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APPLICATION

# Purification of Chlorogenic Acid from Green Coffee using Kinetex® Core-Shell Technology in Axia™ Preparative Formats

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## Introduction

High performance HPLC/UHPLC core-shell material is the latest technological advancement in chromatographic media. When used under analytical conditions, core-shell particles show improved efficiency and performance over fully porous particles of equivalent particle size.[1,2]

With the recent commercialization of a lower pressure 5 µm core-shell media, it is now possible to offer core-shell media in a preparative format (>20 mm ID) that is compatible with standard prep LC systems.

In this technote, we will demonstrate that this new 5 µm core-shell particle size, available in a variety of bonded phases, can be packed efficiently in preparative formats with internal diameter greater than 2 centimeters. We will highlight the advantage of such product for the isolation of antioxidant **chlorogenic acid** from Green Coffee.

## Results and Discussion

Core-shell particles are composed of an inner solid core surrounded by a layer of fully porous silica as shown in **Figure 1**. Those particles were developed more than 50 years ago by C. Horvath[1] and reintroduced in 2009 by Phenomenex due to the advantage they offer over fully porous material in regards to column efficiency. Axia preparative columns (>20 mm ID) were introduced in 2006. The Axia HPLC columns incorporate a patented Hydraulic Piston Compression technology that increases bed density and eliminates media bed collapse as a source of premature column failure **Figure 2**. Unlike traditional pre-packed preparative column packing methods, the Axia packing method is completely automated and computer monitored which results in improved efficiencies, peak symmetries, and overall column performance.

**Figure 1.** Core-Shell Particle Technology

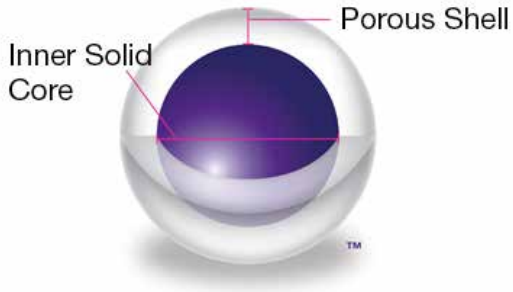
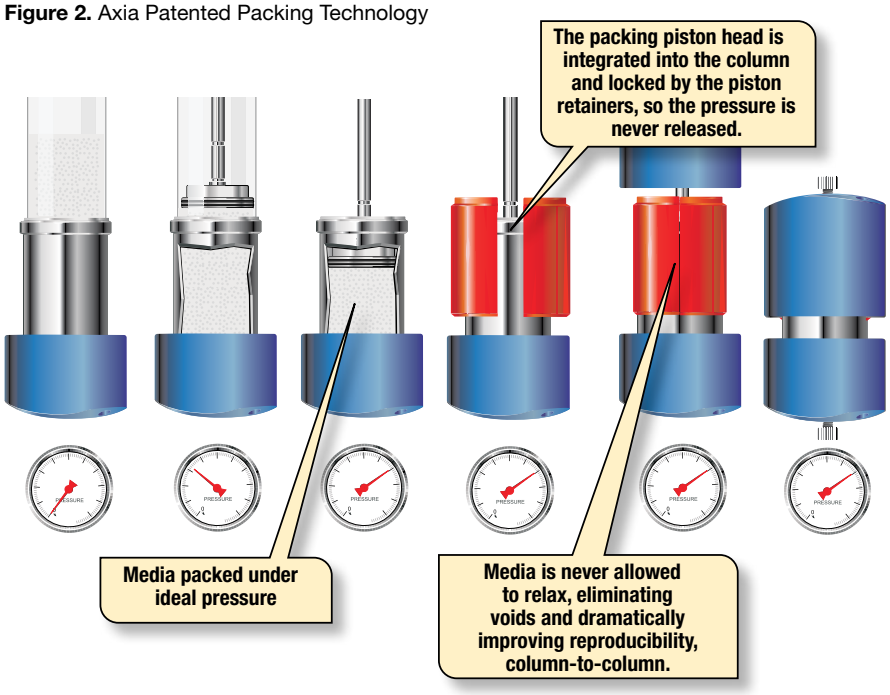



