

# Fast and low-cost determination of anions in municipal drinking water

Authors: Hua Yang and Jeffrey Rohrer  
Thermo Fisher Scientific,  
Sunnyvale, CA, USA

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## Introduction

Ion chromatography (IC) is a well-accepted technique for monitoring inorganic anions in water, including surface, ground, drinking, and waste waters. In the United States, water quality is regulated through the Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA) and enforced through the United States Environmental Protection Agency (U.S. EPA).<sup>1</sup> IC methods have been approved by the U.S. EPA for compliance monitoring of inorganic anions in drinking water since the 1980s through U.S. EPA Method 300.0 that was updated in 1997 to U.S. EPA Method 300.1.<sup>2</sup> Various IC methods for water analysis have been demonstrated in Thermo Scientific™ Dionex™ application notes using standard or microbore flow rate columns with both carbonate/bicarbonate and hydroxide eluents.<sup>3</sup>

This work demonstrates the determination of inorganic anions in drinking water by IC using a Thermo Scientific™ Dionex™ IonPac™ AS22-Fast-4 $\mu$ m column<sup>4</sup> set on a Thermo Scientific™ Dionex™ Easion™ Ion Chromatography System in



Displacement Chemical Regeneration (DCR) mode. Figure 1 shows a diagram of the setup. The Dionex Easion IC system is an integrated, single-channel low-cost system designed for isocratic applications with suppressed conductivity detection. Coupled to the Thermo Scientific™ Dionex™ AS-DV Autosampler, it provides a fast and low-cost choice for routine water analysis.

## Equipment and consumables

- Dionex Easion IC system
- Dionex AS-DV autosampler
- Thermo Scientific™ Dionex™ Chromeleon™ 7.2.10 MuA Chromatography Workstation

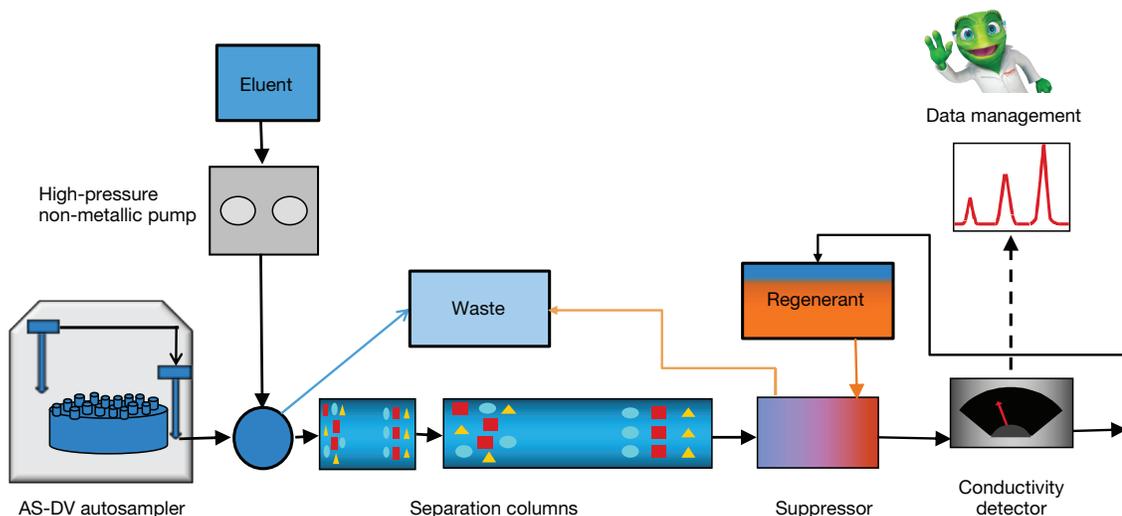


Figure 1. Illustration of an IC system in DCR mode.

Table 1. Consumables

Product name	Part no.
Thermo Scientific™ Dionex™ DCR Installation Kit for 4 mm column	056884
Thermo Scientific™ Dionex™ ACRS 500 Anion Chemically Regenerated Suppressor (4 mm)	085090
Thermo Scientific™ Dionex™ IonPac™ AS22-Fast-4µm Guard Column (4 x 30 mm)	088487
Thermo Scientific™ Dionex™ IonPac™ AS22-Fast-4µm Analytical Column (4 x 150 mm)	088486
Thermo Scientific™ Dionex™ Displacement Chemical Regeneration (DCR) Reagents	057559
Thermo Scientific™ Dionex™ AS22 Eluent Concentrate (100x)	063965
Thermo Scientific™ Dionex™ AS-DV Autosampler PolyVial (5 mL) with filter cap (20 µm), 250 pack	038141

## Experimental

All reagents (eluent, regeneration solution, and standard) were prepared with degassed deionized (DI) water with 18 MΩ-cm resistance or better.

