounding union
D	Grounding union to source (probe)
E	Reference calibrant to valve

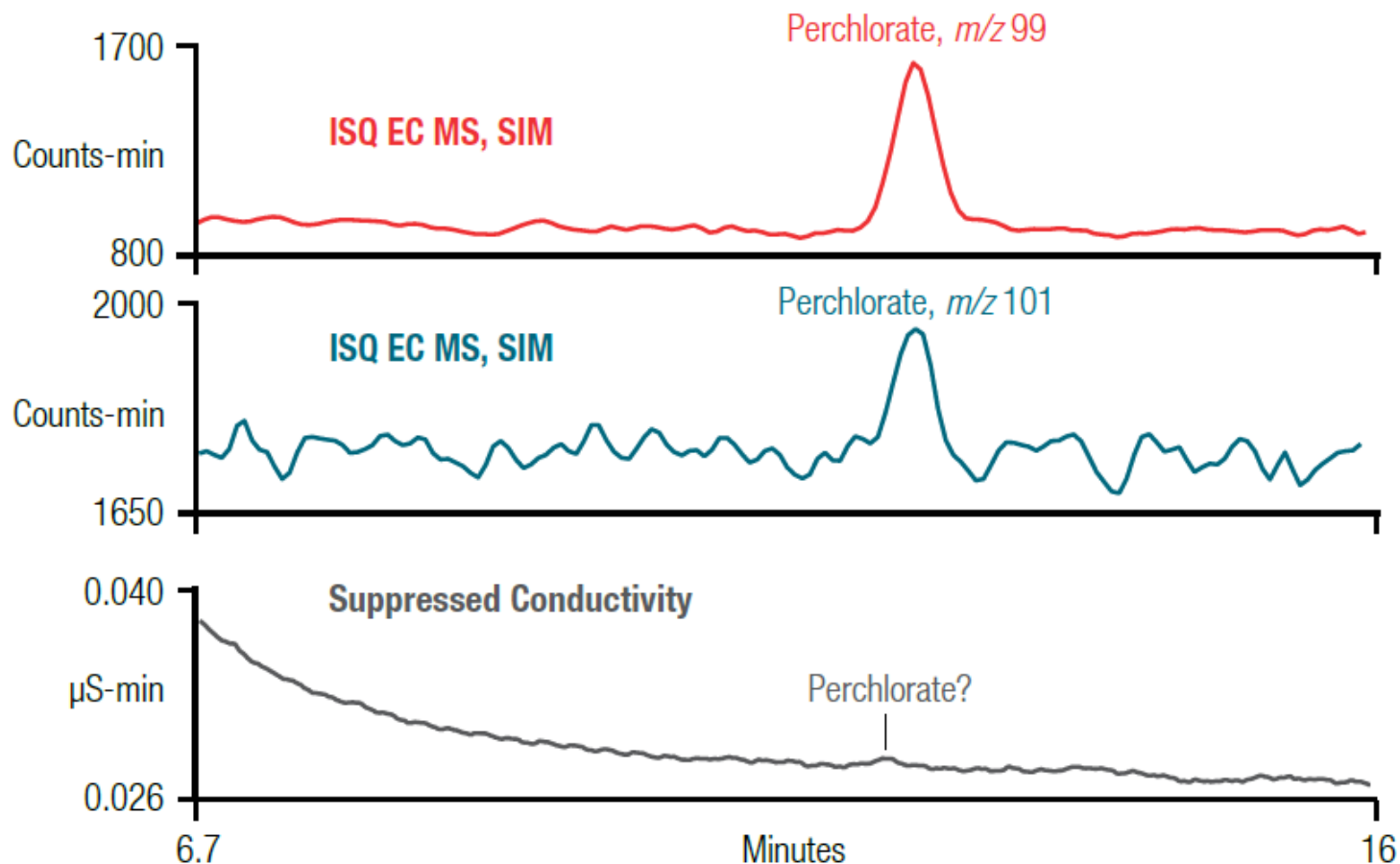
- ✓ Robust source **maintains ionization stability** over a wide range of flow rates
- ✓ Convenient built-in **spray needle calibration** adjustment tool further aids robustness
- ✓ **Enhanced spray stability** in wider flow rate range with redesigned needle tip
- ✓ Orthogonal spray geometry and automated gas flow streams for **solid performance** with dirty samples
- ✓ **Worry-free operation** with intelligent, experiment-based method editor and built-in leak sensor

IC-MS Schematics



* not required on the new ISQ EC MS but most methods would benefit from it

IC-MS: Improved Low-Mass Sensitivity in Drinking Water



thermoscientific

AU72507

APPLICATION UPDATE 72507

Determination of perchlorate in environmental waters using a compact ion chromatography system coupled with a single quadrupole mass spectrometer

