



# Analysis of migratory elements in toy samples using the Thermo Scientific iCAP 7200 ICP-OES

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## Keywords

ASTM F963, EN 71-3, ISO 8124-3,  
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## Goal

This application note describes the analysis of migratory elements in toy samples, according to the present regulations, using the Thermo Scientific iCAP 7200 ICP-OES.

## Introduction

The analysis of toy samples for toxic trace elements has been carried out for many years, however, a number of recent cases have attracted global media coverage due to toys being contaminated with heavy metals. This has led to an increased number of toy manufacturers carrying out in-house testing to ensure compliance with current regulations. This can prove to be more cost-effective than outsourcing such analyses. Regulations from around the world are largely based on a test method which monitors the levels of trace elements which can migrate from a toy material into an acidic solution. This is designed to simulate the release of toxic elements when toy components are ingested by a child.

The three most common test methods used are EN 71-3:2013+A2:2017 and ISO 8124-3:2010 “Safety of toys – Part 3: Migration of certain elements” and ASTM F963-17 “Standard Consumer Safety Specification for Toy Safety”. The maximum permissible concentration of the migrated elements is the same for these standards as shown in Table 1. These values are based on the bioavailability of the elements and the average quantities of toy components that are inadvertently consumed by a child on a daily basis (estimated at 8 mg per day).

**Table 1. Limits of element migration from toy materials according to DIN EN 71-3:2013+A2:2017, ASTM F963-17 and ISO 8124-3:2010. All values are mg·kg<sup>-1</sup> in solution.**

|   | As | Ba   | Cd | Cr | Hg | Pb | Sb | Se  |
|---|----|------|----|----|----|----|----|-----|
| Any toy material with exception of modelling clay | 25 | 1000 | 75 | 60 | 60 | 90 | 60 | 500 |
| Modelling clay                                    | 25 | 250  | 50 | 25 | 25 | 90 | 60 | 500 |

## Instrumentation

The Thermo Scientific™ iCAP™ 7200 ICP-OES Duo was used for the analysis. This is a dual view compact ICP-OES instrument that achieves powerful analyte detection and provides a highly cost effective solution for routine analysis of liquids in laboratories with standard sample throughput requirements. The Thermo Scientific™ Qtegra™ Intelligent Scientific Data Solution™ (ISDS) Software incorporates simplified method development and enables simple 'out-of-the-box' analysis with little or no requirement for method development.

## Method development and analysis

Three toy materials were analyzed from a small toy car and a baby rattle. These were sampled as followed:

- Orange unpainted rubber body of a toy car (sample 1)
- Unpainted blue wheels of a toy car (sample 2)
- Sections of yellow plastic from a baby rattle (sample 3)

All samples were prepared in accordance with EN 71-3, ASTM F963-17 and ISO 8124-3:2010. A portion of the sample (a minimum of 100 mg) was immersed in 0.07 mol·L<sup>-1</sup> hydrochloric acid (50 times the mass of the sample) and agitated in the dark at 37 °C for one hour, followed by one more hour of immersion without agitation. All solid material was removed from the sample by filtration using a membrane filter. The remaining filtrate was analyzed immediately. A spike of each sample was also prepared to check recovery of the target elements in the matrix; this was added to the relevant sample prior to agitation.

Standards were prepared by diluting 1000 mg·L<sup>-1</sup> aqueous single element standards to the concentrations listed in Table 2. All standards were prepared to contain 0.07 mol·L<sup>-1</sup> hydrochloric acid.

**Table 2. Concentrations of the standards prepared. All values are in mg·kg<sup>-1</sup>.**

| Element | Blank | Standard 1 | Standard 2 | Standard 3 |
|---------|-------|------------|------------|------------|
| As      | 0     | 10         | 20         | 30         |
| Ba      | 0     | 100        | 500        | 1000       |
| Cd      | 0     | 25         | 50         | 75         |
| Cr      | 0     | 10         | 30         | 60         |
| Hg      | 0     | 10         | 30         | 60         |
| Pb      | 0     | 25         | 30         | 90         |
| Sb      | 0     | 5          | 10         | 25         |
| Se      | 0     | 50         | 100        | 500        |

The standard sample introduction kit was chosen for the analysis as recommended by the method, the instrument was calibrated and samples analyzed in a single run (Analysis A). Re-analysis of the identical samples was also performed the following day to simulate a typical sample analysis regime (Analysis B). Parameters used are shown below in Table 3.

**Table 3. Instrument parameters.**

| Parameter                   | Setting  |                  |
|-----------------------------|--|------------------|
| Pump Tubing (Standard Pump) | Sample Tygon® orange/white<br>Drain Tygon® white/white |                  |
| Spray Chamber               | Glass cyclonic   |                  |
| Nebulizer                   | Glass concentric                                       |                  |
| Center Tube                 | 2.0 mm   |                  |
| Pump Speed                  | 45 rpm   |                  |
| Nebulizer Gas Flow          | 0.18 MPa   |                  |
| Auxiliary Gas Flow          | 0.5 L·min <sup>-1</sup>                                |                  |
| Coolant Gas Flow            | 12 L·min <sup>-1</sup>                                 |                  |
| RF Power                    | 1150 W   |                  |
| Exposure Time               | <b>Axial UV</b>  | <b>Radial UV</b> |
|                             | 5 s  | 5 s              |

## Results

The spiked value and results of the method detection limit (MDL) are shown in Table 4. This table also includes the plasma view used for each wavelength. The method detection limit study was carried out by analyzing a 10 replicate, acid matched blank. The standard deviation of the 10 replicates was multiplied by three to determine the method detection limit. In all the samples analyzed all toxic elements were below the detection limit (except Ba), this is shown in Table 5. A search through the literature was carried out and this was found to be common. It is indicative of the high level of GMP (Good Manufacturing Practice) adhered to by the toy industry.

