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Measurement of traces of heavy metals in cosmetic raw materials and finished products according to ISO/DIS 21392:2021 using triple quadrupole ICP-MS

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Keywords: Cosmetics, Argon Gas Dilution (AGD), inductively coupled plasma mass spectrometry, ICP-MS, heavy metals, ISO 21392, interference removal

GOAL

This application note highlights a complete and comprehensive workflow for the analysis of heavy metals in different types of cosmetic products, including raw materials, and will demonstrate the need to use triple quadrupole ICP-MS technology to achieve complete interference removal. As described in ISO/DIS 21392:2021, the samples were prepared using a microwave system prior to analysis.

INTRODUCTION

The cosmetics market is experiencing significant growth due to several factors. An increasing global population, particularly in emerging economies, leads to a larger consumer base for cosmetics. Additionally, evolving beauty standards, innovations such as natural and organic products, the rise of social media and influencer marketing, and the expansion of e-commerce and online shopping platforms have all contributed to the growing demand for cosmetic products.

Analyzing heavy metals in cosmetic products is an important aspect of ensuring consumer safety and compliance with regulations. The regulations for analyzing heavy metals in cosmetic products may vary depending on the country or region. However, there are some common requirements that are followed in many jurisdictions.

In the European Union, limits for heavy metals in cosmetic products are outlined in the Regulation (EC) No 1223/2009[1] on cosmetic products. Maximum limits are established for heavy metals such as chromium and lead (10 $mg \cdot kg^{-1}$), arsenic and cadmium (5 $mg \cdot kg^{-1}$), and mercury (1 $mg \cdot kg^{-1}$). To ensure compliance with these maximum limits of heavy metals, cosmetic manufacturers are required to conduct regular testing and analysis of their products following regulated and validated analytical methods.

The ISO/DIS 21392:2021[2] specifies an analytical procedure for determination of selected trace elements (chromium, cobalt, nickel, arsenic, cadmium, antimony and lead) in finished cosmetics products by inductively coupled plasma mass spectrometry (ICP-MS). This standard method represents a turning point for laboratories that deal with cosmetic samples because it univocally defines the method for quantification of trace levels of heavy metals in cosmetic products. This study will describe how a triple quadrupole ICP-MS can satisfy the standard method ISO/DIS 21392:2021 with improved accuracy for potentially interfered elements in cosmetic products.

EXPERIMENTAL

A Thermo Scientific™ iCAP™ MTX ICP-MS and a Thermo Scientific™ iSC-65 autosampler were used for analysis. The ICP-MS was operated using the parameters highlighted in Table 1. Due to the great variability of total dissolved solids (TDS) used in cosmetic matrices, the instrument was operated using Argon Gas Dilution (AGD). Thus, all calibration standards and samples were automatically diluted approximately five times to ensure analytical robustness for all sample types, such as raw materials and finished products. Due to the potential presence of interferences, the iCAP MTX ICP-MS was operated in collision (SQ-KED) and reaction (TQ-O_2) modes to remove polyatomic and isobaric interferences, and to reach the best quantification limits for critical elements.

Table 1. Instrument parameters used in this study for the iCAP MTX ICP-MS

Parameter	Value
Nebulizer	iCAP MX Series Nebulizer
Interface cones	Ni – tipped sample and skimmer
Spray chamber	Cyclonic quartz
Injector	Quartz, 1.5 mm ID
Torch	PLUS torch
Auxiliary flow ($L \cdot min^{-1}$)	0.8
Cool gas flow ($L \cdot min^{-1}$)	14
AGD dilution level	Level-5
AGD humidifier	ON
Nebulizer flow ($L \cdot min^{-1}$)	0.45
Argon gas dilution flow ($L \cdot min^{-1}$)	0.50
QCell KED flow ($mL \cdot min^{-1}$)	4.91
QCell O_2 flow ($mL \cdot min^{-1}$)	0.31
RF power (W)	1,550
Number of replicates	3
Spray chamber temp. (°C)	2.7

Sample and standard preparation

A total of 25 cosmetic samples (Table 2) were selected as part of this study. Seventeen samples were finished cosmetic products sold on the French and European market, and eight samples were raw materials used in the development of cosmetic products. This panel of samples is representative of the different types of texture (powder, cream, liquid, etc.) used and marketed in the cosmetic industry.

Given the different physical properties of the samples, microwave assisted acid digestion is the most suitable and universal approach for sample preparation. It is also recommended for sample preparation as per ISO/DIS 21392:2021. The details on the digestion procedure are summarized in Table 3.

To improve the reproducibility and the productivity of the workflow, an EasyFILL acid dispenser (Milestone™ Srl., Sorisole, Bergamo, Italy) was used to precisely add 1 mL of H_2O, 5 mL of HNO_3, and 1 mL of HCl to all digestion vessels. The EasyFILL utilization allowed the workflow to be completed with minimal operator interaction and ensured that the exothermic reaction safely proceeded within its enclosure for the 30 minutes between the addition of HNO_3 and HCl as recommended by the ISO/DIS 21392.

