

A New Generation of IC Consumables: Introducing the Capillary Format

John Madden, Navette Shirakawa, and Yan Liu
Dionex Corporation, Sunnyvale, CA, USA

ABSTRACT

In March 2010, Dionex introduced a new ion chromatography system, the ICS-5000. This instrument represents the first commercially available capillary IC system on the market. To support the ICS-5000 system, a new generation of consumables was developed to perform ion chromatographic separations of target analytes at flow rates ranging from 0.005–0.020 $\mu\text{L}/\text{min}$ that are typical of capillary systems.

Because the ICS-5000 capillary system is an RFIC-EG™ system, a new generation of electrolytic products was developed, including an Eluent Generator Cartridge (EGC), Continuously Regenerated-Trap Column (CR-TC), and the Capillary Electrolytic Suppressor (CES). Additionally, the Carbonate Removal Device was redeveloped for the capillary scale, and new formats for the guard and analytical columns were developed.

Here, the authors introduce the capillary format consumables developed for the ICS-5000 and future generations of capillary ion chromatography systems. The advantages of capillary ion chromatography and some key applications for the capillary IC format are also discussed.

INTRODUCTION

The new ICS-5000 capillary system required a whole new generation of capillary scale products and consumables to support RFIC-EG operation at capillary flow rates (typically from 0.005 to 0.020 mL/min). These consumables include a new Eluent Generator Cartridge, Continuously Regenerated Trap Column, Capillary Electrolytic Suppressor, and Carbonate Removal Device as well as a selection of guard and analytical columns.

ELUENT GENERATOR CARTRIDGE

The capillary version of the Eluent Generator Cartridge—EGC (Capillary)—delivers potassium hydroxide or methanesulfonic acid at concentration ranges from 0.1 mM to 200 mM . This compares to a maximum of 100 mM for the analytical-scale EGC products.

The EGC (Capillary) has an 18 month lifetime, regardless of use (under typical conditions). This allows the system to be left running for extended periods of time without concern for reduced EGC life.

Now sold under the
Thermo Scientific brand

Thermo
SCIENTIFIC



Figure 1. Eluent generator cartridge.

CONTINUOUSLY REGENERATED TRAP COLUMN

Similar to the standard-bore and microbore scale CR-TC, the CR-TC (Capillary) is designed to remove ionic contaminants from the eluent immediately prior to analysis. The CR-TC (Capillary) is virtually identical to the CR-TC, but has reduced dead volume to make it compatible with capillary flow rates. The ICS-5000 system features an improved power supply to improve CR-TC performance by more closely matching the applied voltage to the system flow rate.



Figure 2. CR-TC Analytical



Figure 3. CR-TC Capillary

CARTRIDGE DESIGN

To simplify installation, setup, and operation, many capillary scale IC consumables and accessories are provided in a cartridge design. The EG degasser, column and guard set, suppressor, and CRD are all housed in cartridges that are easily plugged into the instrument. Upon installation, these cartridges automatically interface with their appropriate regenerant ports establishing the correct regenerant flow. The suppressor cartridge establishes its electrical connections when plugged in, and the column and guard cartridge plugs into a miniature column heater that maintains the column at a precise temperature without having to heat other components.



Figure 4. IC Cube™ with cartridge-based consumables.

CAPILLARY ELECTROLYTIC SUPPRESSOR

The CES 300 is a new concept in electrolytic suppression. As demonstrated in Figure 5, the CES suppressor uses a three-element design to minimize dead volume while maximizing suppression capacity and reducing noise. The first element is the ion-exchange membrane capillary, which is wound into a coil that facilitates the efficient exchange of the eluent counterions for regenerant ions. The next element is the regenerant chamber; this chamber is filled with ion-exchange resin, and the ion-exchange membrane capillary is coiled in this bed. The regenerant bed is an ion-exchange resin in the opposite form to the eluent. This bed of resin provides the regenerant ions for the capillary membrane eluent chamber.

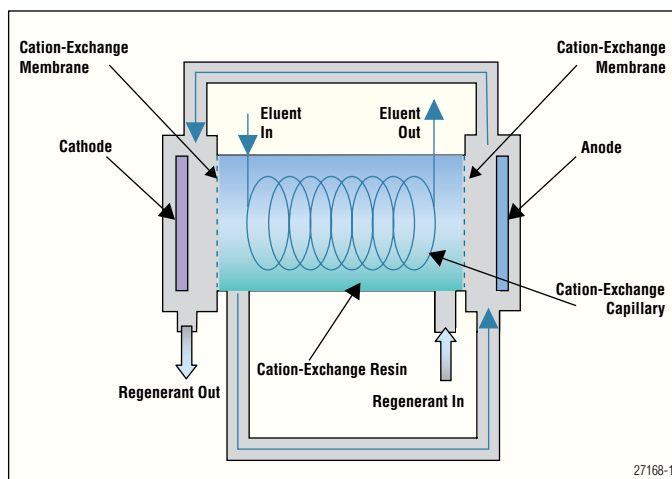


Figure 5. Anion capillary electrolytic suppressor (ACES™ 300).

The final element—the electrolysis chambers—is actually two chambers separated from the ion-exchange chamber by a pair of ion-exchange membranes. When a current is passed through the electrodes, the regenerant ions are generated in the first electrode chamber. These ions are pushed into the regenerant chamber through an electric field, maintaining the regenerant chamber bed in the regenerant form. After counterions exchange from the eluent ion-exchange capillary membrane, the counterions are pushed out of the regenerant chamber through the electric field into the second electrode chamber. Finally, these counterions are neutralized by the ions generated in the second electrode chamber. The eluent suppression process is illustrated for an anion suppressor in Figure 6 below.

