#### **Thermo Fisher** s c i e n t i f i c

# Advances in trace elemental analysis with ICP spectrometry

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EMEA Regional Marketing Manager, TEA & IOMS **Discovery Days** 



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# **Industry Applications for Elemental Analysis**



# **Typical Challenges Increasing the Effort**



**Biased results –** Interferences affecting data quality

Speed of Analysis – Cost driver and delaying answers to clients

**Overhead times –** Limiting productive time of an instrument

**Limited flexibility –** Different sample matrices may require different configurations

# **A Complete Portfolio of Innovative Instruments**

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#### **Features include:**

- Single- or multi-element analysis
- Low-cost of ownership, high-throughput systems
- Space-saving ergonomic design with low gas consumption





Single Quadrupole ICP-MS





HR-ICP-MS

Triple Quadrupole ICP-MS

#### Measure elemental impurities:

- Any sample matrix
- Measurement at concentrations from parts per trillion to percent

## **Considerations for instrument selection – AAS vs. ICP**



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# **Applications Overview**

Wastewater and Soil Analysis			$\checkmark$	
Drinking Water		*		$\sim$
Food Safety	$\checkmark$	$\checkmark$	$\checkmark$	$\sim$
Pharmaceutical				
Petrochemical			$\sim$	
Mining/Metallurgy	$\sim$			

\* Not generally suitable, limitations may apply

# Thermo Fisher Scientific >70 years of elemental analysis



- Spectroscopy since 1950s
  with Quantometer 8200
  - iCAP 61e was the gold standard of PMT based ICP-OES in the 1980s
  - Bench top Iris was the first CID based ICP-OES allowing full spectral analysis (1990s)



- iCAP 6000/7000 ICP-OES
  - Launched in 2006
  - Revolutionary ICP-OES, market leading sensitivity and robustness in a compact design
  - Redefined ICP-OES instruments



**Thermo Fisher** 

- iCAP PRO Series ICP-OES
  - Introduced in 2020
  - First vertical duo torch from Thermo Scientific
  - Enables analysis of high matrix samples without comprising performance

### And Now the Next Innovative ICP-OES Instrument

# Thermo Scientific<sup>™</sup> iCAP<sup>™</sup> PRO Series ICP-OES Following 60 years history of innovation in ICP-OES...

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### **iCAP PRO Series ICP-OES**



# What is NEW in the iCAP PRO Series ICP-OES

### **Speed, Robustness and Simplicity**



### **iCAP PRO Series ICP-OES**



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# **Applications - iCAP PRO ICP-OES**

#### Food & Beverage / Environmental / Water analysis



# **Applications - iCAP PRO ICP-OES**

#### Oil & Gas / Industrial / Mining & Raw material / Battery



# **Thermo Fisher Scientific > 35 years of ICP-MS experience**



- Quadrupole ICP-MS
  - 1<sup>st</sup> commercialized Q-ICP-MS in 1983
  - 5<sup>th</sup> Generation of single quadrupole ICP-MS instruments



- High Resolution ICP-MS
  - 1<sup>st</sup> routine HR-ICP-MS introduced in 1994
  - Following instrument generations with significantly improved performance and extended dynamic range



**Thermo Fisher** 

- Triple Quadrupole ICP-MS
  - Added in 2017 with a strong focus on combining superior interference removal and ease of use in a compact system
  - Bringing TQ-ICP-MS into applied analytical testing labs

# Thermo Scientific<sup>™</sup> iCAP<sup>™</sup> Qnova Series ICP-MS



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Exchangeable Skimmer Cone Inserts: Allow to easily adjust the instrument's characteristics for improved matrix tolerance or highest sensitivity

### Thermo Scientific<sup>™</sup> iCAP<sup>™</sup> Qnova Series ICP-MS

### Single Quad vs. Triple Quad – What is needed?



Is the better level of interference removal required for my labs?

Are there issues with robustness or matrix tolerance?

What is the return on investment?



Thermo Scientific<sup>™</sup> iCAP<sup>™</sup> RQ ICP-MS

Thermo Scientific<sup>™</sup> iCAP<sup>™</sup> TQ ICP-MS

## Advantages of TQ-ICP-MS over SQ-ICP-MS



#### **Better Interference Removal**

- Overcome false positives Always an interruption to the daily workplan and a significant cost as well
- Open up new options future proof your laboratory today



#### **Better Sensitivity and LOD's**

- More confidence Sometimes there is more than "less than"
- Take on new challenges Analysis of emerging contaminants



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#### **Option to increase productivity**

- Reduce sample turnover times –
  Provide right answers faster
- Simple method development Easy and straightforward to leverage new technology from day 1.

