

Summary

The Savillex C-Flow 400e (C400e) PFA concentric nebulizer combines the reliability of a low flow glass concentric nebulizer with the chemical resistance and low elemental background of a PFA concentric nebulizer. In addition, its unique constant diameter capillary gives the C400e excellent resistance to clogging. The C400e body has an ESI type thread to allow direct connection to the ESI FAST discrete sampling system used with ICP-MS.



Savillex C400e PFA Concentric Nebulizer

While microconcentric (uptake rate 200 $\mu\text{L}/\text{min}$ or less) PFA nebulizers are used as standard with ICP-MS for semiconductor applications, most non-semiconductor ICP-MS labs use low flow glass nebulizers due to their more suitable uptake rate and relatively low cost. The Savillex C400e was designed specifically for non-semiconductor ICP-MS use and while it can free aspirate, it is designed to be pumped and is optimized for the typical uptake rates (350-400 $\mu\text{L}/\text{min}$) of today's ICP-MS systems. Molded from high purity virgin PFA, the C400e offers the chemical resistance and low metal background of a conventional PFA nebulizer, but with several unique features. Its two-piece precision molded design allows precise optimization of back pressure during manufacture, ensuring consistently high performance. It also features an inner body that supports the capillary all the way to the tip, making it more robust and giving it a longer lifetime compared to other PFA nebulizers. The C400e is optimized for use at 1SLPM to match the carrier gas flow rates of all common ICP-MS, and its 6 mm OD body fits all common spray chamber end caps.

The C400e is also extremely resistant to clogging by particulates: inside the nebulizer body, a constant ID capillary avoids the changes in ID that cause potential blockage points. And because the capillary is supported at the tip, the C400e can be easily and safely backflushed – without the need for tools. The C400e is capable of handling over 15% total dissolved solids (TDS). The C400e connects directly to all of the ESI FAST uptake line connectors for reliable, reproducible connections and the fastest possible washout. A threaded PFA gas inlet fitting ensures a reliable, leak-free carrier gas connection and includes a range of adapters to connect to common gas line sizes. Like all Savillex nebulizers, the C400e is designed, molded and assembled by Savillex, and its design has enabled a significant reduction in assembly time and subsequent price reduction. As a result, the C400e offers all the benefits of PFA nebulizers at a price comparable to low flow glass nebulizers.

Combining high performance and ruggedness with fast washout, high matrix tolerance, chemical inertness and long lifetime, at an excellent price point, the C400e is the perfect choice for any ICP-MS equipped with the ESI FAST.

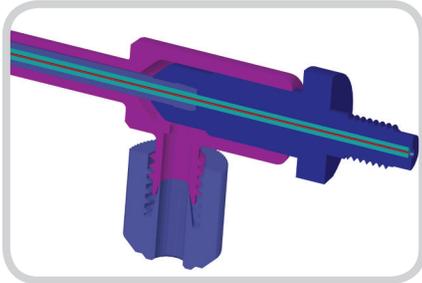
Note: For the routine, non-semicon ICP-MS use, without ESI FAST, choose the C400d, which is the same nebulizer as the C400e, but with a removable 80 cm uptake line and a Savillex zero dead volume connection. The Savillex uptake line cannot be used with the C400e since thread fittings are different.

C-Flow Design - Body

Unlike all other PFA nebulizers, the C-Flow is unique in that the body assembly is comprised of two molded PFA parts: an outer body and an inner body that supports the capillary. Saville's molding expertise allows for the parts to be manufactured to extremely tight tolerances. The photograph below shows the two components prior to assembly. Note the quality of the molding and finish. The 4 mm nebulizer gas fitting is shown connected to the outer body.



C400e Nebulizer Prior to Assembly; Showing Outer Body and Inner Capillary Support



C400e - Inner Support Shown in Blue



C400e - Uptake Line Disconnected

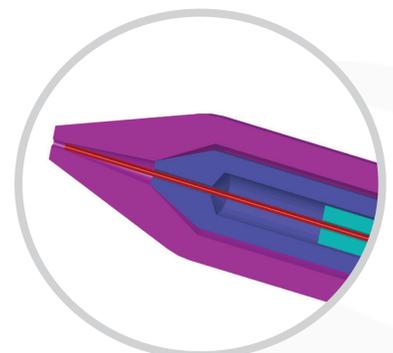
C-Flow Tip Design

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 and the capillary is positioned centrally within the body, making it the only PFA nebulizer that is a true concentric nebulizer. The design requires highly accurate moldings to ensure the inner support axially aligns with the orifice. Saville's unique molding expertise and design capabilities make this possible. Because the capillary is positioned with very high accuracy and precision, performance variability is much lower than with other PFA nebulizer designs.

