



Application Note AN-C-195

Cation quantification with increased performance using microbore IC

Benefits of microbore ion chromatography for cation analysis

Analytical performance with ion chromatography (IC) is typically determined by the signal-to-noise (S/N) ratio that the analytical equipment can reach. The S/N ratio strongly depends on chromatographic peak shapes. Peak shapes improve in miniaturized IC systems with less dead volume [1].

Microbore IC combines 2 mm separation columns, microbore capillaries, and a conductivity detector with reduced cell volume to create a miniaturized IC system with optimal sensitivity [2]. Such systems provide shorter retention times and consume less

eluent, increasing sample throughput and reducing the costs of daily routine analytics.

In this Application Note, a microbore IC system (MB) was compared to a standard bore IC system (SB). The microbore IC system showed improved resolution and better peak heights (a factor of ~30% more for lithium ions). Microbore IC uses less solvents and can result in cost reductions of up to 75% compared to using standard bore ion chromatography systems. Using MB systems has the potential to improve the performance of many typical IC applications.

SAMPLE AND SAMPLE PREPARATION

This study was conducted with alkali metal ions, alkaline earth metal ions, and ammonium. A mixed standard solution ($c(\text{Li}^+) = 25 \text{ }\mu\text{g/L}$, $c(\text{Na}^+, \text{NH}_4^+) = 125 \text{ }\mu\text{g/L}$, $c(\text{K}^+, \text{Mg}^{2+}, \text{Ca}^{2+}) = 250 \text{ }\mu\text{g/L}$) was prepared

from 1000 mg/L stock solutions (Standards for IC, TraceCERT®, Sigma-Aldrich, Merck) by dilution in ultrapure water.

EXPERIMENTAL

A microbore IC system comprised of a 930 Compact IC Flex Oven/DEG/MB together with an IC conductivity detector MB (Figure 1) was compared to its respective standard bore IC system configuration (930 Compact IC Flex Oven/DEG).

The MB setup from Metrohm has a reduced dead volume with shorter capillaries and smaller capillary inner diameters (0.18 mm) wherever possible.

The microbore conductivity detector has a small inner cell volume (0.3 μL) and a low noise level ($<0.1 \text{ nS}$). Furthermore, it even tolerates challenging eluents such as methanesulfonic acid (MSA). Microbore columns, which have a 2 mm inner diameter and associated reduced eluent flow rates, lead to better S/N. This increases sensitivity even further and lowers limits of detection.

The mixed cation standard solution was injected using a 5 μL loop and then separated on a 2 mm version of the Metrosep C 6 column on both tested IC systems.

Figure 1. Instrumental setup including a miniaturized 930 Compact IC Flex Oven/Deg/MB and an 858 Professional Sample Processor.

The conductivity was directly recorded (non-suppressed cation analysis, Table 1).

Table 1. IC method parameters for both standard bore and microbore IC systems.

Column	Metrosep C 6 - 150/2.0
Eluent (from Merck concentrate Sigma-Aldrich, Merck 19399)	$c(\text{HNO}_3) = 1.7 \text{ mmol/L}$ $c(\text{DPA}) = 1.7 \text{ mmol/L}$
Flow rate	0.25 mL/min
Temperature	30 °C
Injection volume	5 μL
Detection	Direct conductivity

For performance comparison reasons, the retention times, resolution, peak heights, and repeatability were

evaluated with MagIC Net software (version 4.1).

RESULTS

Overall performance was improved when using the MB system for analysis. Retention times were shorter with the MB system (approximately 0.2 minutes in this case) than with the SB system (Figure 2).

Resolution with the MB system was ~115% better than with the SB system (Table 2). Peak heights were higher, with most improvement shown for the early-

eluting peaks (lithium, sodium, ammonium) on the MB system (Table 3). The noise was comparable for both tested IC setups.

Minimal improvement effects were observed for later eluting peaks (e.g., potassium, magnesium, and calcium). For all other relevant parameters, MB and SB showed similar results (e.g., repeatability).