#### There are good reasons for TQ-ICP-MS in a busy laboratory

### Thermo Scientific<sup>™</sup> iCAP<sup>™</sup> Qnova Series ICP-MS

Thermo Scientific<sup>™</sup> iCAP<sup>™</sup> RQ ICP-MS





Thermo Scientific<sup>™</sup> iCAP<sup>™</sup> TQ ICP-MS

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iCAP RQ ICP-MS (C1)	iCAP RQ ICP-MS (C2)	iCAP TQe ICP-MS	iCAP TQ ICP-MS	iCAP TQs ICP-MS
Single quad ICP-MS instrument with best-in- class interference removal	Single quad ICP-MS instrument with added flexibility for key contaminants	Triple quad ICP-MS optimized for throughput orientated labs in applied markets	Triple quad ICP-MS for best performance and highest flexibility	Specific solution for the requirements of semicon or ultra-high purity chemicals analysis
Collision/Reaction Cell Technology with automatically applied low mass cut-off		Triple Quadrupole ICP-MS to fully leverage reactive gases for interference removal without side reactions		
1 Channel, helium KED mode only	2 channels, helium KED and option for selected reactive gases (i.e. H <sub>2</sub> )	2 channels, helium and oxygen 4 channels, enabling the use of a wide variety of reactive gases		

# **Applications - iCAP RQ and iCAP TQ ICP-MS**

#### Food & Beverage / Environmental / Water analysis / Clinical



### Thermo Fisher

# **Applications - iCAP RQ and iCAP TQ ICP-MS**

#### Industrial / Metallurgy / Semicon / Pharma / Research





# Extending the scope of ICP-MS to the analysis of elemental species

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# **ICP-MS** benefits and limitations

- Measures almost the whole periodic table in any matrix
  - · Highly efficient and robust sample decomposition in plasma
  - · Elemental concentrations and isotope ratios
  - Little to no matrix effects compared to other ion sources
    used with mass spectrometry



Thermo Scientific<sup>™</sup> iCAP<sup>™</sup> Qnova Series ICP-MS Single Quadrupole and Triple Quadrupole ICP-MS



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ICP-MS is a highly sensitive and versatile elementspecific detection technique... but all information on the chemical form in which an element is present is lost!

# **Elemental species in food – Speciation analysis**

Speciation analysis provides the certainty that this sushi is safe to eat!



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# What is speciation analysis?

• IUPAC Definition:

Speciation analysis is the analytical activity of identifying and/or measuring the quantities of one or more individual chemical species in a sample.

Elemental species are described at the level of isotopic composition, oxidation state, inorganic compounds, organic complexes and organometallic structures, and complexes with macromolecules.

More information here

# The toolbox for speciation analysis

**IC-ICP-MS** Predominant separation technique required

Charged ions such as Cr, As, Se, I, Br...



**HPLC-ICP-MS** Less often used in combination with ICP-MS

Sulfur and phosphorous as proxy elements for protein and DNA quantitation

Some alternative methods to analyze "classical" elements

**GC-ICP-MS** Special applications

Organotin compounds, methylated mercury and lead, sulfur in oils and refinery products

# **Creating a hyphenated system**



#### Hardware connection

 Easy interchange between speciation and total elemental analysis with liquid chromatography

Slightly more complicated with GC

#### Single control software

✓ ChromControl Plug-in for Thermo Scientific<sup>™</sup> Qtegra<sup>™</sup>
 Intelligent Scientific Data Solution<sup>™</sup> (ISDS) Software



#### **Integrated data analysis**

tQuant data evaluation plug-in delivers full suite of data integration and species quantification features

✓ Option to export data into Thermo Scientific<sup>™</sup> Chromeleon<sup>™</sup> CDS Software

# **Iodine speciation in seaweed**

- Seaweeds are becoming more and more popular as an alternative nutrient in the future
- Seaweed is a rich natural resource of iodine (up to 8  $g \cdot kg^{-1}$ )
- lodine is an essential element for humans and animals, but excessive intake could have an adverse effect on human health





lodate



lodide

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### **Experimental conditions**



ICS-6000 HPIC System

Can IC-ICP-MS be used for the quantitative determination of different iodine species extracted from seaweed?



