

Gradients in ion chromatography



Optimal separation with shorter analysis time

Gradients yield precise results faster

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The goal of ion chromatography – in a nutshell – reads: optimum separation within an acceptable time. It is not always possible to have both at once: late-eluting ions may delay results. These could be the analytes that are to be determined or they might simply be other ionic components that must be flushed from the column prior to the next injection.

Gradients provide an elegant solution to this problem: depending on the elution behavior of the individual ions, gradients alter the strength of the eluent shortening retention times.

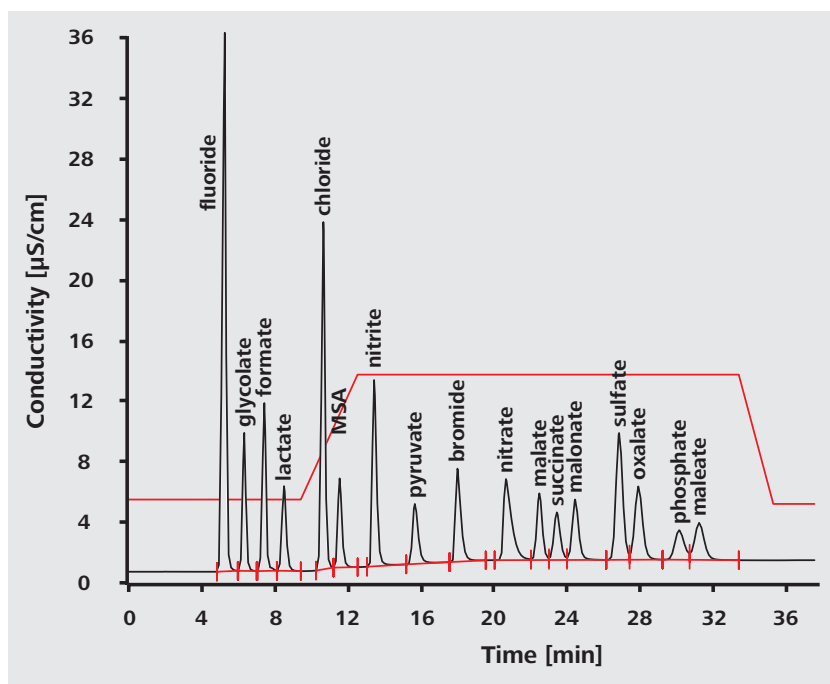
This offers practical advantages, particularly for routine analyses, since measurement results are available faster, enabling higher sample throughput.

Three versions to fit your needs

Metrohm offers three types of gradients: high-pressure, low-pressure and Dose-in Gradients.

- High-pressure gradients achieve the highest precision and accuracy
- Low-pressure gradients have the most compact gradient module
- Dose-in Gradients are universally applicable systems that can be retrofitted anytime

All three versions have in common that they can be used with eluents of any composition, concentration of salts or acids, and proportion of organic modifiers. The Dose-in Gradient can be used with mixtures of up to five eluents, while the high-pressure and low-pressure systems can be used with up to four or three eluents, respectively.