Authors

Beibei Huang and Jeffrey Rohrer
Thermo Fisher Scientific,
Sunnyvale, CA, USA

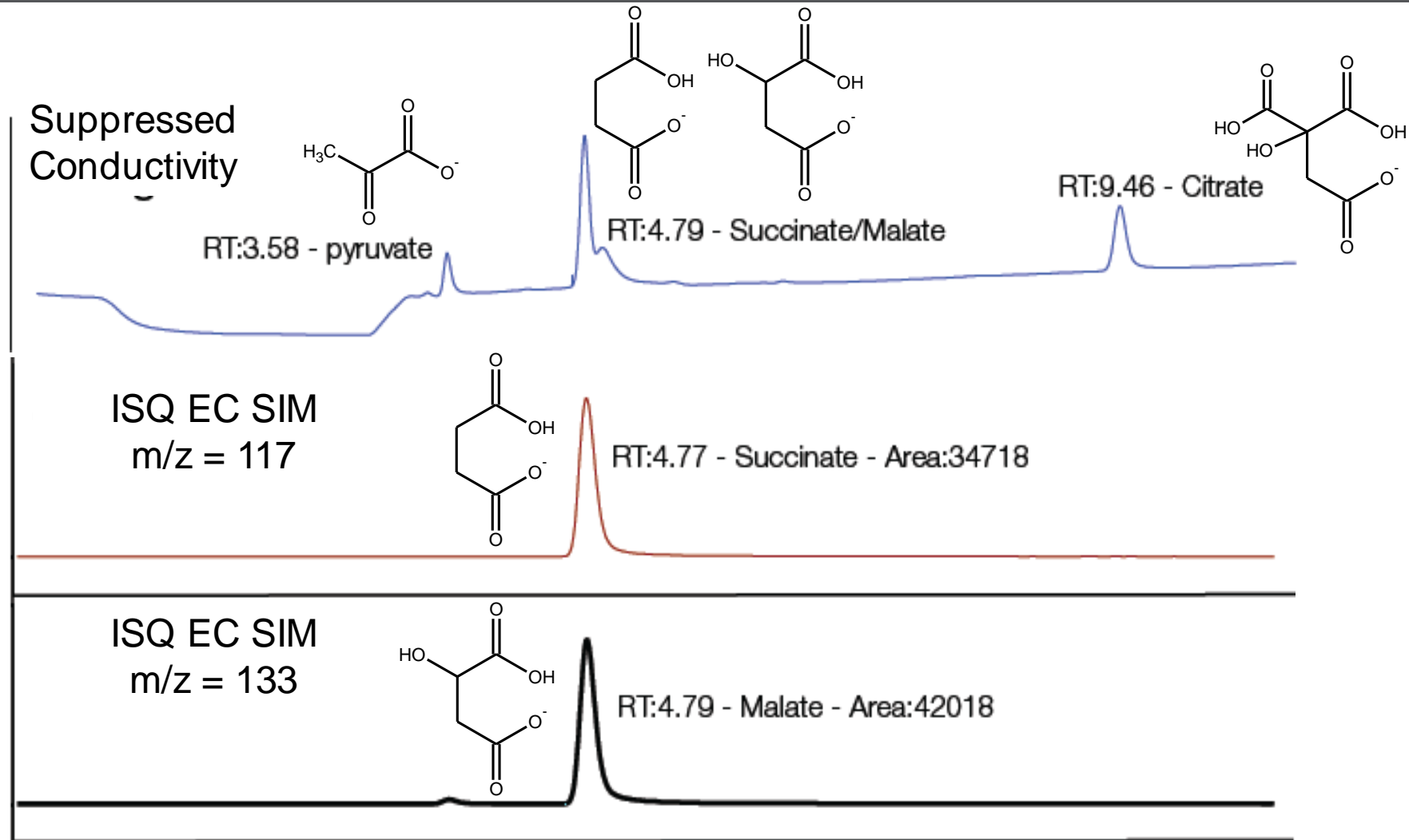
Introduction

Perchlorate has been used as an oxidizer in rockets, munitions, and fireworks since the 1950s. It has been found to cause thyroid dysfunction and has been linked to tumors in humans. Perchlorate is regulated under the Safe

pH = 7
 $[\text{H}^+] = [\text{OH}^-] = 10^{-7} \text{ mol/L}$
Mass conc. (OH^-) \approx 200 ppt

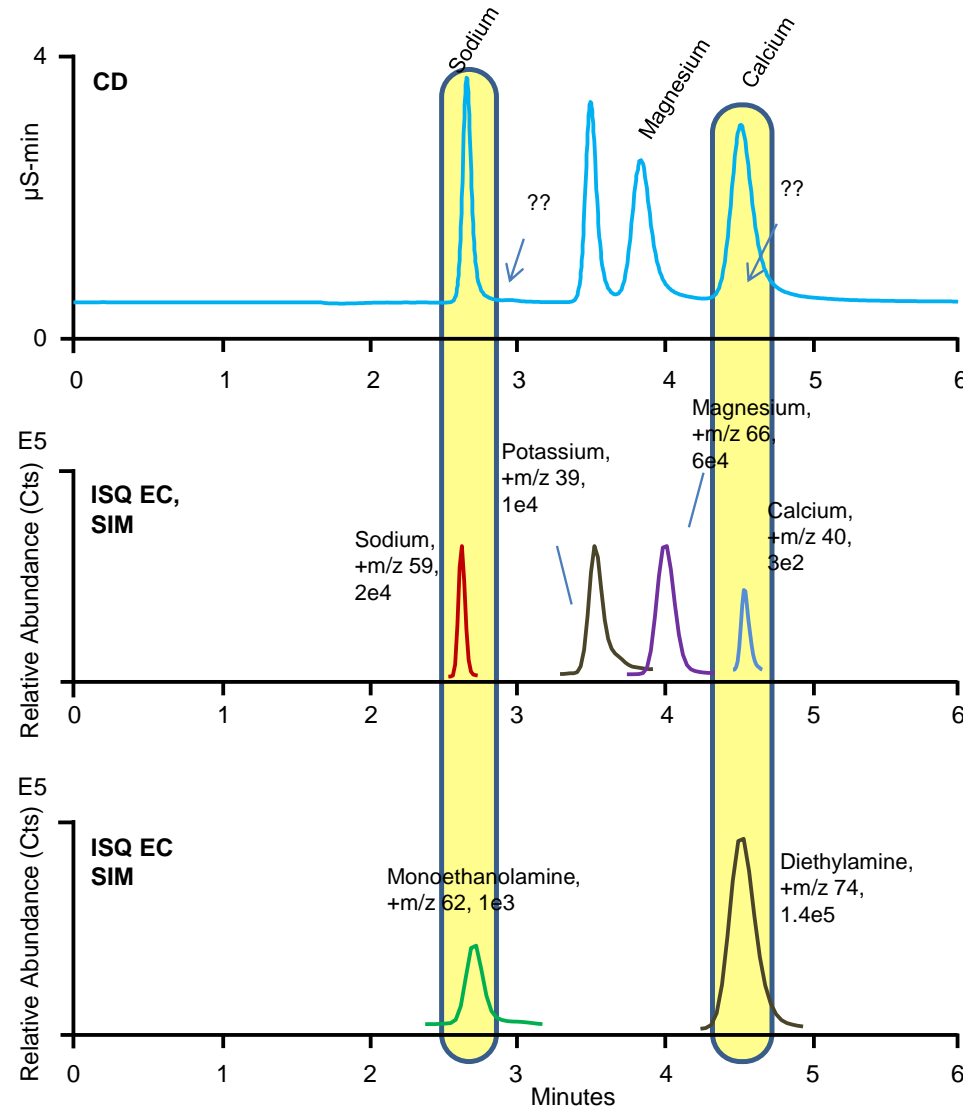
Required LODs are not achievable by Conductivity Detector, as CD is not SELECTIVE enough

