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Application Note

February 2012

Keywords or phrases:
Ultrapure Water, Trace Analysis, ICP-MS, Pharma, Food and Beverage, Environmental Industries, Analytical Laboratories

Ultrapure Water for Trace Analysis With ICP-MS

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Introduction

Inductively coupled plasma mass spectrometry (ICP-MS) is a highly sophisticated multi-element analytical technique that is increasingly being used for trace analysis in the pharmaceutical, food and beverage, and environmental industries, as well as in analytical laboratories.

The ICP-MS technique is capable of analysis down to sub-ppt (parts per trillion) detection limits, whereby the lowest detection limits can be achieved only in a clean room environment.

Because water is used early in tests for trace elemental analysis with ICP-MS, it is obvious that any contamination from the water can compromise an entire analysis. Therefore, the water used must be of a high analytical grade quality (e.g., ASTM Type I water). The objective of the analytical test series described below is to ensure that the ultrapure water generated by the Arium® Pro UV water systems has a high purity level (in this case, free of metal elements, particularly undetectable metal elements) and can be used without any problems for trace analysis of elements performed with ICP-MS devices.

Principle of ICP-MS Technology

ICP technology was built on the principles of atomic emission spectroscopy. Samples are decomposed into positive charged ions based on their mass-to-charge ratio in a high temperature argon plasma followed by passage through a mass spectrometer for detection. In principle, ICP-MS consists of the following steps: sample preparation and introduction, aerosol generation, ionization by an argon plasma source, mass discrimination, and identification by the detection system, including data analysis according to Worley and Kvech.[1]

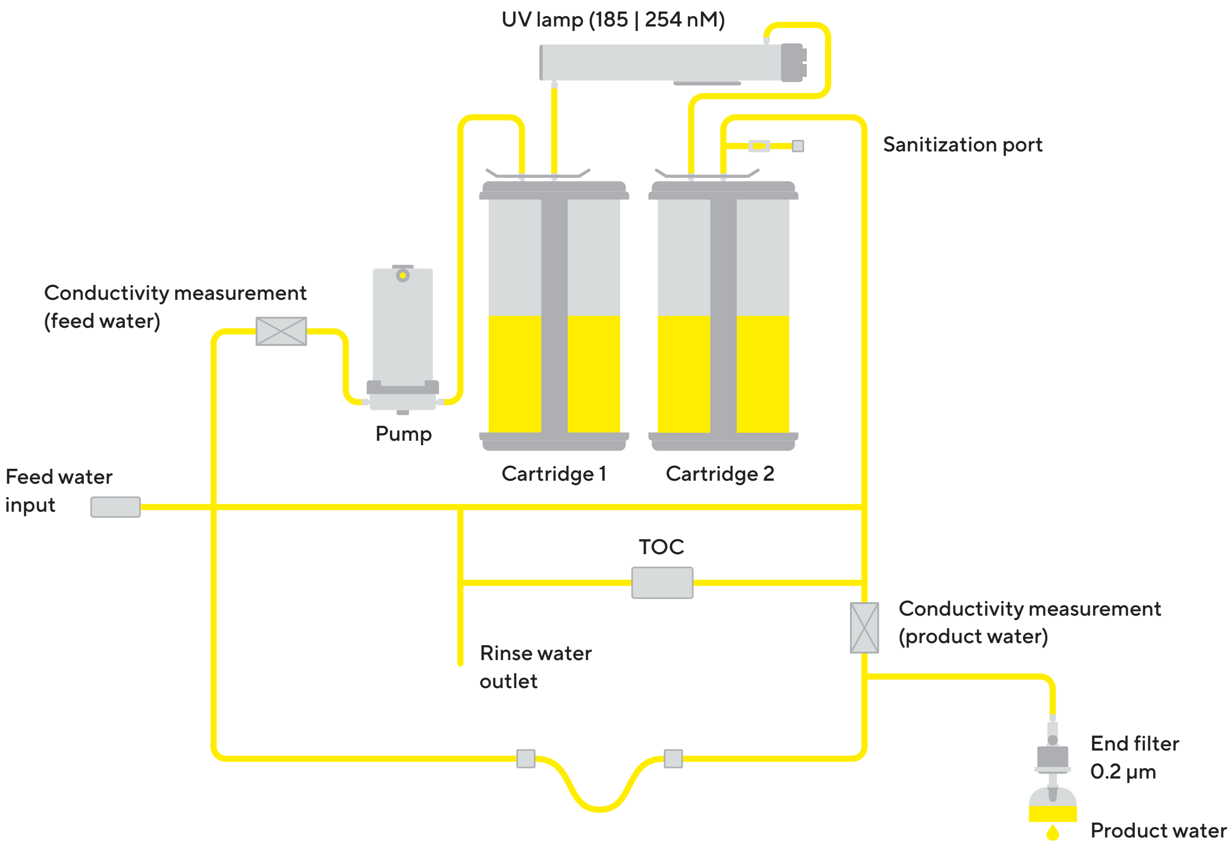
The Ultrapure Water System

The Arium® Pro UV system (Figure 1) is designed to produce ultrapure water from pre-treated water sources by removing trace levels of residual contaminants. For general water purification, various technologies (distillation, reverse osmosis, deionization, and electrodeionization) are used. The production of ultrapure water with Arium® requires continuous recirculation and constant flow. This is carried out by a pump system with pressure regulation. The conductivity of the water is measured at the water feed inlet and the water outlet (downstream product). The total organic carbon content (TOC) is controlled by a TOC monitor.

