ICP-OES: The Often Underestimated Workhorse in Trace Elemental Analysis

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ABSTRACT

It is without doubt that trace elemental analysis is becoming more and more important to make sure that the environment is clean and our food and other consumer products are safe. ICP-OES certainly is an important technique to obtain this information, however, in comparison to other techniques, it may be causing higher running costs (comparing gas consumption for example against AA) and not offering ultimate sensitivity and detection limits (as compared to ICP-MS).

However, in many application fields, such as environmental or food analysis, fast and cost effective multi-elemental analysis is required without the need to measure elemental concentrations at ultra-trace levels. Especially high throughput laboratories highly appreciate the outstanding robustness and flexibility of ICP-OES, and use the technique as their preferred option. Although commercially established since many years, and certainly a mature technique, there are still options to further improve the inherit advantages of ICP-OES, for example through dedicated design of the sample introduction system as well as improving application related parameters as the elimination of spectral interferences or dynamic range.

This poster will show how ICP-OES can be successfully applied to achieve fast and sensitive multi-elemental analysis in key application areas and how it can help you to turn over samples faster and with lower running costs.

INTRODUCTION

Aqueous solutions which contain up to 3% m/v total dissolved solids (TDS) can be analyzed with a relatively basic sample introduction system, consisting of a concentric nebulizer and a single pass cyclonic spray chamber. This combination is very efficient at converting the liquid sample in to an aerosol and removing large droplets of solvent from the aerosol prior introduction to the plasma.

High solid solutions containing up to 20% m/v TDS need a specific nebulizer which is designed not to block when aspirating high salt solutions. The spray chamber used will typically be a double pass which removes a greater proportion of the sample (when compared to the single pass described above).
The use of this spray chamber serves at least two purposes, it prevents the plasma loading (the amount of sample entering the plasma) becoming too high, and, it also helps to prevent salt crystallization on the torch or center tube.
Also, a large bore center tube should be used because this helps to reduce the risk of blockage. Additional accessories like the argon humidifier or the sheath gas adapter help to achieve long term stability.

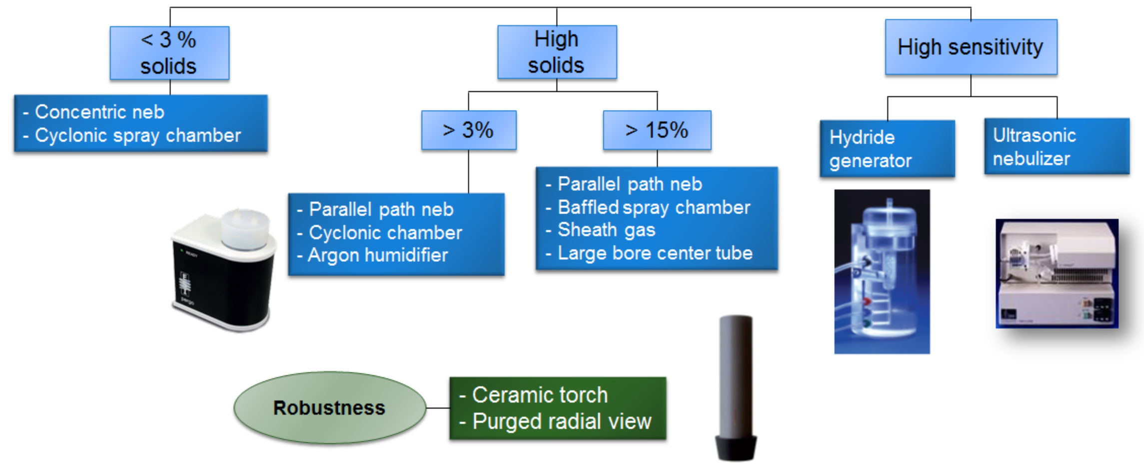

Figure 1. Aqueous sample introduction recommendations.

When it comes to particles in solution, nebulizers can typically handle particle sizes of up to one third of the capillary diameter before blockage occurs. When aiming for high sensitivity of some elements, an ultrasonic nebulizer or a hydride generator may be used to improve detection capability of the instrumentation.