If Coelution Causes False Positive Quantitation... Use IC-MS



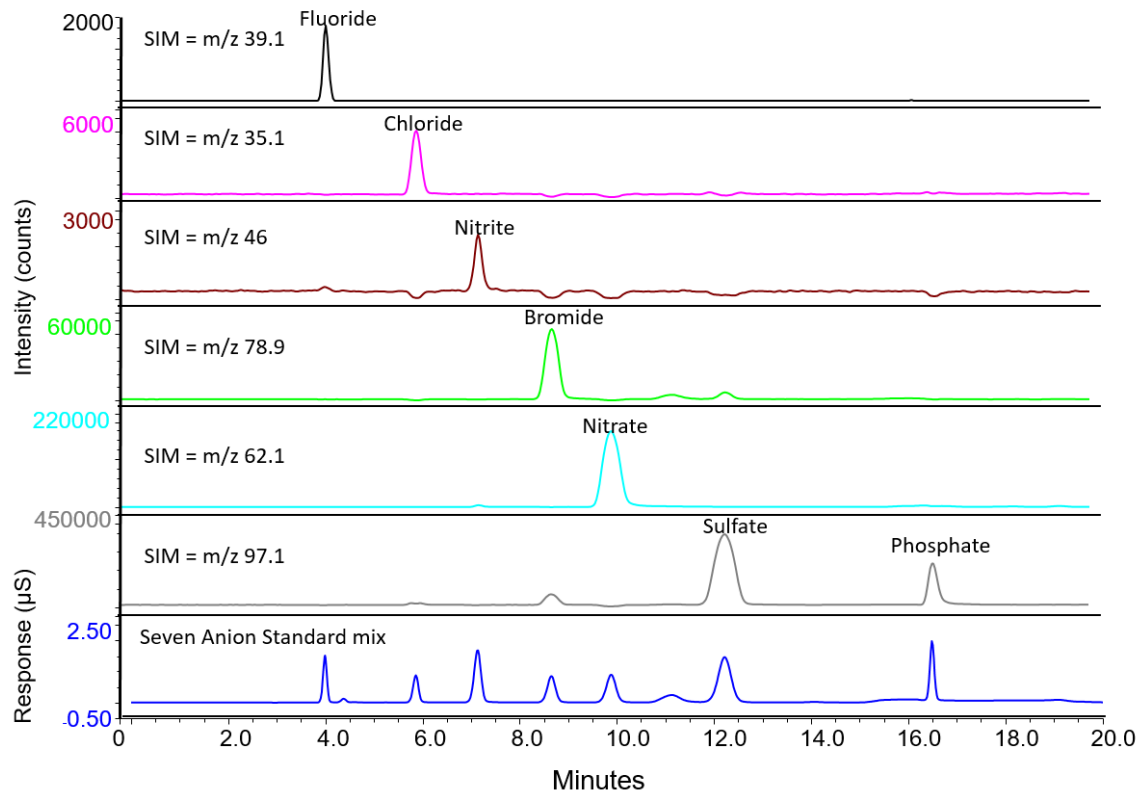
Why IC-MS? Because separation by IC may not be enough.