The actual purification process depends on the Arium® model and the technology used. This system works with two different cartridge kits. The cartridges are filled with a special active carbon adsorber and a special mixed bed exchange resin designed to deliver high-purity water with a low level of extractables. In the system, a UV lamp, which operates at 185 and 254 nm is used as an oxidizing agent. A final microfilter at the outlet is normally installed to remove any particles or bacteria from the ultrapure water as it is dispensed. The general process described is depicted in Figure 2.

Figure 1: *The Arium® Pro UV Ultrapure Water System*

Figure 2: *Schematic Drawing of the Working Principle of the Arium® Pro UV Ultrapure Water System*



Test Method

The tests were carried out with the Sartorius Arium® Pro UV pure water system in a Class 1 clean hood. Samples were taken from the product water side (without a final microfilter capsule installed) and were analyzed with an ICP-MS system 7500 cs (Agilent).[2]

Results

Trace element analysis requires reagents and/or solvents and water of high purity to ensure that the accuracy of the ICP-MS instrument is not negatively influenced. For example, pure water is necessary to create instrument blanks, calibration curves, and standard solutions. Purified water is also necessary for sample preparation and thus must be free of those elements under investigation.

Standard solutions of the elements mentioned below were injected together with an instrument blank (zero value) into the ICP-MS system to generate calibration curves. Figures 3 and 4 show examples of the calibration curves of lead (Figure 3) and chromium (Figure 4) as a function of signal value plotted against the concentration of the element expressed in ppt. The concentrations of each element in the samples tested were calculated from the corresponding calibration curves and are shown in Table 1.

Table 1: *Trace Analysis in Arium® Pro UV Product Water*

Element	Detection Limit in ng/L (ppt)	Concentration in Arium® Pro UV Product Water (0.055 µs/cm)
Arsenic AS	1 ppt	Below detection limit
Boron B	10 ppt	Below detection limit
Cadmium Cd	0.5 ppt	Below detection limit
Chromium Cr	0.5 ppt	Below detection limit
Lead Pb	0.5 ppt	Below detection limit
Mercury Hg	5 ppt	Below detection limit
Selenium Se	10 ppt	Below detection limit

Figure 3: *Typical Calibration Curve for Lead Pb (CPS = counts per second)*

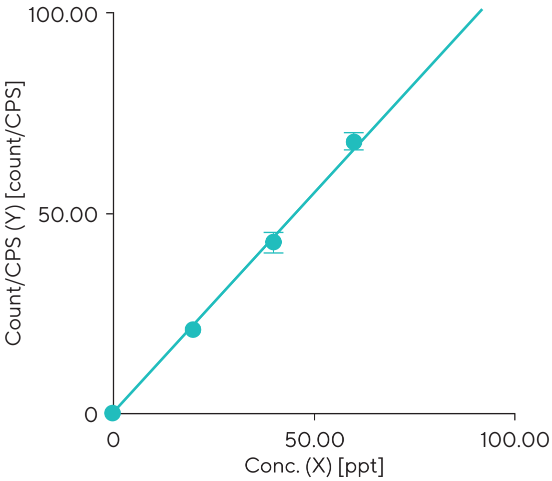
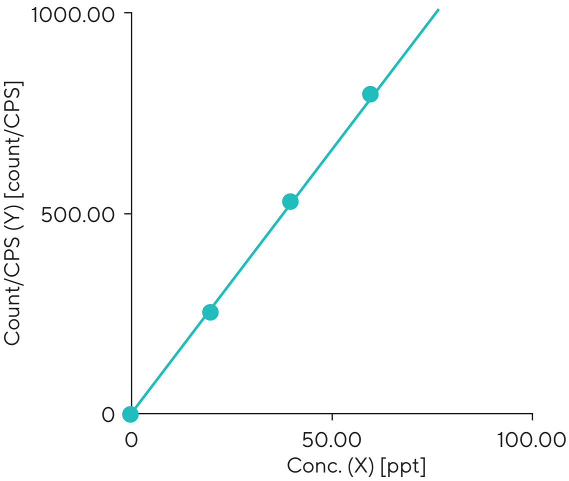


Figure 4: *Typical Calibration Curve of Chromium Cr (CPS = counts per second)*



Conclusion

It can be clearly seen that under the given test conditions, the ng/L (ppt) quantities of the different elements, specified above, are below the detection limits. To achieve such high-quality water, all system parts including the tubing have been specially designed for the ICP-MS application and are used for the serial production of Arium® Pro UV devices. The results obtained clearly illustrate that ultrapure water produced by Arium® Pro UV is exceptionally suitable for use in ICP-MS technology because error sources or risks of inaccuracies due to the presence of the trace elements mentioned above are prevented. Such conditions are prerequisite to trace analysis of these elements in pharmaceutical and environmental industries, as well as in analytical laboratories.

References

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2. Reinstwasseranalyse am Auslauf der "Arium® Pro UV Anlage" ATU GmbH-Analytik für Technik und Umwelt, Herrenberg, 2011

Acknowledgements

Special thanks to ATU GmbH—Analytik für Technik und Umwelt for the literature and results provided, as well as the discussions concerning the ICP-MS technology described.

First published in G.I.T. Laboratory Journal Europe 1-2, Volume 16

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