Savillex Technical Note

C-Flow PFA Microconcentric Nebulizers - Performance

Overview

The Savillex C-Flow PFA concentric nebulizer range includes four low uptake rate "microconcentric" versions: the C200, C100, C50 and C35, with free aspiration uptake rates of 200, 100, 50 and 35 uL/min respectively. These microconcentric versions are used with ICP-MS for semiconductor analysis and various low sample volume applications (predominantly in geochemistry), and also with desolvation devices such as the CETAC Aridus II.

Savillex PFA C-Flow Nebulizer

The key requirements for PFA microconcentric nebulizers (for ICP-MS) are:

- High sensitivity
- Low oxide and doubly charged ion formation
- Low RSDs
- Free aspiration sample uptake rate accuracy: actual uptake rate vs. target uptake rate
- Nebulizer to nebulizer performance reproducibility
- Maximum resistance to clogging
- Optimum performance with conventional sample introduction systems and desolvators

The design of the C-Flow features a unique two-piece construction, which allows for very precise assembly and optimization of argon back pressure. This is key because back pressure directly impacts droplet size and signal sensitivity. The design also gives better reproducibility in performance than any other microconcentric nebulizer. This is especially important for the lowest uptake rate nebulizers, which are the most challenging to manufacture. As a result, C-Flow target uptake rate ranges are narrower than any other microconcentric nebulizers. The two-piece C-Flow design also offers additional benefits: because the capillary is supported all the way to the tip, all C-Flows can be backflushed safely without risk of damaging the capillary, and lifetime is significantly increased compared to other PFA nebulizers. All C-Flow microconcentric nebulizers feature a uniform capillary ID all the way from the sample to the tip, giving better than expected tolerance to particulates and high TDS (total dissolved solids). Finally, C-Flows are manufactured in both conventional and desolvator versions, which allows for optimum performance at the widely different operating temperatures of both applications.

Fundamental ICP-MS Performance

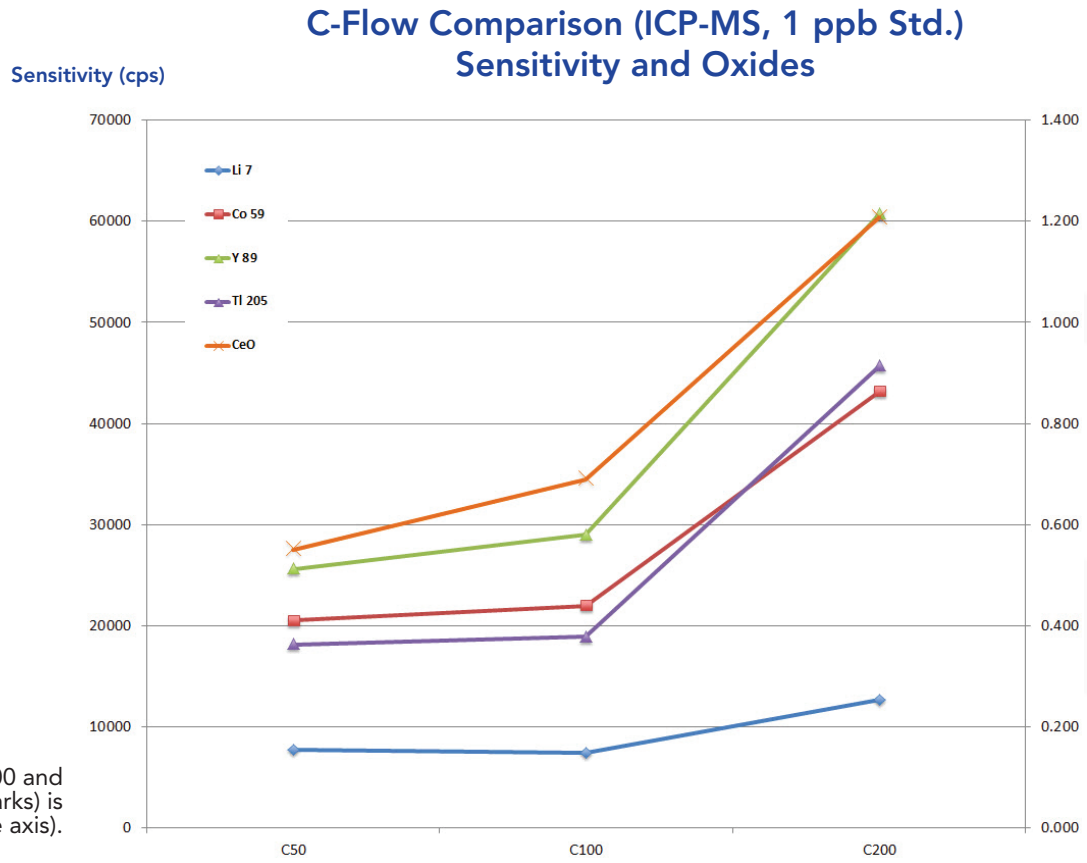
Three different C-Flow nebulizers (C200, C100 and C50 – conventional, non-desolvator versions) were used on a quadrupole ICP-MS to compare performance. A standard quartz Scott-type spray chamber was used, at 2°C. Nebulizer gas flow was 1 SLPM with 0.11-0.12 SLPM make up gas added at the spray chamber end cap, and the nebulizers were operated in free aspiration mode. Prior to installation on the ICP-MS, the sample uptake rate of each nebulizer at 1 SLPM was calculated by aspirating water at room temperature from a beaker placed on a balance and measuring the weight loss over time. Table 1 on the next page shows the performance of each nebulizer. Measured uptake rate is shown below. All three nebulizers were within uptake rate specification, which is 40-60, 85-115 and 170-230 uL/min for C50, C100 and C200 respectively. Carrier gas and make up gas flow rates are also shown.

