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Next generation suppressor for ion chromatography

Thermo Scientific Dionex ERS 500
Electrolytically Regenerated Suppressor

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The Next Generation
Suppressor

The Thermo Scientific™ Dionex™ ERS™ 500 Electrolytically Regenerated Suppressor is a new generation suppressor redesigned from the ground up to address the growing demands of the ion chromatography (IC) market. The suppressor is housed in a new hardware and provides unparalleled performance, particularly when coupled with our 4 µm-based IC columns. The high-capacity suppressor serves virtually all analytical scale IC applications, for both anions and cations, and is available in 2 and 4 mm formats. The new Dionex ERS 500 suppressor redefines the way IC is performed.

Suppressor History

The suppressor device has been a key component of modern IC technology since its inception in 1975. It enhances the conductivity signal of an ion, while simultaneously reducing the conductivity of the eluent (mobile phase) and the associated noise. Thus, signal-to-noise is considerably improved with the suppressor device. Historically, improvements in IC technology have been closely tied to suppressor improvements.

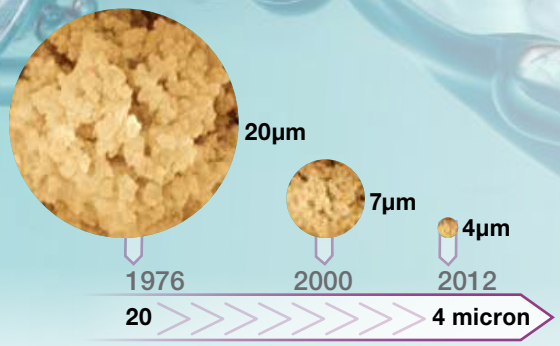
The original packed bed suppressor, which was described in a 1975 Dow patent, required periodic regeneration. Although the regeneration step was labor intensive and cumbersome, this invention transformed IC from an analytical curiosity to a reliable tool for ion analysis. Over the years, the suppressor design has evolved from the original packed bed suppressor configuration to a membrane-based continuously regenerated format that greatly improved its ease of use and utility. However, to maintain continuous operation, the continuously regenerated membrane-based suppressors required a flow of regenerant chemical (sulfuric acid for anions or tetrabutyl ammonium hydroxide for cations).

Further practical improvements in suppressor design occurred when the simple electrolysis of water was applied to the generation of the regenerant ions within the suppressor and precluded the need for a regenerant acid or base reagent. This innovation was the foundation for the Thermo Scientific™ Dionex™ SRS™ Self-Regenerated Suppressor and Dionex ERS 500 Electrolytically Regenerated Suppressor product line.

Dionex SRS Suppressor Evolution

Since the Dionex SRS suppressor introduction there has been continuous efforts to improve the suppressor performance to cater to the analytical needs of the IC market. These include:

- **Low peak dispersion** — will not erode the peak efficiency of the analytical columns used
- **High suppression capacity** — provide the required delivery rate of the electrolytically generated suppressor ion
- **Low noise** — suitable for trace analysis
- **Backpressure resilience** — allows the use of post suppressor detectors, such as photometric (UV/Vis) or mass spectrometric detection



Ion Chromatography

Column Technology Trends

There has been a general trend towards smaller particle packed IC columns. From 1976 to 2012 the column particle size has decreased from 20 µm to 4 µm. The recent development of IC column products with 4 µm ion-exchange particles substantially improved column efficiency. This advancement allows one to increase the flow rate to achieve faster separations while retaining optimal resolution. The use of such high efficiency packing material places an increased demand on the suppressor to maintain the peak efficiencies generated by the new column technology. The development of the Dionex ERS 500 suppressor occurred simultaneously with the development of 4 µm column technology, resulting in a product tailored for high efficiency separations.

