TECHNICAL NOTE

ICP-Optical Emission Spectroscopy

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Enhancing Cesium Analysis Using the Expanded Wavelength Range of the Avio 220 Max ICP-OES

Introduction

PerkinElmer's Avio® 220 Max hybrid simultaneous ICP-OES is a unique instrument featuring an innovative dual-monochromator optical system[1] and a novel dual backside illuminated charge-coupled device (DBI-CCD) detector[2], which provide both outstanding sensitivity and flexibility, along with the ability to use any wavelength from 165 – 900 nm. This combination allows for enhanced analyses and opens the potential for new analytical wavelengths, unlocking applications that are difficult to accomplish on other ICP-OES systems.

Improving Cesium Analysis

Traditionally, cesium (Cs) is challenging to measure with ICP-OES, mainly because its two most common wavelengths (455.531 nm and 459.320 nm) are less sensitive. The low sensitivity is compounded by the fact that Cs has a low ionization potential (3.89 eV), meaning that most Cs is converted to ions in the plasma, leaving only small quantities available in the atomic state to emit. Plasma conditions can be modified to reduce ionization, but the sensitivity for Cs is still very weak, meaning that only high concentrations can be reliably measured at these two common wavelengths.

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However, the Avio 220 Max ICP-OES has the ability to view any wavelength up to 900 nm, allowing the use of the atomic Cs atom line at 894.347 nm, which has a much higher intensity than either the 455.531 or 459.320 nm lines. When combined with its high sensitivity, it is easy to see peaks for ppb levels of Cs, as shown in Figure 1a – even under normal, hot plasma conditions. If the cooler plasma conditions are used to reduce ionization (such as increasing the nebulizer flow), Cs intensity increases (Figure 1b), allowing lower concentrations to be measured.

The enhanced sensitivity results in excellent Cs detection limits of 1-2 ppb (as determined by 3 times the standard deviation of 10 replicate measurements of a calibration blank), which is 200-300x lower than for Cs 455.531 nm, the conventional wavelength used for Cs analysis. As a result, low-level calibrations are possible, as shown in Figure 2.

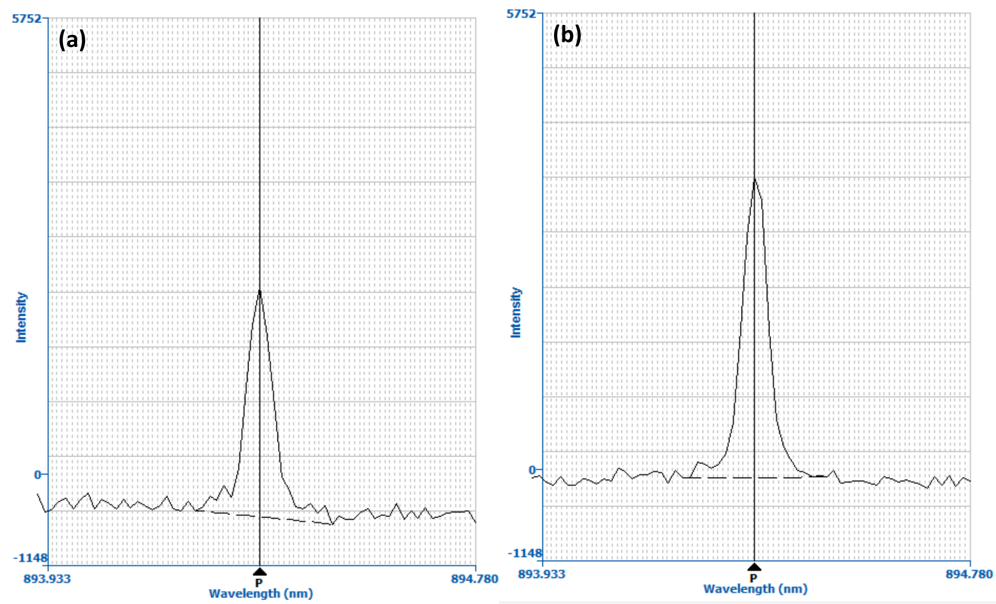
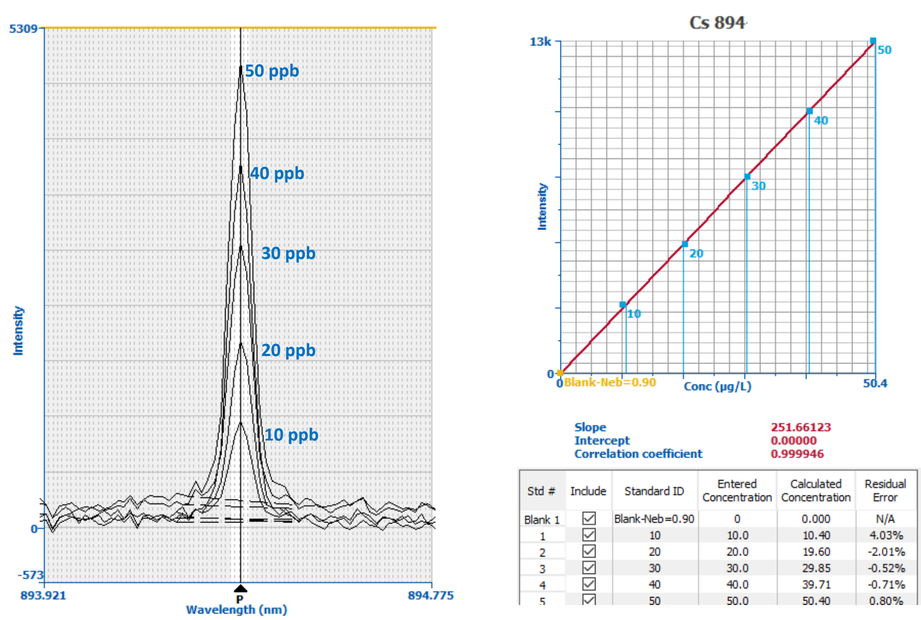