				Li 7		Co 59		Y 89		Ce 140		Tl 205		2+ 70/140	Oxide 156/140	Mass 220 bkg
Nebulizer Serial Number	Uptake Rate (uL/min)	Carrier Gas (SLPM)	Make-Up Gas (SLPM)	Counts	RSD (%)	Counts	RSD (%)	Counts	RSD (%)	Counts	RSD (%)	Counts	RSD (%)	%	%	Counts
C50 A3232	47	1.00	0.11	7714	1.93	26110	1.87	28641	1.22	29478	1.19	20780	1.42	2.837	0.586	1.2
C100 A3146	92	1.00	0.12	7425	2.06	23363	1.70	31400	1.53	31272	1.55	21530	1.74	2.481	0.717	1.0
C200 A2981	217	1.00	0.12	12642	1.91	45662	2.55	60926	1.79	62281	1.95	45466	1.88	1.960	1.194	1.9

Table 1. ICP-MS performance comparison of C50, C100 and C200 nebulizers. 1 ppb Tune Solution.

As expected, the sensitivity of the C200 is highest due to it's higher sample uptake rate. The sensitivity of the C50 however, is almost identical to the C100, which is due to the higher efficiency of the C50. In fact for Li, the C50 is actually more sensitive than the C100. RSDs are between 1-2% for all nebulizers and analytes. Since this data was taken from the ICP-MS software tune window, actual RSDs achieved during an analysis will be better than obtained here. CeO ratios vary widely, from 0.58% for the C50 to 1.2% for the C200. As the plasma is loaded with more sample, sensitivity increases, but the additional water from the sample solution cools the plasma, which increases the CeO ratio. When evaluating nebulizers with ICP-MS, make up gas is usually adjusted to achieve the same oxide ratio so that the sensitivity of different nebulizers can be directly compared. In the case of low uptake rate nebulizers such as the C50, C100 and C200 however, the uptake rate varies so widely that it is not possible to compensate for it by adjusting make up gas flow rate, so make up gas was essentially kept constant. The reason the C50 has equivalent sensitivity to the C100 is due to its higher efficiency: a very high proportion of the C50 aerosol passes to the plasma and very little goes to the spray chamber drain. Oxides are lower than might be expected with the C50 because there is very little water to cool the plasma.

The chart below shows a sensitivity comparison of the three nebulizers across the mass range. The orange line with crosses is the oxide ratio (right side axis).