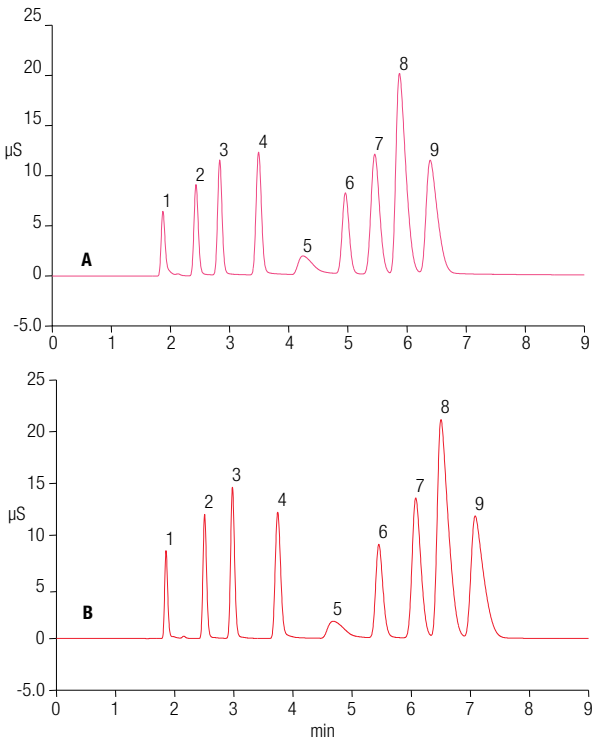
Columns packed with the 4 µm diameter particles provide up to 30–40% improvement in peak efficiency over the older columns packed with the 7 µm diameter particles.

Table 1. Comparison of column efficiencies (Plates) for chromatograms 1A and 1B shown in Figure 1

Peaks:	1A (Plates)	1B (Plates)
1. Fluoride	3800	6030
2. Chlorite	5170	7870
3. Chloride	6670	9250
4. Nitrite	6780	7640
5. Carbonate	1230	1310
6. Bromide	8190	9360
7. Sulfate	6400	8110
8. Nitrate	5810	5950
9. Chlorate	5220	5510

Figure 1A shows the performance of a Thermo Scientific™ Dionex™ IonPac™ AS18-Fast 7 µm column using a Dionex ASRS 300 suppressor. Figure 1B shows the performance of a Dionex IonPac AS18-4µm column using a Dionex AERS 500 suppressor. The column efficiencies shown in the associated table are substantially greater for the 4 µm column using the Dionex AERS 500 suppressor, particularly for the early eluting peaks.

Column:	A: Dionex IonPac AS18-Fast (2 x 150 mm) B: Dionex IonPac AS18-4µm (2 x 150 mm)
Eluent Source:	Thermo Scientific Dionex EGC III KOH Cartridge
Eluent:	23 mM KOH
Flow Rate:	0.25 mL/min
Inj. Volume:	5 µL
Column Temp.:	30 °C
Detection:	A: Suppressed conductivity, Dionex ASRS 300 Suppressor, 2 mm, recycle mode,15 mA B: Suppressed conductivity, Dionex AERS 500 Suppressor, 2 mm, recycle mode, 15 mA
Peaks:	
1. Fluoride	0.5 mg/L
2. Chlorite	5.0
3. Chloride	3.0
4. Nitrite	5.0
5. Carbonate	20.0
6. Bromide	10.0
7. Sulfate	10.0
8. Nitrate	10.0
9. Chlorate	10.0



Design Improvements

The Dionex ERS 500 suppressor incorporates various design elements to achieve a multitude of benefits

The backpressure tolerance to downstream flow resistance is critical to long-term suppressor reliability. The new suppressor has matched channels and is constructed with even torque along its perimeter. This ensures an improved backpressure resilience. The leak pressure limit of the Dionex suppressor product line has improved from 100 psi (1995), to 300 psi (2007), to over 500 psi with the new Dionex ERS 500 suppressor (2013). Accordingly, the improved pressure resiliency of the Dionex ERS 500 suppressor delivers more flexibility in adding post-column detectors and post-suppressor devices such as the Thermo Scientific™ Dionex™ CRD 200 and 300 Carbonate Removal Devices.