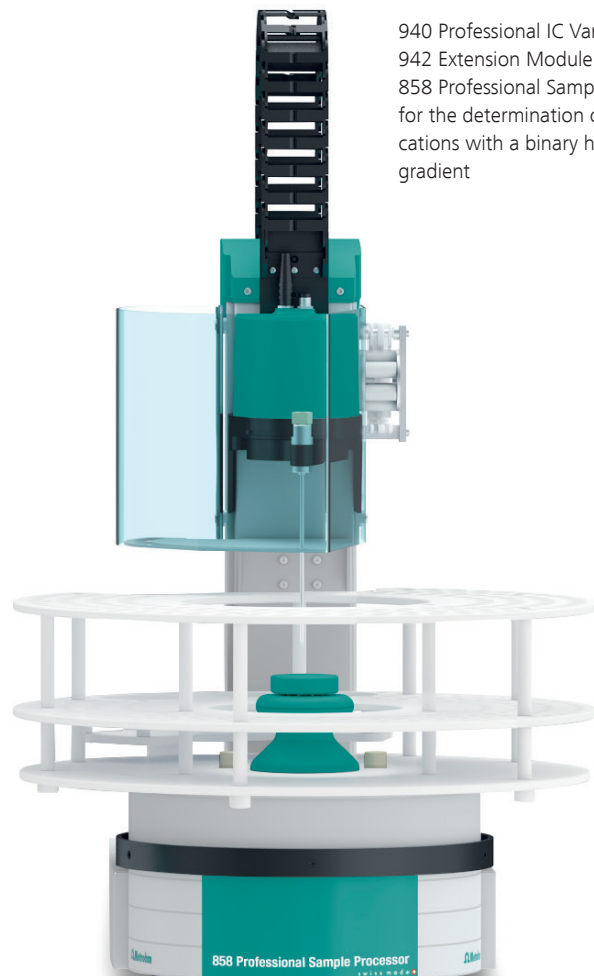
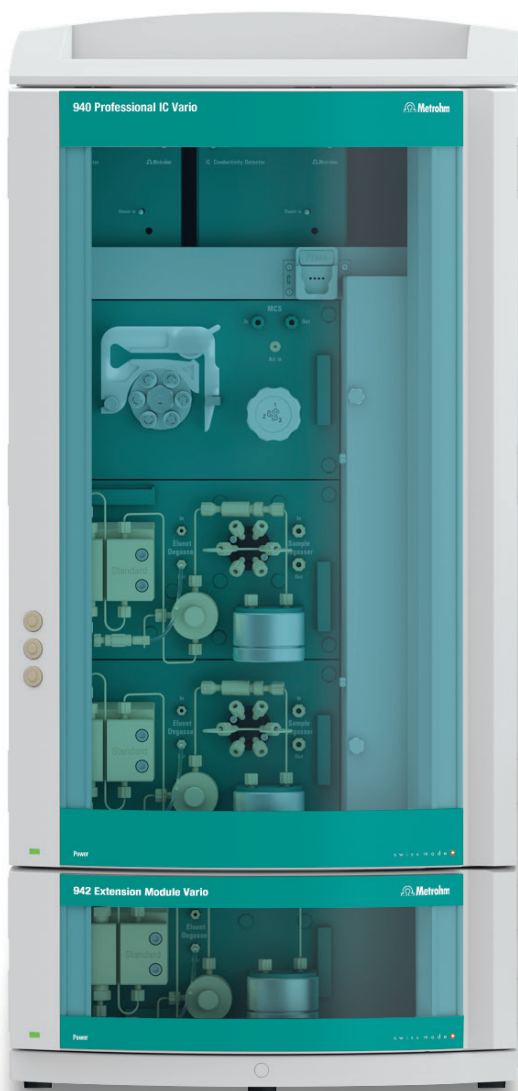


Separation of 17 organic and inorganic anions within 35 minutes. The concentration gradient profile used is shown in red. Column: Metrosep A Supp 16 - 150/4.0; eluent A: ultrapure water; eluent B: 7.5 mmol/L Na_2CO_3 , 0.75 mmol/L NaOH; loop: 20 μL ; flow rate: 0.8 mL/min; temperature: 40 °C; standard solution, each with: 20 mg/L per anion; detection technique: sequentially suppressed conductivity; high pressure gradient

Highlights

- Time-optimized separation of anions, cations, sugars, amino acids, and polar substances
- Acceleration of late-eluting analytes, and matrix ions
- High-pressure, low-pressure, and Dose-in Gradient options, depending on the requirements
- Any eluent component and concentration can be used
- Solvent stability
- Easy to program and modify
- Metal-free

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940 Professional IC Vario with a 942 Extension Module Vario and 858 Professional Sample Processor for the determination of anions and cations with a binary high-pressure gradient

