Application Note: ANWPGENUVUF 0614

Trace Metal Analysis of Water Produced From a Thermo Scientific Barnstead GenPure UV/UF-TOC Water Purification System

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Key Words
ICP-MS, IC, Ultrapure Water, Thermo Scientific Barnstead, GenPure, Ions, ASTM Type 1

Abstract
Laboratory water produced from a Thermo Scientific™ Barnstead™ GenPure™ UV/UF-TOC water purification system was analyzed for 40 elements by M. Reutz and R. Braitmayer at Analytik für Technik und Umwelt GmbH.

Introduction
Effective and repeatable purification is critical for the production of ultrapure water with trace levels of ions, which is necessary in many analytical procedures. Although ultrapure water, which measures 18.2 Megohm·cm, is theoretically ion-free, it may still contain parts per trillion (ppt) levels of ionic species. For many scientific applications, these trace levels of ions are below detection limits and will not interfere with their results. As modern analytical instrumentation continues to push the boundaries of ultralow sensitivities, allowing for the elemental analysis of samples at levels of parts per trillion, extreme care must be taken to ensure that the sample is not contaminated during preparation, storage or handling.

An ASTM[1] Type 1 water purification system is only required to produce water that is 18.0 Megohm·cm and achieve <50 ppb total organic carbon (TOC) per the standard. As analytical applications become more sensitive to ppt levels of ions, water systems have become more advanced in their ability to remove trace ions.

To help ensure the ultrapure water produced by the Barnstead GenPure water system has ultralow levels of ions, the water system employs several purification technologies as the ions could be simply dissolved in the water or bound as a ligand with organics in the feed water (Figure 1). As the feed water enters the system, it is exposed to an ultraviolet (UV) lamp. The dual wavelength lamp (185/254 nm) will oxidize any organic impurities in the feed water, releasing any metal ligands that could be present.

The next purification step is the ultrapure cartridge, where ionic impurities are sequestered in the ion exchange resin. The cartridge in the GenPure UV/UF-TOC system uses high-quality ion exchange resins (semiconductor grade) to effectively and consistently produce ultrapure water with a resistivity of 18.2 Megohm·cm and a TOC of <5 parts per billion (ppb).

Additionally, the wetted parts in the water system are constructed with high-purity materials including virgin polypropylene and high-purity fluoropolymer delivery components to reduce contamination from the system itself.

Water from a GenPure UV/UF-TOC system was analyzed using validated trace element techniques in a clean room environment. Inductively coupled plasma mass spectrometry (ICP-MS) and ion chromatography (IC) were used to analyze the water for trace metal and ion contamination. The water was tested for 40 ionic impurities.

Materials and Methods
Performed by: M. Reutz and R. Braitmayer, Analytik für Technik und Umwelt GmbH, Herrenberg, Germany

A GenPure UV/UF-TOC system was fed with deionized (DI) water in a clean room. The water feeding the GenPure system was from the laboratory's central water system and exceeded the minimum feed water requirements as described in the GenPure system's operational manual[2]. The system was initially rinsed with DI water for two days prior to sampling the water for analysis. All sampling was performed using clean techniques. Anions and cations were analyzed using a Thermo Scientific™ Dionex™ model IC 20 ion chromatograph. Trace metals were analyzed using Agilent™ model ICP-MS 7500cs. Because of interferences using ICP-MS, silica was analyzed by a PerkinElmer™ model GF-AAS 3030.

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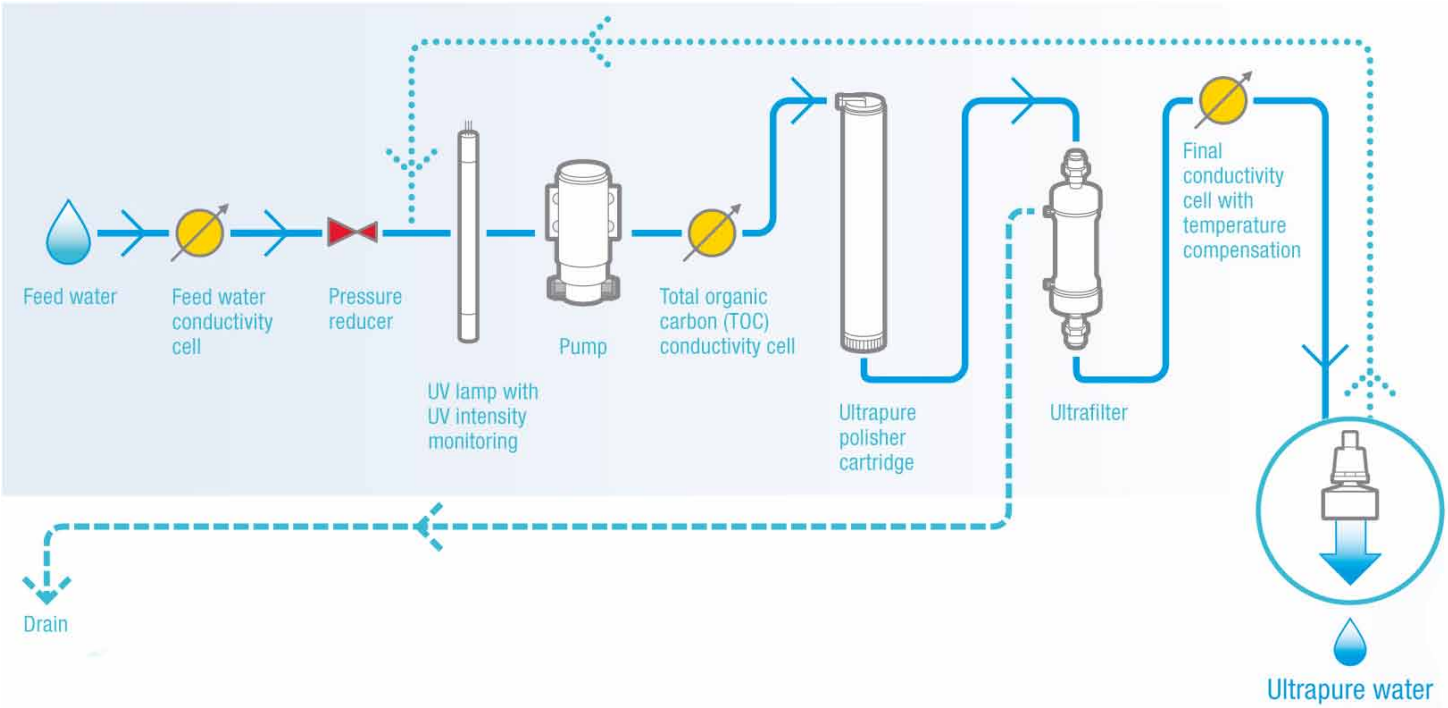
Figure 1. Flow diagram of a GenPure UV/UF-TOC water system.