An ultraWAVE microwave system (Milestone Srl., Sorisole, Bergamo, Italy) with Single Reaction Chamber (SRC) technology was used for the sample digestion[3].

Complete digestion was not possible for all types of samples, and especially for raw materials. As described in the standard ISO/DIS 21392, a temperature of 200 °C must be maintained for 30 min during the digestion process to obtain comparable results. Despite this temperature plateau at 200 °C, raw materials are rarely completely digested with a persistent deposit.

Digested solutions were transferred and diluted to 50 mL with ultrapure water, then a further 4-time dilution of the particle- free supernatant with ultrapure water was applied. To remove any residue from the sample before analysis (especially for raw materials with silica), the final solution was filtered using a 0.45 µm membrane filter.

Table 2. List of cosmetic samples used in the study

Finished products (FP)	FP physical characteristics	Raw materials (RM)	RM physical characteristics
Scrub cream	Cream	Iron oxide mica	Powder
Moisturizing micellar water	Liquid	Titanium dioxide (Anastasi)	Powder
Hand cream	Cream	Iron oxide mica/Aluminum oxide	Powder
Pink clay mask	Paste	Hollow silica sphere	Powder
Exfoliating cleansing gel	Gel	Ophiopogon japonicus root extract	Powder
Nourishing body milk	Cream	Titanium dioxide	Powder
Hair perfume	Liquid	Titanium dioxide/iron oxide/silica	Powder
Eau de Cologne	Liquid	Mica pellets coated with iron oxides and titanium dioxide	Powder
Varnish	Varnish	White powder A	Powder
Solid perfume	Solid	White powder B	Powder
Perfume mist	Liquid		
Rose varnish	Varnish		
Red varnish	Varnish		
Lip balm	Solid		
Perfume	Liquid		
Eau de toilette	Liquid		
Toothpaste	Paste		

Table 3. Sample preparation conditions recommended by ISO/DIS 21392:2021

Sample amount	Digestion mixture	Final volume	Final acidity (V/V)	Dilution factor
200 mg	1 mL H_2O + 5 mL HNO_3 + 1 mL HCl	200 mL	2.5% HNO_3 0.5% HCl	× 1000

Following the Standard ISO/DIS 21392:2021, the calibration standards were prepared by diluting the mixed stock solution to obtain a concentration range from 0.5 to 10 $\mu g \cdot L^{-1}$ with similar acid concentration as for the samples (in this case 2.5% HNO_3 and 0.5% HCl). For other elements present in high concentration (Al, Ti, Fe), calibration standards with concentrations up to 2.5 $mg \cdot L^{-1}$ were prepared in the same acid matrix. A solution containing different internal standards was added online (1,000 $\mu g \cdot L^{-1}$ germanium, rhodium, indium, lutetium, and iridium) before nebulization to compensate for matrix effects in the plasma for all analytes.

Table 4 summarizes the analytical figures of merit for all analytes, including acquisition mode, correlation coefficient (R^2), blank equivalent concentration (BEC), limit of detection (LOD), and quantification limit of the method (MQL). Whereas the LOD only considers what can be detected by the instrument, the MQL also accounts for the complete sample preparation (i.e., the sample weight and the dilution factor recommended by the Standard ISO/DIS 21392:2021).

Table 4. Compilation of acquisition mode, R^2, BEC, LOD, and MQL for 19 analytes potentially present in cosmetic finished products

Analyte	Mode	Q1 ion targeted (*m/z*)	Q3 ion targeted (*m/z*)	R^2	BEC ($\mu g \cdot kg^{-1}$)	LOD ($\mu g \cdot kg^{-1}$)	MQL ($mg \cdot kg^{-1}$)	Maximum limit ($mg \cdot kg^{-1}$)
Be	SQ-KED	-	^{9}Be	0.9986	<0.001	<0.001	≤0.001	-
Al	SQ-KED	-	^{27}Al	>0.9999	0.517	0.335	1.118	-
Ti	TQ-O_2	^{48}Ti	$^{48}Ti.^{16}O$	>0.9999	0.345	0.351	1.169	-
Cr	TQ-O_2	^{52}Cr	$^{52}Cr.^{16}O$	0.9998	0.057	0.012	0.041	10
Mn	TQ-O_2	^{55}Mn	^{55}Mn	0.9997	0.006	0.002	0.005	-
Fe	SQ-KED	-	^{56}Fe	0.9999	0.211	0.045	0.149	-
Co	SQ-KED	-	^{59}Co	0.9998	0.002	0.001	0.002	-
Ni	SQ-KED	-	^{60}Ni	0.9999	0.031	0.034	0.115	-
Zn	TQ-O_2	^{66}Zn	^{66}Zn	>0.9999	1.040	0.070	0.232	-
As	TQ-O_2	^{75}As	$^{75}As.^{16}O$	0.9999	0.026	0.009	0.031	5
Se	TQ-O_2	^{80}Se	$^{80}Se.^{16}O$	0.9999	0.151	0.215	0.718	-
Cd	TQ-O_2	^{111}Cd	^{111}Cd	0.9996	0.001	0.003	0.010	5
Sn	SQ-KED	-	^{118}Sn	>0.9999	0.017	0.014	0.047	-
Sb	SQ-KED	-	^{121}Sb	0.9999	0.005	0.003	0.010	-
W	SQ-KED	-	^{182}W	0.9964	0.116	0.030	0.101	-
Pt	SQ-KED	-	^{195}Pt	0.9997	0.011	0.007	0.023	-
Hg	TQ-O_2	^{201}Hg	^{201}Hg	0.9968	0.005	0.005	0.017	1
Tl	SQ-KED	-	^{205}Tl	0.9998	0.003	0.001	0.002	-
Pb	SQ-KED	-	^{208}Pb	0.9996	0.017	0.001	0.004	10