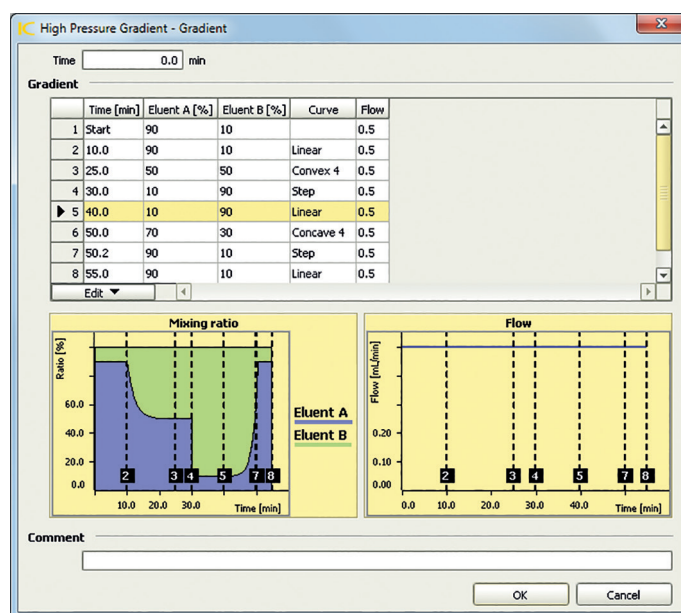
High-pressure gradient – for maximum precision and accuracy

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The high-pressure gradient makes it possible to achieve the highest precision and accuracy with eluent mixtures. High-pressure gradients are known from HPLC, and are characterized by their ease of operation.

The most frequent application is the binary high-pressure gradient. For this, the two solutions to be mixed with one another are supplied by two individually controllable high-pressure pumps. The two solutions converge in a T-connector and are subsequently mixed together under high pressure through multiple coils in a mixing capillary (see «Flow Path», page 5). The system can also be upgraded with a 942 Extension Module Vario so that high-precision compositions of up to four solutions can be produced.

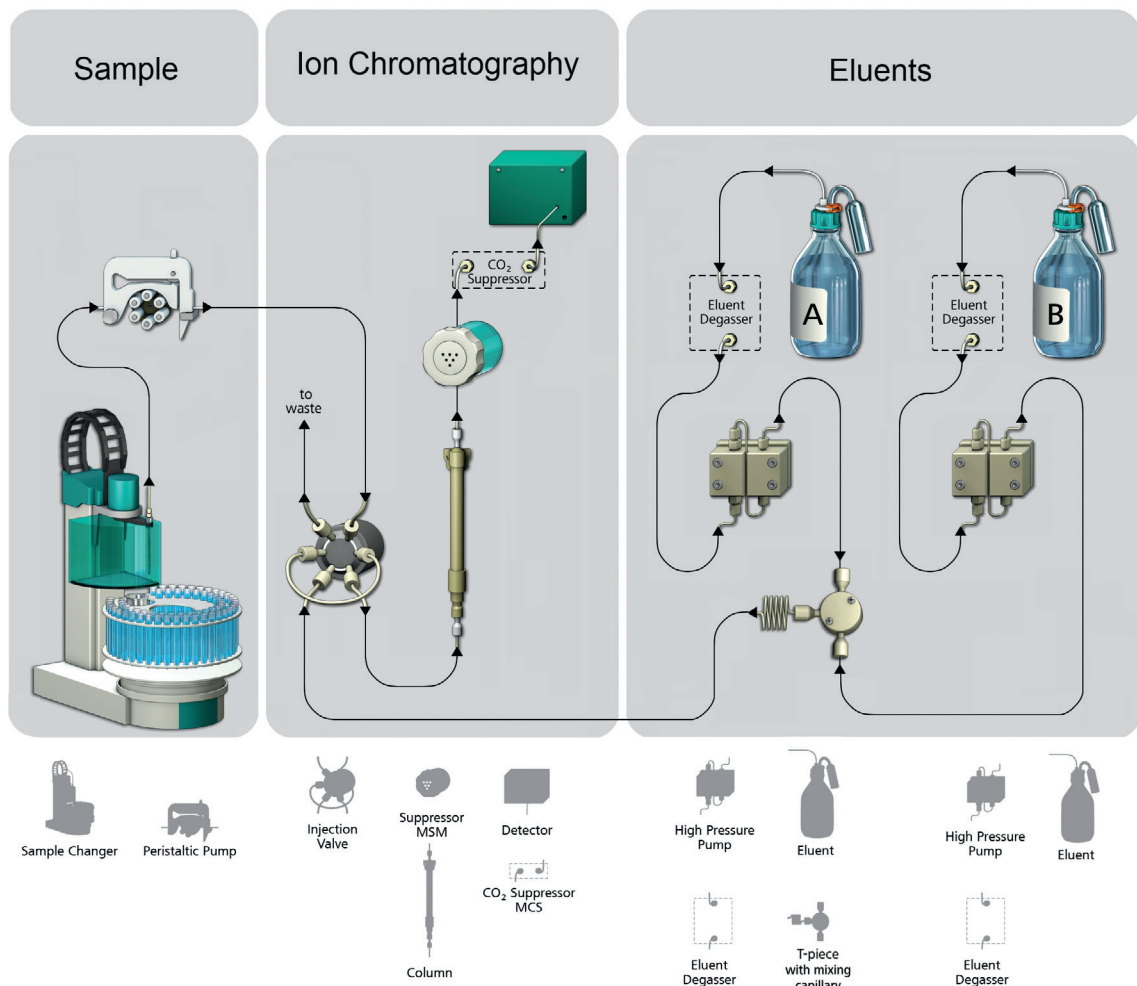
The mixing ratio for the two solutions can be adapted in the method according to the sample requirements and the separation behavior. The selected gradient profile can be visualized in a graphic display. Users can select between several types of concentration transitions from one concentration level to the next, including steps, linear ramps, and concave and convex transition forms. Optimal performance for the high-pressure gradient is with mixing ratios between 10% and 90%.



