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MEINHARD®

Advantages of High Pressure Nebulizers

Why has the TR-50-C1 been Meinhard's best selling nebulizer?

At FACSS 33 in September 2006, a paper (No. 340) by Stux, Dulude, Dolic, and Neal reported that nebulizers operated at higher pressure yield better precision, better signal-to-noise, better stability, and better detection limits. This was not news at Meinhard where the TR-50-C1 has been the best selling nebulizer for more than 6 years. Glass concentric nebulizers have usually been operated at 30 psi, but the TR-50-C1 requires 50 psi to achieve a carrier flow of 1 L/min and a natural aspiration rate of 1 mL/min. Meinhard's High Efficiency Nebulizer (HEN) requires as much as 170 psi to achieve a carrier flow of 1 L/min and liquid flow of 100 uL/min. To understand why high pressure nebulizers offer better performance, there are several things to consider, but we will keep the discussion simple.

First, as the mean aerosol droplet size is reduced, aerosol is desolvated faster (to smaller droplets and particles) and more is transported to the plasma. In fact, with conventional ICP nebulizers the primary role of the spray chamber is to reduce the mean droplet size from perhaps 20 um to about 5 um in order to control the consistency of desolvation/vaporization. Unfortunately, that aerosol processing usually results in about 95% of the sample going to waste. If the primary aerosol droplet size can be reduced, less sample will go to waste and more will get to the plasma. Second, some nebulizer parameters can be adjusted in order to reduce the mean size of the primary aerosol formed at the nozzle.

In the 1930s, a pair of Japanese engineers carefully studied the nebulization process and developed an equation which approximately relates droplet size ($d_{3,2}$) to various parameters. The Nukiyama-Tanasawa equation (Figure 1) basically tells us that we can reduce the liquid flow (Ql) relative to the nebulizing gas flow (Qg), or we can change the velocity difference between the gas and liquid (V), or we can change both. But, among other things, changing the liquid flow might be considered less

NUKIYAMA AND TANASAWA EQUATION

$$d_{3,2} = \frac{585}{V}\left[\frac{\sigma}{\rho}\right]^{0.5} + 597\left[\frac{\eta}{(\sigma\rho)^{0.5}}\right]^{0.45}\left[\frac{10^{3}Q_{l}}{Q_{g}}\right]^{1.5}$$

$d_{3,2}$ = Sauter mean diameter - (μm)
V = Velocity difference of gas-liquid - (m/s)
σ = Surface tension - (dyn/cm)
ρ = Liquid density - (g/cm^3)
η = Liquid viscosity - (Poise or dyn·s/cm^2)
Q_l = Volume flowrate, liquid - (cm^3/s)
Q_g = Volume flowrate, gas - (cm^3/s)

S. Nukiyama and Y. Tanasawa, Trans. Soc. Mech. Eng., Tokyo, 1938-40, Vol. 4 – 6, Reports 1 – 6.

Figure 1.

(***continued on page 2***)

Aerosol-to Liquid Particle Extraction System (ALPES)

A new device collects and concentrates airborne metals into a liquid sample for onsite/real time or laboratory analysis. Useful as a tool for coupling ICPMS/OES to airborne particle analysis, the ALPES can offer near real time sampling and analysis of welding fumes, workplace exposure measurement, or environmental metal particle monitoring. The device is portable and consumes only 12 watts of power.

The ALPES is based on the long-proven use of wet electrostatic precipitation to separate particles from air. The collection efficiency is greater than 90 percent for particles less than 0.3 micrometers diameter. Particles in air are drawn through the device at up to 200 LPM, are charged at 8,000 volts, then are collected in a liquid volume of 10-20 mLs. Concentration factors with this device can approach 100,000 within minutes of sampling. The solution with the captured particles can easily be analyzed for important metals such as Pb, Cr, Zn, Hg, Sb, and Be, directly with no further dilution or preparation.

The ALPES is equipped with a self-contained electronics module, a control panel, and collection system components that are attached to a robust, field-ready platform, and has a footprint of under 1 square foot. Please call Meinhard at 303-277-9776 or sales@meinhard.com for more information.