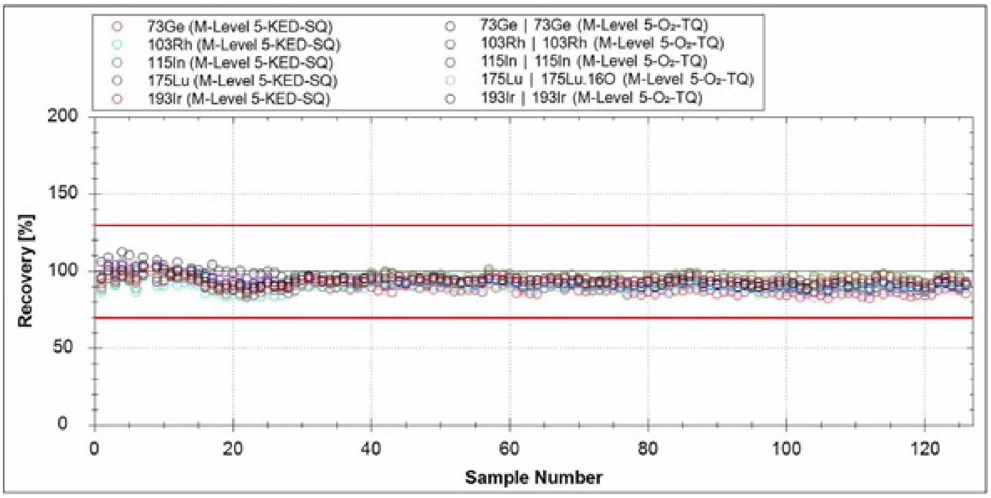


Figure 1. Internal standard stability during the acquisition of more than 120 samples.

Robustness

The Standard ISO/DIS 21392:2021 recommends using rhodium and lutetium as internal standards (i.e., rhodium for the analysis of chromium, cobalt, nickel, arsenic, cadmium and antimony; lutetium for lead). In this study, a wider range of internal standards was used to check the workflow robustness. The robustness of the system is demonstrated through the consistent response of all internal standards during more than 8 hours of analysis.

Thanks to the automatic 5-times dilution delivered by the iCAP MTX ICP-MS, all internal standards could be read out with highly similar response between 80–110% (well within the accepted range of 70–130%) compared to the first sample in both modes utilized (KED and TQ-O_2). The data is summarized in Figure 1.

RESULTS AND DISCUSSION

All results are given in Table 5 for finished products and Table 6 for cosmetic raw materials.

Table 5. Element concentration (in $mg\cdot kg^{-1}$) in cosmetic finished products

	Nail varnish	Balm and lipstick	Perfumes	Toothpaste	Micellar water	Cream and gel	Body milk
Be	0.05–0.08	0.01–0.10	< MQL–0.03	< MQL	< MQL	< MQL	< MQL
Al	667–1,079	< MQL–311	0.08–33.0	31.6	< MQL	< MQL–11344	< MQL
Ti	10.4–364	0.01–332	< MQL–6.44	4.77	0.55	1.62–308	1.42
Cr	0.17–0.29	0.01–0.37	< MQL–21.6	0.65	< MQL	< MQL–8.00	< MQL
Mn	1.09–49.6	0.01–5.01	0.01–2.14	0.26	0.07	0.02–3.80	0.03
Fe	256–352	0.01–138	< MQL–89.4	15.0	< MQL	< MQL–955	< MQL
Co	0.04–0.06	0.01–0.09	< MQL–0.39	0.04	< MQL	< MQL–0.37	< MQL
Ni	0.12–0.20	0.01–0.33	< MQL–20.5	< MQL	< MQL	< MQL	< MQL
Zn	11.5–46.4	< MQL–54.8	0.03–76.8	27.1	11.0	13.2–1677	16.3
As	< MQL	< MQL–0.09	< MQL	< MQL	< MQL	< MQL	< MQL
Se	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL
Cd	< MQL–0.01	< MQL–0.04	< MQL	< MQL	< MQL	< MQL	< MQL
Sn	0.02–0.25	0.01–18.1	< MQL–0.23	0.77	< MQL	< MQL–0.67	< MQL
Sb	< MQL–0.02	< MQL–0.08	< MQL–0.01	< MQL	< MQL	< MQL	< MQL
W	< MQL	< MQL–0.14	< MQL–0.06	< MQL	< MQL	< MQL	< MQL
Pt	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL
Hg	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL
Tl	< MQL–0.01	< MQL–0.04	< MQL	< MQL	< MQL	< MQL	< MQL
Pb	0.17–0.64	< MQL–0.86	0.01–5.59	0.85	0.17	0.27–2.30	0.19