The spike recoveries were all within acceptable limits of <10% of the prepared values (Table 5). Re-analysis of the same samples on the following day (Analysis B) demonstrated good reproducibility, again with all samples below the detection limit and comparable results for the spike recoveries (this is shown in Table 5).

**Table 4. Sample spike concentrations and MDL concentrations in mg·kg<sup>-1</sup>.**

| Element | Wavelength (nm) | Plasma view | Spike value | MDL   |
|---------|-----------------|-------------|-------------|-------|
| As      | 193.759         | Axial       | 1.5         | 0.024 |
| Ba      | 233.527         | Radial      | 25          | 0.009 |
| Cd      | 214.438         | Axial       | 2.5         | 0.001 |
| Cr      | 267.716         | Axial       | 1.5         | 0.022 |
| Hg      | 194.227         | Axial       | 1           | 0.228 |
| Pb      | 220.353         | Axial       | 2.5         | 0.019 |
| Sb      | 206.833         | Axial       | 0.5         | 0.029 |
| Se      | 196.090         | Radial      | 2.5         | 0.024 |

**Table 6. Results of the sample spikes from the two different analyses (A and B) in mg·kg<sup>-1</sup>.**

| Element | Sample 1 spiked |      | Sample 2 spiked |       | Sample 3 spiked |       |
|---------|-----------------|------|-----------------|-------|-----------------|-------|
|         | A               | B    | A               | B     | A               | B     |
| As      | 1.57            | 1.52 | 1.65            | 1.53  | 1.61            | 1.59  |
| Ba      | 23.09           | 23.2 | 23.22           | 24.34 | 26.91           | 25.02 |
| Cd      | 2.67            | 2.59 | 2.54            | 2.46  | 2.63            | 2.53  |
| Cr      | 1.56            | 1.54 | 1.6             | 1.47  | 1.48            | 1.52  |
| Hg      | 1.01            | 1.03 | 1.09            | 0.99  | 0.99            | 1.02  |
| Pb      | 2.48            | 2.45 | 2.66            | 2.59  | 2.65            | 2.49  |
| Sb      | 0.49            | 0.51 | 0.53            | 0.51  | 0.51            | 0.51  |
| Se      | 2.56            | 2.49 | 2.57            | 2.51  | 0.53            | 0.51  |

**Table 5. Results of the sample analysis (Analysis A) and the measured spike concentration as well as spike recoveries.**

| Element | Sample 1 (mg·kg <sup>-1</sup> ) | Sample 1 spiked (mg·kg <sup>-1</sup> ) | Sample 1 spike recovery (%) | Sample 2 (mg·kg <sup>-1</sup> ) | Sample 2 spiked (mg·kg <sup>-1</sup> ) | Sample 2 spike recovery (%) | Sample 3 (mg·kg <sup>-1</sup> ) | Sample 3 spiked (mg·kg <sup>-1</sup> ) | Sample 3 spike recovery (%) |
|---------|---------------------------------|--|-----------------------------|---------------------------------|--|-----------------------------|---------------------------------|--|-----------------------------|
| As      | <DL                             | 1.57                                   | 104.7                       | <DL                             | 1.65                                   | 110                         | <DL                             | 1.61                                   | 107.3                       |
| Ba      | 0.015                           | 23.09                                  | 92.4                        | <DL                             | 23.22                                  | 92.9                        | <DL                             | 26.91                                  | 107.6                       |
| Cd      | <DL                             | 2.67                                   | 106.8                       | <DL                             | 2.54                                   | 101.6                       | <DL                             | 2.63                                   | 105.2                       |
| Cr      | <DL                             | 1.56                                   | 104                         | <DL                             | 1.6                                    | 106.6                       | <DL                             | 1.48                                   | 98.7                        |
| Hg      | <DL                             | 1.01                                   | 101                         | <DL                             | 1.09                                   | 109                         | <DL                             | 0.99                                   | 99.2                        |
| Pb      | <DL                             | 2.48                                   | 99.2                        | <DL                             | 2.66                                   | 106.4                       | <DL                             | 2.65                                   | 106                         |
| Sb      | <DL                             | 0.5                                    | 99.2                        | <DL                             | 0.53                                   | 106                         | <DL                             | 0.51                                   | 102.2                       |
| Se      | <DL                             | 2.56                                   | 102.4                       | <DL                             | 2.57                                   | 102.8                       | <DL                             | 0.53                                   | 106                         |

\*<DL = below detection limit

## Conclusion

The analysis of migratory elements from toys in hydrochloric acid using the Thermo Scientific iCAP 7200 ICP-OES was made simple by using the intuitive workflow of the Qtegra (ISDS) Software. With the use of a pre-defined sample introduction system, the iCAP 7200 ICP-OES Duo instrument provides a total solution for regulatory compliant toy sample analysis.

The integrated software tools and the ease of use design of the iCAP 7000 Plus Series ICP-OES enable both, novice and experienced analysts to achieve excellent results with minimal requirements for method development, providing a highly cost effective solution for laboratories performing these analyses.

Find out more at [thermofisher.com/ICP-OES](http://thermofisher.com/ICP-OES)

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