IC-MS: Resolving Coelution and Quantitation in Spoiled Grape Juice

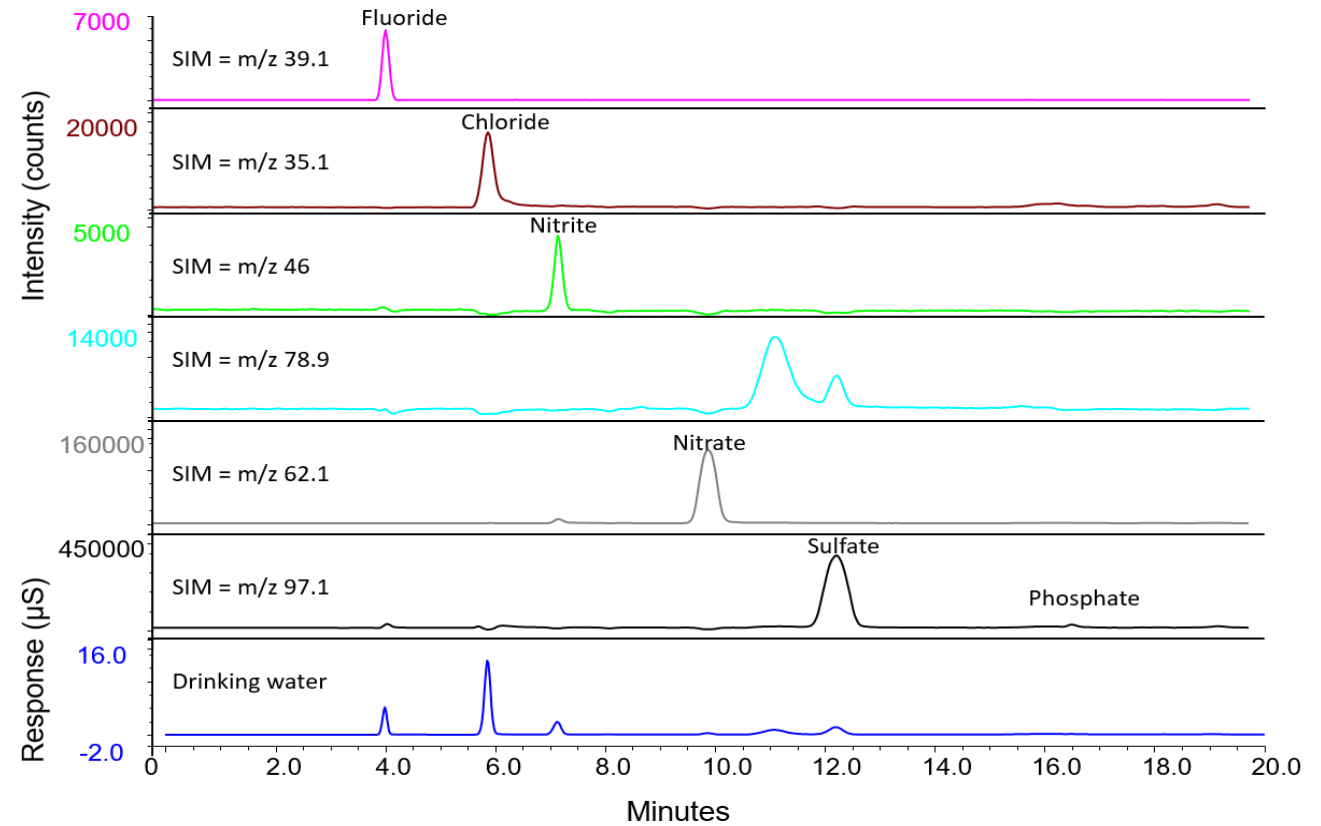


Resolve monoethanolamine and diethylamine in MS dimension

IC-MS of Anions



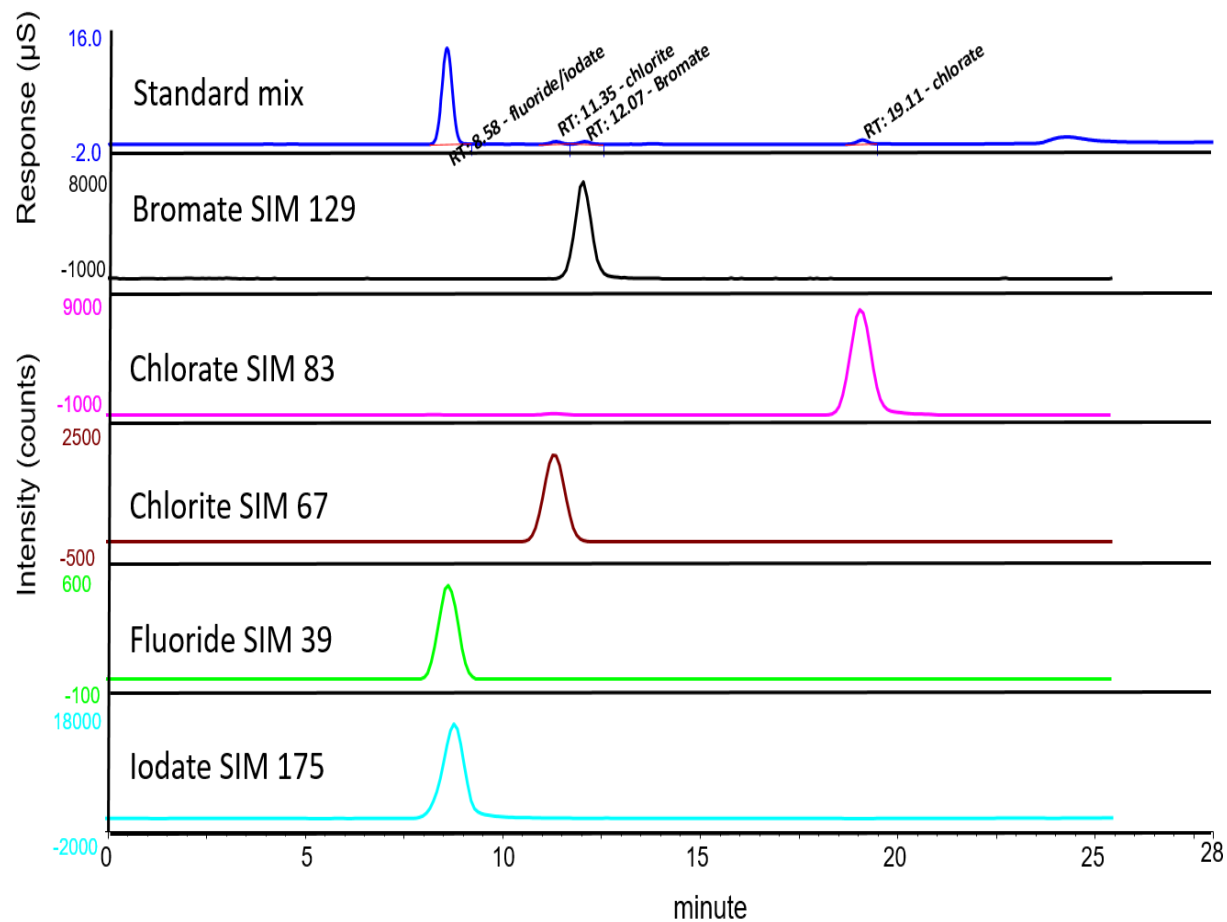
7 Anion Standard



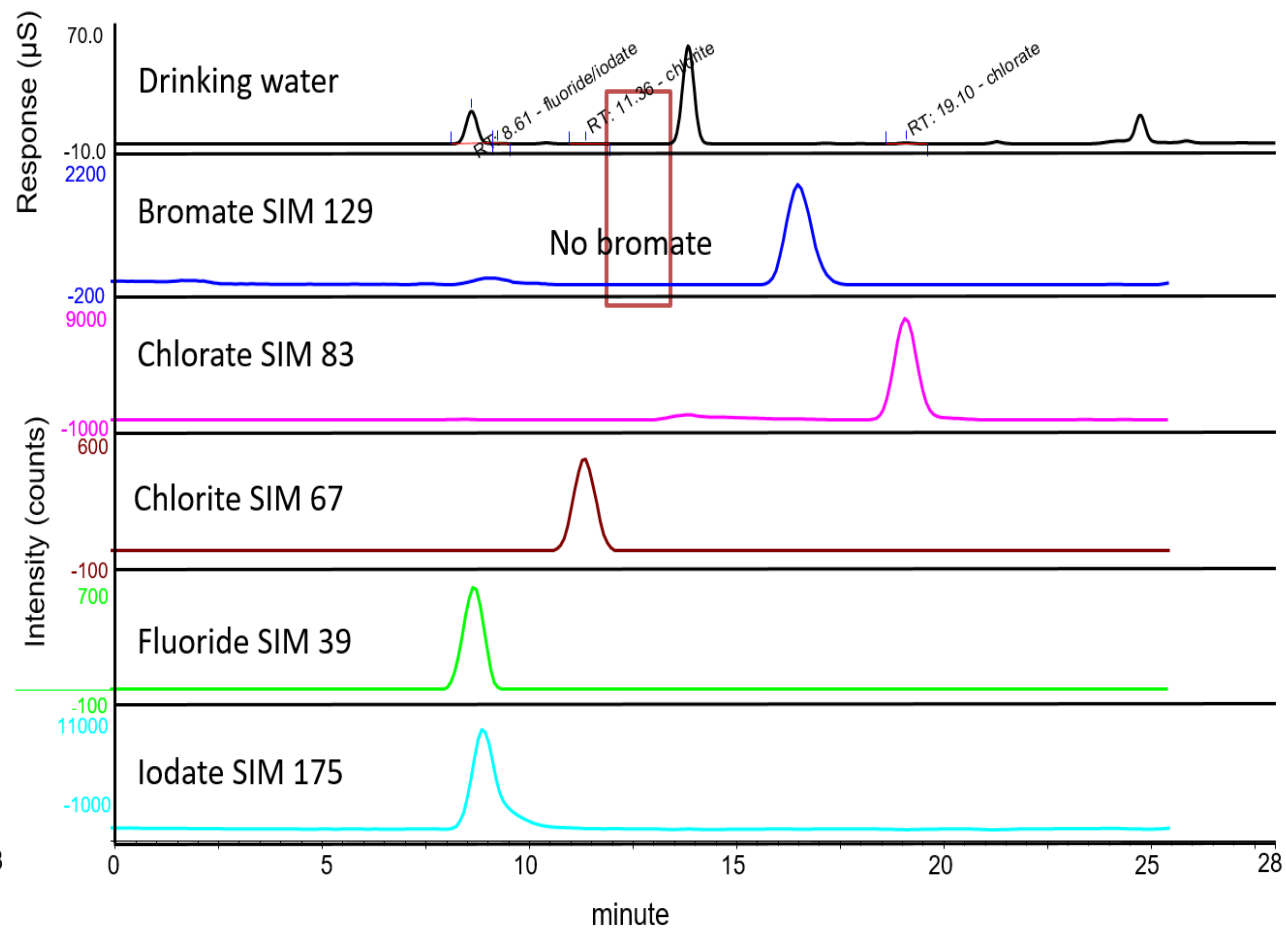
Municipal Drinking Water

Fluoride detected as $[F(HF)]^-$ at $m/z = 39.1$

Oxyhalides

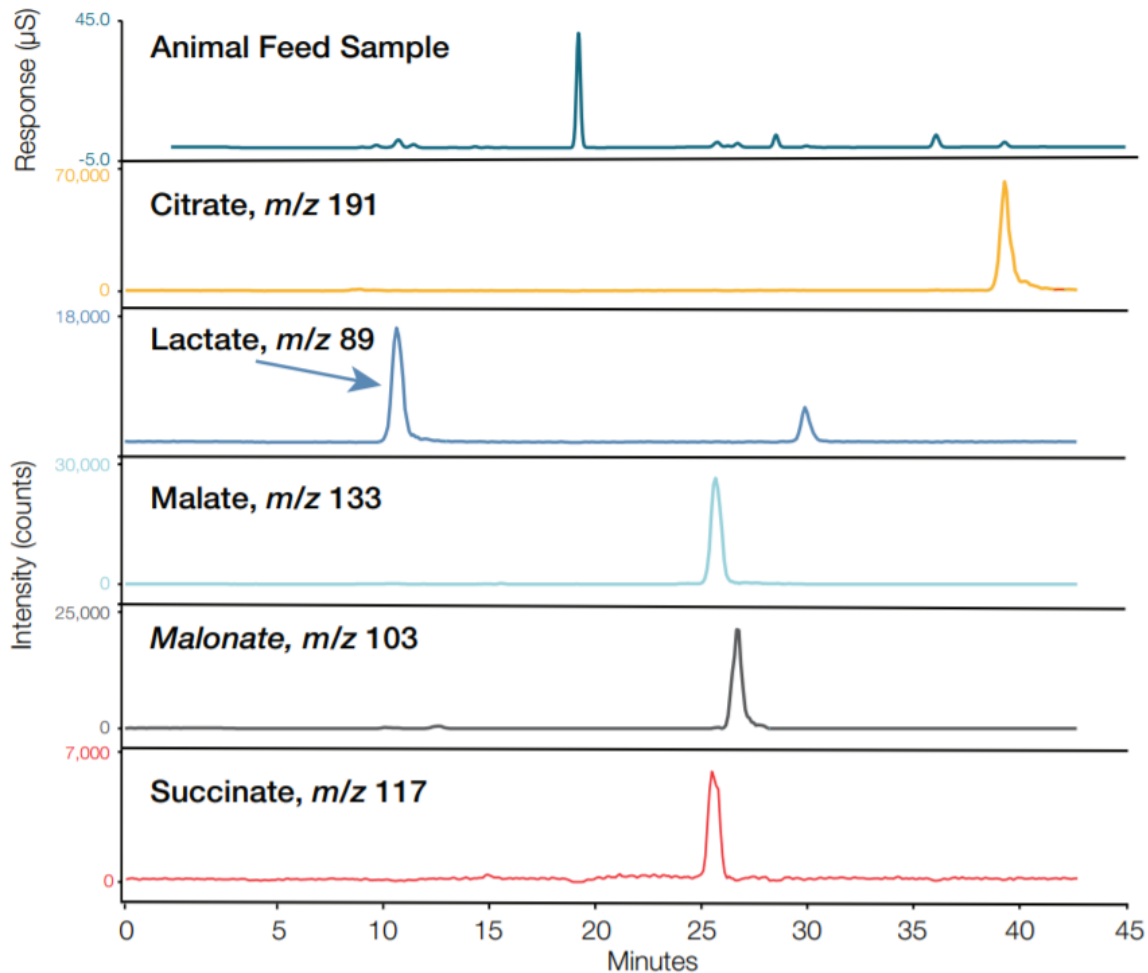


Oxyhalide Standard



Oxyhalides in Drinking Water

IC-MS of Animal Feed