Table 6. Element concentration (in $mg\cdot kg^{-1}$, unless otherwise stated) in cosmetic raw materials

Raw material	Iron oxide mica	Titanium dioxide (anastase)	Iron oxide mica/ Aluminium oxide	Hollow sílica sphere	Ophiopogon japonicus root	White powder A	White powder B	Titanium dioxide	Titanium dioxide/iron oxide/silica	Mica pellets coated with iron and titanium
Digestion process	Incomplete	Incomplete	Incomplete	Incomplete	Complete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
Be	6.58	< MQL	3.74	< MQL	< MQL	< MQL	< MQL	< MQL	0.82	0.64
Al	5.8% (w/w)	14.1	5.2% (w/w)	6.17	23.8	8.68	7.00	0.1% (w/w)	3.2% (w/w)	1.8% (w/w)
Ti	258	212	196	2.71	0.63	194	180	246	249	422
Cr	8.18	< MQL	5.84	0.28	0.14	3.50	5.01	0.50	15.7	3.04
Mn	165	0.07	28.4	0.17	17.2	0.60	0.78	1.23	376	851
Fe	18.0% (w/w)	15.6	16.8% (w/w)	17.8	11.5	26.2	36.2	7.90	10.7% (w/w)	19.4% (w/w)
Co	3.37	< MQL	3.09	0.01	0.08	0.26	0.12	0.01	5.12	3.94
Ni	11.3	0.11	2.69	0.26	0.32	1.95	2.63	0.15	17.8	4.62

(continued on next page)

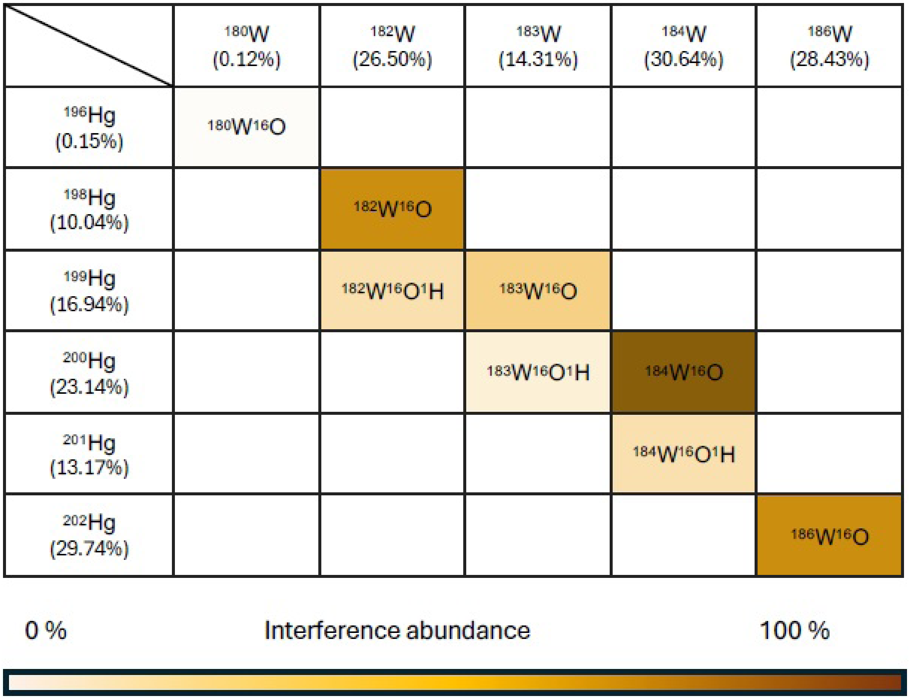
Table 6. Element concentration (in mg·kg^{-1}, unless otherwise stated) in cosmetic raw materials (continued)

Raw material	Iron oxide mica	Titanium dioxide (anastase)	Iron oxide mica/ Aluminium oxide	Hollow sílica sphere	Ophiopogon japonicus root	White powder A	White powder B	Titanium dioxide	Titanium dioxide/iron oxide/silica	Mica pellets coated with iron and titanium
Zn	97.9	0.93	15.8	42.8	5.12	24.9	22.8	32.8	39.8	36.0
As	0.21	< MQL	0.14	< MQL	0.62	0.09	< MQL	< MQL	< MQL	< MQL
Se	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL
Cd	< MQL	< MQL	< MQL	< MQL	0.04	< MQL	< MQL	< MQL	< MQL	< MQL
Sn	56.0	< MQL	21.8	< MQL	< MQL	0.05	0.06	0.03	160.8	5.02
Sb	0.16	< MQL	< MQL	0.03	0.02	< MQL	< MQL	0.01	< MQL	< MQL
W	14.0	0.04	10.9	0.06	0.02	0.01	0.01	0.01	0.01	0.02
Pt	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.11	0.01	0.01
Hg	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL	< MQL
Tl	1.58	0.01	0.55	0.00	0.02	0.01	0.01	0.00	0.27	0.19
Pb	4.63	0.66	5.51	2.78	0.05	4.20	4.08	2.26	4.35	5.96

It is noteworthy that some samples contain impurities that induce interferences on key analytes required for analysis. For example, high concentrations of tungsten (above 10 µg·g^{-1}) were determined in two raw materials: iron oxide mica (14.0 µg·g^{-1}) and iron/aluminum oxide (10.9 µg·g^{-1}).