**Figure 2.** Axia Patented Packing Technology



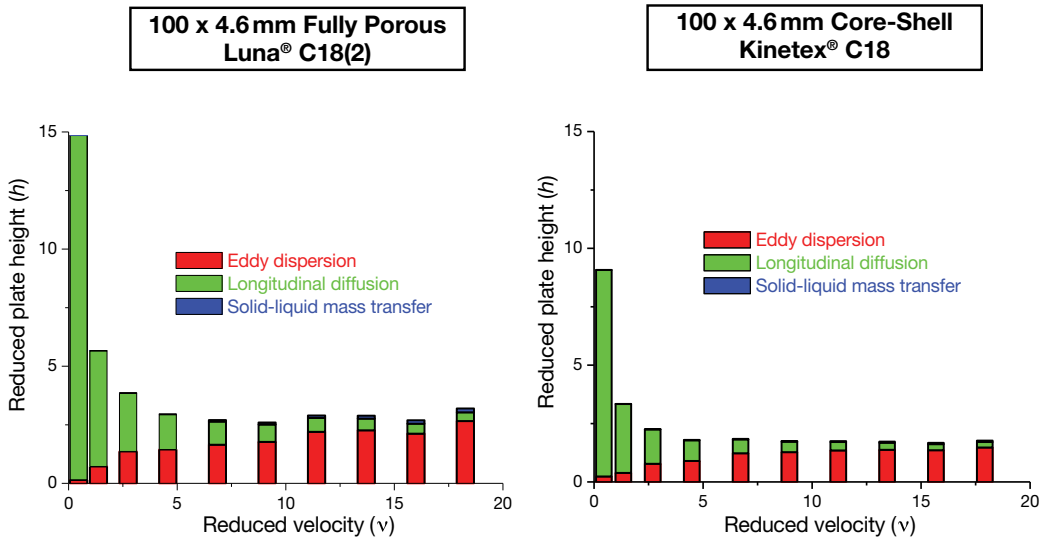
## Results and Discussion *(cont'd)*

One investigation performed by F. Gritti and G. Guiochon[1] analyzes the Van Deemter equation for fully porous and core-shell analytical columns and evaluates the contributions of the A, B, and C coefficients to plate height H. They determined that core-shell media significantly reduces band broadening by affecting Eddy dispersion (A), and longitudinal diffusion (B), while mass transfer (C) was determined to be a minor component as depicted in **Figure 3a**. The high column performance is explained essentially by a more homogeneous column packing.[2] Combining 5 µm core-shell and Axia™ technology results in efficiency N that can reach up to 125,000 plates/meter for a 21.2 mm ID prep column **Figure 3b**.

The Kinetex core-shell family of particles are designed such that the shell volume to particle size ratio is maintained throughout the particle size. This means that regardless of particle size (1.3, 1.7, 2.6, and 5 µm), the retention and the selectivity remains constant, allowing for excellent scalability of methods from particle and/or system platforms. Kinetex core-shell 5 µm particles are available in eight (8) different phases for unique selectivities (phases currently available are C18, XB-C18, EVO C18, C8, Phenyl-Hexyl, Biphenyl, PFP and HILIC). Six phases are seen in **Figure 4.**

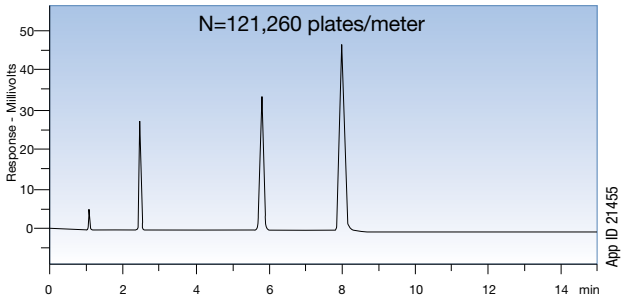
Prior to the scale-up of preparative conditions, we screened 6 RP core-shell phases to evaluate the selectivity in order to choose the best phase for the isolation of pure **chlorogenic acid** from green coffee extract (the green coffee extract was obtained from ChromaDex®). The results using a 20 min gradient are represented in **Figure 4**. Under 0.1 % TFA conditions, the best separation was obtained on a Kinetex 5 µm XB-C18 column. It is interesting to note that with the C8 phase, the selectivity was reversed between **chlorogenic acid** and impurity B.