Results

Tables 1 and 3 list the levels of ionic species determined in the product water of a GenPure UV/UF-TOC water system. Of the 40 elements and ions tested, 37 were below the detection level of the system. Three elements — calcium, sodium, and zinc — demonstrated an increase in their amount when their levels in the feed and product water were compared. It is possible that the ultrafilter, which is one of the last purification steps in the water system, could be introducing these impurities as it is located after the ion exchange cartridge, but the data set does not address this question. Because of this risk, ultrapure water systems configured with only a UV lamp are recommended for sensitive applications, whereas laboratories doing molecular or cellular biology experiments are recommended to configure their systems with a UV lamp and ultrafilter to remove pyrogens and nucleases. Additionally, some of the elements had no detectable levels of ions in the feed water. Assessing the levels of compounds in the water produced by a water purification system without some measurable level in the feed water demonstrates that the system, as configured, did not introduce contamination, but does not indicate whether the system has the ability to remove these impurities.

Table 2 lists the measured TOC of the system's product water, which is within the published specifications of the system.

References

1. Standard Specification for Reagent Water, ASTM D1193-06. Federal Test Method Standard No. 7916.
2. Operational Instructions for the Thermo Scientific Barnstead GenPure Water Purification System, Thermo Fisher Scientific, Niederelbert, Germany.

Table 1: Ion analysis of the feed and product water of a GenPure UV/UF-TOC water purification system using ion chromatography.

Parameter	Detection Limit, ppt	Results, ppt
Ammonium NH^{4+}	10	< 10
Fluoride F-	5	< 5
Chloride Cl-	5	< 5
Bromide Br-	5	< 5
Nitrite NO^{2-}	5	< 5
Nitrate NO^{3-}	5	< 5
Phosphate PO_4^{3-}	20	< 20
Sulfate SO_4^{2-}	10	< 10

Table 2: Determination of the TOC level in the feed and product water of a GenPure UV/UF-TOC system using ICP-MS

Parameter	Detection Limit, ppt	Results, ppt	
		Feed Water	Product Water
TOC	0.1	6.5	2.0

Table 3: Results from the analysis of the feed and product water of a Barnstead GenPure UV/UF-TOC water purification system.

Element	Detection Limit, ppt	Results, ppt		Method
		Feed Water	Product Water	
Aluminium Al	0.3	< 0.3	< 0.3	ICP-MS
Antimony Sb	0.5	< 0.5	< 0.5	ICP-MS
Arsenic As	0.5	< 0.5	< 0.5	ICP-MS
Barium Ba	0.1	< 0.1	< 0.1	ICP-MS/IC
Bismuth Bi	0.5	0.6	< 0.5	ICP-MS
Boron B	20	560	< 20	ICP-MS
Cadmium Cd	0.5	< 0.5	< 0.5	ICP-MS
Calcium Ca	1	< 1	2.8	ICP-MS/IC
Chromium Cr	0.2	0.6	< 0.2	ICP-MS
Cobalt Co	1	1.2	< 1	ICP-MS
Copper Cu	0.5	< 0.5	< 0.5	ICP-MS
Iron Fe	0.5	2.4	< 0.5	ICP-MS
Lead Pb	0.2	2.5	< 0.2	ICP-MS
Lithium Li	0.1	0.2	< 0.1	ICP-MS/IC
Magnesium Mg	0.1	0.2	< 0.1	ICP-MS/IC
Manganese Mn	0.5	2.8	< 0.5	ICP-MS
Molybdenum Mo	0.2	0.6	< 0.2	ICP-MS
Nickel Ni	0.2	0.7	< 0.2	ICP-MS
Palladium Pd	0.2	< 0.2	< 0.2	ICP-MS
Platinum Pt	1	< 1	< 1	ICP-MS
Potassium K	0.5	1.0	< 0.5	ICP-MS/IC
Silicon Si	200	Not determined	< 200	GF-AAS
Silver Ag	0.2	< 0.2	< 0.2	ICP-MS
Sodium Na	0.1	0.3	0.6	ICP-MS/IC
Strontium Sr	0.2	< 0.2	< 0.2	ICP-MS/IC
Tantalum Ta	0.2	< 0.2	< 0.2	ICP-MS
Tin Sn	1	< 1	< 1	ICP-MS
Titanium Ti	0.2	< 0.2	< 0.2	ICP-MS
Tungsten W	0.5	< 0.5	< 0.5	ICP-MS
Vanadium V	0.2	< 0.2	< 0.2	ICP-MS
Zinc Zn	0.5	1.7	17	ICP-MS
Zirconium Zr	0.2	< 0.2	< 0.2	ICP-MS

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