Complete sample introduction systems, including an autosampler equipped with an auto-dilution or even intelligent dilution solution provide a simple integrated workflow. By using both, prescriptive and intelligent, fully automated auto-dilution steps, manual dilution during analyses is eliminated. This increases productivity as it prevents re-runs of samples and reduces cost of ownership.

The total analysis time of a system typically consists of the uptake time that the sample needs to reach the plasma, the actual analysis time where data is acquired and a wash time to rinse the system from the former sample analyzed. The Thermo Scientific™ iCAP™ 7600 ICP-OES Analyzer uses an integrated Sprint Valve to minimize the uptake/wash time and with this maximizes throughput even more.

The iCAP 7000 Plus Series ICP-OES Analyzer can be coupled with two different auto-dilution sample introduction systems, the Teledyne CETAC SDX High Performance Liquid Dilution System (HPLD) and ESI prep*FAST* (figure 2). Both systems transfer the sample to the introduction system of the ICP-OES and to carry out automatic prescriptive and intelligent dilutions, respectively.

Figure 3. The iCAP 7600 ICP-OES Analyzer.

A WORKHORSE FOR HIGH THROUGHPUT

Comparison of two auto-dilution systems

For the comparison of the analysis time between the two autodilution systems (figure 2) an analysis of waste water was performed according to U.S. EPA Method 200.7.
With the Teledyne CETAC SDX HPLD system the total analysis time of a sample depends on the dilution factor whereas with the ESI prep*FAST* the measurement time is the same for each sample, details are shown in Table 1.

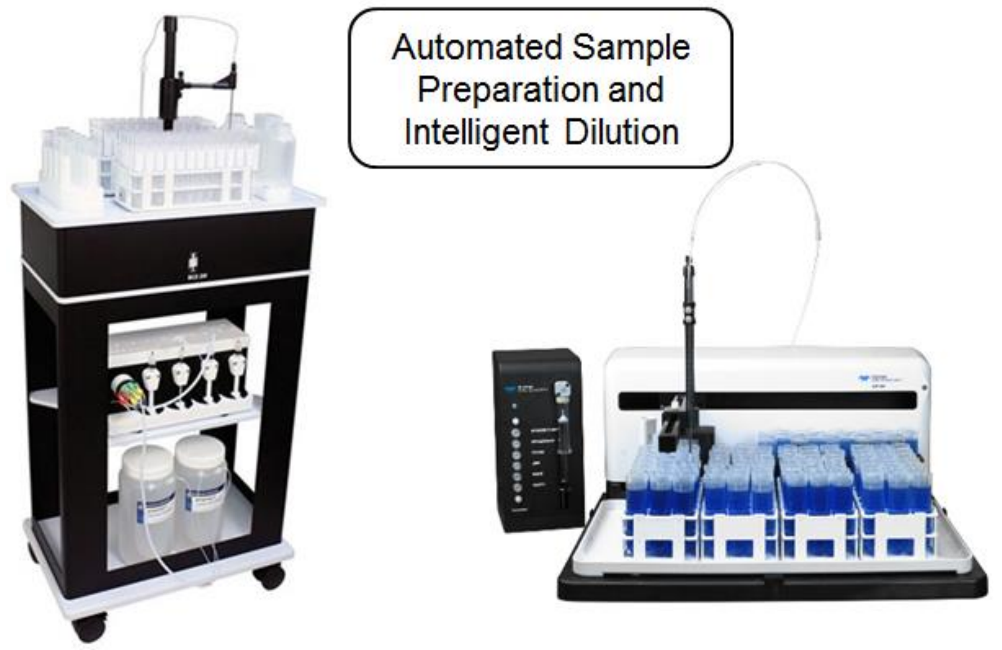

Figure 2. ESI prep*FAST* (left) and CETAC SDX High Performance Liquid Dilution System (HPLD) (right).

Table 1. Analysis times including uptake and wash time with the CETAC SDX HPLD and ESI prep*FAST*.

	CETAC SDX HPLD	ESI prep*FAST*
Measurement Time 1 x dilution	2 min 50 sec	2 min 30 sec
Measurement Time 5 x dilution	3 min 37 sec	2 min 30 sec
Measurement Time 10 x dilution	3 min 33 sec	2 min 30 sec
Measurement Time 100 x dilution	3 min 29 sec	2 min 30 sec

Speeding up with the Sprint Valve

Total analysis time typically consists of the uptake time that the sample needs to reach the plasma, the actual analysis time where data is acquired and a wash time to rinse the system from the former sample analyzed. Shortening acquisition times leads to a decrease of method performance as shown in the previous section. To keep the performance of the analytical method, the uptake and wash time can be reduced by using a fast sample introduction system like the Sprint Valve (Fig. 4).