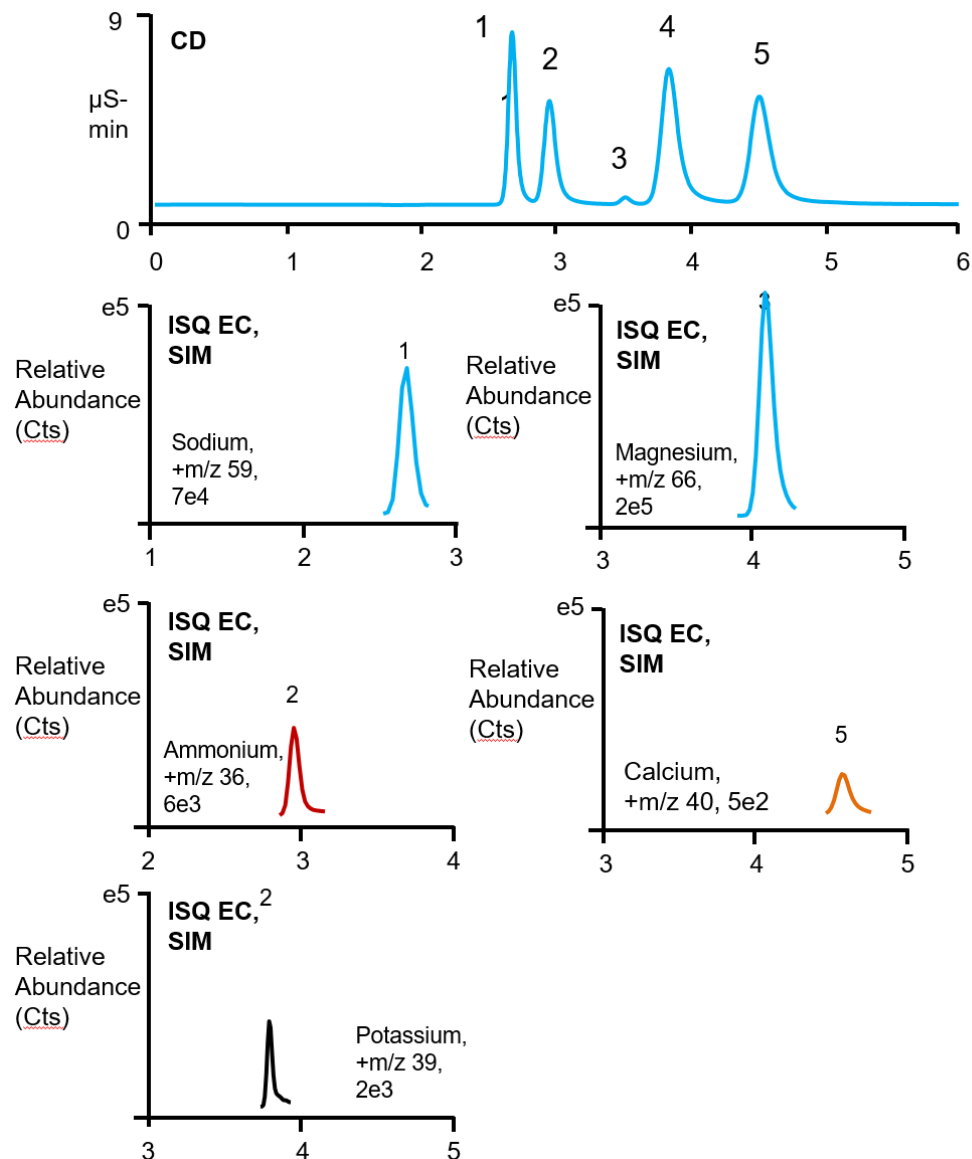


System: Thermo Scientific™ Dionex™ Integrion HPIC System, ISQ EC MS
Columns: Thermo Scientific™ Dionex™ IonPac™ AS11-HC-4µm Guard, 2x50mm, Dionex IonPac AS11-HC-4µm Analytical, 2x250mm
Eluent Source: Thermo Scientific™ Dionex™ EGC 500 KOH cartridge, Thermo Scientific™ Dionex™ CR-ATC™ 600 trap column
Gradient: 1mM KOH (0-8min), 1-30mM (8-30min), 30-60 mM (30-44min), 60mM (44-45min)
Column Temp.: 40°C
Flow Rate: 0.35 mL/min
Inj. Vol.: 2.5 µL
Oven Temp.: 30 °C