Possible gradient profile for a binary high-pressure gradient

In addition to concentrations, the flow parameters can also be varied. Flow increments in the range of a few nL can be achieved with maximum accuracy using the precise high-pressure pump. This offers even more flexibility required for solving applications with difficult separations.

The individually adjustable flow and concentration gradients enable the quantification of results of a multitude of analytes.



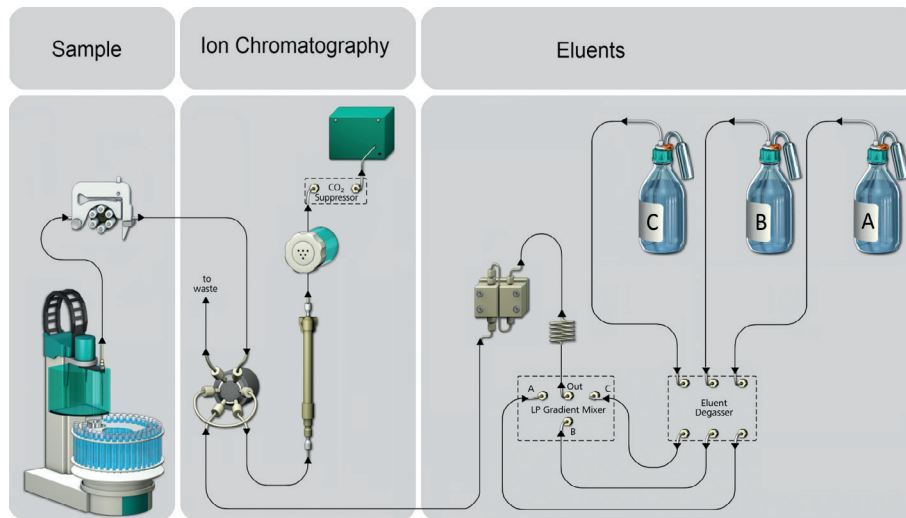
Flow path of a sequentially suppressed ion chromatograph with a binary high-pressure gradient

Low-pressure gradient – the most compact gradient module

Low-pressure gradients are preferably used when it is necessary to mix more than two solutions within the most limited space. In such cases, low-pressure gradients offer the best price-performance ratio. The solutions are aspirated through a mixing capillary using a single high-pressure pump. A low-pressure valve that produces the desired mixing ratio is installed upstream from the mixing capillary. As in the case of the high-pressure gradient, the

eluent profiles are individually adjustable, and a selection can be made at each step between linear ramps, steps, or concave or convex concentration changes.