A schematic diagram of the nebulizer is shown in the drawings below. Ar carrier gas flows around the inner support, forming an annular gas stream around the end of the capillary. The capillary protrudes into space behind the tip, several mm from the orifice itself. As sample liquid exits the capillary, the annular gas stream shears the liquid, causing prefilming around the entire inner circumference of the tip. Liquid/gas interaction and energy transfer is optimized, resulting in a very fine aerosol with narrow droplet size distribution. The high, annular gas velocity around the end of capillary also prevents salt deposition – even with very high TDS solutions.

The tip design provides several key benefits:

- Excellent reproducibility from nebulizer to nebulizer
- High sensitivity due to efficient gas/liquid energy transfer and fine aerosol
- Extremely resistant to salt deposition
- Longer lifetime than other PFA nebulizers, because the capillary is physically supported at the tip so its axial position is very stable
- Rugged – can be backflushed without damaging the nebulizer



Nebulizer Tip
(Capillary Shown in Red)

Large Bore Sample Uptake Path

Unlike other PFA nebulizers, the capillary ID inside the nebulizer is uniform all the way to the tip, ensuring exceptional resistance to blockages. Very high TDS and particulate containing samples can be aspirated over long periods without deposition or clogging.

If a blockage should occur, the C400e can be easily cleared by backflushing with nebulizer gas. With the nebulizer gas flowing, a gloved finger is placed over the nebulizer tip, forcing gas back down the capillary and uptake line. Because the capillary is supported at the tip, it is not damaged by backflushing. And because there is no ID reduction at any point inside the nebulizer body, any blockage would occur at the connector.



Clearing a Blockage by Backflushing a C-Flow. No Need for Tools or Wires. Simply Place a Gloved Finger Over the Tip While Ar Nebulizer Gas is Flowing.

Performance

The table below compares the fundamental ICP-MS performance of the C400d (same nebulizer as the C400e but with a different sample line connector) with a low flow glass concentric and a PFA concentric. As can be seen, sensitivity and stability of the C400d is excellent.

Nebulizer	Carrier Gas (L/min)	Make-up Gas (L/min)	Li 7 (cps)	RSD (%)	Co 59 (cps)	RSD (%)	Y 89 (cps)	RSD (%)	Ce 140 (cps)	RSD (%)	Tl 205 (cps)	RSD (%)	Ce2+/Ce (%)	CeO/Ce (%)
PFA Concentric	1.02	0.18	1366260	1.8	3976851	1.4	5568545	1.3	5790358	1.4	4391985	1.4	2.4	1.12
Low Flow Glass Concentric	1.01	0.12	1220192	1.9	4133376	1.1	5829760	1.0	5765322	0.9	3910300	1.1	1.4	1.10
Savillex C400d	1.03	0.13	1450372	1.5	4399051	1.3	6149808	1.2	6249449	1.2	4525158	1.3	1.7	1.17

Table 1. ICP-MS performance comparison. Carrier and make-up gas were adjusted to give the same oxide level so performance could be directly compared. A 10 ppb tune solution, with a sample uptake rate of 350 uL/min (pumped) was used.

Cleanliness and Chemical Compatibility

The C400e is designed, molded and manufactured in house at Savillex. Savillex uses only the purest grades of virgin PFA resin. These grades have the lowest leachable trace metals levels of any injection molding grade PFA resin. Unlike borosilicate glass nebulizers which generate a very low, but measurable (by ICP-MS) contribution to the boron background, the C-Flow does not generate any measureable background contribution. Also, the chemical compatibility of PFA is higher than any other material including PEEK. In addition to concentrated HF, PFA is resistant all other concentrated mineral acids, and to every organic compound except certain halogenated complexes containing fluorine.

Ordering Information

Item	Part Number
C400e Nebulizer	800-3-040-00-00
*For use only with ICP-MS fitted with an ESI FAST system. Connects directly to ESI FAST connector line.	