#### Thermo Scientific<sup>™</sup> iCAP<sup>™</sup> TQ ICP-MS System

Ion chromatography		Inductively coupled plasma mass spectrometry		
Column	Thermo Scientific <sup>™</sup> Dionex <sup>™</sup> IonPac <sup>™</sup> AG20 (2 × 50 mm) column Thermo Scientific <sup>™</sup> Dionex <sup>™</sup> IonPac <sup>™</sup> AS20 (2 × 250 mm) column	Plasma Power	1550 W	
Elution conditions	100 mM KOH in 5% (v/v) MeOH, isocratic	Sample introduction configuration	PFA-LC nebulizer, 1.04 L⋅min <sup>-1</sup> nebulizer gas flow, nickel cones, high sensitivity insert	
Injection volume	5µL	Operation mode	SQ-KED, 4.5 mL·min <sup>-1</sup> helium	
Flow rate	0.25 mL · min <sup>-1</sup>	Scan settings	<sup>127</sup> I, 0.1 s dwell time	

## **Optimization of separation conditions**



• Higher concentrations of KOH needed to achieve complete elution in approx. 13 minutes

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- Elution order of iodide and MIT changing for KOH concentrations above 70mM
- Addition of MeOH to increase detection sensitivity in ICP-MS
- Observer LOD and LOQ for in ppt range (ng/L) and RSD between 2 – 8%
- Also, additional iodine compounds can be observer if we zoom in into the chromatogram

## **Applications**

#### Speciation analysis with ICP-MS

#### thermo scientific

APPLICATION NOTE

#### Determination of iodine-containing species in seaweed using IC-ICP-MS

Authors: Ana Jerše<sup>1</sup>, Daniel Kutscher<sup>1</sup>, Carl Fisher<sup>1</sup>, Jens J. Sloth<sup>1</sup> 'National Food Institute, Technical University of Derimark (DTU Food) 7Thermo Fisher Scientific

Keywords: IC-ICP-MS, Dionex IonPac AS20 column, speciation, lodide, iodine excess

#### Gual

To domentative the use of a hypheneticd IC-ICIP-MS method for the quantitative determination of different Indine-containing spaces extracted from salesest

#### Introduction

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Seawoods are a tich natural source thiedhe and can contain enternely high amounts of lodino (up to 1) g-kg \* sky weight?: Concumption of suswood may therefore result in an accessive loting intake. The possibilities for a reduction of lodino contant to seawooid and surwood products therefore need to be investigated.



todine can be present in morganic torms (odda), todate: and organic forms (prodominantly '3-loda-C-tyronine-(monoiodotyrosinn, MIT) and [LII-dilodo-L-tyrosinal rithydrate (DC)]. The indexed amino acids MIT and DIT and mainly integrated in proteins and are more difficult. to release without assyme involvement, while inorganic intake, which can also be harmful expectedly for picole with are absent. Knowing which lodine speciel are present in the seaweed may therefore again in developing new tools and procedures to enable reduction of the lodine content. However, Iturature on methods for indee speciation is littled.

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#### Comparing IC and HPLC systems for speciation analysis - a case study



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Speciation of Bromine Compounds in Ozonated Drinking Water using Ion Chromatography and Inductively Coupled Plasma Mass Spectrometry

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# Application of Trace Elemental Analysis Techniques for the Characterization of Battery Materials

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# **Rise of the battery Gigafactory's in Europe**



#### The lithium-ion battery market

- Sharp increase in growth in recent years and predicted over the next years, driven by the electric vehicle (EV) and energy storage system (ESS) sectors
- Producers investing in R&D to reach next level of battery safety, performance (lifetime / charge capacity) and cost reduction
- Ensuring optimum battery cathode, anode and electrolyte performance requires a range of analytical technologies
- Thermo Scientific instruments provide a complete workflow solution for all analysis aspects of Li-ion battery research, development and production as well as supporting raw material mining, refining and battery recycling







#### Areas of the battery supply chain served by TEA, IC and GC-MS instruments

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### **Unsurpassed and evolving portfolio for battery**

#### **Thermo Fisher** S C | E N T | F | C





Lab Equipment



LIMS

Lab

Consumables

Environmental Chambers



Lab Equipment, Chemicals

and Digital Science

Laboratory Chamicala Scientific Supplies

Chemicals



Chromatography

**Elemental Analysis** 

Mass

Spectrometry

Chromatography &

Mass Spectrometry



Electron Microscopy

XRD

FTIR





Rheometers & Extruders



Belt & Check Weighers



X-ray product inspection





Electrode Press Gauge



Electrode Coating Gauge







Separator Film Gauge

Gauging



Spectroscopy &

Microscopy

#### Application notes for elemental and ion chromatography battery material analysis

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Includes Li and impurity quantitation in brine, cathode / anode (graphite) material analysis and electrolyte measurement using ICP-OES, but also ion chromatography and gas chromatography



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# Questions

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# Thank you

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