

Resolving haloacetic acids in water

Increased sensitivity thanks to coupling IC with a MS detector

Summary

During drinking water disinfection with chlorine, chloramine, or ozone, potentially toxic halogenated byproducts can be formed. The disinfectants can react with naturally occurring bromide and/or organic matter in the source water and form one of the most common disinfection byproducts (DBPs): haloacetic acids (HAAs).

HAAs are highly toxic water-soluble compounds. Mono- to tri-halogenated acetic acids mainly contain bromine and/or chlorine. To protect human health, their maximum tolerable levels in drinking waters are regulated. Currently the EPA states a maximum contamination level of 60 g/L for drinking water (EPA 816-F-09-004) for five HAAs («HAA5»): dichloroacetic acid (0 mg/L), trichloroacetic acid (20 g/L), monochloroacetic acid (70 g/L), with both bromoacetic and dibromoacetic acid having no defined contamination levels.

EPA Method 557 specifies the analysis of HAAs by ion chromatography coupled to mass spectroscopy (IC-MS) with LODs varying from 0.02–0.11 g/L. In this manner, the HAAs can be separated and determined at the required low levels due to an increased sensitivity by mass detection. Even with single MS, a high sensitivity is achieved to determine the current MCLs within an adequate accuracy.

Configuration



2.940.1340 - 940 Professional IC Vario ONE/ChS/PP/HPG

The 940 Professional IC Vario ONE/ChS/PP/HPG is the intelligent IC instrument with chemical suppression, a peristaltic pump for suppressor regeneration and binary high-pressure gradient. It can be extended with the 942 Extension Modules to up to a quaternary gradient system. The instrument can be used with any separation and detection methods.

Typical areas of application: Gradient applications for anion determinations with chemical suppression;



6.1006.230 - Metrosep A Supp 5 - 250/2.0

The Metrosep A Supp 5 - 250/2.0 is the microbore high-performance separation column with which even complex separation problems can be solved easily and reproducibly. The range of applications possible with this column far exceeds the detection of standard anions. The Metrosep A Supp 5 - 250/2.0 is used wherever maximum separating efficiency must be combined with both the lowest of detection limits and low eluent consumption. With its low eluent flow, this column is particularly suitable for IC-MS coupling.



2.889.0020 - 889 IC Sample Center – cool

The 889 IC Sample Center – cool is the appropriate automation solution when you have only a very small amount of sample. In comparison with the 889 IC Sample Center, it possesses in addition a cooling function and is thus the ideal sample changer for biochemically relevant or thermally unstable samples.



6.2832.000 - MSM Rotor A

Suppressor rotor for all IC instruments with MSM (Metrohm Suppressor Module)



6.2148.000 - Remote Box

For connection of a barcode reader and a PC keyboard to the KF Coulometer and to Titrinos



6.6059.402 - MagIC Net 4.0 Professional: 1 license

Professional PC program for controlling all intelligent Professional IC systems, Compact IC systems and their peripherals, all detectors and various Auto samplers, 800 Dosino, 771 Compact Interface, etc. The software permits checks, data acquisition, data evaluation and data monitoring as well as report generation of ion chromatographic analyses. Graphical user interface for routine operations, extensive database programs, method development, configuration and manual system control; very flexible user management, powerful database operations, extensive data export functions, individually configurable report generator, control and monitoring of all system components and the chromatography results. MagIC Net Professional complies fully with FDA Regulation 21 CFR Part 11 as well as GLP. MagIC Net is available in 16 dialog languages: German, English, Chinese, Traditional Chinese, French, Italian, Spanish, Portuguese, Bulgarian, Czech, Hungarian, Japanese, Korean, Russian, Slovakian, Polish. 1 license. The installation and documentation is delivered on a USB Stick.

Sample and Sample Preparation

Spiked and unspiked mineral water samples are measured to simulate contaminated water sources. The samples are spiked with the following components in varying concentrations: bromate, chlorite, monochloroacetic acid (MCAA), monobromoacetic acid (MBAA), bromochloroacetic acid (BCAA), bromodichloroacetic acid (BDCAA), dibromoacetic acid (DBAA), dichloroacetic acid (DCAA), tribromoacetic acid (TBAA), chlorodibromoacetic acid (CDBAA), and trichloroacetic acid (TCAA). Recoveries are calculated by comparing spiked and unspiked sample equivalents. All samples are stabilized with ammonium chloride.

Experimental

The measurements are conducted with an IC equipped with a gradient pump coupled to a mass spectrometer (MS) (Waters SQ Detector 2) (**Fig. 1**). The separation of the individual components is performed with a Metrosep A Supp 5 - 250/2.0 column in combination with a Metrosep A Supp 10 column guard. The 2 mm diameter column allows a low eluent flow, which enables a direct measurement with the subsequent MS without any additional flow splitter. The high pressure gradient of the mobile phase (composed of a mixture of potassium hydroxide, sodium carbonate, and acetonitrile) has been optimized to separate the individual components.

Instrument control and data evaluation is performed with Empower™. The Metrohm Driver 2.1 for Empower™ promotes the analyses with this powerful software and of course handling of hyphenated techniques as a single-software solution.

