Technical Application Bulletin

Validation of NANOpure® DIamond™ UV Water Trace Metals, Anion and Cations

Modern analytical instrumentation allows for the determination of metals and ions in water at the low parts per trillion level. At these low levels, extreme care must be taken to ensure that a sample is not contaminated during sampling, storage or handling. Water from a NANOpure DIamond UV 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 or ion contamination. The results indicate that the water is below the limit of detection for all calibrated compounds, which include 13 major anions and cations and 68 trace metals.

Methods

The Barnstead NANOpure DIamond uses the highest quality ion exchange resins (semiconductor grade) to remove ionic contamination and produce pure water with a resistivity of 18.2 MΩ-cm. The final wetted parts in the system consist of high purity materials including virgin polypropylene cartridge tubes and high-purity fluoropolymer delivery components. Additionally, the DIamond UV uses a 185/254 nm UV lamp upstream of a final polishing resin to oxidize and subsequently sequester any organically bound metals that may otherwise interfere with an application. Although water that measures 18.2 MΩ-cm is theoretically pure, in reality it may still contain parts per trillion levels of various ionic species and therefore needs to be validated with the highest-sensitivity instrumentation. A NANOpure DIamond UV (Model # D11911) was set up with an Organic Free Cartridge (Model # D50280 for reverse osmosis or distillation feed and # D50281 for deionized feed) in a clean room at Balazs Analytical Laboratory in Sunnyvale, CA. The water feeding the DIamond was from the laboratory's central water system and exceeded the DIamond's minimum feed requirements. The pack was purged of air with the "air purge" menu selection and allowed to recirculate for several days to condition the cartridge pack and system components. A new 0.2 micron hollow-fiber, cellulose-acetate final filter was also installed. This filter is an important component of the system since it removes submicron particles and bacteria from the product water. The filter was initially purged with 10 L of water to condition it and then subsequently purged with 0.5 L of water prior to sampling the water for analysis. All sampling was performed using clean techniques with acid-washed bottles. Anions and cations were analyzed using a Dionex Model 500DX ion chromatograph with dual columns and dual conductivity detectors. Trace metals were analyzed using ICP-MS with a quadrupole detector for the lowest limits of detection. Because of interferences using ICP-MS, silica was analyzed by a wet chemical spectrophotometric method in which dissolved silica reacts with molybdate to form a colored complex.

Results

All of the calibrated compounds were below the limit of detection in the DIamond UV product water. The results are reported as < (Limit of Detection) in Tables 1-3.

Table 1 Anions by Ion Chromatography

Fluorine (F^-)	<0.1
Chloride (Cl^-)	<0.02
Nitrite (NO_2^-)	<0.02
Bromide (Br^-)	<0.02
Nitrate (NO_3^-)	<0.02
Phosphate (HPO_4^{2-})	<0.02
Sulfate (SO_4^{2-})	<0.05

Results reported as < Limit of Detection

Table 2 Cations by Ion Chromatography

Lithium (Li^+)	<0.01
Sodium (Na^+)	<0.01
Ammonium (NH_4^+)	<0.05
Potassium (K^+)	<0.02
Magnesium ($Mg2^+$)	<0.02
Calcium (Ca^{2+})	<0.02

Results reported as < Limit of Detection

See Table 3 on page 339.

Validation of NANOpure® DIamond™ UV Water Trace Organic Compounds

TABLE 3 TRACE METALS BY ICP-MS

Element	Result	Element	Result
Aluminum (Al)	<0.003	Neodymium (Nd)	<0.001
Antimony (Sb)	<0.002	Nickel (Ni)	<0.004
Arsenic (As)	<0.005	Niobium (Nb)	<0.001
Barium (Ba)	<0.001	Osmium (Os)	<0.002
Beryllium (Be)	<0.003	Palladium (Pd)	<0.002
Bismuth (Bi)	<0.001	Platinum (Pt)	<0.009
Boron (B)	<0.05	Potassium (K)	<0.1
Cadmium (Cd)	<0.003	Praseodymium (Pr)	<0.001
Calcium (Ca)	<0.2	Rhenium (Re)	<0.003
Cerium (Ce)	<0.001	Rhodium (Rh)	<0.001
Cesium (Cs)	<0.001	Rubidium (Rb)	<0.001
Chromium (Cr)	<0.004	Ruthenium (Ru)	<0.002
Cobalt (Co)	<0.001	Samarium (Sm)	<0.002
Copper (Cu)	<0.003	Scandium (Sc)	<0.01
Dysprosium (Dy)	<0.001	Selenium (Se)	<0.02
Erbium (Er)	<0.001	Silicon (Si)*	<0.5
Europium (Eu)	<0.001	Silver (Ag)	<0.001
Gadolinium (Gd)	<0.001	Sodium (Na)	<0.007
Gallium (Ga)	<0.002	Strontium (Sr)	<0.001
Germanium (Ge)	<0.003	Tantalum (Ta)	<0.004
Gold (Au)	<0.006	Tellurium (Te)	<0.005
Hafnium (Hf)	<0.001	Terbium (Tb)	<0.001
Holmium (Ho)	<0.001	Thallium (Tl)	<0.006
Indium (In)	<0.001	Thorium (Th)	<0.003
Iridium (Ir)	<0.002	Thulium (Tm)	<0.001
Iron (Fe)	<0.02	Tin (Sn)	<0.005
Lanthanum (La)	<0.001	Titanium (Ti)	<0.002
Lead (Pb)	<0.003	Tungsten (W)	<0.005
Lithium (Li)	<0.002	Uranium (U)	<0.002
Lutetium (Lu)	<0.001	Vanadium (V)	<0.003
Magnesium (Mg)	<0.002	Ytterbium (Yb)	<0.001
Manganese (Mn)	<0.002	Yttrium (Y)	<0.001
Mercury (Hg)	<0.02	Zinc (Zn)	<0.005
Molybdenum (Mo)	<0.004	Zirconium (Zr)	<0.005

**Silicon analyzed using colorimetry*
Results reported as < Limit of Detection