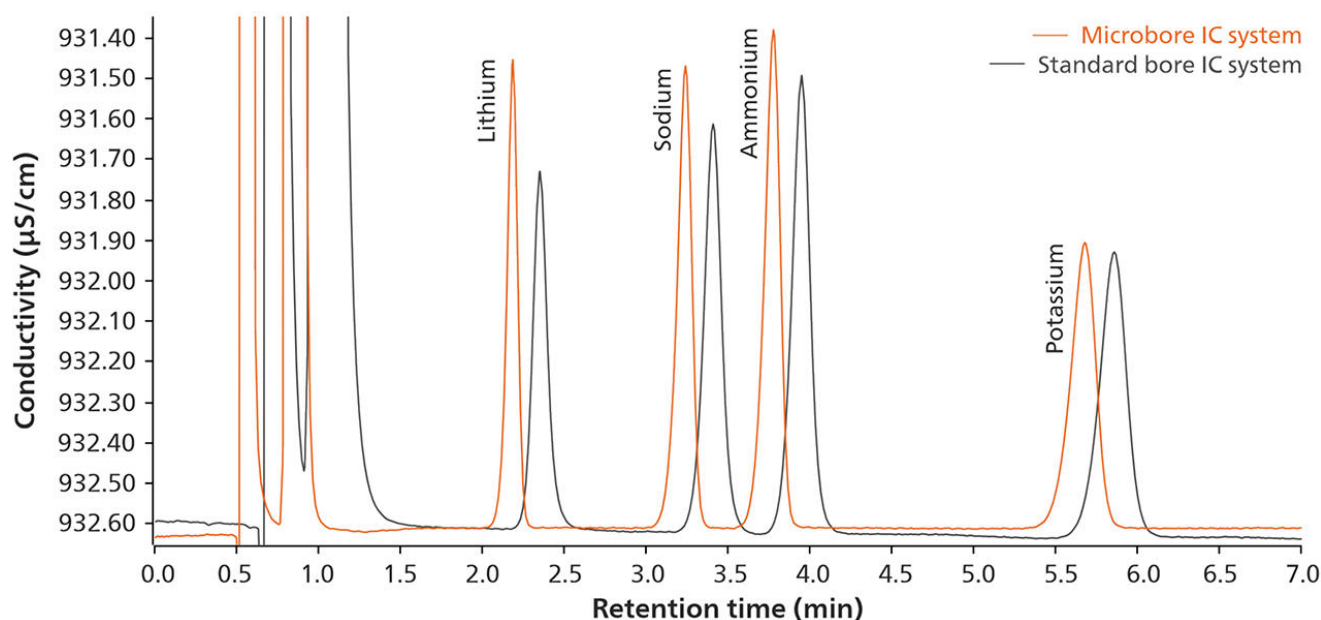


Figure 2. Comparison of the chromatograms for alkali metal ions (lithium, sodium, and potassium) and ammonium on a Metrosep C 6 microbore column with microbore IC (MB, orange chromatogram) and on a standard bore IC system (SB, grey chromatogram). The microbore IC system shows improved peak shapes, increased peak heights, and shorter retention times.

Table 2. Comparison of peak resolution for alkali metal ions and ammonium as measured by MB and SB systems.

Resolution	MB	SB
Lithium	5.6	5.6
Sodium	3.0	2.6
Ammonium	7.9	7.3
Potassium	6.0	5.8

Table 3. Comparison of peak heights and associated improvement factors for MB vs. SB systems.

Peak height [$\mu\text{S}/\text{cm}$]	MB	SB	Improvement factor
Lithium	1.16	0.88	131%
Sodium	1.14	1.01	113%
Ammonium	1.23	1.13	108%
Potassium	0.71	0.70	100%

CONCLUSION

The MB system combines microbore capillaries, a conductivity detector with reduced cell volume, and a 2 mm separation column—all of which lead to improved peak shapes and shorter retention times. This enables increased sensitivity and lower limits of detection. Lower flow rates reduce eluent consumption and overall running costs.

Non-suppressed MB systems in combination with 2 mm columns deliver significant improvements with respect to resolution and sensitivity. For sequentially suppressed IC systems (SES) including a microbore

CO₂ suppressor (MCS) with reduced dead volume, the main improvement is shorter retention times. This is helpful with low flow rates, and especially in combination with gradient applications as changes in the eluent composition will quickly impact the analysis and the effect will not be delayed by unnecessary dead volume.