Figure 1: Spectra of 30 ppb Cs acquired at 894.347 nm with a nebulizer flow of 0.70 L/min (a) and 0.90 L/min (b).



Std #	Include	Standard ID	Entered Concentration	Calculated Concentration	Residual Error
Blank 1	☑	Blank-Neb=0.90	0	0.000	N/A
1	☑	10	10.0	10.40	4.03%
2	☑	20	20.0	19.60	-2.01%
3	☑	30	30.0	29.85	-0.52%
4	☑	40	40.0	39.71	-0.71%
5	☑	50	50.0	50.40	0.80%

Figure 2: Spectra and calibration curve for Cs 894.347 from 10, 20, 30, 40, and 50 ppb standards.

Application Examples

The advantages of Cs 894 provide benefits in various application areas. One common application is the recovery of Cs from salt lakes and brines resulting from desalination. Although Cs can be mined, recovery from brines can be easier and more economically feasible. However, measuring Cs in brines is challenging: typically, ICP-OES struggles to see low concentrations, and although ICP-MS can easily measure low Cs concentrations, it cannot handle the dissolved solid content of brines (up to 30% total dissolved solids), requiring significant dilution or sample pre-treatment. The Avio 220 Max ICP-OES overcomes these limitations: the robust plasma handles 30% dissolved solids without dilution, and the wavelength of Cs at 894.347 nm provides excellent sensitivity. Even in a brine solution, the peak from 10 ppb Cs can be easily seen, as shown in Figure 3.

Another area where the determination of Cs is challenging is in the analysis of silver (Ag) catalysts used in the production of ethylene oxide and other organic compounds. The addition of Cs changes the morphology and size of the Ag crystals, enhancing its ability to catalyze reactions[3]. Depending on the catalyst, the Ag concentration can range from 12-23 wt%, while the Cs concentration can range from 50-350 ppm; both the Ag and Cs concentrations must be accurately measured in the final product. However, it is challenging to measure Cs at 455.531 nm in an Ag matrix because Ag has an atomic emission line at 455.552 nm, which can overlap the Cs 455.531 line at high concentrations, as shown in Figure 4a. This issue can be overcome since there is no Ag interference at Cs 894.347, as shown in Figure 4b, allowing for simple, accurate analysis of Cs in an Ag matrix.