Detection: Suppressed conductivity, ThermoScientific™ Dionex™ AERS™ 500e suppressor, 2mm, Autosuppression, 52 mA, external water mode (0.7 mL/min) via ASP pump

MS conditions are the same as shown in method except for as below:
SIM mode: 89, 103, 117, 133, 191

Identification of common organic acids in an animal feed sample by the comparison of t_R and m/z

Determination of Cations in a Ground Water Sample

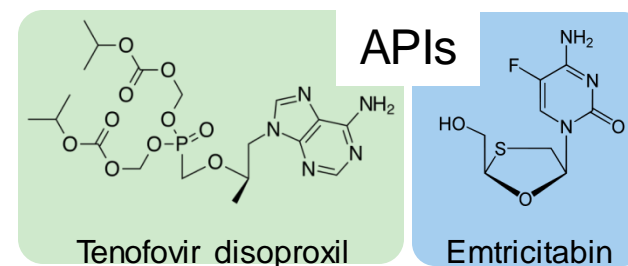
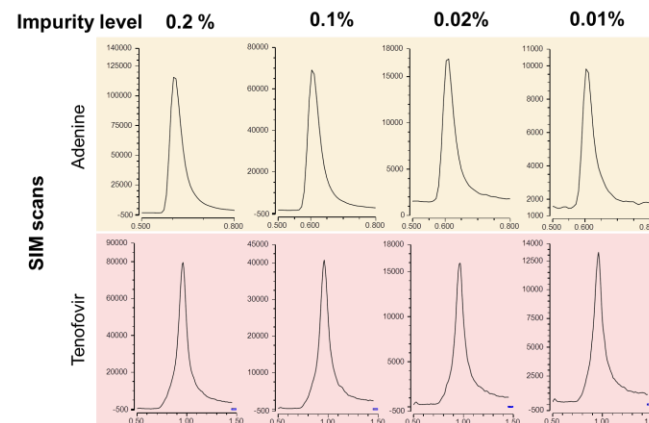
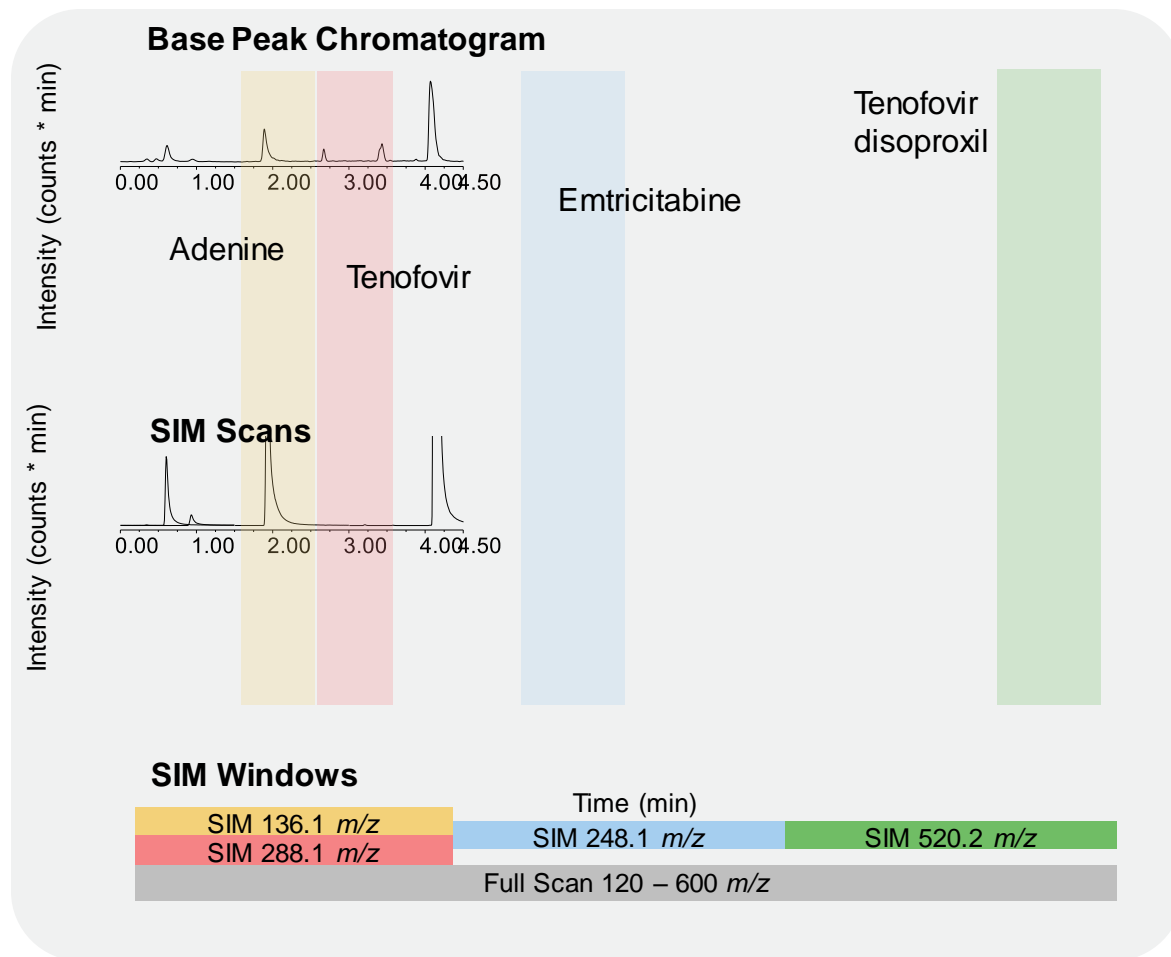