Individual anion standard stock solutions (1000 mg/L) were prepared by dissolving sodium or potassium salts

(A.C.S. reagent grade or better) in DI water. Aliquots of these standard were combined and diluted with DI water to prepare mixed calibration standards (Table 2).

A drinking water sample was collected locally. No filtration was needed as filter caps were used on the Dionex AS-DV autosampler vials.

The chromatography conditions are listed in Figures 2 and 3.

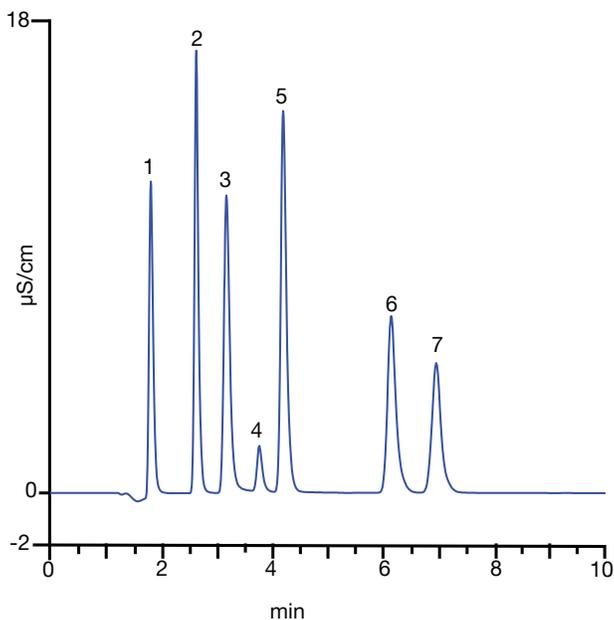
Table 2. Calibration standards (mg/L)

Level	1	2	3	4	5	6	7
Fluoride	0.1	1	5	10	20	-	-
Chloride	0.2	2	10	20	40	50	100
Nitrite-N	0.1	1	5	10	20	-	-
Bromide	0.1	1	5	10	20	-	-
Nitrate-N	0.1	1	5	10	20	-	-
Phosphate-P	0.2	2	10	20	40	25	50
Sulfate	0.2	2	10	20	40	50	100

## Results

Figure 2 shows a separation of inorganic anions within 10 min using the Dionex IonPac AS22-Fast-4 $\mu$ m column. As this figure shows, seven inorganic anions are well resolved. The Dionex IonPac AS22-Fast-4 $\mu$ m column can be used for compliance monitoring of inorganic anions in water. Compared to the 15 min method using Thermo Scientific™ Dionex™ IonPac™ AS22 column, this method is fast and saves per injection, allowing two additional samples to be run every hour.

Figure 3 shows the determination of inorganic anions in a drinking water sample. Among the common anions, fluoride, nitrate, and nitrite are regulated with the Maximum Contaminant Level (MCL) for fluoride at 4 mg/L, nitrite at 1 mg/L, and nitrate at 10 mg/L. The results show that the drinking water sample contains chloride (3.84 mg/L), sulfate (1.96 mg/L) with less than 1 mg/L of fluoride (0.54 mg/L), nitrite (0.01 mg/L), and nitrate (0.06 mg/L), which meet the safety criteria.