The improved thermal stability keeps the suppressor leak-free, even after exposure to temperatures up to 80 °C, making it less prone to thermal damage when exposed to high temperatures during shipping or when pursuing high temperature applications.

Improved Flow Characteristics

The regeneration chamber in the Dionex ERS 500 suppressor has a sequential flow through the suppressor. This ensures that even flow occurs in both regenerant channels. The symmetric nature of the regenerant and the eluent channels allows uniform sealing and fluid flow pathway. In addition, the entrance and exit of the eluent flow path is now entirely linear without any bends in the fluidic pathway, helping to maintain peak integrity. The Dionex ERS 500e suppressor differs from the Dionex ERS 500 suppressor in that it has a parallel flow through the regeneration chambers of the suppressor. This improves compatibility with mobile phases that contain electrochemically active components such as borate, methanol, and acetonitrile. It also decreases the restriction across the regenerant chambers, making pressurized water delivery possible with lower pressures.

Full Regeneration without Reagents

When operating the suppressor without power for a short duration, the operational capacity of the suppressor may become exhausted. If, for some reason, the suppressor resin is exhausted, it can be regenerated electrolytically without the addition of regenerant acid or base.

Design Characteristics

The physical structure of the Dionex ERS 500 suppressor is shown in Figure 2. The key to this suppressor's performance is its ingenious simplicity. The suppressor flow chamber is uniformly packed with the required ion-exchange resin; cation-exchange resin for anion analysis and anion-exchange resin for cation analysis.

The eluent from the IC column flows uniformly straight through the suppressor resin chamber and is routed to the detector without any turns. This simple, unique flow path preserves the column efficiency delivered by our 4 µm IC columns.

The regenerant flow in the Dionex ERS 500 suppressor passes through the two regenerant chambers in series, as shown in Figure 2. Alternatively, the regenerant flow in the Dionex ERS 500e suppressor passes through the two regenerant chambers in parallel (not shown). The electrodes at either side of the suppressor electrolyze water to deliver the regenerant ions; hydronium ions for anion analysis and hydroxide ions for cation analysis. The regenerant chambers are separated from the eluent flow by ion-exchange membranes that allow the uniform supply of the regenerant ions to the suppressor resin.

The simple leak-free seal design ensures that the suppressor can withstand a backpressure over 500 psi without leaking, although operational pressures are lower.

The benefits of the new Dionex ERS 500 suppressor are:

- Improved peak efficiency for improved performance, particularly when coupled with 4 µm based columns.
- Improved backpressure resilience for compatibility with a wide range of post suppressor devices and detectors.
- Improved thermal stability to reduce installation failures due to damage during shipment and handling.
- Full electrolytic regeneration without reagents allowing easier recoveries after operation without current.

