TECHNICAL NOTE

ICP-Optical Emission Spectroscopy

Vertical Dual View on the Avio Max Series ICP-OES

The PerkinElmer Avio® Max series ICP-OES incorporates a vertically oriented plasma with complete dual-viewing optics under computer and software control. Any wavelength can be used in the radial, axial, or mixed viewing modes in a single method.

Radial or Axial Plasma Viewing?

Radial viewed plasmas have been utilized for many years for analytical measurements in ICP-OES. The radial view emission of interest occurs in the central channel of the plasma and the spectrometer views the analyte emission from the side of the plasma through the background argon emission. The viewing height is a very important parameter with radially viewed plasmas because elements undergo emission at various heights in the plasma (usually expressed as height above the load coil).

The Avio Max series ICP-OES provides automated optimization for individual emission line viewing height. For use with radially viewed plasmas, a spectrometer normally is designed to image a vertical slit in the plasma (Figure 1a). This vertical slit has the effect of averaging the analyte emission intensity over the height of the slit. In comparison, an axially viewed plasma system looks down the central channel of the plasma (Figure 1b) and collects all the analyte emission over the entire length of the plasma. The net effect is that the emission pathlength is increased relative to a radially-viewed plasma. This increases the measured analyte emission and improves sensitivity. However, axial viewing does not extend the dynamic measurement range available - it merely shifts the range downward to encompass lower concentrations. Radial viewing of the plasma complements axial viewing by providing an equivalent working range at higher concentrations. A system that provides both radial and axial viewing offers the advantages of both.

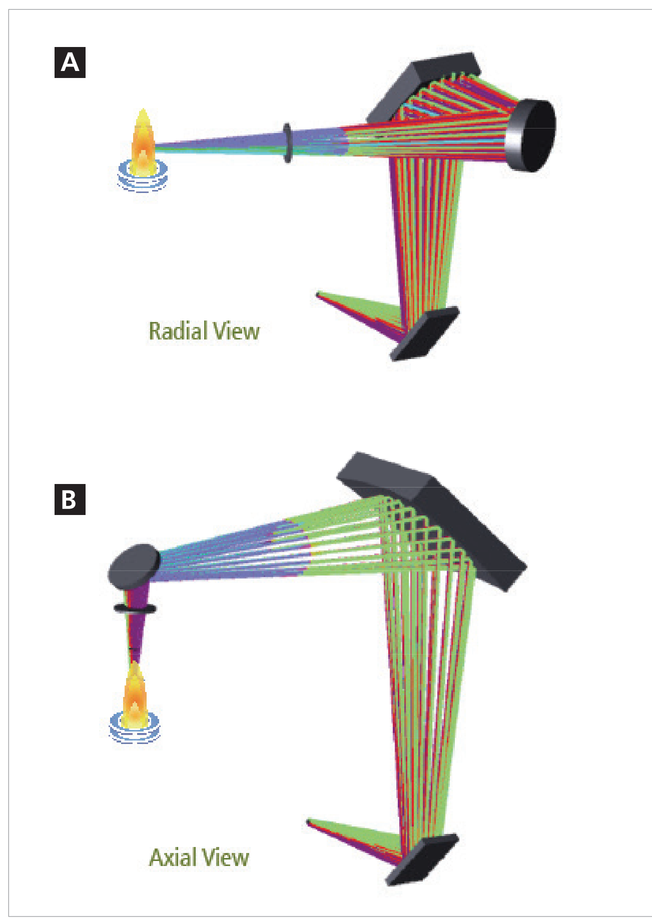

Figure 1. (A) Radially viewed plasma with a vertical slit image in the plasma. (B) Axially viewed plasma with a circular slit image in the plasma.

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For the Better

Why Not Use Alternate Wavelengths to Extend the Working Range?

The use of alternate, less sensitive wavelengths to extend the working range is a viable alternative in some instances. However, the use of multiple wavelengths for the same element also has potential drawbacks:

- Regulatory methods frequently specify that the analysis must be performed at a prescribed wavelength. Use of an alternate wavelength could mean that the analysis was non-compliant.
- Even with methods that allow the use of alternate wavelengths, those wavelengths must be evaluated for each sample matrix, increasing method development time. For example, the alternate line should be examined for potential interferences not found at the normal wavelength.
- Not all elements have multiple usable wavelengths with appropriately different sensitivities, e.g., sodium. What do you do when a satisfactory alternate wavelength isn't available?
- The use of alternate wavelengths requires extra calibrations to be performed at each additional wavelength, potentially increasing analysis times.

The use of a system that can conveniently provide both axial and radial viewing eliminates these limitations.

Detection Limit Improvements

The improvement in sensitivity with an axially-viewed plasma typically yields a 5- to 10-fold improvement in detection limits. This provides a powerful tool for environmental analysis, including many U.S. Environmental Protection Agency (EPA) and DIN methods. In fact, the Avio Max series ICP-OES systems in their axially viewed plasma mode meet the U.S. EPA Contract Required Quantitation Limits (CRQL) for all 22 elements in the protocol (CERCLA Statement of Work ILM05.3/ILM05.4 or ISM01.1). Without axial viewing, the detection limits for some of these elements previously required the use of graphite furnace atomic absorption (GFAA) or ICP mass spectrometry (ICP-MS).

With the Avio Max series ICP-OES and axial viewing, laboratory productivity is greatly improved because the number of sample preparations is reduced, data reduction is simplified, and operator training is minimized. A single sample preparation is all that is required, saving time, minimizing reagent usage, and reducing waste generation. Also, since all the results are acquired on a single instrument, report generation is simplified.