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desirable under normal circumstances since less mass per unit time will reach the plasma. Therefore, we should focus on increasing V insofar as practical.

The parts of a glass concentric nebulizer are identified in Figure 2. For the present discussion, we will pay closest attention to the gas annulus (between the outside diameter of the solution capillary and the inside diameter of the nozzle) at the end of the nozzle as shown in Figure 3. If the volume flow of carrier gas is maintained at 1 L/min and the annular gap is reduced, the velocity of the nebulizing gas through the annulus must increase. In order to maintain the carrier flow through a smaller gap, the backpressure must increase.

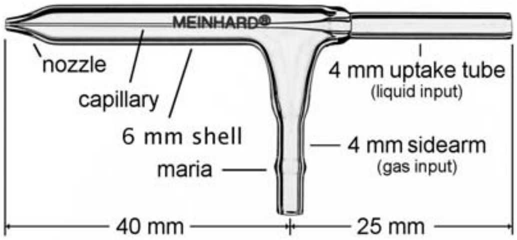

Figure 2.

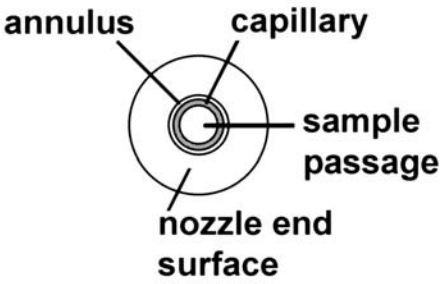

Figure 3.

The TR-30-A1, among the most common general-purpose nebulizers, has an annular gap of about 100 um. It requires about 30 psi to obtain 1 L/min and 1 mL/min. For a TR-50-C1 (50 psi, 1 L/min, 1 mL/min), the gap is about 50 um, with the result that the gas velocity is nearly doubled, the droplet size distribution is shifted to a smaller range, and performance is generally improved as described earlier. With Meinhard's HEN-170, the gap is about 20 um; the pressure required to obtain 1 L/min is about 170 psi; the natural aspiration rate is about 100 uL/min. With a HEN-170, the gas velocity is nearly 300 m/sec, the mean droplet size is in the 1 – 2 um range, and nearly 100% of the naturally-aspirated sample reaches the plasma. The HEN-170 represents the nearly-ideal case.

Why doesn't everybody do this? Historically, as Stux et al. pointed out, ICP and ICPMS instruments have not been designed to provide nebulizer pressures in excess of perhaps 40 psi. Many of the latest generation instruments can provide as much as 90 psi and use mass flow controllers to ensure a stable carrier flow. Pressures above 90 psi generally require different, more expensive hardware and so are not common in production instruments. It might also be obvious that the manufacture of a smaller gas annulus is substantially more difficult making the nebulizer more costly. The TR-30-A1 is easier to construct than the TR-50-C1, which is much easier to construct than a HEN-170.

Clearly, there are limits. We can increase the velocity difference with any nebulizer simply by increasing the applied pressure and/or reducing liquid flow. However, if the carrier flow exceeds about1 L/min, residence time is reduced, excitation/ionization is affected, and interferences generally become more prominent. Most ICPs (and ICPMS) today are operated at about 0.6 – 0.8 L/min. We can also reduce the liquid flow (starve the nebulizer) to get smaller droplets and better transport, but the physics of shearing the liquid can result in a more noisy, almost pulsing aerosol production. Finally, research has shown that a typical argon plasma can handle about 100 uL/min of solvent. More than that has adverse effects, particularly in ICPMS.

The TR-50-C1 offers an excellent compromise among cost, performance, and compatibility with most modern instruments. It is also available in quartz, as the TQ-50-C1, for those who wish to minimize boron background.