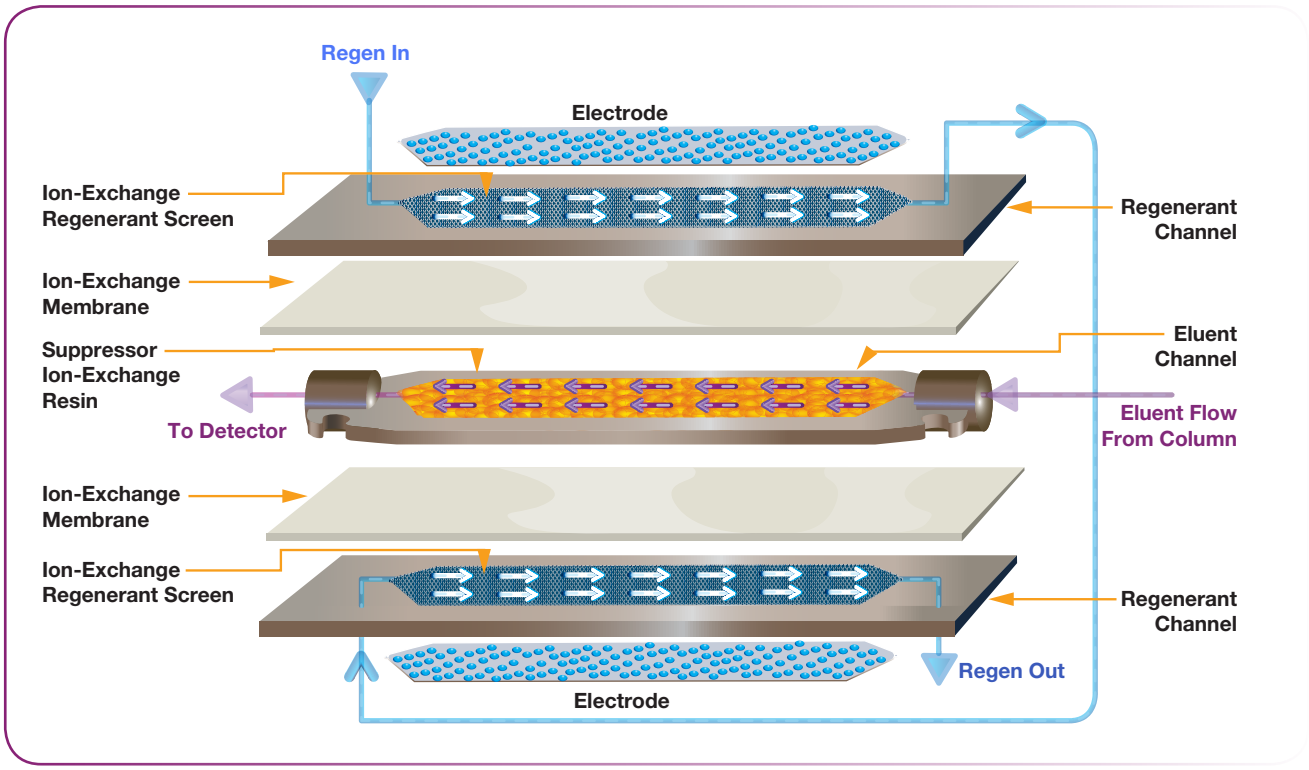


Figure 2. Dionex ERS 500 suppressor design

Eluent Channel

Both the Dionex ERS 500 and Dionex ERS 500e suppressor eluent channels use a unique suppressor chamber that contains a layer of ion-exchange resin. The eluent channel has a column-like structure and has optimal delay volume, thus preserving peak efficiency. Due to the large static capacity, it also extends the operation of the suppressor after the electric current is turned off. This makes the device less prone to capacity depletion issues and consistent peak response can be obtained. Figure 4 shows a comparison of the Dionex AERS 500 suppressor with the Dionex ASRS 300 suppressor for anion analysis. Improved performance in terms of peak efficiency and resolution can be clearly inferred for the Dionex AERS 500 suppressor. The Dionex ERS 500 suppressor will continue to deliver rugged and reliable performance under both isocratic and gradient conditions of operation.

The Dionex ERS 500 suppressor significantly improves ruggedness without sacrificing performance or ease of use. This new suppressor design represents our ongoing commitment to deliver state-of-the-art innovations to IC technology. Figure 4 shows the internal construction of the Dionex ERS 500 suppressor with the various internal components.

