



Application Note AN-S-236

# Drinking water quality by EPA 300.1

## Combining EPA method 300.1 parts A and B in a single IC run

Clean drinking water is cited as a human right by the World Health Organization [1]. Policies as well as standards and robust analytical methods are required to safeguard water quality, and by extension, public health. In Europe, the EU Drinking Water Directive regulates water quality, while the Safe Drinking Water Act (SDWA) is responsible in the US. The SDWA authorized the US EPA to develop minimum drinking water standards and the respective standardized analytical methods. Since the 1980s, EPA method 300.0 has outlined the analytical requirements for determination of major inorganic anions (part A) and harmful inorganic disinfection byproducts (DBPs) in Part B [2–5], corresponding largely to EN ISO 10304-1

and 10304-4, respectively. Inorganic DBPs like chlorite and chlorate are primarily formed via chlorination processes, while bromate is created through ozonation of naturally present bromide [2, 5–7]. When maximum contaminant levels (MCLs) of DBPs were revised, so was the EPA method [5, 6]. To reach the method detection limits (MDLs), different injection volumes are required for parts A and B due to relative concentration differences [8]. Ion chromatography with suppressed conductivity detection using the highly selective Metrosep A Supp 7 column fulfills these requirements in a single-run analysis, increasing lab efficiency and saving money while keeping analytical quality high.

## EXPERIMENTAL

Drinking and tap water samples from sites in Herisau, Switzerland were analyzed according to the requirements of US EPA Method 300.1 [8]. Additionally, standards and spiked samples showing the full analyte range (i.e., fluoride, chlorite, bromate, chloride, nitrite, bromide, chlorate, dichloroacetate (DCA), nitrate, phosphate, and sulfate) were injected for quantification and quality control. Certified reference standards from Merck were used for the standard as well as spiking. All solutions, i.e. samples and standards, were automatically filtered applying Metrohm Inline Ultrafiltration (8.000.5341). EPA Method 300.1 Parts A and B are combined in a single

The signal detection for the analysis was performed with a **conductivity detector** after **sequential suppression** and quantified using the MagIC Net software.

Sequential suppression, i.e. the combination of chemical and CO<sub>2</sub> suppression, reduces the background conductivity and therefore improves the signal-to-noise ratio. Typical background conductivities below 1 µS/cm are reached by completely removing CO<sub>2</sub> and carbonic acid from the eluent. Thus, analysis of very low concentrations is enabled and requirements of the US EPA regarding drift and baseline noise are fulfilled (<5 nS per min over background conductivity) [8].

## RESULTS

The analyzed tap waters contained high concentrations (i.e., mg/L range) of chloride (13 mg/L), sulfate (4 mg/L), and nitrate (8 mg/L) (Table 1 and Figure 2). Bromide and fluoride were detected in minor concentrations (<0.06 mg/L), while the toxic disinfection byproducts chlorate, bromate, and chlorite, as well as nitrite could not be detected. The peak resolutions of >1.5 reveal that the anions are baseline separated (example shown in Figure 2).

The surrogate DCA was not detected in any of the tap waters but it could be separated from the

method and use a common injection volume of 20 µL. The anions, including the surrogate dichloroacetate (DCA), were separated on a Metrosep A Supp 7 - 250/4.0 using a carbonate eluent.

DCA is the acetate form of DCAA (dichloroacetic acid) and can be present in treated drinking waters, but also in groundwater or swimming pools as a reaction product from organic material during the chlorination process [3, 8]. The provisional WHO guideline for DCA in drinking water is 0.05 mg/L because it exhibits potential health hazards [1]. Therefore, it must be separated from the other ions to guarantee appropriate resolution and quantification.



**Figure 1.** Compact, user-friendly Metrohm IC instrumentation to quantify oxyhalides besides standard anions in drinking water.

