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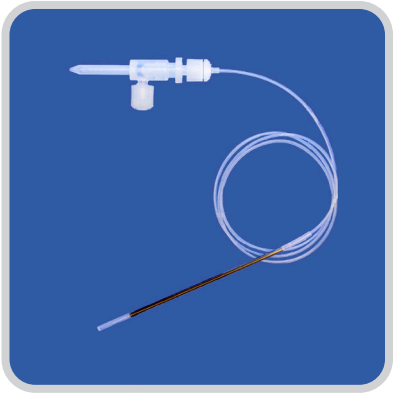
Savillex Technical Note
C-Flow S-Type PFA Nebulizers - Performance

Overview

The Savillex C-Flow s-type PFA concentric nebulizer range is comprised of three versions: C50s, C100s and C250s, with nominal free aspiration uptake rates of 50, 100 and 250 µL/min, respectively. The s-type nebulizer differs from a standard C-Flow with integrated uptake line as it features a demountable uptake line, featuring a new design zero dead volume connector that gives the s-type the same washout performance as an integrated uptake line nebulizer. The s-type also features a new inner body design that has significantly improved nebulization efficiency and, therefore, sensitivity. Compared to all other PFA concentric nebulizers, sensitivity is 10% higher in normal plasma and 15% higher in cool plasma. The fundamental performance of each nebulizer was evaluated. Sensitivity in both normal and cool plasma, RSDs, CeO/Ce ratio and $^{80}Ar_2$ background were compared. The s-type nebulizers are designed for semiconductor analysis and other low sample volume applications of ICP-MS where very high performance is required.



C-flow S-Type Nebulizer with 100 cm Uptake Line and 14.4 cm Carbon Probe

Fundamental ICP-MS Performance

The uptake rate specification for each nebulizer configuration is shown in Table 1. Performance in normal plasma mode was measured on an Agilent 7700s ICP-MS using 1500W forward power and a sampling depth of 13 mm. A standard quartz torch and Scott-type spray chamber were used, at 2°C.

Nebulizer	Uptake Rate Specification	Uptake Rate Range
C50s	50 µL/min +/-20%	40-60 µL/min
C100s	100 µL/min +/-20%	80-120 µL/min
C250s	250 µL/min +/-20%	200-300 µL/min
(all at 0.7 SLPM nebulizer gas flow)		

Table 1. Uptake Rate Specifications – C-Flow S-Type Nebulizers

Nebulizer gas flow was 0.7 SLPM with 0.11-0.12 SLPM of make-up gas added at the spray chamber end cap. Data was collected for each nebulizer configuration using free aspiration mode. So that nebulizer sensitivity could be directly compared, nebulizer gas flow was kept constant while the make-up gas was adjusted to bring the CeO/Ce ratio close to 2%. Prior to installation on the ICP-MS, the sample uptake rate for each nebulizer configuration, at 0.7 SLPM nebulizer gas flow, was calculated by aspirating water at room temperature from a beaker placed on a balance and measuring the weight loss over time. Table 2 shows the performance of each nebulizer in normal plasma mode, using a 1 ppb tune solution.

				Li 7		Co 59		Y 89		Ce 140		Tl 205		CeO
Nebulizer	Uptake rate: µL/min	Carrier Gas (SLPM)	Make-up Gas (SLPM)	Counts	RSD (%)	Counts	RSD (%)	Counts	RSD (%)	Counts	RSD (%)	Counts	RSD (%)	%
C50s	48	0.7	0.80	71495	3.47	504307	2.66	392120	1.52	357480	1.41	206985	1.72	1.94
C100s	107	0.7	0.76	94516	3.95	415092	2.03	603941	1.77	529603	1.58	281092	1.78	1.97
C250s	239	0.7	0.70	125890	4.67	539423	2.15	743662	1.61	626727	1.67	310234	2.38	2.29

Table 2. ICP-MS performance comparison of C50s, C100s and C200s nebulizers – normal plasma. Sensitivity is expressed as counts/sec.

As expected, the C250s has the highest sensitivity due to the higher sample uptake rate. With the exception of Co, nebulizer sensitivity for each element increases with uptake rate. In the case of Co, however, C50s sensitivity was actually higher than the C100s, possibly indicating the presence of an interference that was formed with those plasma conditions. RSDs are approximately 2% for all nebulizers and analytes, but are expected to be better than what is shown as this data was taken from the ICP-MS software tune window. CeO/Ce ratios were approximately 2% (achieved by adjusting make-up gas flow for each nebulizer).

