Tech Note

PlasmaQuant MS Series: Aerosol Dilution

Advantages of the Integrated Aerosol Dilution in the PlasmaQuant MS Series

Introduction

Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) is a well-established technique in trace analysis offering fast, multi-element analysis, unsurpassed detection limits and excellent linear dynamic range. A key limitation though, particularly in comparison to elemental techniques like Atomic Absorption (AAS) and ICP-Optical Emission Spectroscopy (ICP-OES) is the level of total dissolved solids that an ICP-MS can tolerate.

Your Benefits

- Simplifies handling of high TDS samples
- Allows direct analysis of high TDS samples within the equivalent of a 5- or 10-fold dilution

As a general rule, for best instrument performance and stability, it is recommended that samples analyzed by ICP-MS should contain no more than 0.2 %w/v total dissolved solids (TDS): i.e. 0.2 g of TDS per 100 mL of sample or 2000 ppm. The absolute maximum can depend on the major matrix constituent of the sample and 0.2% is often the limit for refractory elements. Seawater on the other hand contains approximately 3.5% TDS, predominantly as NaCl, although other salts of chloride are present at lower concentrations. With NaCl being more easily broken down in the plasma, seawater can typically be analyzed by ICP-MS following a 10-fold dilution.

If a sample with a very high TDS level is analyzed by ICP-MS, the narrow orifices of the interface cones may be partially (or even fully) blocked and result in sensitivity loss and poor detection capability. Space-charge effects resulting from the excessive amount of matrix ions affecting the analyte ion beam can have similar effects on sensitivity which internal standardization can't accurately correct for at these extreme levels. This limitation is easily overcome by physical dilution of the sample with high purity water prior to analysis. The dilution effect is not often a concern in ICP-MS as detection limits are extremely good and far superior to that of AAS and ICP-OES. A concern for many laboratories though is the increased sample handling that comes with an additional dilution step, especially when handling large sample numbers. As more and more laboratories strive to reduce costs and increase revenue, often by reducing sample preparation and analyzing a wider range and greater number of samples by ICP-MS, alternative techniques to sample analyses are being considered.

One technique that has become popular in recent times is aerosol dilution. A typical analysis has the nebulizer operating at an optimized gas flow, typically 0.8-1.1 L/min with a sheath gas added to the aerosol stream between the nebulizer and plasma. The addition of a sheath gas provides a means of optimizing the position of sample aerosol injection into the plasma for maximum sensitivity and reduced doubly charged and oxide interferences, typically in the range of 0.0-0.2 L/min.

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Aerosol dilution on the other hand has these two gas flow rates being reversed. The result is a decrease in the efficiency of nebulization, meaning less sample aerosol is being generated and less sample reaching the plasma. A higher sheath gas flow keeps the total carrier gas flow to the plasma consistent and maintains optimum flow conditions. The higher flow of the clean and dry sheath gas, relative to the nebulizer gas flow, means the density of the aerosol is further reduced upon mixing. This combined dilution effect is known as aerosol dilution and can provide the equivalent of a 10-fold dilution without the need for additional sample preparation. The end result is that samples containing 10 times higher levels of TDS are able to be analyzed directly. Aerosol dilution is particularly well suited to the direct analysis of seawater and other high TDS samples like soils, industrial effluents, ores and metals.

Application

The hardware setup for aerosol dilution is straightforward as shown in figure 1. The sheath gas port is offered as standard on the Analytik Jena PlasmaQuant MS ICP-MS.

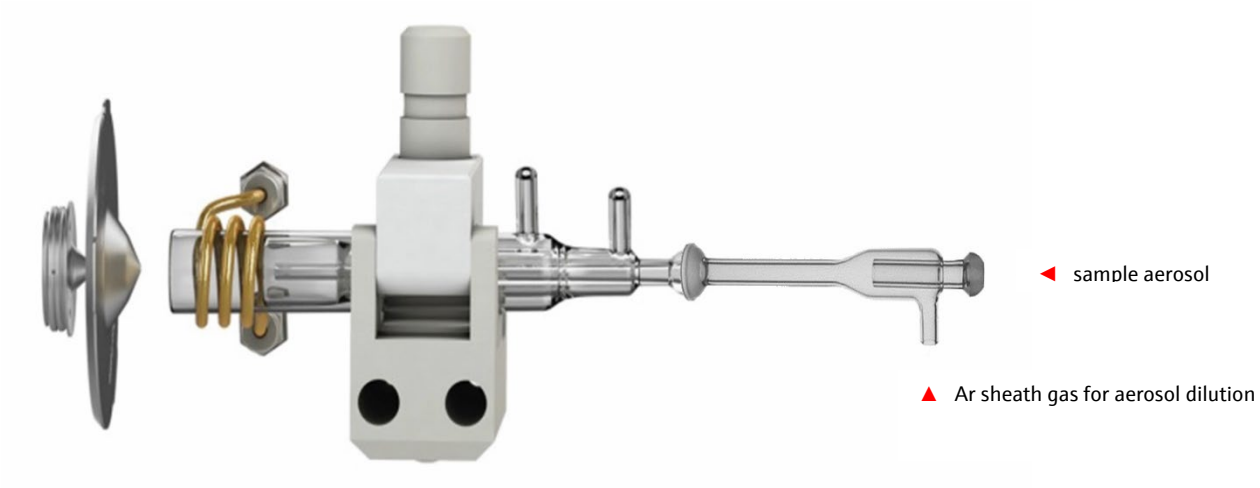

Figure 1: Standard aerosol dilution setup on the Analytik Jena PlasmaQuant MS ICP-MS

The Analytik Jena ASpect MS software features a new auto-optimization routine allowing fast and easy setup of methods using aerosol dilution. Options include:

- Low aerosol dilution - for samples containing up to 1-2% TDS.
- High aerosol dilution - for samples containing up to 2-4% TDS.