With high-pressure nebulizers, the most important factor is the gas velocity. However, In the interest of brevity and simplicity, the foregoing discussion has ignored a number of things, including the compressibility of gases, Joule-Thompson cooling in the gas expansion, the formation of Mach waves in the expansion, nozzle shapes, re-nebulization, collision/agglomeration, etc., each of which has an impact on the aerosol droplet size. We have also ignored the effects of surface tension, density, and viscosity of sample and standard solutions, assuming that those would be consistent if the analysis is properly performed. For those who wish to explore further, the excellent review published in the Journal of Analytical Atomic Spectrometry by Barry L. Sharp (JAAS 1988, 3, 613) is highly recommended.

Meinhard Glass Products is a division of Analytical Reference Materials International, located in Golden, Colorado, USA. Contact us at sales@meinhard.com or 303.277.9776.

Sale on Thermo Ceramic Base Torches

Through March 31, 2007

Thermo Part #	Meinhard Part #	Description	List $US	Sale
12512401	ML127508	Radial Base Torch Kit, High Flow, 1.0 Center Tube	482	425
12512405	ML127512	Radial Base Torch Kit, Slotted, 1.0 Center Tube	492	433
12540700	ML125041	Quartz 1.5 mm Center Tube, for Base Torch	94	83
12540701	ML125040	Quartz 1.0 mm Center Tube, for Base Torch	94	83
12643201	ML127507	Radial Base Torch Kit, High Flow, 1.5 Center Tube	482	425
12643202	ML127506	Radial Base Torch Kit, Low Flow, 1.5 Center Tube	482	425
12643203	ML127510	Trace Axial Base Torch Kit, 1.5 Center Tube	492	433
12643204	ML127513	Radial Base Torch Kit, Slotted, 1.5 Center Tube	512	451
12644001	ML127507N	Radial Base Torch, High Flow, No Center Tube	417	367
	ML127507R	Rebuild of user-supplied torch 127507/12644001	272	240
12644002	ML127506N	Radial Base Torch, Low Flow, No Center Tube	417	367
	ML127506R	Rebuild of user-supplied torch 127506/12644002	272	240
12644003	ML127510N	Trace Axial Base Torch Body, No Center Tube	437	385
	ML127510R	Rebuild of user-supplied torch 127510/12644003	305	269
12644005	ML127511N	DUO Axial Base Torch, w/Hole, No Center Tube	477	420
	ML127511R	Rebuild of user-supplied torch 127511/12644005	371	327
12644006	ML127512N	Radial Base Torch Body, Slotted, No Center Tube	437	385
13650201	ML125042	Quartz 2.0 mm Center Tube, for Base Torch	94	83
13650202	ML125043	Quartz 2.4 mm Center Tube, for Base Torch	94	83
13856200	ML127511	DUO Axial Base Torch Kit, w/Hole, 1.5 Center Tube	532	469

Be sure to check our web site frequently for web-only sale specials!

Pittcon 2007 – Booth 2156 – Show Specials

Stop by our booth to see our new nebulizer fit kits and to pick up your coupon worth 15% off any single (non-sale) item or 25% off purchases of two or more (non-sale) items. Meinhard is known for nebulizers, but offers excellent value in torches, spray chambers, pump tubing, and sample introduction accessories. Pittcon will be in Chicago, February 25 – March 2, 2007.

2007 Winter Conference on Plasma Spectrochemistry

Spetec GmbH will be exhibiting an array of Meinhard products as our European partner. In addition, Meinhard is sponsoring two awards for outstanding student poster presentations which consist of an honorarium and a membership in the Society for Applied Spectroscopy. The 2007 conference will be held in Taormina, Sicily, February 18 – 23.

Student Poster Awards at FACSS 2006

Christina Young of the Georgia Institute of Technology and Gary Dobbs also of Georgia Tech, students working with Prof. Boris Mizaikoff, were the winners of Meinhard-sponsored awards for exceptional poster presentations. Ms. Young's poster was, "Mid-Infrared Gas Sensors Using Hollow Waveguides for Sensing Volatile Organic Pollutants." Mr. Dobbs' poster was "Plasma-assisted Deposition of Fluorocarbon Films for Molecular Recognition Layers in Mid-Infrared Attentuated Total Reflection Chemical Sensors." The winners were selected by a committee of session chairs who presided at FACSS 33 in Lake Buena Vista, Florida.

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