Tungsten is an element that has a great affinity with oxygen, so that $[WO]^+$ interferences are likely to be formed, which would interfere on mercury. Table 7 gives the potential tungsten- based polyatomic interferences on mercury isotopes. The only remaining isotope (^{204}Hg) is not useful for analysis, since it is low in abundance, and moreover isobarically interfered by ^{204}Pb.

Table 7. Significant tungsten-based polyatomic interferences on the mercury isotopes



	^{180}W (0.12%)	^{182}W (26.50%)	^{183}W (14.31%)	^{184}W (30.64%)	^{186}W (28.43%)
^{196}Hg (0.15%)	$^{180}W^{16}O$				
^{198}Hg (10.04%)		$^{182}W^{16}O$			
^{199}Hg (16.94%)		$^{182}W^{16}O^{1}H$	$^{183}W^{16}O$		
^{200}Hg (23.14%)			$^{183}W^{16}O^{1}H$	$^{184}W^{16}O$	
^{201}Hg (13.17%)				$^{184}W^{16}O^{1}H$	
^{202}Hg (29.74%)					$^{186}W^{16}O$

The analysis of the full spectra of these two samples during quantitative analyses (Figure 2) allows confirmation of the presence of tungsten. Indeed, the spectrum highlights the matching of the observed signals with the theoretical abundances.

To eliminate this interference, it is necessary to use oxygen as a reactive gas. While KED mode is a tool to remove polyatomic interferences, it becomes less effective in the high mass range.

Both modes have been used for the analysis of these two samples previously identified to contain tungsten to compare the effectiveness of interference removal. The results are summarized in Table 8 for ^{201}Hg, which is the least interfered isotope for mercury.

Table 8. Comparison of mercury quantitation with KED and TQ-O_2 modes for ^{201}Hg

	^{201}Hg (mg·kg^{-1})	
	KED mode	**TQ-O_2 mode**
Digestion blank	< MQL	< MQL
Iron oxide mica	33.48	< 0.017
Iron and aluminum oxide	31.49	< 0.017

Tungsten and mercury are absent in the digestion blank whether in KED or TQ-O_2 modes. In samples containing tungsten, such as iron oxide mica and iron/aluminum oxide, the KED mode does not completely suppress tungsten-based interferences and overestimates the mercury concentration with measurements close to 30 mg·kg^{-1} on ^{201}Hg (i.e., concentrations significantly higher than the permitted level of 1 mg·kg^{-1}).

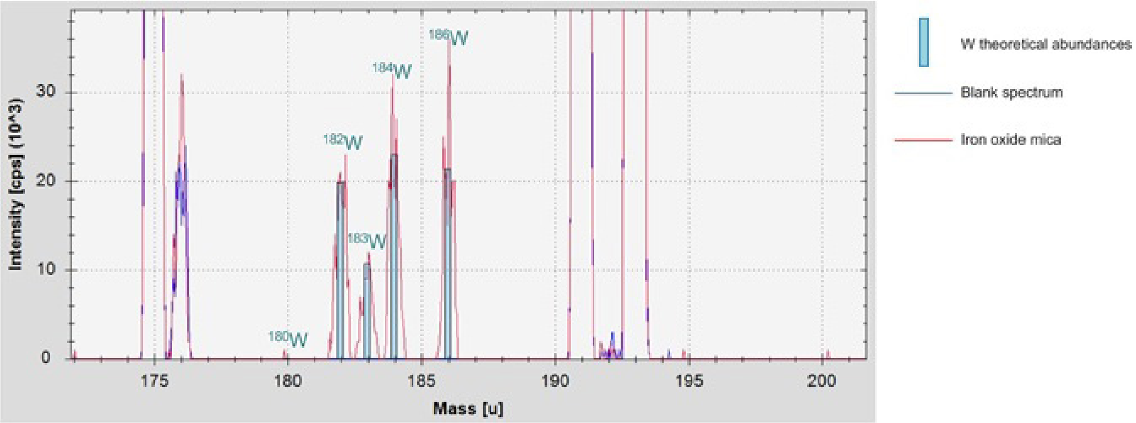


Figure 2. Zoomed-in view of Qtegra ISDS Software full spectrum in the mass range between 172 and 202 amu with the superposition of blank sample, iron oxide sample, and theoretical abundance of tungsten.

On the other hand, the same samples analyzed in TQ-O_2 mode reveal a concentration below the quantification limit of 0.017 µg·kg^{-1}. The process of interference removal by means of an on-mass measurement of the iCAP MTX ICP-MS with the addition of oxygen is detailed in Figure 3 for ^{201}Hg analysis.