PlasmaShear™ Reduces Axially Viewed Plasma Interferences

To remove interferences during axial viewing, you need to eliminate the cool tail plume of the plasma. No instruments do it more effectively, reliably, or economically than the Avio Max series ICP-OES.

While other ICPs use as much as 4 L/min of argon to remove the plume, the Avio system's unique PlasmaShear technology runs on air. No need for ionization suppressants. No high-maintenance, high-extraction systems or cones. Just a fully integrated, fully automated interference-removal system that delivers problem-free axial analysis.

Figure 2 shows a plasma with 1000 ppm yttrium being aspirated. The blue color is from normal emission, and the red zone of the plasma is the cooler tail plume. Self-absorption occurs in this cooler part of the plasma. That is, emission from excited state atoms in the blue zone will be absorbed by the ground state atoms in the cooler red zone of the plasma. With the radially viewed plasma, this is not a problem since the tail plume is not in the optical path.

To eliminate the adverse effects of this cooler tail plume, the axially-viewed Avio configurations use an air shear gas to displace the tail plume out of the optical path (Figure 3). This simple solution provides a number of real advantages. First, compressed air is normally available in most laboratories, so no additional costs are incurred. Second, the plume is displaced before it approaches the entrance to the optical system, minimizing the possibility of corrosion to, or sample deposition on, any optical system component.

As can be seen in Figure 4, the red tail plume is eliminated, and a very thin boundary is created by the shear gas. By comparing Figures 4 and 6, you can see the differences in the optical path length of the red areas of the two plasmas. The Avio Max series ICP-OES with the air shear path, ensures that you will have the largest linear dynamic range possible with axially viewed plasmas.

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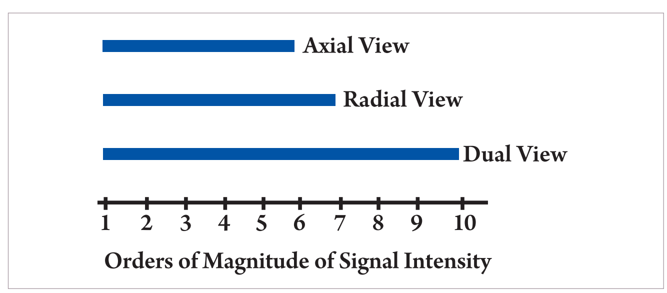

Figure 2. Typical analytical working ranges for the inductively coupled plasma technique.

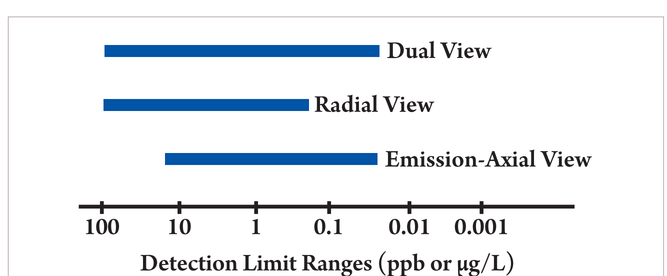

Figure 3. Typical detection limit ranges for inductively coupled plasma viewing modes.

Figure 4. Yttrium plasma with the blue color showing the normal emission and the red color showing the cooler tail plume displaced by the air shear gas.

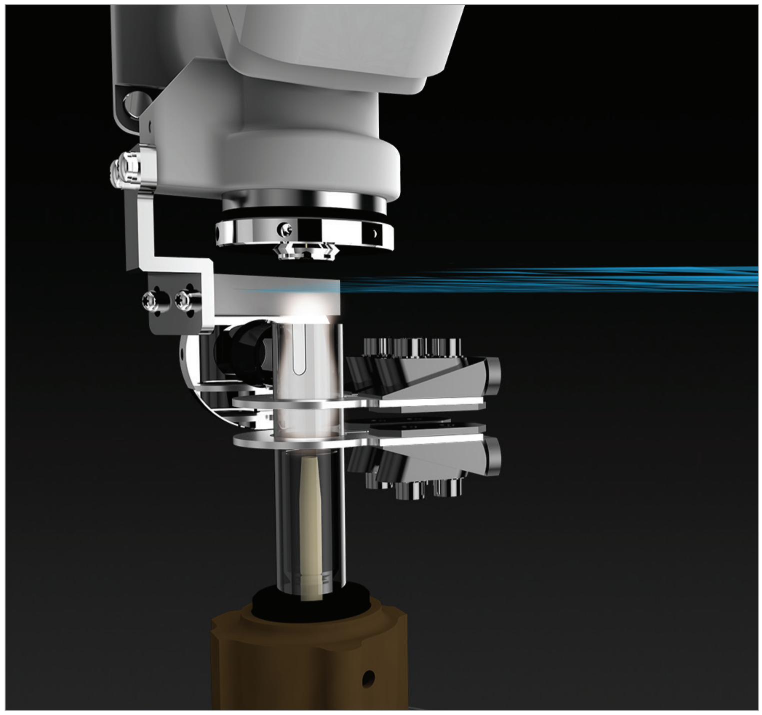

Figure 5. Air shear gas used with the axially viewed plasma of the Avio.

Figure 6. Yttrium plasma with the blue color showing the normal emission and the red color showing the cooler tail plume.

The Best of Both Worlds

Unfortunately, neither viewing configuration – radial or axial – is perfect for all needs. This is why the Avio Max series ICP-OES spectrometers include the dual view (DV) configuration. With the DV system, a software-controlled mirror provides the operator with a simple means of selecting the desired viewing mode. In fact, the viewing mode can be included as a part of the operating method for each analyte. Careful attention has been paid to the size and shape of the slit and the size and location of the viewed image to optimize the analyte intensity and minimize the background emission with both configurations.

The Avio Max series vertical plasma ICP-OES spectrometers with dual view truly offer the best of both worlds.

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