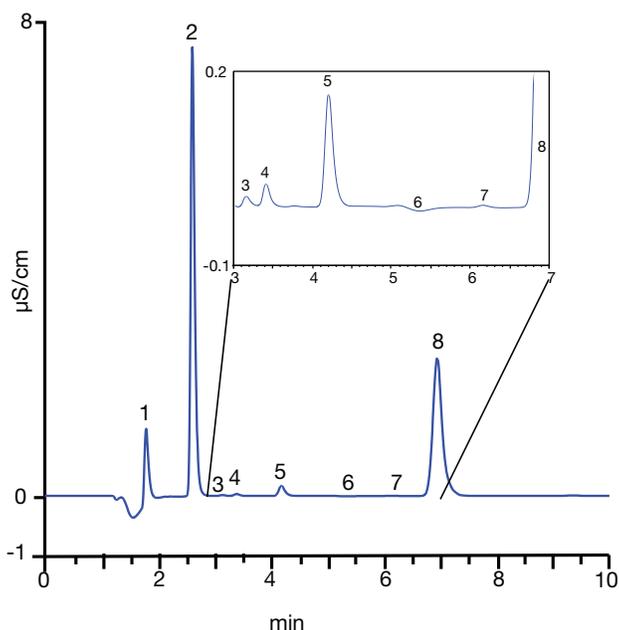


Columns: Dionex IonPac AG22-Fast-4 $\mu$ m, 4 x 30 mm and Dionex IonPac AS22-Fast-4 $\mu$ m 4 x 150 mm  
 Eluent: 4.5 mM  $\text{Na}_2\text{CO}_3$  / 1.4 mM  $\text{NaHCO}_3$   
 Regenerant: 50 mM sulfuric acid  
 Flow rate: 1.2 mL/min  
 Inj. volume: 25.0  $\mu\text{L}$  (full loop)  
 Column temp.: Ambient  
 Detection: Suppressed conductivity, Dionex ACRS 500 Suppressor (4 mm), in DCR mode

Sample: A mix anions standard

Peaks:	min	mg/L
1 Fluoride	1.8	5.0
2 Chloride	2.6	10.0
3 Nitrite	3.2	5.0
4 Bromide	3.8	5.0
5 Nitrate	4.2	5.0
6 Phosphate	6.1	10.0
7 Sulfate	7.0	10.0

Figure 2. Separation of inorganic anions using the Dionex IonPac AS22-Fast-4 $\mu$ m column.



Columns: Dionex IonPac AG22-Fast-4 $\mu$ m, 4 x 30 mm and Dionex AS22-Fast-4 $\mu$ m, 4 x 150 mm  
 Eluent: 4.5 mM  $\text{Na}_2\text{CO}_3$  / 1.4 mM  $\text{NaHCO}_3$   
 Regenerant: 50 mM sulfuric acid  
 Flow rate: 1.2 mL/min  
 Inj. volume: 25.0  $\mu\text{L}$  (full loop)  
 Column temp.: Ambient  
 Detection: Suppressed conductivity, Dionex ACRS 500 Suppressor (4 mm), in DCR mode

Sample: A municipal drinking water sample

Peaks:	min	mg/L
1 Fluoride	1.8	0.55
2 Chloride	2.6	3.44
3 Nitrite	3.2	0.01
4 Unknown	3.4	n.a
5 Nitrate	4.2	0.05
6 Carbonate	~5.4	n.a
7 Phosphate	6.1	NQ
8 Sulfate	7.0	3.44

NQ: not quantified

Figure 3. Analysis of municipal drinking water using the Dionex IonPac AS22-Fast-4 $\mu$ m columns.

## Linearity

**Table 3. Linearity obtained using the Dionex IonPac AS22-Fast-4µm column with a 25.0 µL injection**

Analyte	Range (mg/L)	Coefficient of determination <sup>*</sup> (r <sup>2</sup> )
Fluoride	0.1-20	1.000
Chloride	0.2-100	0.999
Nitrite-N	0.1-20	1.000
Bromide	0.1-20	0.999
Nitrate-N	0.1-20	0.996
Phosphate-P	0.2-50	0.995
Sulfate	0.2-100	0.997

\* Calibration type is linear and forced through the origin.

Table 3 shows the calibrations are linear for the inorganic anions with r<sup>2</sup> from 0.995 to 1.

## Conclusion

This work shows the determination of inorganic anions in a drinking water sample using the Dionex Easion IC system in DCR mode. The integrated Dionex Easion IC system coupled with the Dionex AS-DV autosampler and the Dionex IonPac AS22-Fast-4µm columns provides a fast, simple, and low-cost instrument setup for routine determination of inorganic anions in drinking water.

## References

1. National Primary Drinking Water Regulations <https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations> (Accessed May 27, 2020.)
2. Method 300.1. The Determination of Inorganic Anions in Water by Ion Chromatography; rev 1.0; USEPA, Office of Water: Cincinnati, OH, 1997. <https://www.epa.gov/sites/production/files/2015-06/documents/epa-300.1.pdf> (Accessed May 27, 2020.)
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4. The Dionex IonPac AS22-Fast-4µm IC columns <https://www.thermofisher.com/order/catalog/product/088489#/088489> (Accessed June 10, 2020.)

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