Increasing Efficiency of ICPMS Analysis of Challenging Matrices by Using an Innovative Low Maintenance Nebulizer

Mary Kay Amistadi, Arizona Laboratory for Emerging Contaminants (ALEC) , University of Arizona
Dr. Sergei Leikin, Texas Scientific Products

Introduction

Arizona Laboratory for Emerging Contaminants (ALEC) was introduced in 2008 as a collaboration between five colleges at the University of Arizona to provide analytical support for researchers primarily in mass spectrometry. The inorganic section now houses the Agilent 7700x and 8900 systems (Figure 1) with additional capabilities for LC-ICP-MS.

Figure 1. Agilent 7700x and 8900 ICPMS

Samples submitted to ALEC range from environmental - drinking and wastewaters, soil acid extracts to biological - wood, agricultural - plant tissues , clinical - including undigested whole blood, serum, urine, and digested animal tissues. A few representative examples are below (Figure. 2-5).

Figure 2. Soil Acid Extracts

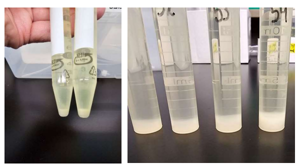

Figure 3. Wood Core Digests

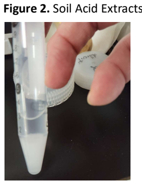

Figure 4. Serum Sample, 1:30 Dilution.
2% (v/v) HNO_3, 5% Ethyl Alcohol, 0.01% Triton X-100™

Figure 5. Whole Blood Samples, 1:20 Dilution.
0.5% HNO3, 0.05% Triton X , 1.5 % Butanol

Robust and reliable ICP-MS analyses of samples with either a complex matrix or with even a small particulate content pose a persistent challenge due to the potential clogging of conventional concentric nebulizers [1]. ALEC, as well as other research laboratories, are faced with the necessity to analyze samples whose different nature and complexity often change daily (Fig.6). Still - with high productivity and sample throughput.
Such a demanding environment requires pre-filtration and/or centrifugation steps, which are time-consuming and add significant costs to the analytical process.

Sample Type	Sample Type	Sample Type
dairy sludge dry and cake	dry biosolids	insects
resin	NaOH cell digests	scorpions
acid extracts	breast milk 2022	mine tailing extracts
sunscreen	fish feed	ghost wipes
wood digests	sugar/water	urines
basalt leachate	cell pellets	furniture finishes
serum/CSF/blood digests	brines and waters	rhamnolipid solutions
plants	tissue/serum/cells	mollusks, feathers, fur

Figure 6. Snapshot of ALEC Sample Logbook

Experimental Setup

To address these challenges a nebulizer with an innovative design (OptiMist ION®, Texas Scientific Products) [2], previously applied for direct analysis of clinical samples [3], has been employed.

Figure 7. OptiMist ION® after Running Whole Blood Samples for 2 Days

Figure 8. Nebulizer setup on Agilent 8900

Figure 9. Nebulizer setup on Agilent 7700

OptiMist ION® (Fig.7) has a robust non-concentric design: gas and sample channels are separated throughout the entire body of the nebulizer. The relatively large internal diameter (ID) of the sample channel of about 0.75 mm provides good resistance to clogging and the ability to tolerate tough matrices. Efficient aerosol generation at a small sample uptake rate is accomplished by employing an impact surface within the proximity to the gas
Orifice at an optimized angle. Test results show that the sensitivity and precision of the new nebulizer are comparable to the sensitivity and precision of commonly used concentric nebulizers.

Since fine aerosol is deflected by the impact surface, the nebulizer is oriented at an angle to the spray chamber. The proper orientation was accomplished by the End Cap specifically designed for the Scott Double Pass spray chamber and supplied with a Nebulizer (Figures 8 and 9).

Results and Discussion

The results of close to a year of continuous operation showed that analyses of a wide variety of challenging samples with high particulate content: digests of environmental soils, woods, plants, animal tissues as well as clinical samples - to name a few - were conducted reliably without pre-filtration and centrifugation steps.

No single nebulizer blockage was observed and the Optimist ION ® did not require any maintenance with over 17,000 samples passed through it (Fig. 10).

Analytical performance is shown by the examples of calibration, and sensitivity data for Hg 202 in comparison to the standard concentric nebulizer (Fig. 11 and 12) and the 10-hour long-term stability (Fig. 13),

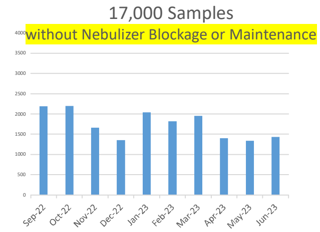

Figure 10. Average Monthly Sample Throughput

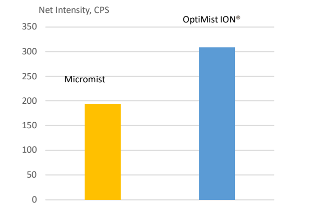

Figure 11. Net Intensity Comparison for Hg 202 at 10 ppt

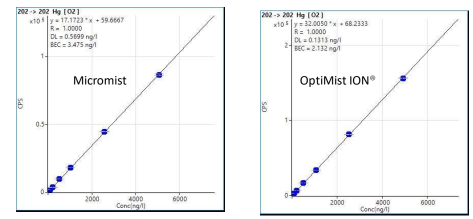

Figure 12. Comparison of the Calibration Data for Hg 202

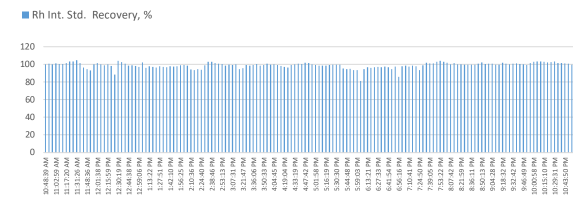

Figure 13. 10-hour Long-Term Stability

Conclusions

- Elimination of the filtration and/or centrifugation steps, combined with the low maintenance feature of the employed nebulizer, allowed for enhanced operational efficiency of the analysis.
- Downtime, common to concentric nebulizers to handle frequent blockages, was eliminated.
- Cleaning and maintenance normally required were significantly reduced.
- At the same time - the increased efficiency has been accomplished without compromising overall analytical performance.
- The results show a practical solution to ICP-MS analyses associated with challenging matrices which can be useful for any commercial and research laboratories.

References

[1] Montaser, A.; Golightly, D. W. Inductively Coupled Plasmas in Analytical Atomic Spectrometry, 2nd Ed. John Wiley & Sons, 1996. p 225.
[2] S. Leikin. Analytical Performance Evaluation of a New Nebulizer for ICPMS Analysis of Difficult Samples. Winter Conference on Plasma Spectrochemistry, Abstracts (2020).
[3] S. Leikin and Mary Kay Amistadi. Reliable Direct Analysis of Challenging Clinical Samples by ICPMS Using a Nebulizer with Innovative Design., Abstracts (2022).