



# MULTINEB OUTPERFORMANCE THE MAIN MARKET REFERENCE NEBULIZERS

## 1. Introduction

Among the various calibration strategies available with ICP-based techniques, the on-line modalities stand out. The use of on-line calibrations plays an essential role in correcting analytical signal suppression (or enhancement) due to matrix effects and signal fluctuations due to temporal variations in the plasma. On-line calibrations are based on the continuous merging of sample and standard solutions (or internal standard) by flow injection strategies improving the mixing of both solutions, reducing their consumption and providing high repeatability. Traditionally, conventional calibration strategies are performed by adding aliquots of standard solution (or internal standard) to all test solutions with a pipette. This modality can increase the accuracy of the analysis, however, it can be very time-consuming, especially when there is a large number of samples to be measured. Alternatively, the standard solution (or internal standard) can be merged on-line to the sample solution prior to nebulization using a second channel of the peristaltic pump and a mixing T-connection (Figure 1).

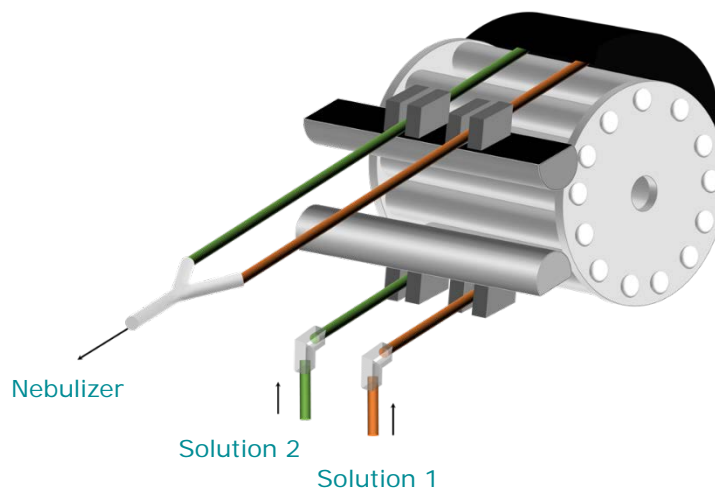


Figure 1. Set-up of on-line calibration strategy using a T-connection.

Recently, the novel **MultiNeb®** nebulizer has been developed which allows a high mixing efficiency between two liquids, miscible or immiscible, since the mixing takes place under turbulent conditions of high pressure at the tip of the nebulizer. This mixing process inside the nebulizer creates a new concept in nebulization and allows a high repeatability mixing in comparison with the T-connection (Figure 2).

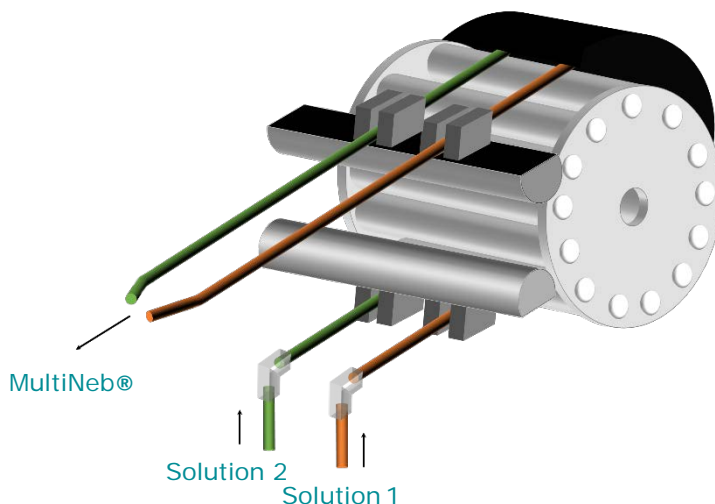


Figure 2. Set-up of on-line calibration strategy using MultiNeb®.

## 2. Experimental

### 2.1 Reagents and solutions

Aqueous calibration standards of 1 mg L<sup>-1</sup> are prepared by appropriate dilution of a 1000 mg L<sup>-1</sup> multi-elemental stock solution (ICP Multi Element Standard Solution IV, CetriPUR, Merck, Darmstadt, Germany) in deionized water (18 MΩ cm resistivity). All aqueous solutions are acidified by adding up to 1 M of HNO<sub>3</sub> 30% high-purity acid (Merck). An aqueous calibration blank containing the same amount of HNO<sub>3</sub> is also prepared.

