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What is the Role of a Next Generation Suppressor?

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Executive Summary

Suppression technology is the heart of an ion chromatography (IC) system. Previous advances in suppressor functionality have focused on continuous operation, achieving high-capacity and ease-of-use. Advances in the future will continue to optimize these parameters, but will also focus on an array of other improvements, including backpressure tolerance, peak efficiency and current efficiency.

What is the function of suppression in ion chromatography?

Suppression greatly enhances the signal-to-noise ratio in IC. In an IC system with a conductivity detector installed, the conductive eluent is delivered to the system using a high-pressure pump. The sample is introduced and flows through the guard into the analytical ion-exchange column where the ion-exchange separation occurs. After separation, the suppressor reduces the conductivity of the eluent by exchanging the eluent and sample counter ions with suppressor derived ions. This process not only reduces the background conductivity, it also reduces the associated noise while simultaneously increasing the conductivity response of most analytes. Thus signal-to-noise is considerably improved with a suppressor compared to non-suppressed IC. An electrolytic also facilitates the recycle of eluent in a Reagent-Free™ Ion Chromatography with Eluent Regeneration (RFIC™-ER) system since the suppressor waste comprises of eluent.

What have previous generations of suppressors offered?

Previous advances in suppressor functionality have focused on: **continuity** - permitting the non-stop operation of a suppressed conductivity detector without the need to take the suppressor off-line for regeneration; **capacity** - allowing use of higher concentration eluents and gradients alongside higher-capacity columns, and therefore allowing the use of large sample injection volumes to achieve low detection limits and high sensitivity; **ease-of-use** - electrolytic operation negating the need for chemical reagents for suppression.

The original packed bed suppressor, first patented in 1975, required regular off-line chemical regeneration. These early suppressors were very large in volume to allow for operation for several hours between regeneration steps, and therefore added a lot of dispersion to the peaks of interest. Separation columns were generally very low capacity so that low ionic strength eluents could be used; this kept the regeneration frequency down, but also meant that only very small volumes of sample could be analyzed. Several researchers also investigated switching packed suppressor devices so that when one device was used for suppression the other device was regenerated. Improvements in this design included a three chamber packed bed suppressor that is still used in some systems today. In this design three separate packed bed suppressors are used; while one pack bed is used as a suppressor the other two are either regenerated or undergo equilibration. In this setup the calibration and analysis is pursued in one of three packed bed suppressors.

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The original packed bed suppressor quickly evolved into a continuously regenerated chemical suppressor. These types of suppressors required a flow of regenerant chemical (sulfuric acid for anions or tetrabutyl ammonium hydroxide for cations), but they eliminated the requirement to take the suppressor off-line for the regeneration step. Aside from the obvious ease-of-use improvements, these suppressors permitted the use of high-capacity columns and relatively large sample volume injections, thereby leading to significant improvements in sensitivity and detection limits. In this design, the same suppressor is unlike the switching type suppressor as the same suppressor is used for all injections during calibration and analysis.

Soon after the continuously regenerated chemical suppressor came the electrolytically regenerated suppressor. The design is very similar to the continuously regenerated chemical suppressor, but instead of using a regenerant chemical, the suppression ions are provided by the electrolysis of water. This precludes any need for a regenerant because the suppressor is constantly regenerated by the continuous electrolysis of water. Another break through in this arena was the use of the suppressed eluent to provide the water required for electrolysis. As a result, no extra pumps or pump maintenance is required. These suppressors are sometimes referred as AutoSuppression suppressors.

What is needed in a next generation suppressor?

Future generations of suppressor must continue to offer the features of previous generations in order to support existing analysis methods, but should also focus on an array of other improvements, including: increased backpressure tolerance – to support the use of post-suppressor devices and detection techniques; peak efficiency – for improved peak shapes, particularly as columns based on small particles such as 4 µm particles become more common; and full electrolytic regeneration – improving the suppressor's recovery from operation without current.