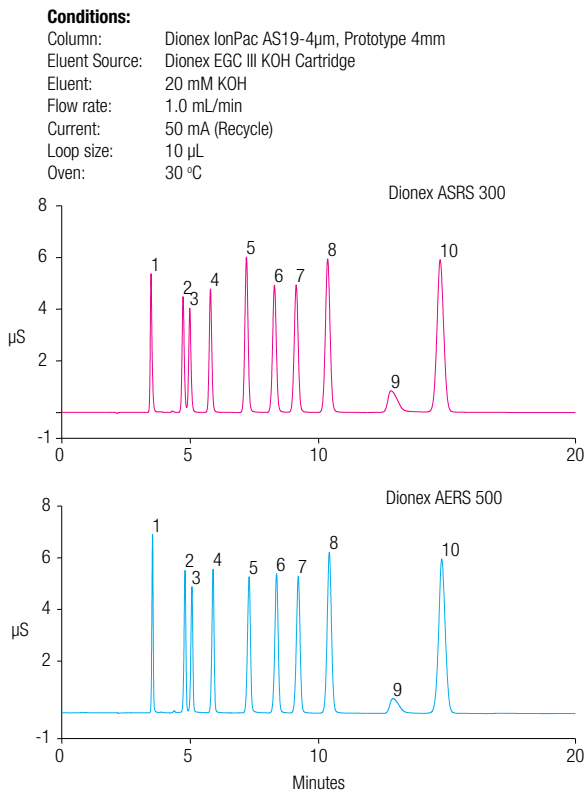


Figure 3: Comparison of the Dionex AERS 500 suppressor to the Dionex ASRS 300 suppressor using an inorganic anion standard. The Dionex AERS 500 suppressor outperforms the Dionex ASRS 300 suppressor, as shown by the peak efficiency and resolution

Peak	Dionex ASRS 300	Dionex AERS 500
Fluoride	13930	22229
Chlorite	15259	21906
Bromate	15536	22129
Chloride	16529	22063
Nitrite	15599	18319
Chlorate	15442	19399
Bromide	16233	19518
Nitrate	15328	18553
Carbonate	5751	6077
Sulfate	15086	15961

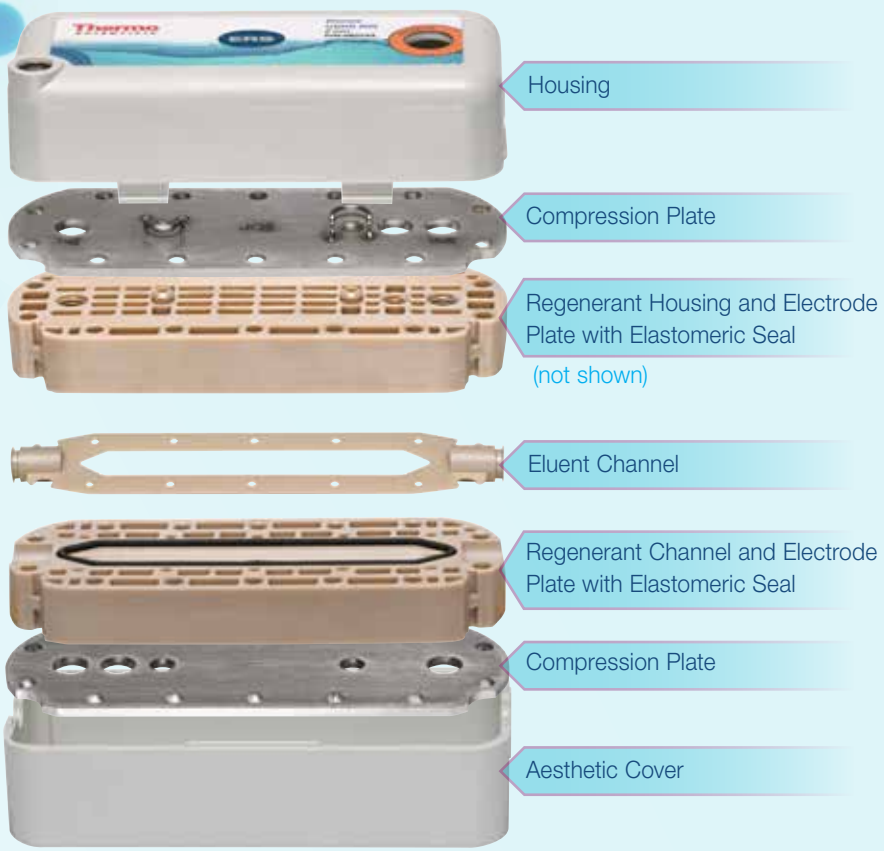


Figure 4: The Dionex ERS 500 suppressor components and assembly

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