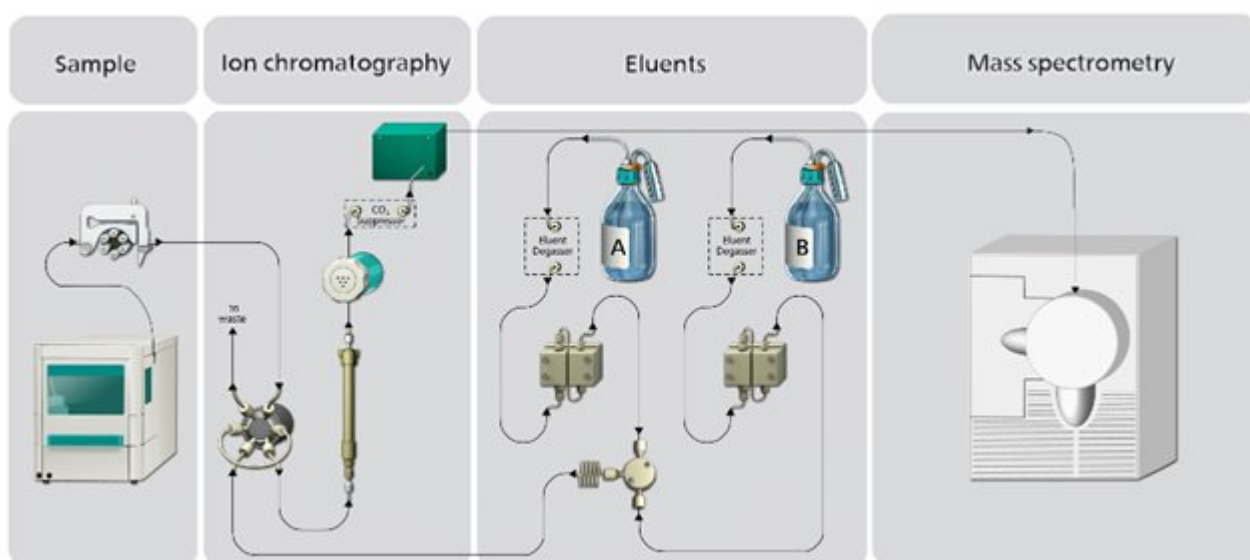


Figure 1. Flow path for the hyphenation of ion chromatography with mass spectrometry. The application requires an ion chromatograph with gradient pumps and sequential suppression. The suppression is required so that the eluent does not interfere with ion spray performance of the MS. An autosampler with a cooling function guarantees sample stability by limiting the decay of the HAAs over time. Beside the mass detection, conductivity detection occurs simultaneously.

Results

The separation of nine HAAs is performed in less than 40 minutes. **Figure 2** shows the separation of the five relevant HAAs for EPA 816-F-09-004, often named as «HAA5». The spiking tests exhibit acceptable recoveries within a range of 74–124%. The estimated limits of

detection are well within the EPA requirements for EPA method 557 regarding MCAA and MBAA (0.2 and 0.064 g/L, respectively). To achieve a higher sensitivity for the other compounds, hyphenation with a triple quadrupole MS is mandatory and can be used to entirely fulfill EPA 557. However, the recent maximum contamination levels for drinking water (EPA 816-F- 09-004) for the five HAAs (DCAA, TCAA, MCAA, MBAC, and DBAA) are in sum 60 g/L. Compared to the estimated LODs (**Table 1**), these are two orders of magnitude lower, showing the suitability of the present single quadrupole IC-MS method for drinking water quality measurements.

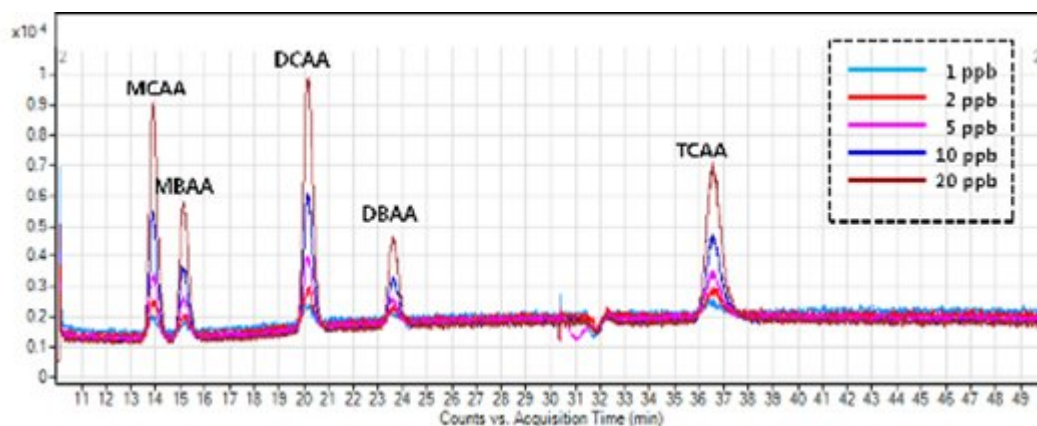


Figure 2. Overlay of multiple mass channels of 25 g/L HAAs in ultrapure water (injection volume 100 L). Mass-specific signal detection enhances the specificity for the individual HAAs, avoiding peak overlaps and increasing sensitivity for the individual compounds.

Table 1. Estimated limits of detection (LOD) for the haloacetic acids based on three times the signal-to-noise ratio.

| Analyte | LOD (g/L) |
|---------|-----------|
| MCAA | 0.045 |
| MBAA | 0.045 |
| DCAA | 0.45 |
| BCAA | 0.60 |
| DBAA | 0.15 |
| TCAA | 1.5 |
| BDCAA | 1.5 |
| CDBAA | 1.5 |
| TBAA | 1.5 |

Conclusion

The coupling of ion chromatography and mass spectroscopy is an ideal combination to achieve low detection limits and increase the specificity of analyses. The unique Metrohm Suppressor Module provides enhanced flexibility for the eluent choice, as the solvent is modified by post-column suppression in order to make it suitable for the ion spray and the MS specifications. For

many different applications, especially in the environmental sector, this combination can provide a more detailed insight than other techniques and expands the field of applications significantly.

Metrohm AG

Ionenstrasse

9100 Herisau

<mailto:info@metrohm.com>