MB systems can be used with 2 mm as well as 4 mm separation columns. These systems are suitable for all IC applications.

REFERENCES

1. Diederich, V.; Riess, A. K. Best Practice for Separation Columns in Ion Chromatography (IC) – Part 2. *Analyze This – The Metrohm Blog*, 2021.
2. Metrohm AG. Metrohm Microbore Ion Chromatography – Maximize the Efficiency of Your Ion Chromatography!, 2023.

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CONFIGURATION



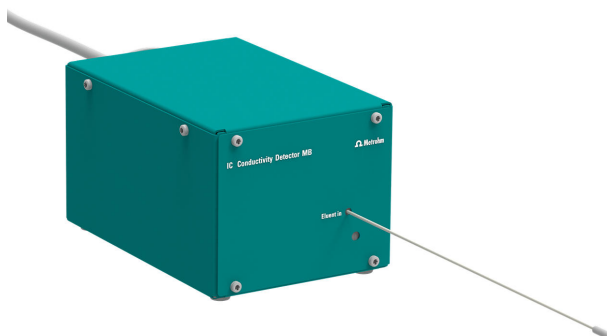
930 Compact IC Flex Oven/DEG/MB

Le 930 Compact IC Flex Oven/DEG/MB est un appareil CI compact intelligent avec un **four à colonne, sans suppression** et avec un **dégazeur** intégré. L'appareil peut être utilisé avec n'importe quelles méthodes de séparation et de détection.

Domaines d'application typiques :

- Déterminations d'anions et de cations sans suppression avec détection de conductivité
- Applications simples avec UV/VIS ou détection ampérométrique
- Optimisé pour les applications microbores (2 mm), convient parfaitement aux techniques de couplage (IC-MS ou IC-ICP/MS)

Pris en charge avec MagIC Net 4.1 et supérieur



IC Conductivity Detector MB

Détecteur de conductivité haute performance compact et intelligent destiné aux appareils CI intelligents. Optimisé pour les colonnes microbores. 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).

Domaines d'application typiques :

- Déterminations d'anions ou de cations avec suppression chimique, suppression séquentielle ou sans suppression et détection de conductivité
- Optimisé pour les applications microbores (2 mm), convient parfaitement aux techniques de couplage (IC-MS ou IC-ICP/MS)

Spécifications en un coup d'œil :

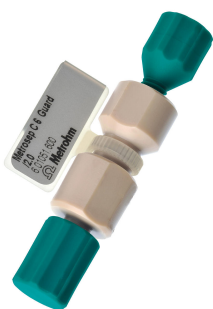
- 0 à 15 000 $\mu\text{S}/\text{cm}$ sans changement de gamme
- Volume de cellule : 0,3 μL
- Électrodes en forme d'anneau en acier inoxydable X2CrNiMo17-12-2 (316 L), compatible MSA
- Pression de fonctionnement maximale : 10,0 MPa (100 bar)
- Température de la cellule : 20 à 50 °C en pas de 5 °C
- Stabilité de la température : < 0,001 °C
- Bruit des lignes de base : < 0,2 nS/cm caractéristique pour la suppression séquentielle
- Capillaires : ID 0,18 mm

Pris en charge avec MagIC Net 4.1 et supérieur



Metrosep C 6 - 150/2,0

Le matériau haute capacité de la C 6 fait de la version microbore de la colonne Metrosep C 6 - 150/4,0 la solution optimale pour la séparation des cations standard à des concentrations très différentes avec des temps de rétention raisonnables. Les eaux potables présentant de faibles teneurs en ammonium peuvent être déterminées à l'aide de cette colonne. La colonne convient pour le couplage CI-SM.



Metrosep C 6 Guard/2,0

La précolonne Metrosep C 6 Guard/2,0 est basée sur le matériau de séparation C 6 et protège des particules et des contaminations. Elle augmente la durée de vie des colonnes de séparation analytiques. La Metrosep C 6 Guard/2,0 fonctionne également selon le « On Column Guard System » et se monte directement sur la colonne de séparation concernée en n'ajoutant pratiquement aucun volume mort.



Équipement CI : MiPT

Jeu d'accessoires pour le montage d'un Dosino pour Partial-Loop-Injection.