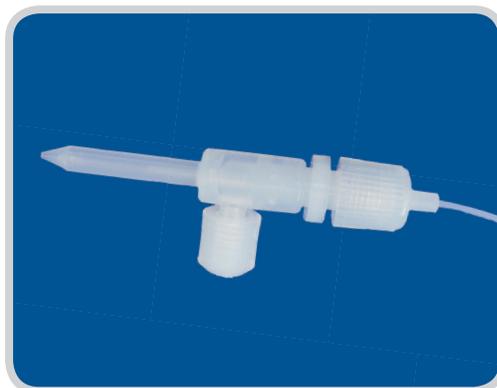


Summary

The Savillex C-Flow 400d (C400d) 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 and removable uptake line with zero dead volume connector give the C400d excellent resistance to clogging and extremely fast washout.



Savillex C400d 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 C400d 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 C400d 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 C400d 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. An 80 cm long uptake line is included.

The C400d 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 C400d can be easily and safely backflushed – without the need for tools. The C400d is capable of handling over 15% total dissolved solids (TDS). The removable sample uptake line connects to the body using Savillex's unique zero dead volume connector 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.

Along with the C700d nebulizer for ICP-OES, the C400d makes up Savillex's d-type (removable uptake line) nebulizer range. Like all Savillex nebulizers, d-type nebulizers are designed, molded and assembled by Savillex, and the design of the d-type range has enabled a significant reduction in assembly time and subsequent cost reductions. As a result, Savillex d-type nebulizers offer all the benefits of PFA nebulizers and more - all 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 C400d is the perfect choice for routine, non-semiconductor ICP-MS applications.

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.



*C-Flow Nebulizer Prior to Assembly;
Showing Outer Body and Inner Capillary Support*

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



Figure 1 C-Flow - Inner Support Shown in Blue

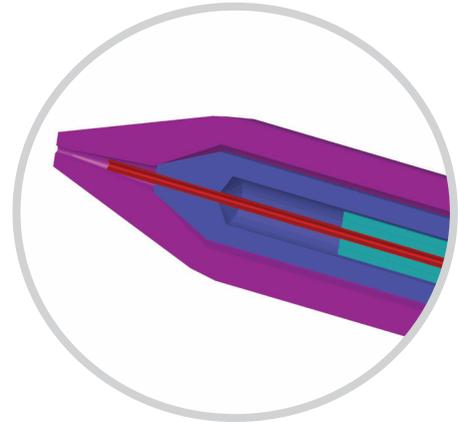


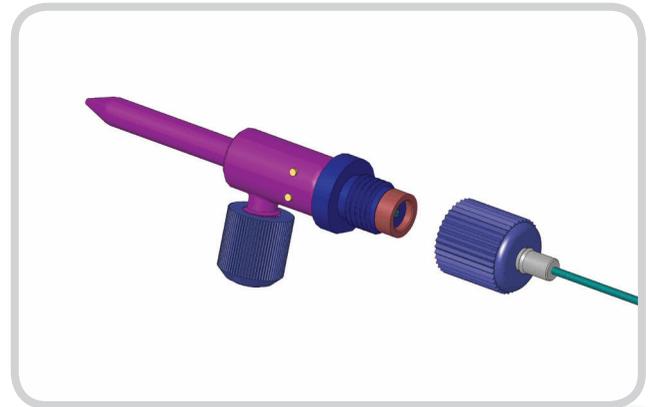
Figure 2 Nebulizer Tip - Capillary Shown in Red

Savillex PFA Zero Dead Volume Connector

Like other general purpose nebulizers, the C400d features a removable uptake line (d-type). A common problem with nebulizer uptake line connectors, however, is dead volume caused by small voids, leading to increased washout and memory. Poor reproducibility of alignment following disconnection and reconnection can also be a problem with screw type connectors. For the d-type nebulizers, we designed the ultimate zero dead volume connector. The uptake line is secured to the nebulizer body by a threaded connector, which is captive on the uptake line.

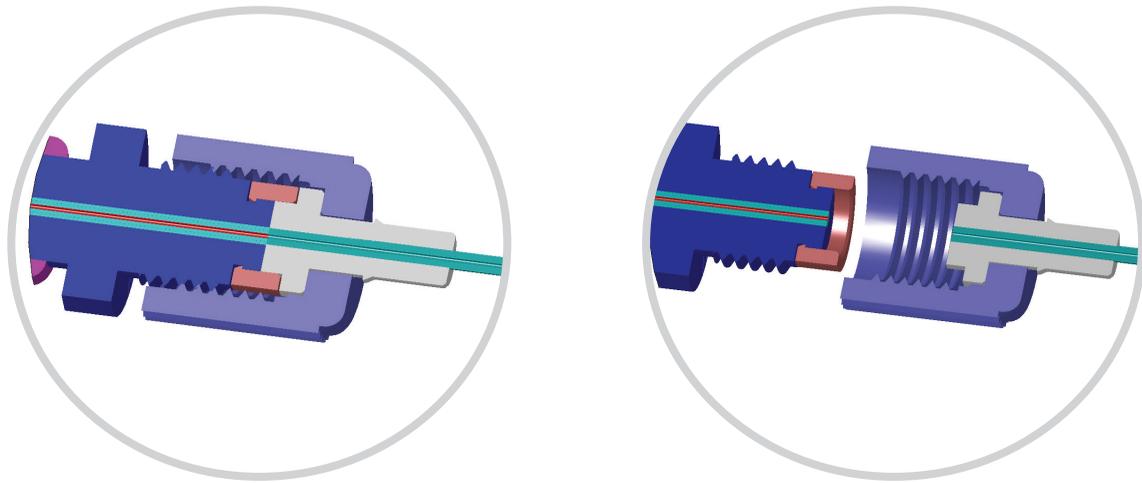


C400d Showing Uptake Line Connected



C400d Showing Uptake Line Disconnected

A PFA fitting, bonded to the uptake line, locates into a PFA ring on the back of the nebulizer body, which ensures that the uptake line and capillary inside the nebulizer body are precisely aligned every time. The mating faces of the connector are smooth and perfectly flat, eliminating voids that could cause washout or memory issues – a significant benefit for high throughput labs. All components are PFA.



C400d Connector – Close Up Showing Locating Ring Shown in Brown

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 C400d 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.

Savillex Technical Note

C400d PFA Concentric Nebulizer for ICP-MS

Performance

The table below compares the fundamental ICP-MS performance of the C400d 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 C400d 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
C400d Nebulizer, with 80 cm Uptake Line	800-2-040-01-00
Replacement Uptake Line for C-Flow d-Type Nebulizer (80 cm)	830-050



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