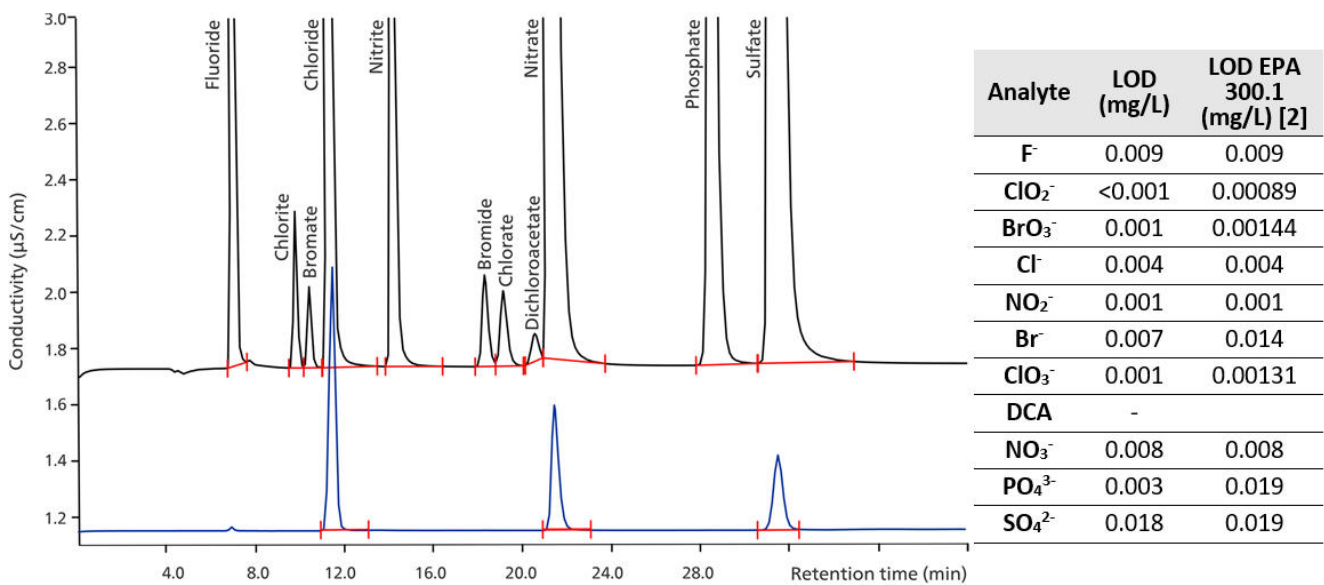
predominant nitrate (30 mg/L) in the mixed standard with a resolution of 1.2 (Figure 2).

The relative standard deviations (RSDs) for repeated tap water analysis below 2.5% (Table 1, with exceptions for chlorite and bromate) and spike recoveries of 82–120% are within the common quality criteria and highlight the **repeatability**, **accuracy**, and **robustness** of the method. The determined detection limits (LODs) (according to DIN 62645) fit the EPA requirements (Figure 2) [8].

Aside from the applicability to surface, ground, and

finished drinking waters as specified in the **EPA Method 300.1** [8], the presented setup was approved for a variety of different waters including bottled water, mineral water, and swimming pool water. The analytical procedure is also suitable for both **EN ISO 10304-1**: bromide and nitrate (working range  $\geq 0.05$  mg/L), chloride, fluoride, nitrate, orthophosphate, and sulfate (working range  $\geq 0.1$  mg/L) and **EN ISO 10304-4**: chlorate (working range  $\geq 0.03$  mg/L), chloride (working range  $\geq 0.1$  mg/L), and

chlorite (working range  $\geq 0.05$  mg/L). With the excellent separation achieved using the **Metrosep A Supp 7** column, all requirements for possible anionic interferences mentioned in these norms are fulfilled. In contrast to the EPA, ISO allows usage of UV/VIS detection (bromide, nitrate, nitrite, chlorite) or amperometric detection (chlorite) to achieve a higher sensitivity if needed. DCA is not covered by ISO 10304-1 or 4.



**Figure 2.** Chromatograms for a tap water sample (Herisau, Switzerland, blue—see Table 1 for average concentrations) and a standard (black) containing the relevant analytes with high concentrations of major anions for EPA 300.1 (fluoride 2.0 mg/L, chloride 10.0 mg/L, nitrite 5.0 mg/L, nitrate 30.0 mg/L, phosphate 15.0 mg/L, and sulfate 40 mg/L) beside low concentrations for disinfection byproducts and bromide (chlorite 1.0 mg/L, bromate 1.0 mg/L, bromide 1.0 mg/L, chlorate 1.0 mg/L, and dichloroacetate 1.0 mg/L). Anions were separated on a Metrosep A Supp 7 - 250/4.0 column (eluent: 3.6 mmol/L sodium carbonate, flow rate 0.8 mL/min, column temperature 45 °C, sample volume 20 µL). The conductivity signal was recorded after sequential suppression. The limits of detection (LODs, on the right) determined by DIN 62645 are in line with the EPA requirements [8].