As the use of hyphenated detection becomes more common, the amount of backpressure placed on a suppressor has increased over the years. Detectors such as UV-Vis, Mass Spectrometric Detection (MSD), ICP and ICP-MS are placing higher and higher demands on suppressor backpressure tolerance. The role of a suppressor with these detectors is just as important as it is with conductivity detection, therefore suppressors with higher backpressure tolerance are being sought more and more often.

Chromatographic separations using packed columns benefit from a high number of theoretical plates per column. The number of theoretical plates can be increased by the use of packing smaller particles into the columns. Typically IC columns use resin particles ranging from 7–9 µm in diameter; previous generations suppressors of have sufficiently low dispersion to support these columns. However, recent developments in resin technology have allowed the use of 4 µm resin particles in ion-exchange columns. Next generation suppressors must have lower peak dispersion properties to support these columns and the very narrow peaks they generate.

Previous generation electrolytic suppressors are very good at maintaining their regenerated form electrolytically, but if the suppressor loses its regenerated form for some reason (such as being operated without current, particularly during installation and startup) the baseline quickly becomes unstable and peak area response diminishes. Chemical regeneration is usually needed to restore the suppressor to the correct form before electrolytic suppression can resume. Future generation suppressors should be more current efficient and should have sufficient static capacity allowing a suppressor to recover from this condition without the need for chemical regeneration.

What next generation suppressor solutions exist on the market?

The Thermo Scientific™ Dionex™ ERS™ 500 Electrolytically Regenerated Suppressor exhibits backpressure tolerance up to 900 psi, has peak efficiencies optimized for 4 µm resin bead based columns and has very high current efficiency and static capacity.

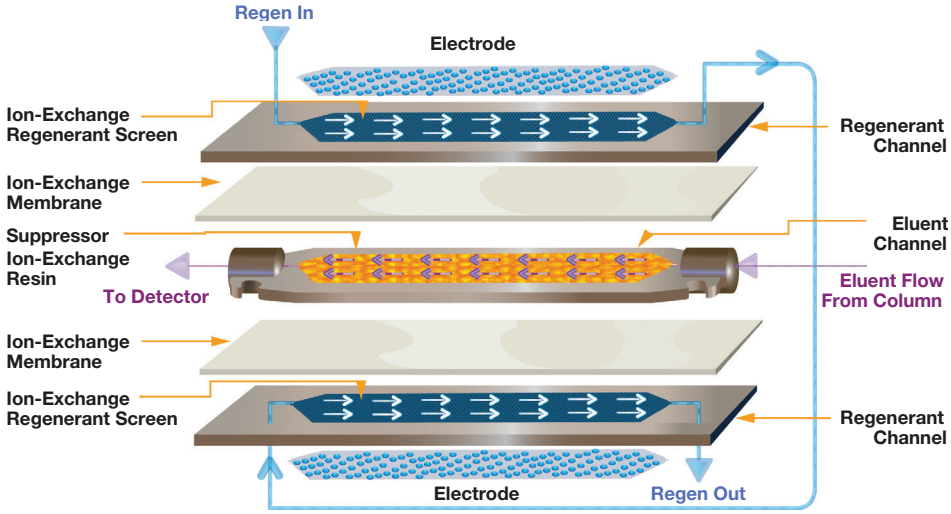

Figure 1. The Dionex ERS 500 suppressor design

Additionally, this suppressor is an integral part of RFIC systems, where the sample is determined using suppressed conductivity detection in the lowest possible background of high-purity water. AutoSuppression means ease-of-use; you don't need to make regenerant because the suppressor is constantly regenerated by the continuous electrolysis of water derived from the cell effluent.

Figure 2. The Dionex ERS 500 suppressor components and assembly

References:

- http://www.dionex.com/en-us/products/accessories/suppressors/lp-73569.html
- http://www.dionex.com/en-us/products/accessories/suppressors/srs-300/lp-73601.html
- http://www.dionex.com/en-us/webdocs/4270-DS-Eluent-Suppressors-23Nov10-LPN1290-10.pdf
- Dionex ERS 500 Suppressor Brochure
- Dionex ERS 500 Suppressor Product Support Package

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