Columns: Dionex IonPac CG12A, CS12A, 2 mm
 Eluent: 22 mM Methanesulfonic Acid (MSA)
 Eluent Source: Thermo Scientific™ Dionex EGC™ 500 MSA cartridge,
 Thermo Scientific™ Dionex™ CR-CTC™ 600 trap column
 Flow Rate: 0.5 mL/min
 Inj. Vol.: 100 μL
 Oven Temp.: 30 °C
 Detector 2: ISQ EC MS, +ESI, +3000 V source, HESI II
 Scan mode: Full scan: 18-250 m/z, and SIM
 Make-up solvent: none
 Source Temp.: Vaporizer 250 °C , Ion Transfer 300 °C
 N₂ Gas flow (psi): Sheath 60, Aux 26, Sweep 0.5
 Sample Prep.: 100-fold dilution with DI

Peaks:	m/z	CID (V):
1. Sodium $\cdot 2\text{H}_2\text{O}^+$	59	10
2. Ammonium $\cdot \text{H}_2\text{O}^+$	36	2
3. Potassium	39	45
4. 2Magnesium $\cdot \text{H}_2\text{O}^+$	66	5
5. Calcium	40	45

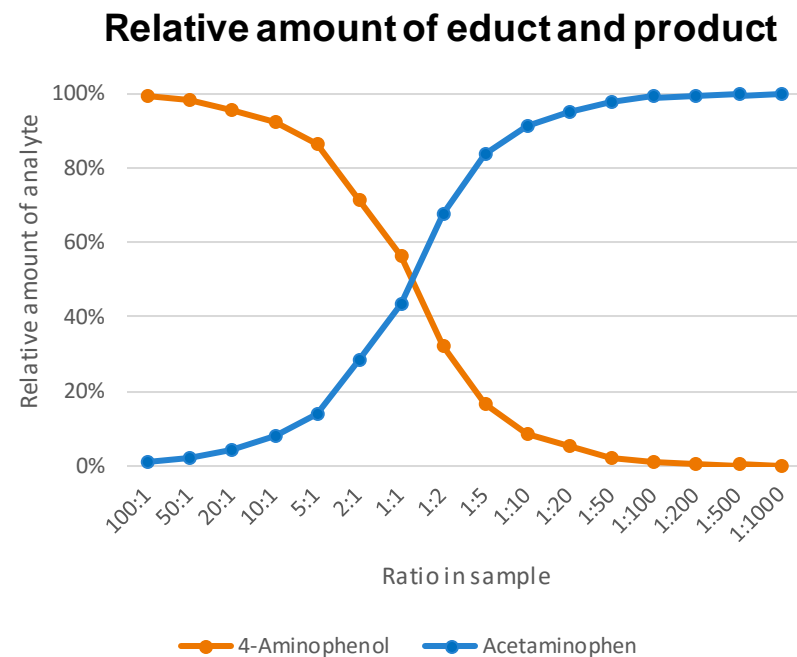
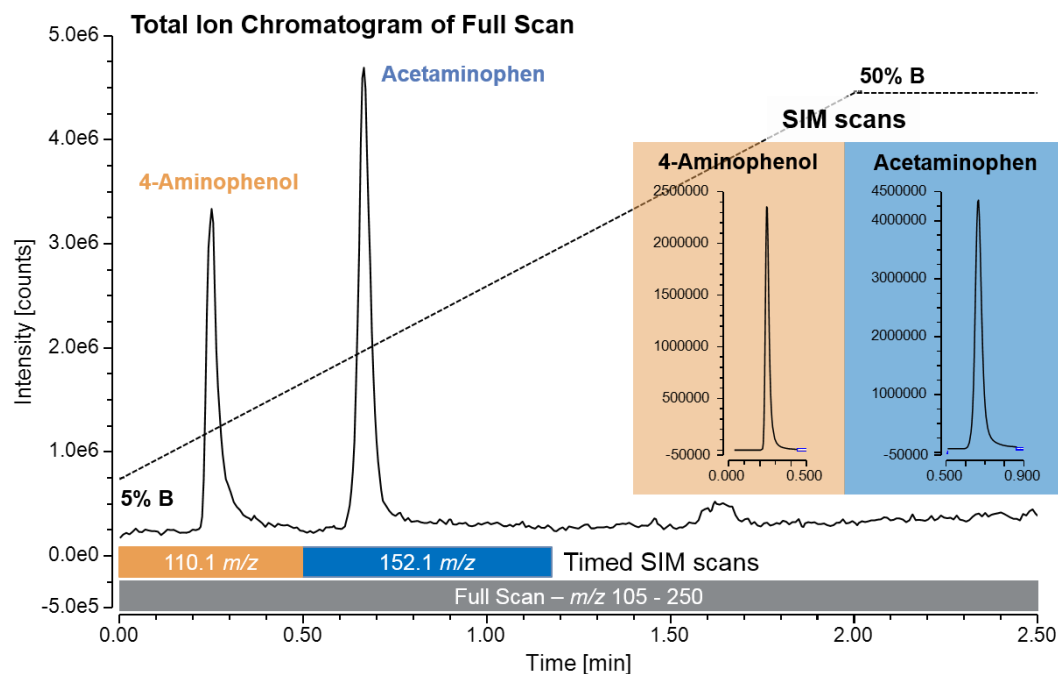
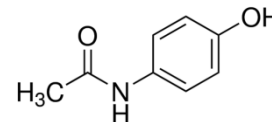
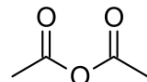
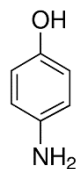
LC-MS: To simultaneously quantitate targets and screen for unknowns

ISQ EC MS



Why MS? Because it is both more universal and more selective detector.