**Figure 3a.** Core-Shell Particles Impact on Band Broadening and Column Efficiency



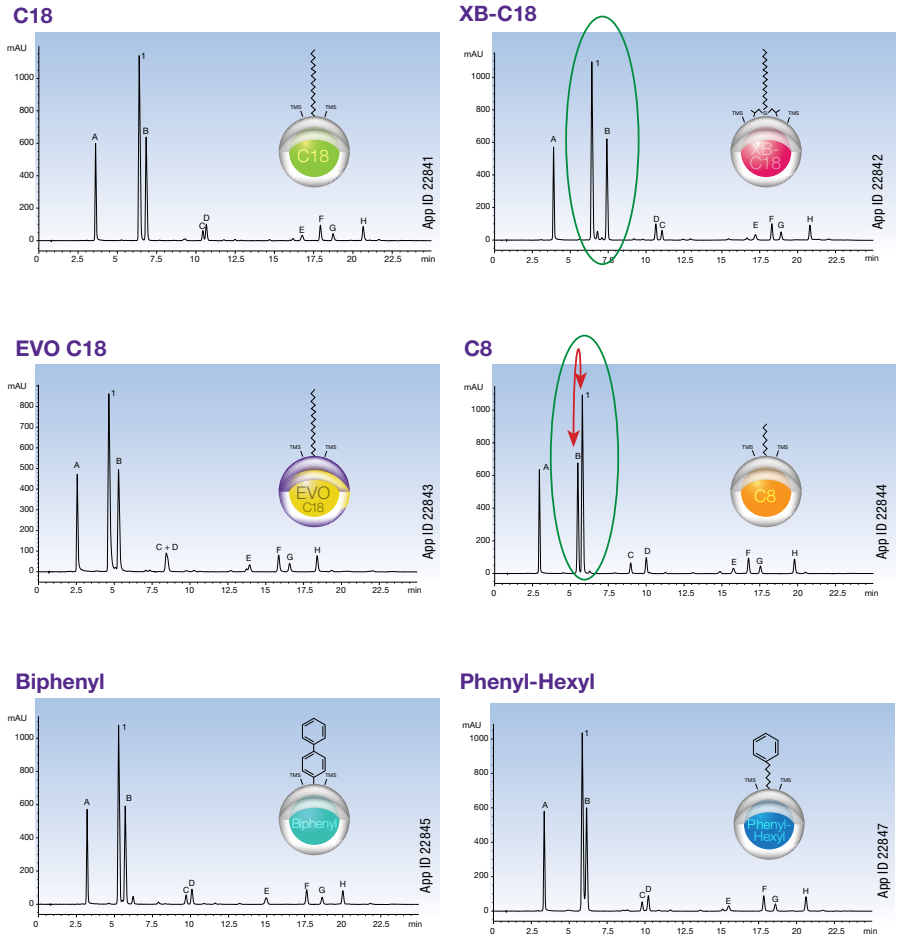

**Van Deemter Equation:** $H = A \cdot d_p + B/\mu + C \cdot d_e^2 \cdot \mu$

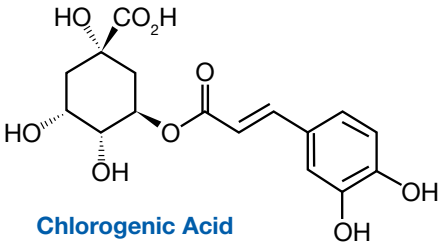
**Figure 3b.** Naphthalene peak efficiency for a Kinetex 5 µm XB-C18 Axia preparative column




