

Developing and validating an analytical method to control toxic metals in urine using ICP-MS

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Introduction

Trace elements are dietary minerals essential to an organism's health but in a very small quantity. They can be found in food, drinking water, atmospheric air or cigarette smoke. However, elevated levels can be toxic and cause serious health problems like cancer or even death.

The analytical trace laboratory at the Edouard Herriot Hospital carries out urinary controls in professional toxicology by Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

The ICP-MS is a powerful analytical tool to determine metal proportioning in biological samples. It also allows multielement analysis and therefore seems an ideal technique in the case of acute intoxications, clinical or medico-legal toxicology.

The work consisted of developing and validating an analytical technique for urinary proportioning of several Cadmium, Cobalt and Nickel isotopes.

Experimental method

Analysing trace elements requires many precautions as the material and the products used can be sources of contamination and therefore distort the results. Thus, all the material was decontaminated in an aqueous 2% nitric acid solution for 24 hours and then was disposed of.

Each urine sample was mixed with 0.1% HNO₃, yttrium and a known concentration of a multielement solution (0, 0.26, 0.5, 1, 2.5, 5, 10, 20 µg/L). Preparation of samples in this manner made it possible to account for matrix effects. Dilution of the sample also allowed these interferences to be decreased. However, at too high dilutions, the limit of detection is approached leading to inaccurate measurements. In addition the use of an internal standard can compensate the physical and matrix interferences.

Several tests were carried out varying the parameters (power of torch, gas of the reaction cell, internal standard, RPq, dilutions...) on an ICP-MS ELAN DRC with collision chamber (DRC) to determine the optimal detection conditions of the desired elements. Table 1 shows the conditions retained.

A validation was then carried out to test the repeatability, reproducibility inter laboratory, the accuracy, the linearity, the percentage of recovery and to determine the limits of detection and quantification.

| | |
|---|--|
| ICP-RF Power | 1500 W |
| Plasma Gas Flow | 15 L/min |
| Auxiliary Gas Flow | 1.2 L/min |
| Nebulizer Gas Flow | 0.95 L/min |
| Lens Voltage | 8.5 Volt |
| Sample Flush | 35 s |
| Wash Delay | 60 s |
| Read Delay | 30 s |
| Replicates | 3 |
| Cell Gas | CH ₄ |
| Elements in standard mode | ⁵⁹ Co, ¹¹¹ Cd, ¹¹⁴ Cd |
| Parameter of discharge of the quadripolar filter (RPq), standard mode | 0.25 |
| Elements in DRC mode | ⁵⁸ Ni, ⁶⁰ Ni |
| Parameter of discharge of the quadripolar filter (RPq), DRC mode | 0.80 |
| Internal Standard | Yttrium (200 µg/L) |
| Sample dilution | 1/10 |
| Solution dilution | HNO ₃ 0.1% |
| Wash liquid | HNO ₃ 2% |

Table 1. Parameters of the ICP - MS

Results and conclusion

Table 2 shows some results obtained with the different elements. All the validation criteria were approved for cobalt and cadmium: LOD, LOQ, repeatability (CV < 5%), reproducibility (CV < 10%), accuracy (value in confidence interval), linearity (~1.00) and the recovery percentage (~100%, variations due to uncertainties of the materials). In the case of nickel further experiments will be required to validate the method especially for the DRC quantification. As the limit of detection is approached, variability in results become more significant. Consequently, elemental measurements contain larger errors. The results obtained demonstrate that the method developed using the ICP-MS can be used to accurately determine cadmium and cobalt levels in urine samples and will be routinely used. In addition these encouraging results will be useful to obtain a COFRAC accreditation in 2015.

| Analyses mode | Element | LOD (µg/L) | LOQ (µg/L) | Repeatability* (%) | Reproducibility* (%) | Accuracy Value - Interval (µg/L) | Linearity (R ²) | Recovery* (%) |
|---------------|-------------------|------------|------------|--------------------|----------------------|----------------------------------|-----------------------------|---------------|
| Standard | ¹¹¹ Cd | 0.04 | 0.15 | 1.66 | 1.95 | 13.9 - (7.70-16.7) | 1.00 | 102.2 |
| | ⁵⁹ Co | 0.02 | 0.06 | 0.97 | 2.88 | 20.2 - (17.2-25.7) | 0.97 | 104.7 |
| | ⁵⁸ Ni | 0.45 | 1.49 | 1.98 | 4.50 | 23.5 - (19.6-29.4) | 0.63 | 108.5 |
| DRC | ⁵⁸ Ni | 4.50 | 14.99 | 2.01 | 6.88 | 22.8 - (19.6-29.4) | 0.98 | 101.4 |

Table 2. Results (*urine 10ug/L)



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