### 2.2 Instrumentation

All measurements are made using an axial view inductively coupled plasma optical emission spectrometer Agilent 720 ES (Agilent). The operating conditions are shown in Table 1. In this work, the precision obtained with three different sample introduction system (SIS) were compared. The MultiNeb® was employed in the SIS-1, SeaSpray® in the SIS-2, and Conikal® in the SIS-3.

Table 1. Experimental conditions of the ICP OES

Parameters	SIS-1	SIS-2	SIS-3
Plasma power (kW)	1.2	1.2	1.2
Plasma gas flow rate (L min <sup>-1</sup> )	15	15	15
Auxiliary gas flow rate (L min <sup>-1</sup> )	1.5	1.5	1.5
Total nebulizer gas flow rate (L min <sup>-1</sup> )	0.75	0.75	0.75
Liquid flow rate of channel 1 (mL min <sup>-1</sup> )	1.0	1.0	1.0
Liquid flow rate of channel 2 (mL min <sup>-1</sup> )	1.0	1.0	1.0
Replicates	10	10	10
Read time (s)	1.0	1.0	1.0
Nebulizer	MultiNeb®	SeaSpray®	Conikal®
Spray chamber	Cyclonic	Cyclonic	Cyclonic

### 3. Results and discussions

#### 3.1. Evaluation of the precision

The precision values are evaluated for all SISs and compared. The precision is expressed as relative standard deviation in percentage (i.e., RSD (%)). Table 2 summarizes the RSD values obtained with all SISs and the relative RSD is defined as the ratio between the value of RSD obtained with the SIS-1 (i.e., **MultiNeb®**-based system) and the value of RSD obtained with the other SISs (i.e., **SeaSpray®**-based system or **Conikal®**-based system). For instance, the relative RSD value of 1 means no difference between the two SISs. As noted, the **MultiNeb®**-based system (i.e., SIS-1) provides values of relative RSD lower than 1 for all emission lines evaluated.

Table 2. RSD values obtained using all ample introduction systems (SISs).

Emission line (nm)	SIS-1	SIS-2		SIS-3	
	RSD (%)	RSD (%)	Relative RSD	RSD (%)	Relative RSD
AgI (328.068)	0.71	0.88	0,80	1.12	0,63
AlI (396.153)	0.74	1.65	0,45	1.37	0,54
BI (249.772)	1.40	1.57	0,89	1.86	0,75
BaII (493.408)	0.78	1.21	0,64	1.40	0,56
BiI (223.061)	2.28	3.07	0,74	3.17	0,72
CaII (396.847)	0.93	1.12	0,83	1.19	0,78
CdII (226.502)	0.75	1.14	0,66	1.37	0,55
CrII (267.716)	0.71	1.24	0,57	1.75	0,41
CuI (324.754)	1.02	1.38	0,74	1.76	0,58
FeI (238.204)	1.01	1.23	0,82	1.67	0,61
Gal (417.206)	1.29	1.48	0,88	1.30	0,99
InII (325.609)	1.54	1.69	0,91	1.98	0,78
KI (766.491)	0.86	1.24	0,70	1.37	0,63
LiI (670.783)	1.12	1.56	0,72	1.68	0,67
MgII (280.270)	0.74	2.07	0,36	1.75	0,42
MnII (257.610)	0.76	1.09	0,69	1.76	0,43
NaI (588.995)	0.57	0.98	0,58	1.57	0,36
NiII (216.555)	1.35	1.52	0,89	2.16	0,63
PbII (220.353)	2.00	2.59	0,77	2.02	0,99
SrI (407.771)	0.72	1.19	0,61	1.37	0,53
TiII (276.789)	5.06	5.68	0,89	6.19	0,82
ZnII (202.548)	0.99	1.49	0,66	1.16	0,85

### 4. Conclusions

The **MultiNeb®** provides excellent RSD values when two solution are mixed at the tip of the nebulizer in comparison with those obtained with a T-connection. The nebulizer offers a simple and robust alternative for on-line merging system without requiring any special connection. The results obtained in this study demonstrate the better analytical performance of the **MultiNeb®** compared with other nebulizers.