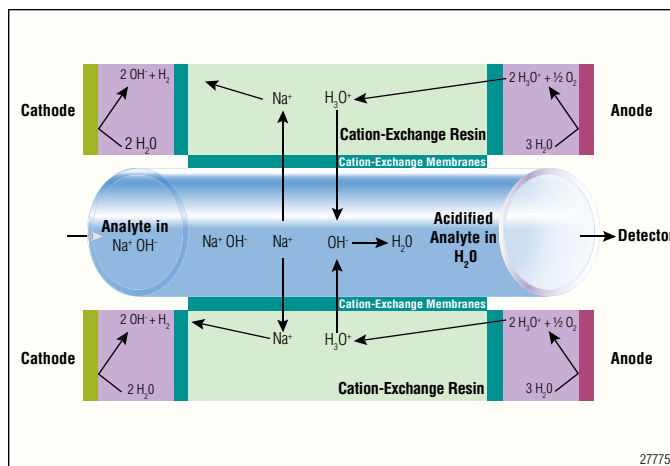


Figure 6. Eluent suppression in an ACES 300.

Table 1. New Capillary Columns Available From Dionex	
Column	Features
IonPac AS18-Fast	At 0.4 × 150 mm, the IonPac AS18 column is 40% shorter than a standard AS18 column allowing higher flow rates and faster run times. The packing material is standard AS18 resin making it an excellent choice for common anions. Because of the reduced length, the column has 40% less resolution and capacity than a standard AS18, and is therefore well suited for relatively clean matrices such as drinking water.
IonPac AS19	The IonPac AS19 column is a 0.4 mm version of the standard-bore and microbore AS19 columns and has almost identical performance, but at 1/100th the flow rate of the 4 mm version. The AS19 column has very high capacity and excellent resolution of oxyhalides, making it ideal for bromate and other oxyhalide analyses in relatively complex matrices.
IonSwift MAX-100	The new Dionex MAX-100 column demonstrates new technology for ion chromatography. IonSwift is a new generation of separation media developed using monolith technology. The IonSwift MAX-100 is a high-capacity anion-exchange column with selectivity similar to the IonPac AS11-HC column. The MAX-100 column can be used at relatively high linear velocity due to its low backpressure and fast kinetics. In order to help keep the linear velocity high, it is offered in a 0.25 mm rather than the 0.4 mm format in packed capillary columns. The MAX-100 column can be substituted for most AS11-HC applications, but typically has 40–50% faster run times.
IonPac CS12A	The CS12A column is the workhorse of cation analyses. At 0.4 mm, this column has virtually identical performance to the standard-bore and microbore formats, but at 1/100th the flow rate of the 4 mm version.
IonPac CS12A-5 μm	Like the AS18-Fast column, the CS12A-5μm column is designed to provide faster run times than the standard CS12A column. However, this column is packed with a 5 μm resin beads, rather than the 8 μm beads used in the CS12A column. This small bead improves resolution, allowing very fast separations of common inorganic cations without much compromise to resolution.
CarboPac PA20	The CarboPac PA20 column enables fast, efficient separations of mono- and disaccharides without compromising resolution. Carbohydrates, without derivatization, are separated by anion-exchange chromatography at high pH and detected by pulsed electrochemical detection. The PA20 column's unique selectivity makes it highly suitable for the separation of the six common monosaccharides found in glycoprotein hydrolysates. A unique benefit of the capillary version is its compatibility with the EGC-Capillary, which can deliver the 200 mM hydroxide required for the column's regeneration process. This makes this application completely reagent-free.

CARBONATE REMOVAL DEVICE

Like the standard-bore and microbore scale CRD 200, the CRD 200 (capillary) reduces the carbonate peak after the chromatographic separation, thereby improving peak integration and quantitation for analytes such as sulfate and nitrite. The CRD 200 (Capillary) has a similar design to the CRD 200 (2 mm), but has reduced dead volume to make it compatible with capillary flow rates. The CRD 200 is housed in a cartridge allowing simple installation and automatic connection of the regenerant ports.

COLUMNS

With the introduction of the capillary system, four IonPac® and one CarboPac® columns were released at the capillary scale. All these columns use the same packing material as their standard-bore and microbore counterparts, but are packed into 0.4 mm i.d. tubing to provide a 1 in 100 decreased flow rate while maintaining equivalent linear velocity, and therefore performance. Also, a new IonSwift™ column was introduced in capillary format, the MAX-100 column. The following table discusses the new capillary columns available from Dionex.

IonPac and CarboPac are registered trademarks and ACES, IonSwift, IC Cube, CCES, and RFIC-EG are trademarks of Dionex Corporation.

Passion. Power. Productivity.



Dionex Corporation

1228 Titan Way
P.O. Box 3603
Sunnyvale, CA
94088-3603
(408) 737-0700

North America

U.S. / Canada (847) 295-7500

South America

Brazil (55) 11 3731 5140

Europe

Austria (43) 1 616 51 25 Benelux (31) 20 683 9768; (32) 3 353 4294
Denmark (45) 36 36 90 90 France (33) 1 39 30 01 10 Germany (49) 6126 991 0
Ireland (353) 1 644 0064 Italy (39) 02 51 62 1267 Sweden (46) 8 473 3380
Switzerland (41) 62 205 9966 United Kingdom (44) 1276 691722

Asia Pacific

Australia (61) 2 9420 5233 China (852) 2428 3282 India (91) 22 2764 2735
Japan (81) 6 6885 1213 Korea (82) 2 2653 2580 Singapore (65) 6289 1190
Taiwan (886) 2 8751 6655

www.dionex.com



LPN 2630-01 8/10
©2010 Dionex Corporation