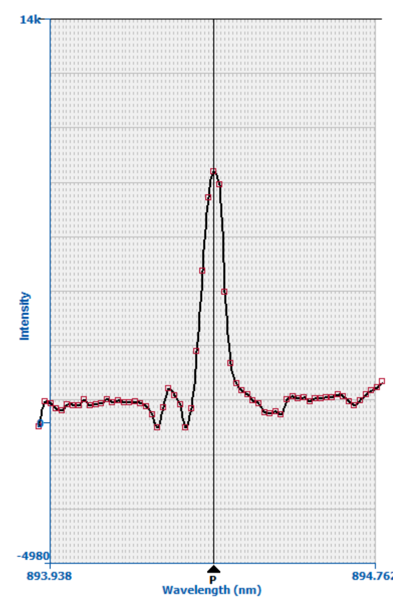


Figure 3: Spectrum of 10 ppb Cs in 30% NaCl at Cs 894.347 nm.

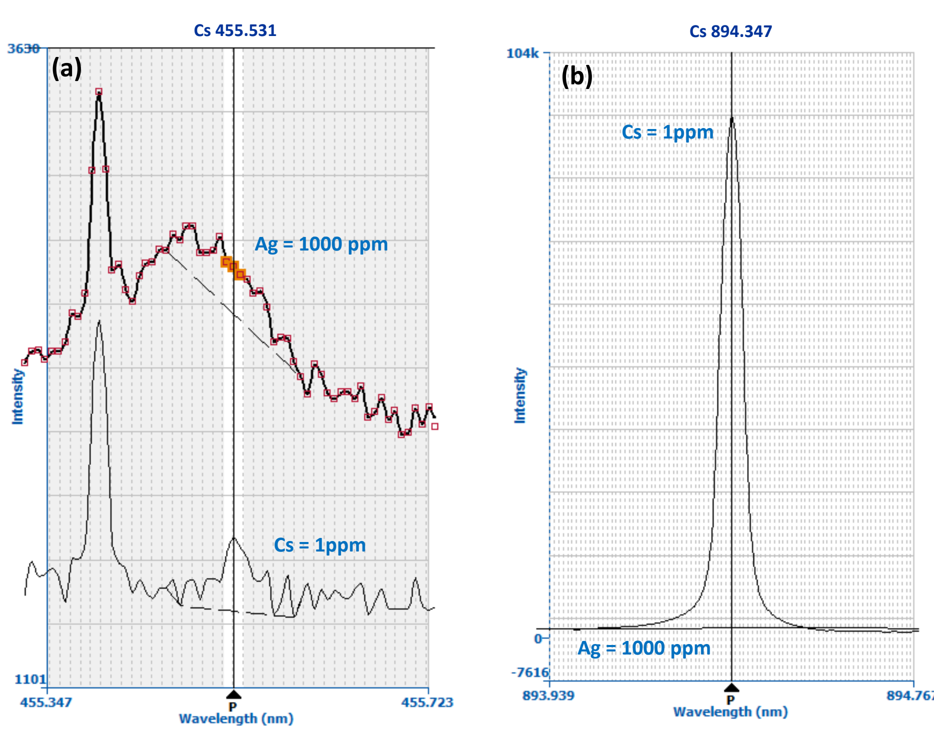


Figure 4: Spectra of 1 ppm Cs and 1000 ppm Ag at Cs 455.531 nm (a) and Cs 894.347 nm (b).

Summary

The unique optics and detector of the Avio 220 Max hybrid simultaneous ICP-OES allow Cs to be measured at 894.347 nm, which emits more strongly than other Cs lines at lower wavelengths, providing enhanced sensitivity. As a result, much lower concentrations of Cs can be measured on the Avio 220 Max than on other ICP-OES systems. Another advantage of Cs 894.347 nm is that it is relatively interference-free. The combination of sensitivity and lack of interferences opens new application areas to the analysis of Cs using the Avio 220 Max hybrid simultaneous ICP-OES.

References

1. "The Avio 220 Max ICP-OES: A Unique Double-Monochromator Optical System", Technical Note, PerkinElmer Inc., 2020.
2. "Avio 220 Max ICP-OES Custom-Designed Solid-State Detector with Hybrid Simultaneous Analysis", Technical Note, PerkinElmer Inc., 2020.
3. "Method of Making Catalysts for the Production of Ethylene Oxide", US Patent 4350616, 1980.

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