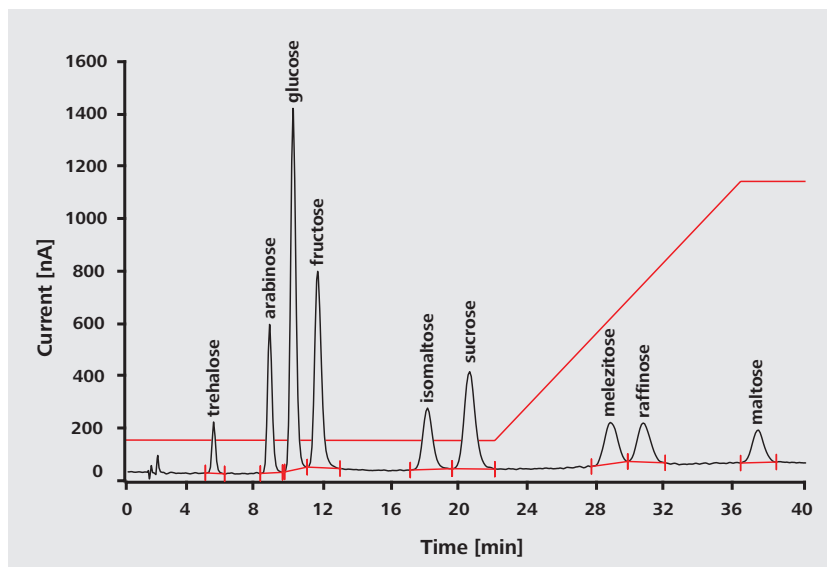
The Metrohm low-pressure gradient is 100% solvent-stable, an advantage that comes with every Metrohm gradient system.



Sequentially suppressed ion chromatograph with a ternary low-pressure gradient

The low-pressure gradient is particularly well suited for routine applications, but can also be used in method development. The practically maintenance-free gradient offers the best performance at mixing ratios between

20% and 80%. The low-pressure gradient is very compact, providing consistent and reproducible performance in restricted space.



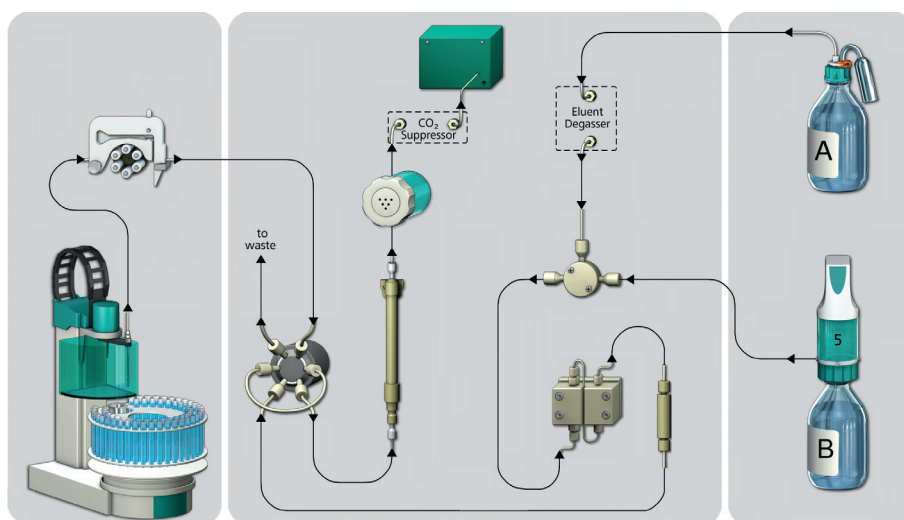
Multi-sugar analysis with the low-pressure gradient (profile shown in red). Column: Hamilton RCX-30 - 250/4.6; eluent A: 30 mmol/L NaOH, 7.5 mmol/L sodium acetate; eluent B: 200 mmol/L NaOH, 7.5 mmol/L sodium acetate; loop: 20 μ L; flow rate: 1.5 mL/min; temperature: 30 $^{\circ}$ C; standard solution with 5 or 10 mg/L per sugar; Inline Sample Preparation Technique: Dialysis; detection technique: Amperometry (PAD)

Dose-in Gradient – for universal use

The Dose-in Gradient is the most flexible of the three Metrohm gradients. It can be used with any of the intelligent Metrohm IC systems. Even if you initially work on a system without gradients, it can always be retrofitted with the Dose-in Gradient version.