**Table 1.** Results for repeated tap water analysis (n = 6) with 5 µg/L spikes (indicated by \*) of the oxyhalides chlorite, bromate, and chlorate, which were not contained in the unspiked tap water. Analytes which were not detected in the tap water are indicated with «n. d.».

| Tap water n = 5 | Result (mean ± SD) [mg/L] | RSD [%] | Spike conc. [mg/L] | Recovery % |
|-----------------|---------------------------|---------|--------------------|------------|
| Fluoride        | 0.064 ± 0.002             | 2.5     | -                  | -          |
| Chlorite*       | 0.004 ± <0.001            | 8.3     | 0.005              | 82         |
| Bromate*        | 0.006 ± <0.001            | 5       | 0.005              | 113        |
| Chloride        | 12.5 ± 0.1                | 1.0     | -                  | -          |
| Nitrite         | n.d.                      | -       | -                  | -          |
| Bromide         | 0.008 ± <0.001            | 1.6     | -                  | -          |
| Chlorate*       | 0.006 ± <0.001            | 1.9     | 0.005              | 120        |
| Nitrate         | 7.9 ± 0.1                 | 1.5     | -                  | -          |
| Sulfate         | 3.9 ± 0.06                | 1.5     | -                  | -          |
| Phosphate       | n.d.                      | -       | -                  | -          |

## CONCLUSION

The greatest challenge involved with combining the requirements of EPA 300.1 parts A and B within a **single method** was to separate and measure high concentrations of inorganic anions (e.g., chloride, nitrate, and sulfate in the mg/L range) beside lower concentrations of DBPs (i.e., bromate, chlorite, and chlorate) and nitrite. To measure such analytes accurately over a very large concentration range (five orders of magnitude or more), **a high linearity of the detector is required**. Here, the Metrohm conductivity detector exhibited an excellent performance with a linearity range of 0–15,000 µS/cm. Additionally, the separation of the analytes listed in EPA Method 300.1 parts A and B requires a **dedicated analytical column**

which shows a high resolution, especially for the oxyhalides (i.e., the DPBs).

The **Metrosep A Supp 7** column shows a very high resolution, especially for the oxyhalides. It separates all ions of interest including dichloroacetate in an isocratic method. This keeps the analysis straightforward and the setup simple (**Figure 1**).

US EPA method 300.1 [8] is the main standard method for the analysis of oxyhalides and common anions in drinking water with global acceptance. The requirement of using two injections, one for the standard anions and a second for the trace anions, dramatically reduces the sample throughput for laboratories.

Metrohm offers a very comprehensive way to combine the two parts of EPA 300.1 **without any quality losses** by using a setup with the Metrosep A Supp 7 - 250/4.0 separation column in combination with conductivity detection after sequential suppression. The analytical procedure is also in line with the requirements for **EN ISO 10304 parts 1 and 4**

and can be modified by using UV/VIS detection for higher sensitivity. Further integration of Metrohm Inline Sample Preparation (MISP) techniques ([8.940.5004](#)) such as Ultrafiltration or Inline Dilution provides additional benefits to laboratories by increasing the analytical efficiency through the reduction of analysis time.

## REFERENCES

1. World Health Organization. *Guidelines for Drinking-Water Quality: First Addendum to the Third Edition, Volume 1 : Recommendations*; Geneva: WHO, 2006.
2. Boorman, G. A. Drinking Water Disinfection Byproducts: Review and Approach to Toxicity Evaluation. *Environ. Health Perspect.* **1999**, *107* (suppl 1), 207–217.
3. Evans, S.; Campbell, C.; Naidenko, O. V. Analysis of Cumulative Cancer Risk Associated with Disinfection Byproducts in United States Drinking Water. *Int. J. Environ. Res. Public Health* **2020**, *17* (6), 2149.
4. *Some Drinking-Water Disinfectants and Contaminants, Including Arsenic IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Volume 84*; International Agency for Research on Cancer, Ed.; IARC monographs on the evaluation of carcinogenic risks to humans; IARC: Lyon, 2004.
5. Jackson, P. E. Ion Chromatography in Environmental Analysis. In *Encyclopedia of Analytical Chemistry*; Meyers, R. A., Ed.; John Wiley & Sons, Ltd: Chichester, UK, 2000; p a0835.
6. EPA National Primary Drinking Water Regulations: Disinfectants, and Disinfection Byproducts. *Fed. Regist.* **1998**, *63* (241), 69389–69476.
7. Singer, P. C. Control of Disinfection By-Products in Drinking Water. *J. Environ. Eng.* **1994**, *120* (4), 727–744.
8. EPA Method 300.1 - Determination of Inorganic Anions in Drinking Water by Ion Chromatography. In *Methods for the Determination of Organic and Inorganic Compounds in Drinking Water*, United States Environmental Protection Agency: USA, 2000; p 300.1-1–300.1-42.