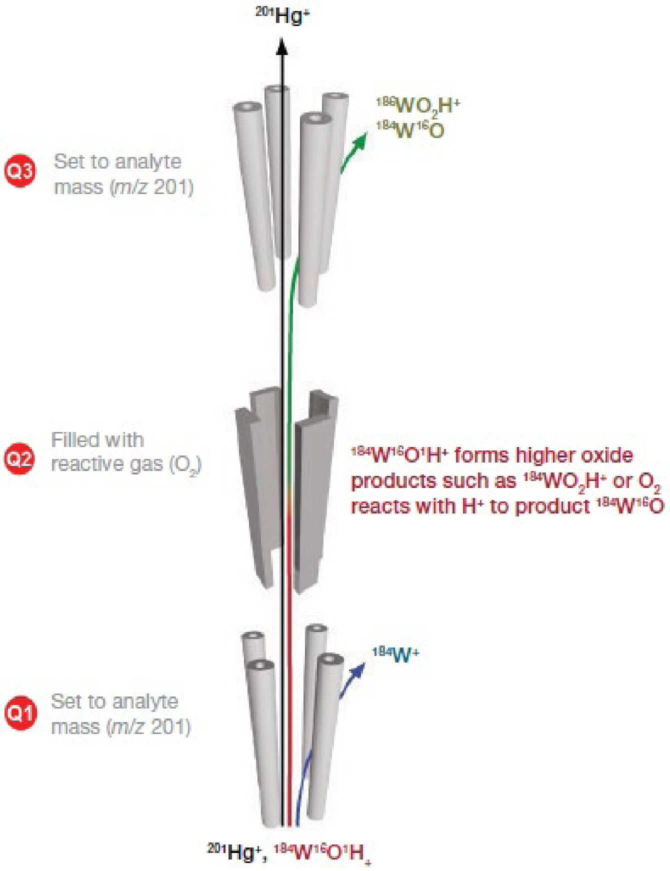


Figure 3. On-mass operating mode of the iCAP MTX ICP-MS with the addition of oxygen as reactive gas for mercury analysis.

The first quadrupole (Q1) is set to *m/z* 201 to let only the $^{201}Hg^+$ ions pass and prevent the transmission of tungsten isotopes into the reaction cell (Q2). The initial polyatomic interference based on tungsten $^{184}W^{16}O^1H^+$ reacts with the oxygen introduced in the cell and is eliminated in the third quadrupole (Q3). Thus, only $^{201}Hg^+$ reaches the detector and can be detected free from interferences.

Cadmium is another toxic element that can suffer from interferences in cosmetic products. The presence of tin (often present in cosmetic powders) or indium (used as an internal standard) leads to potential isobaric overlaps that can be avoided by selecting ^{111}Cd for analysis. These isobaric interferences can be quickly detected with the help of the full spectrum that can be performed at each analysis in Thermo Scientific™ Qtegra™ Intelligent Scientific Data Solution™ (ISDS) Software. The zoom on the cadmium isotope region highlights the isobaric interferences (Figure 4) in the cosmetic raw material composed with titanium dioxide, iron oxide, and silica oxide.

Furthermore, cadmium can also be affected by polyatomic interferences based on zirconium and molybdenum (i.e., $[^{95}Mo^{16}O]^+$ or $[^{94}Zr^{16}O^1H]^+$), which are often present in the raw materials of cosmetic products. Again, only the TQ-O_2 mode effectively eliminates these interferences as illustrated in Figure 5.

To highlight the need for a triple quadrupole ICP-MS for cadmium analysis in cosmetic products, different amounts of zirconium were spiked into a sample. The results for ^{111}Cd are given in Figure 6 for both acquisition modes.

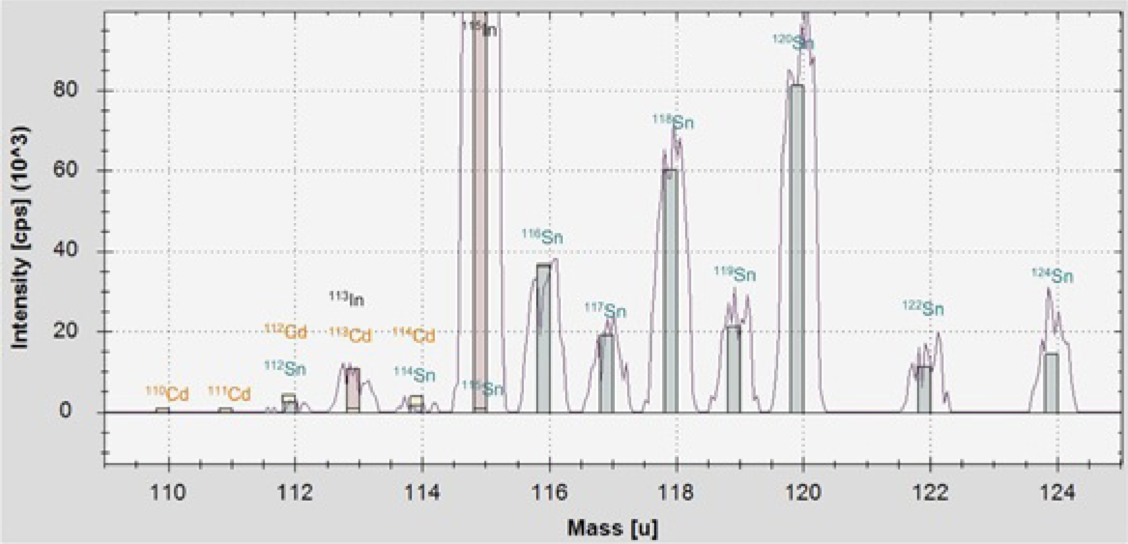


Figure 4. Zoomed-in view of Qtegra ISDS Software full spectrum in the mass range between 110 and 124 amu of cosmetic raw material, overlapped with theoretical abundance of cadmium, indium, and tin.