Thermo Scientific ISQ EC MS as LC-MS: Synthesis Monitoring & Reaction Confirmation



More robust, off-the-shelf solution with reduced support needs

IC-MS Published Applications

- Published Thermo Scientific™ Dionex™ IC-MS applications:

- Perchlorate in Environmental Waters (AN151 & APN 203)
- Determination of Low Molecular Mass Organic Acids in Biomass (AB104)
- Determination of Acrylamide in Water (AN409)
- Determination of Fluoroacetic Acid in Water (AN276)
- Determination of Common Anions and Organic Acids (AN243)
- Determination of Common Cations and Amines (AN269)
- Determination of Haloacetic Acids in Drinking Water (AN454 & AN630)
- Determination of Polar Pesticides and their Breakdown Products in Environmental Water (AN491)
- Determination of Polar Pesticides and their Breakdown Products in Food Samples (AN661)
- Determination of Nitrogen Mustard Hydrolysis Products as Ethanolamines in Water Samples
- Determination of Endothall in Water (AN263)
- Determination of Ultratrace Level Perchlorate in Liquid and Powdered Baby Formula
- Determination of Small Organic Acids in Sea Water by IC-MS (AN1000)
- Pathway-Targeted Metabolomic Analysis in Oral/Head and Neck Cancer Cells using IC-MS (AN622)
- Using ion chromatography with electrospray ionization mass spectrometry for the determination of cations and amines in alkanolamine scrubbing solutions soon to be published (AN72609)

EPA Method 557 – Analysis of Haloacetic Acids, Dalapon, and Bromate in Drinking Water by IC-MS/MS

Jonathan H. Deak, Teri Chubb, and Hans Schwaninger, Thermo Fisher Scientific, San Jose, CA

Key Words: Environmental analysis, ion chromatography, disinfection byproducts, haloacetic acids, HAA5, dalapon, bromate, IC-MS/MS

Goal: To demonstrate a simple and sensitive IC-MS/MS method for analyzing haloacetic acids, the pesticide dalapon, and bromate in water using EPA Method 557.

Introduction: Haloacetic acids (HAA5) are formed as disinfection byproducts when water is chlorinated to kill bacteria. Chlorine reacts with naturally occurring organic and inorganic matter in the water, such as decaying vegetation, to produce disinfection byproducts (DBPs) that include HAA5. Of the nine species of HAA5, five are currently regulated by the U.S. Environmental Protection Agency (EPA): HAA5: monochloroacetic acid (MCAA), dichloroacetic acid (DCAA), trichloroacetic acid (TCAA), tetrachloroacetic acid (TetraCAA), and pentachloroacetic acid (PentCAA). The remaining four HAA5 are currently unregulated: bromochloroacetic acid (BCAA), bromodichloroacetic acid (BDCAA), dibromochloroacetic acid (DBCAA), and tribromochloroacetic acid (TBCAA). However, they are of health concern and are often analyzed along with the HAA5. This method allows for the analysis of all nine HAA5, plus bromate and the pesticide dalapon in the same IC-MS/MS run without sample preparation.

According to the EPA, there is an increased risk of cancer associated with long-term consumption of water containing levels of HAA5 that exceed 0.08 mg/L (80 µg/L). EPA Methods 412.1, 412.2, and 412.3 are used to determine the level of all nine HAA5 in drinking water. These methods require derivatization and multiple extraction steps followed by gas chromatography (GC) with electron capture detection (ECD).

In compliance to the conventional EPA methods using GC with ECD, the combination of ion chromatography and mass spectrometry (IC-MS and IC-MS/MS) offers sensitive and rapid detection without the need for sample pretreatment. In order to develop a simple, easy to use direct injection method, the EPA promulgated Method 557 for the analysis of haloacetic acids, bromate, and dalapon in drinking water by IC-MS/MS.

Experimental:

Ion Chromatography: Ion chromatography analysis was performed on a Thermo Scientific™ Dionex™ ICS-5000™ Reagent Free™ IC system (SP Single Pump, IC Eluent Generation, and IC Detector Column modules). Samples were directly injected and no sample pretreatment was required. The IC conditions used are shown in Table 1.

The sample was injected without cleanup or concentration onto a Thermo Scientific™ Dionex™ IonPac™ AS24 column specifically designed to separate method analytes from the following common matrix components in drinking water: chloride, carbonate, sulfate, and nitrate.

Hydroxide eluent was generated using electrochemical generators, which provide accurate and precise gradients without buffer salts. A continuously regenerated ion eluent continuously removes contaminants to provide peak clarity throughout the run. A Thermo Scientific™ Dionex™ ADR™ 500 suppressor was placed in the flow after the column that chemically converted halide eluent into water and simultaneously removed cations present in the drinking water and eluent. See Figure 1.

Thermo Scientific

thermo scientific

APPLICATION NOTE

Fast routine analysis of polar pesticides in foods by suppressed ion chromatography and mass spectrometry

Kateřina Boučková,¹ Cees Bruggink,² Michal Godula¹

¹Thermo Fisher Scientific, Special Solutions Center, Dreieich, Germany

²Thermo Fisher Scientific, Special Solutions Center, Breda, Netherlands

In addition, glyphosate is used as a crop desiccant to suppress weeds in parks and at residences. Consequently, these pesticides often occur in foods as residues and in the environment as contaminants of surface waters. There are concerns about their potential adverse effects on human health, such as their potential carcinogenicity, although the latest toxicological assessments do not predict risks for humans under normal conditions or environmental exposures.¹ Current regulations offer maximum residue levels (MRLs) of glyphosate and its metabolite aminomethylphosphonic acid (AMPA) at 100 mg/L in drinking water, in food and beverage samples, higher MRLs typically apply, ranging generally from 10 mg/kg for food intended for consumption by children up to hundreds of mg/kg in other matrices.²

The analysis of glyphosate and other polar compounds presents a difficult analytical challenge. Their polarity does not allow the direct analysis by reversed phase HPLC, so alternative methods need to be applied. Derivatization of glyphosate prior to analysis³ or application of specific chromatographic columns, such as the Thermo Scientific™ Hypersil™ columns, are the common approaches.⁴

Key Words: Glyphosate, AMPA, polar pesticides, pesticide residues, IC-MS, TSD Evaporator, integration

Goal: To develop and test an IC-MS/MS multi-residue method that can be applied for high-throughput screening and quantification of polar pesticide residues and their metabolites in food matrices below the current legislative requirements.

Introduction: The presence of very polar ionic pesticides in surface and drinking water, as well as food and beverages, has become a controversial issue in recent years. The development of genetically modified crops tolerant to glyphosate and glufosinate, for example, promoted the use of these broad spectrum herbicides.

ThermoFisher Scientific

- IC-MS is the method of choice for sensitive and selective determinations of ions
- Aqueous samples can be directly injected into the IC system, eliminating the need for derivitization with minimal sample preparation
- IC-MS can be used to confirm the identity of small polar molecules

Join the Fun! *Cache a Chromeleon* Game

- Use your mobile device to complete challenges and earn a Charlie Chromeleon plush toy!
- If you are playing, you have earned points for attending this seminar. Be sure to scan the barcode on the desk outside the door.
- Ask booth staff for more details on how to play.



Please join me in the
Ion and Liquid Chromatography
sections of our booth where I'll
address additional comments and questions.