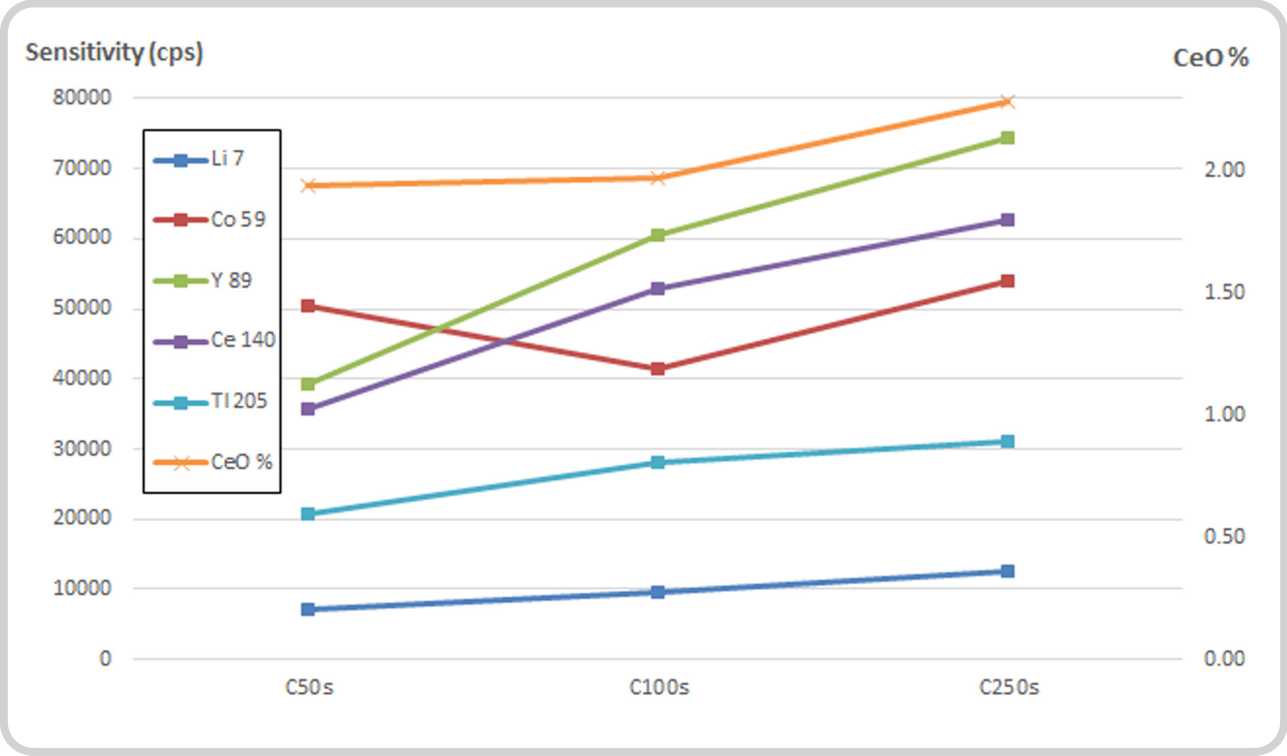


Figure 1. Sensitivity comparison for C50s, C100s and C200s. Orange line (with cross marks) is CeO ratio (right side axis).

Figure 1 above shows the sensitivity of the three nebulizers plotted across the mass range (normal plasma). The orange line (with cross marks) is the oxide ratio (right side axis). Sensitivity plots are relatively flat – i.e. sensitivity is not a direct function of uptake rate. The sensitivity of the C50s and C100s is more than would be expected based on uptake rate. This is either due to higher nebulization efficiency or higher transport efficiency of the sample introduction system at lower sample uptake rates.

To evaluate performance in cool plasma mode, forward power was set to 600W, the sampling depth to 18 mm, and the make-up gas optimized to reduce plasma-based interferences. Interference removal performance was measured by monitoring the reduction in $^{80}Ar_2$ signal. When the ratio $^{59}Co/^{80}Ar_2$ reached 1/2000, interference removal performance was considered to be good. In the case of the C50s, where ^{59}Co sensitivity was lower, a $^{59}Co/^{80}Ar_2$ ratio of 1/2000 was difficult to achieve, so an m/z 80 signal of 20cps or lower was considered acceptable. Table 3 below shows the performance of each nebulizer in cool plasma mode, using a 1ppb tune solution.

				Mass 7		Mass 59		Mass 205		Mass 80
Nebulizer	Uptake rate: µL/min	Carrier Gas (SLPM)	Make-up Gas (SLPM)	Counts	RSD (%)	Counts	RSD (%)	Counts	RSD (%)	Counts
C50s	46	0.7	1.02	99222	1.77	11038	4.57	1911	9.03	18
C100s	105	0.7	0.90	201857	1.42	40878	2.18	6279	4.87	20
C250s	233	0.7	0.73	279083	1.43	67276	1.53	12893	3.38	32

Table 3. ICP-MS performance comparison of C50s, C100s and C200s nebulizers – cool plasma. Sensitivity is expressed as counts/sec.

In cool plasma mode, the sensitivity of the C50s relative to the C100s and C250s is lower than in normal plasma mode. This is due to the plasma conditions required to achieve good interference reduction with the C50s. In order to prevent the ionization, and therefore detection, of plasma-based interferences such as ^{56}ArO and $^{80}Ar_2$, plasma temperature must be sufficiently reduced. This is achieved by reducing forward power and increasing sampling depth, though solvent (water) loading of the plasma will also contribute to the lowering of plasma temperature. In the case of the C50s, the lower uptake rate means that solvent loading is reduced. To compensate for this, makeup gas must be increased to cool the plasma which, in turn, reduces the residence time of the aerosol in the plasma. This reduces ionization and, therefore analyte sensitivity.

For these reasons, the C50 is highly recommended for applications with limited sample volume and/or where the matrix would overload the plasma if sample uptake rate was too high, (e.g. a high silicon matrix, from bulk silicon analysis).

Conventional vs. Desolvator Use

With conventional sample introduction systems, nebulizers operate between 20°C and 2°C (or lower with organics), but when used with a desolvation device, they are operated in a spray chamber heated to 110°C. In order to achieve the most reproducible performance with desolvators, C-Flow versions specifically designed for use at 110°C are available. They are assembled and tested at 110°C using a special assembly process. C-Flow s-type nebulizers are designed only for operation in conventional sample introduction systems and should not be used in desolvators.

Summary

C-Flow s-type microconcentric nebulizers combine the high performance, low dead volume and fast washout with the convenience of a demountable uptake line. Every C-Flow nebulizer is tested prior to release and ships with a test certificate showing uptake rate measured across an argon gas flow rate range from 0.6 – 1.1 SLPM.

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