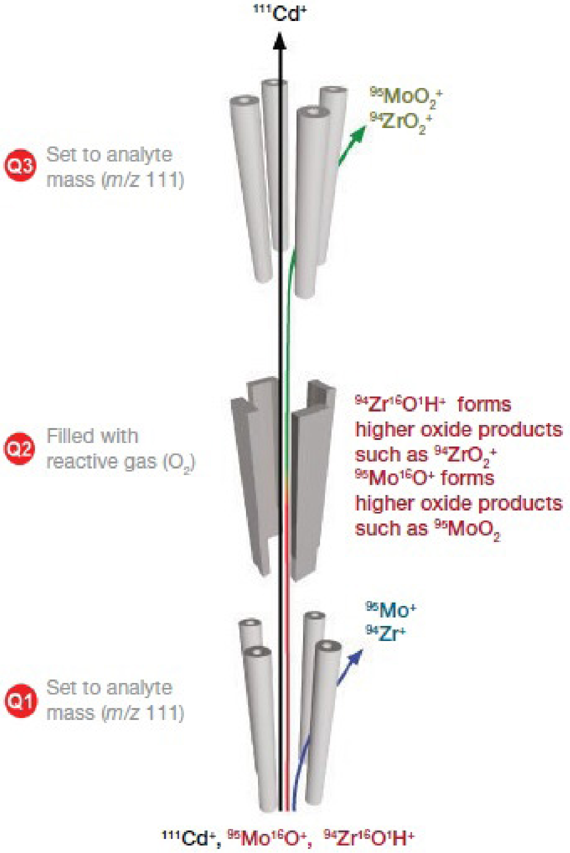


Figure 5. On-mass operating mode of the iCAP MTX ICP-MS using oxygen as the reactive gas for cadmium analysis.

If the raw material is devoid of zirconium, the measured concentration of cadmium is close to zero in both KED and TQ-O_2 acquisition modes. The addition of 1 µg·g^{-1} of zirconium leads to an overestimation of the concentration of ^{111}Cd in KED mode, with a false positive result of 0.54 µg·g^{-1}. On the other hand, the same samples deliver cadmium concentration close to zero when using TQ-O_2 mode. The results are equivalent with an addition of 10 µg·g^{-1} zirconium. The zirconium-based interferences are therefore effectively eliminated in triple quadrupole mode.

Accuracy

To confirm the accuracy of KED and TQ-O_2 measurement modes for each element according to the Standard ISO/DIS 21392:2021, additions of a multi-element solution (0.2 ng·g^{-1} for Hg; 1 ng·g^{-1} for Be, Cr, Co, Ni, As, Se, Cd, Sn, Sb, Tl; 2 ng·g^{-1} for Mn; 10 ng·g^{-1} for Pb; 100 ng·g^{-1} for Zn; 1,000 ng·g^{-1} for Al, Ti, Fe) in the cosmetic product samples were carried out before the microwave digestion step. The recovery values of the spikes are given in Figure 7 and show excellent agreement within the 70–150% limits set by the ISO/DIS Standard for all sample types.

