Quantifying the Elemental Composition of Materials Using ICP-OES

Inductively coupled plasma optical emission spectroscopy (ICP-OES) is an indispensable tool in the determination of elemental composition and concentration down to parts per billion levels in a wide range of sample types. In applications ranging from steel manufacturing to environmental testing to contaminant quantification, it is imperative to accurately determine the elemental composition of a sample. Given this, ICP-OES is an ideal tool to perform quality control, as well as R&D.

ICP-OES is a spectroscopic technique that excites atoms and ions and measures the wavelength of the emitted light when electrons return to their lower energy level. To accomplish this, specimens are nebulized and introduced into a high temperature argon plasma. This plasma provides enough energy to excite the atoms, whose emission rays are then measured by a detector. Due to the technique's ability to measure multiple wavelengths of a single element, as well as utilize methods such as internal standardization and inter-element correction, even samples containing a high number of analytes at varying concentrations can be accurately analyzed.
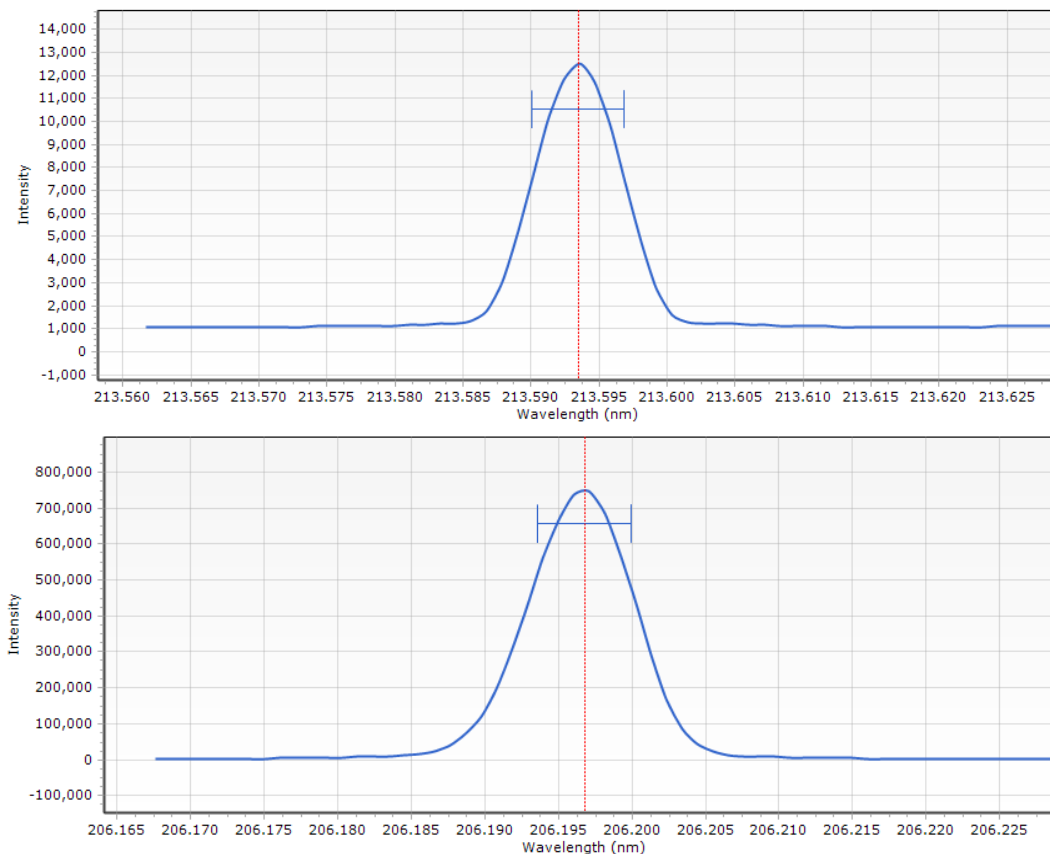

Figure 1. Cu 213.598 peak (top), and Zn 206.200 peak (bottom).

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To demonstrate the capabilities and accuracy of ICP-OES, a 2008 penny was analyzed to determine its copper and zinc composition using an Agilent 5900 ICP-OES. In order to prepare the penny for analysis, a solution of 10 mL 50% HNO_3 and 10 mL 25% HCl was prepared, and the penny was placed in the solution and heated at 60 ℃ until it was completely dissolved. Afterwards, the solution was diluted to an appropriate concentration for testing.

Figure 1 shows the ICP-OES results for the Cu 213.598 and Zn 206.200 spectral lines. These wavelengths were chosen due to a lack of spectral interferences and signal strength. Table 1 displays the measured concentration in ppm of each component of the analysis, as well as the comparison of the calculated percent composition to the actual percent composition of a 2008 penny[1].

Table 1 ICP-OES Analytical Results of a Dissolved 2008 Penny

Element	Concentration (ppm)	Calculated (wt %)	Theoretical (wt %)
Copper	0.7	2.5	2.5
Zinc	26.2	97.5	97.5

The Agilent 5900 ICP-OES is equipped with a software called IntelliQuant analysis. Although less accurate than a standard ICP-OES test, an IntelliQuant analysis has the added benefits of producing concentration estimates quickly for multiple elements that are not calibrated for, and can be performed alongside a standard test. Table 2 shows IntelliQuant analysis results on the dissolved penny.

Table 2 IntelliQuant Analytical Results

Element	Concentration (ppm)	Calculated %	Theoretical %
Copper	0.6	2.4	2.5
Zinc	23.2	97.6	97.5

As illustrated through the 2008 penny analysis, ICP-OES can accurately determine the elemental composition of a sample. Additionally, this technique can accommodate materials with element concentrations magnitudes in difference. These facts make this technique ideal to quantify trace components as well as bulk constituents of a sample.

1) U.S. Mint. https://www.usmint.gov/coins/coin-medal-programs/circulating-coins/penny (Accessed 25 April 2022).

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