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## CONFIGURATION

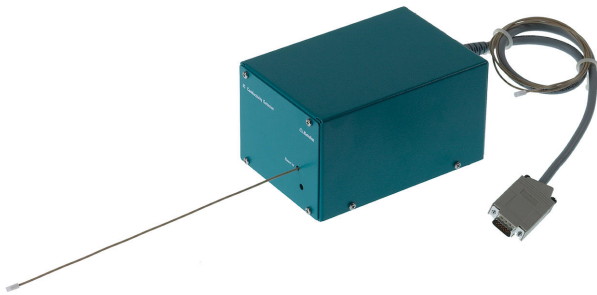


### 940 Professional IC Vario ONE/SeS/PP

Le 940 Professional IC Vario ONE/SeS/PP est l'appareil CI intelligent avec **suppression séquentielle** et **pompe péristaltique** pour la régénération du supprimeur. L'appareil peut être utilisé avec n'importe quelles méthodes de séparation et de détection.

Domaines d'application typiques :

- Déterminations d'anions ou de cations avec suppression séquentielle et détection de conductivité
- Analyse de traces pour les anions ou les cations
- Surveillance en ligne pour les anions ou les cations



### IC Conductivity Detector

Détecteur de conductivité haute performance compact et intelligent destiné aux appareils CI intelligents. Excellente constance de la température, tout le traitement du signal au sein du bloc de détecteur protégé et DSP – Digital Signal Processing – de la dernière génération garantissent une précision de mesure optimale. Grâce à la plage de travail dynamique, aucun changement de plage n'est nécessaire (même automatique).



### **Metrosep A Supp 7 - 250/4.0**

Les produits secondaires du traitement de l'eau (disinfection by-products) sont soupçonnés d'être non seulement nocifs pour la santé, mais aussi cancérigènes. C'est la raison pour laquelle les oxohalogénures sont devenus l'objet de nombreuses recherches et de normes (p. ex. EPA 300.1 partie B, EPA 317.0, EPA 326.0). Il s'agit en premier lieu du bromate, produit du bromure lors de l'ozonisation de l'eau potable. La colonne Metrosep A Supp 7 - 250/4.0 est une colonne de séparation haute performance pour la détermination en parallèle des anions standard, des oxyhalogénures et de l'acide dichloracétique. Avec cette colonne, ces ions peuvent être déterminés jusque dans la gamme inférieure des  $\mu\text{g/L}$  de manière sûre et précise. La sensibilité de détection élevée est atteinte par l'utilisation d'un polymère à base d'alcool polyvinylique de  $5\ \mu\text{m}$ , permettant d'obtenir un nombre de plateaux très élevé et, par conséquent, d'excellentes propriétés de séparation et de détection. En plus, par modification de la température, il est possible d'adapter la séparation aux exigences spécifiques de l'application.



### **858 Professional Sample Processor – Pump**

Le 858 Professional Sample Processor – Pump traite des échantillons de  $500\ \mu\text{L}$  à  $500\ \text{mL}$ . Le transfert des échantillons s'opère soit au moyen de la pompe péristaltique bidirectionnelle à deux voies intégrée soit par un 800 Dosino.



#### MagIC Net 4.0 Compact : 1 licence

Programme PC professionnel pour le contrôle d'un appareil Compact IC intelligent, d'un détecteur et d'un passeur d'échantillons ou d'une 771 Compact Interface. Le logiciel assure le contrôle, permet d'enregistrer, d'évaluer et de contrôler les données, ainsi que de générer les rapports d'analyses par chromatographie ionique.

Interface utilisateur graphique pour les opérations de routine, programmes gestionnaires de base de données complets, développement de méthodes, configuration et panneau de configuration manuel ; administration des utilisateurs très adaptable, opérations de bases de données performantes, fonctions d'exportation de données complètes, générateur de rapports personnalisable, commande et contrôle de tous les composants du système et des résultats de chromatographie.

MagIC Net Compact satisfait totalement à la directive FDA 21 CFR Part 11 ainsi qu'aux BPL.

MagIC Net est disponible dans 16 langues de dialogue : allemand, anglais, chinois, chinois traditionnel, français, italien, espagnol, portugais, bulgare, tchèque, hongrois, japonais, coréen, russe, slovaque, polonais

1 licence.

L'installation et les documents sont fournis sur une clé USB.