Sensitivity comparison for C50, C100 and C200. Orange line (with cross marks) is CeO ratio (right side axis).

C-Flow Reproducibility

The C-Flow is unique among PFA nebulizers in that the capillary is physically supported all the way to the inside of the nebulizer tip. The capillary is positioned centrally within the body, making it the only PFA nebulizer that is a true concentric nebulizer. The design requires very precisely molded components to ensure the inner support aligns axially with the orifice. Savillex's unique molding expertise and design capabilities make this possible. Because the capillary is positioned inside the orifice with very high accuracy and precision, back pressure can be precisely optimized: as a result, sensitivity and free aspiration uptake variability is much lower than with other PFA nebulizer designs. The benefits of the unique construction of the C-Flow become especially apparent at ultra low flow rates (35 uL/min and lower) where reproducibility in performance has been traditionally difficult to achieve.

Table 2 (below) shows the ICP-MS performance data obtained from five different C100 nebulizers. Once again, this data was acquired using the ICP-MS software tune window, so signal RSDs can be expected to be lower for an actual analysis. The reproducibility in performance from nebulizer to nebulizer is excellent: the RSD of the sensitivity obtained from the five different nebulizers is between 10-14% across the mass range. Also note the consistency in uptake rate, and agreement of the average uptake rate with the target (100 uL/min). The reproducibility in performance is a direct result of the manufacturing precision achieved with the two-piece design and a great benefit in routine operation, allowing for nebulizer changeover with little or no modification to the method or retuning of the instrument.

				Mass 7		**Mass 59**		**Mass 89**		**Mass 140**		**Mass 205**		**2+** 70/140	**Oxide** 156/140	**Mass** 220 bkg
Nebulizer	Uptake Rate (uL/min)	Carrier Gas (SLPM)	Make-Up Gas (SLPM)	Counts	RSD (%)	Counts	RSD (%)	Counts	RSD (%)	Counts	RSD (%)	Counts	RSD (%)	%	%	Counts
C100 A3146	92	1.00	0.12	7425	2.06	23363	1.70	31400	1.53	31272	1.55	21530	1.74	2.5	0.72	1.0
C100 A3152	103	1.00	0.12	6054	2.14	20494	1.71	27148	1.69	26068	1.76	16409	1.95	2.1	0.69	1.6
C100 A3153	99	1.00	0.12	5538	2.38	18214	1.61	24938	1.57	24457	1.50	15959	1.79	2.1	0.65	1.4
C100 A3108	112	1.00	0.10	7068	1.94	23629	2.29	29519	1.33	29284	1.40	19522	1.83	2.4	0.69	1.4
C100 A3131	97	1.00	0.10	7494	2.02	24119	2.25	31982	1.36	31665	1.42	21241	1.49	2.2	0.70	1.3
	100.6 Average		**Average**	**6716**	**2.11**	**21964**	**1.91**	**28997**	**1.50**	**28549**	**1.53**	**18932**	**1.76**	**2.3**	**0.7**	**1.3**
			SD	874.4		2529.4		2951.7		3184.7		2628.2				
			RSD	**13.0**		**11.5**		**10.2**		**11.2**		**13.9**				

Table 2. Reproducibility study of five different C100 nebulizers.

Constant ID Capillary

A limitation of most microconcentric nebulizers, both glass and PFA, is the potential for blockages due to particulates in the sample. The microconcentric C-Flows have an integrated uptake line which eliminates dead volume and are unique in having constant ID capillary all the way from the sample to the tip, avoiding any reductions in ID inside the nebulizer body which become blockage points. As a result, tolerance to particulates and high TDS (total dissolved solids) is surprisingly good: the C200 can aspirate 10% TDS routinely.

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 such as the CETAC Aridus II, 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. This ensures that the correct back pressure, uptake rate and sensitivity is achieved at 110°C.

Summary

C-Flow microconcentric nebulizers combine high performance, reproducibility and robustness and are available in conventional and desolvator versions, over a wide range of uptake rates. Every C-Flow microconcentric 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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