Figure 4. Teledyne CETAC ASXpress Sprint Valve.

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Table 2. Sprint Valve load and analysis times for different loop sizes.

Loop (mL)	1	1.5	2	3.5	4.5
Load time (s)	3	4	5	7	9
Possible analysis time (s)	15	35	50	115	150

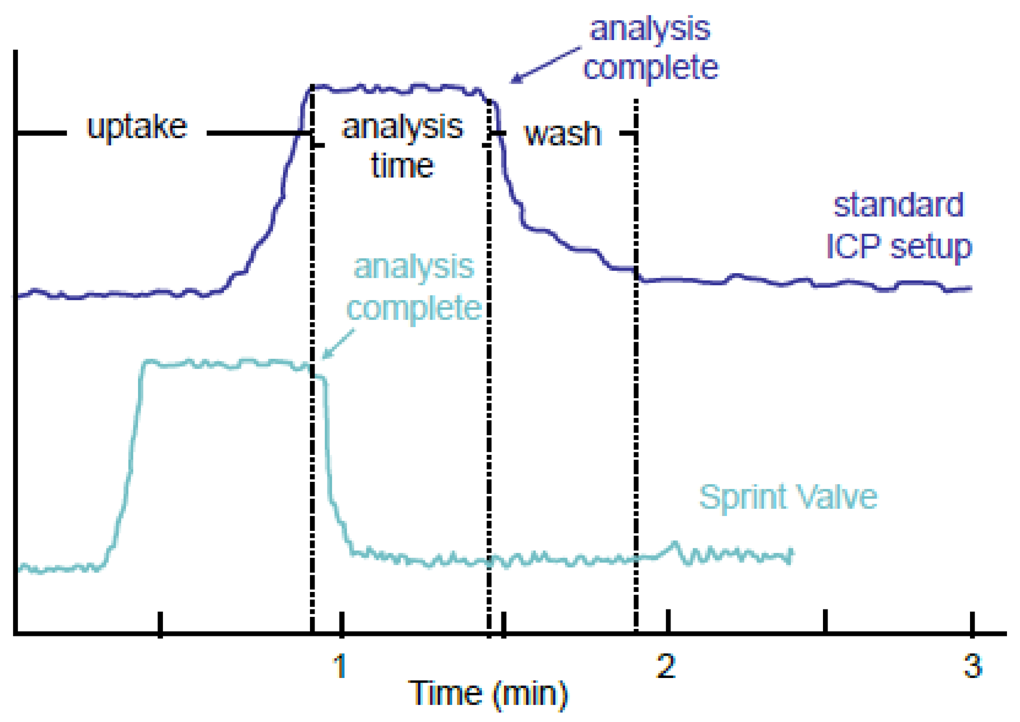

Figure 5. Total analysis time with and without Sprint Valve.

CONCLUSIONS

Selection of a sample introduction system can be complex. However, the use of dedicated kits for specific applications simplifies the choice, limiting the options to a number of pre-optimized kits.

The Thermo Scientific™ Qtegra™ ISDS Software based control of the complete system provides a single, simple integrated workflow, eliminating manual dilution in both prescriptive and intelligent, fully automated, analyses. Eliminating manual intervention increases productivity, prevents re-runs and reduces cost of ownership.
The analysis time can further be reduced by using a rapid sample introduction system like the integrated Sprint Valve, increasing sample throughput to a maximum.

REFERENCES

1. Product Spotlight 44369 - Ultrafast analysis using the integrated Sprint Valve sampling loop.
2. Application Note 43171 - EU Water Analysis Using the Thermo Scientific iCAP 7400 ICP-OES Duo.
3. Application Note 43376 - U. S. EPA Method 200.7 - Wastewater Analysis for Trace Metals Using an Auto-Dilution System Coupled to the Thermo Scientific iCAP 7000 Plus Series ICP-OES.

TRADEMARKS/LICENSING

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