Low dilution defines method parameters that will provide approximately a 5-fold aerosol dilution factor – ideal for samples containing up to 1-2% w/v TDS, depending on the nature of the matrix.

High dilution defines method parameters that will provide approximately a 10-fold aerosol – ideal for samples containing up to 2-4% w/v TDS, depending on the nature of the matrix. The more volatile NaCl form in samples such as seawater, often define the upper limit.

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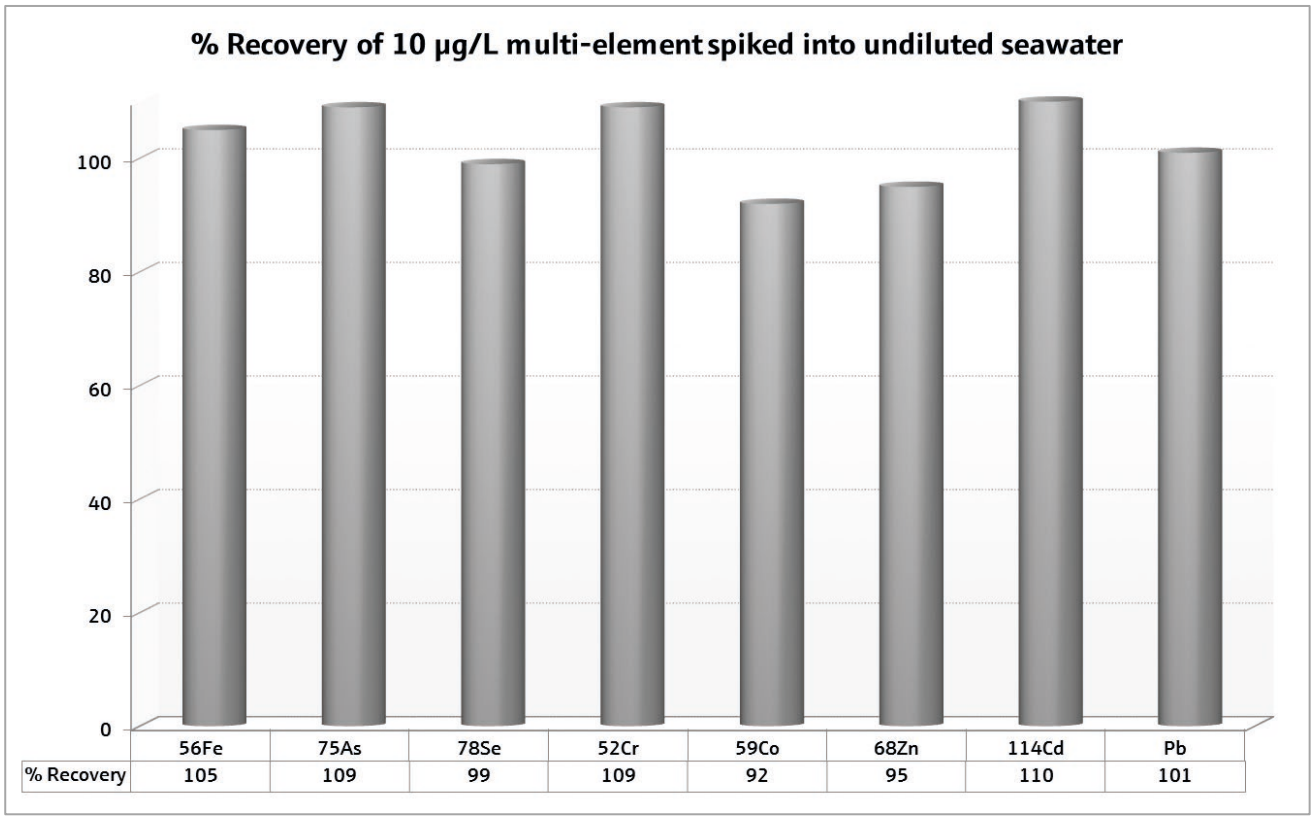
Results

Figure 2 shows the typical recovery results for a 10 µg/L multi-element spiked into an undiluted NASS-seawater reference material using the aerosol dilution technique. A nebulizer gas flow rate of 0.3 L/min and sheath gas flow of 0.9 L/min were used. The addition of a small amount of nitrogen gas to the plasma is known to benefit As and Se performance. Nitrogen gas was added to the auxiliary gas line at a flow of 40 mL/min via the Nitrox gas accessory. Spectroscopic interferences were removed using the patented integrated Collision Reaction Cell (iCRC) technology. Fe, As and Se were measured using H_2 iCRC gas, while other elements were measured using He iCRC gas.



	56Fe	75As	78Se	52Cr	59Co	68Zn	114Cd	Pb
% Recovery	105	109	99	109	92	95	110	101

Figure 1: Initial results of using aerosol dilution for direct analysis of undiluted seawater.

As shown in figure 2, very good spike recoveries were observed for a range of environmental important and highly interfered elements in undiluted seawater. The analysis was calibrated against standards prepared in dilute nitric acid and highlights the ability of ICP-MS and the aerosol dilution technique to deliver fast and accurate results without the need for matrix matching.

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Summary

The aerosol dilution capability is fully integrated into the Analytik Jena PlasmaQuant MS series. No additional hardware is required. The inclusion of a new auto-optimization sequence for aerosol dilution within the Analytik Jena ASpect MS ICP-MS software makes method setup fast and easy. Press a button and you are ready in a few seconds to start analyzing your toughest samples.

Further information

For further updates, applications and other literature, please visit the Analytik Jena website at www.analytik-jena.com.

Reference: TechNote_ICP_MS_Aerosol_Dilution_en.docx

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