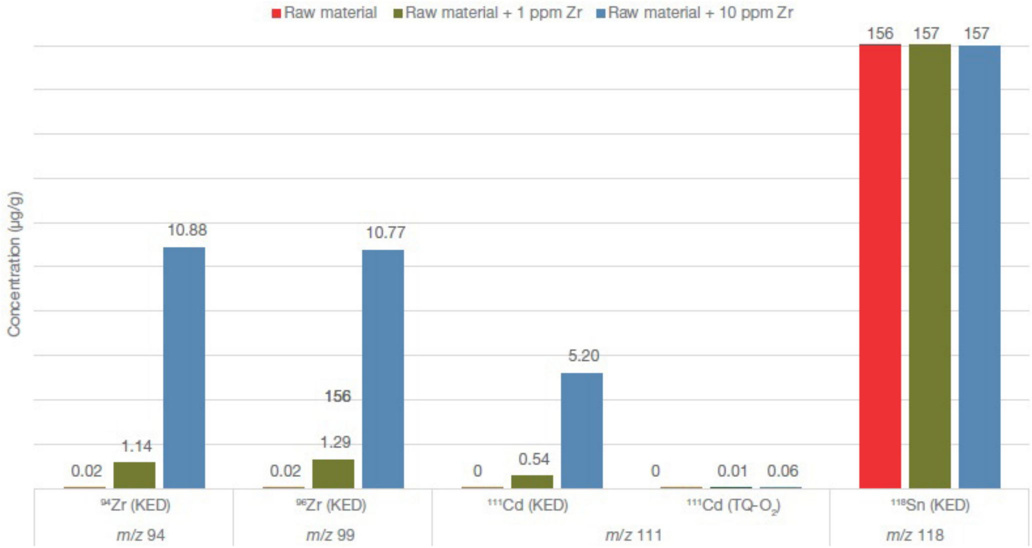
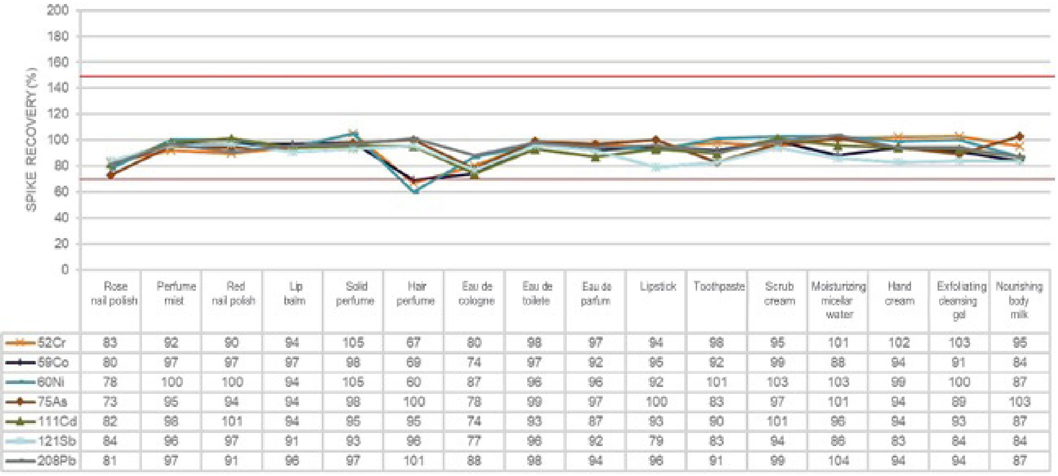


Figure 6. Comparison of cadmium concentration with KED and TQ-O_2 modes with zirconium and tin interferences.



	Rose nail polish	Perfume mist	Red nail polish	Lip balm	Solid perfume	Hair perfume	Eau de cologne	Eau de toilete	Eau de parfum	Lipstick	Toothpaste	Scrub cream	Moisturizing micellar water	Hand cream	Exfoliating cleansing gel	Nourishing body milk
52Cr	83	92	90	94	105	67	80	98	97	94	98	95	101	102	103	95
59Co	80	97	97	97	98	69	74	97	92	95	92	99	88	94	91	84
60Ni	78	100	100	94	105	60	87	96	96	92	101	103	103	99	100	87
75As	73	95	94	94	98	100	78	99	97	100	83	97	101	94	89	103
111Cd	82	98	101	94	95	95	74	93	87	93	90	101	96	94	93	87
121Sb	84	96	97	91	93	96	77	96	92	79	83	94	86	83	84	84
208Pb	81	97	91	96	97	101	88	98	94	96	91	99	104	94	94	87

Figure 7. Spike recoveries (%) on finished products.

CONCLUSION

As the demand for cosmetic products continues to grow worldwide, the testing of raw materials and finished cosmetic products becomes a key activity to ensure consumer safety with respect to exposure to potentially toxic heavy metals.

Maintaining stringent safety standards remains a priority to protect consumer health and uphold the reputation of the industry. The proposed method provides a powerful and reliable option for both manufacturers as well as testing laboratories to obtain high quality data in combination with the often-required productivity. It ensures regulatory compliance with ISO/DIS 21392:2021, but also provides valuable insights as also other elements, currently not under regulation, can be determined free from interferences and potential biases. Some key advantages are summarized below:

- The automated sample preparation with the combination of the EasyFILL Acid Delivery and the ultraWAVE SRC microwave system ensures an efficient and reproducible method for the acid digestion of the cosmetic samples.
- EasyAGD delivers a constant and automatic 5-times dilution for all samples, which allows laboratories to analyze finished products as well as raw materials in the same batch with excellent robustness.
- The use of the iCAP MTX ICP-MS allows the leveraging of oxygen as a reactive gas in TQ-O_2 mode to overcome critical interferences and to obtain the lower quantification limits required by the regulation for highly toxic heavy metals.
- The presence of high concentrations of tungsten, tin, and zirconium in certain raw materials can create isobaric and polyatomic interferences on toxic heavy metals such as mercury and cadmium. The use of TQ-O_2 mode guarantees excellent method accuracy for all sample types.
- Workflows can be further streamlined using innovative features such as the Get Ready process for automatic and scheduled plasma start. The Thermo Scientific™ Hawk™ Consumables and Maintenance Assistant within Qtegra ISDS Software allows contract testing laboratories to ensure all maintenance activities are accomplished before unexpected downtime of the system impacts laboratory productivity.

REFERENCES

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