The Dose-in Gradient is the latest of the three Metrohm gradients and also operates in the low-pressure range.

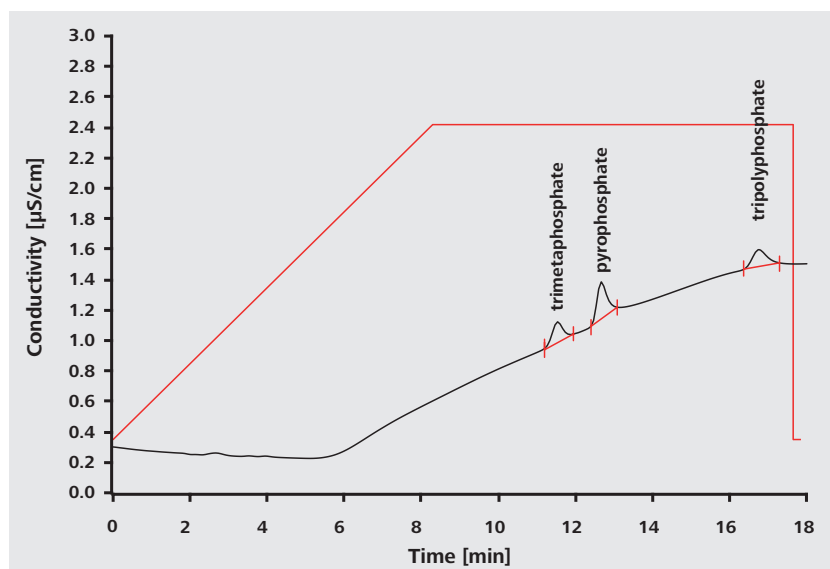
The system uses the patented Dosino technology to feed additional solutions into the main eluent stream via a 6-port adapter. A high-pressure pump controls the flow rate and ensures a low-pulsation background. The mixing ratio for up to five eluents can be adjusted between 5% and 95%, either linearly or stepwise. The Dose-in Gradient is a particularly low maintenance system.



Sequentially suppressed ion chromatograph with a binary Dose-in Gradient

The Dose-in Gradient lives up to its reputation as the universal solution. Not only can it be retrofitted to an existing system fast and without difficulty, it is also so simple to use that anyone can switch between gradient profiles in

no time. In addition, the Dose-in Gradient is compatible with organic solvents, and can be used for any type of eluent.



Separation of polyphosphates (Dose-in Gradient profile in red).
 Column: Metrosep A Supp 15 - 50/4.0; eluent A: 7.5 mmol/L Na_2CO_3 , 2 mmol/L NaOH; eluent B: 120 mmol/L Na_2CO_3 , 2 mmol/L NaOH; loop: 20 μL ; flow rate: 0.8 mL/min; temperature: 45 °C; 10 mL dosing unit for Dose-in Gradient; Metrohm intelligent Partial Loop Injection Technique (MiPT) and Inline Ultrafiltration; detection technique: sequentially suppressed conductivity

Ordering information

High-pressure gradients

2.940.1140	940 Professional IC Vario HPG
2.940.1240	940 Professional IC Vario ChS/HPG
2.940.1340	940 Professional IC Vario ChS/PP/HPG
2.940.1440	940 Professional IC Vario SeS/HPG
2.940.1540	940 Professional IC Vario SeS/PP/HPG
2.942.0040	942 Extension Module Vario HPG

Low-pressure gradients

2.940.1150	940 Professional IC Vario LPG
2.940.1250	940 Professional IC Vario LPG
2.940.1250	940 Professional IC Vario ChS/LPG
2.940.1350	940 Professional IC Vario ChS/PP/LPG
2.940.1450	940 Professional IC Vario SeS/LPG
2.940.1550	940 Professional IC Vario SeS/PP/LPG

Dose-in Gradient

2.800.0010	800 Dosino
6.5330.150	IC equipment: Dose-in Gradient
6.3032.210	10 mL Dosing unit
6.3032.220	20 mL Dosing unit
6.3032.250	50 mL Dosing unit

The selection of the dosing unit depends on the application, which is why this is not included in the IC equipment: Dose-in Gradient.

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