**Column:** Kinetex 5 µm XB-C18 Axia Packed
**Dimensions:** 150 x 21.2 mm
**Mobile Phase:** Water/ Acetonitrile (50:50)
**Injection Volume:** 10 µL
**Flow Rate:** 25 mL/ min
**Temperature:** Ambient
**Detection:** UV @ 254 nm
**Instrument:** Shimadzu® LC 20
**Injection Volume** 2 mL
**Sample:** 1. Uracil
2. Acetophenone
3. Toluene
4. Naphthalene

**Figure 4.** Screening of Green Coffee Extract on Various Kinetex® Phases




**Chlorogenic Acid**

**Conditions for all columns:**

**Columns:** Kinetex 5 µm C18
Kinetex 5 µm XB-C18
Kinetex 5 µm EVO C18
Kinetex 5 µm C8
Kinetex 5 µm Biphenyl
Kinetex 5 µm Phenyl-Hexyl

**Dimensions:** 100 x 4.6 mm

**Mobile Phase:** A: 0.1 % TFA in Water
B: 0.1 % TFA in Acetonitrile

**Gradient:**

| Time (min) | % B |
|---|---|
| 0 | 5 |
| 20 | 20 |
| 22 | 20 |
| 22.5 | 5 |
| 25 | 5 |

**Flow Rate:** 1.5 mL/min

**Temperature:** 25 °C

**Detection:** UV @ 330 nm

**Instrument:** Agilent® 1100

**Sample:** 1. Chlorogenic Acid
Others: Antioxidants from green coffee

## Phase Characteristics

| Packing Material | Particle Size (µm) | Pore Size (Å) | Surface Area ($m^2/g$) | Carbon Load (%) | pH Range | Applications: Small Molecules | Applications: Peptides | Applications: Proteins | Applications: Chiral | Applications: Oligonucleotides | Type of Compounds: Acids | Type of Compounds: Polar | Type of Compounds: Hydro-phobic | Type of Compounds: Bases | Loading: Available Surface Area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kinetex C18 | 1.3, 1.7, 2.6, 5 | 100 | 200 | 12 | 1.5-8.5* | ● | ● | | | | ◐ | | ● | ● | ◐ |
| Kinetex XB-C18 | 1.7, 2.6, 5 | 100 | 200 | 10 | 1.5-8.5* | ● | ● | | | | ◐ | | ● | ● | ◐ |
| Kinetex EVO C18 | 1.7, 2.6, 5 | 100 | 200 | 11 | 1-12 | ● | ● | | | | ◐ | | ● | ● | ◐ |
| Kinetex C8 | 1.7, 2.6, 5 | 100 | 200 | 8 | 1.5-8.5* | ● | ● | | | | ◐ | | ● | ◐ | ◐ |
| Kinetex Phenyl-Hexyl | 1.7, 2.6, 5 | 100 | 200 | 11 | 1.5-8.5* | ● | ● | | | | ◐ | ● | ◐ | ◐ | ◐ |
| Kinetex Biphenyl | 1.7, 2.6, 5 | 100 | 200 | 11 | 1.5-8.5* | ● | ● | | | | ◐ | ● | ◐ | ● | ◐ |

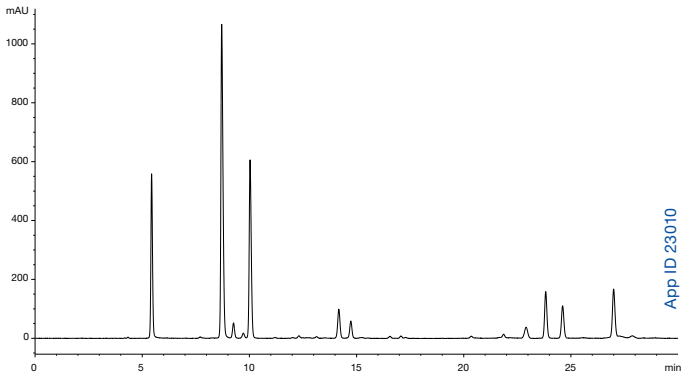
**Key:** ● Best Suited ◐ Very Good

*Columns are pH stable from 1.5-10 under isocratic conditions. Columns are pH stable 1.5-8.5 under gradient conditions.

## Results and Discussion *(cont'd)*

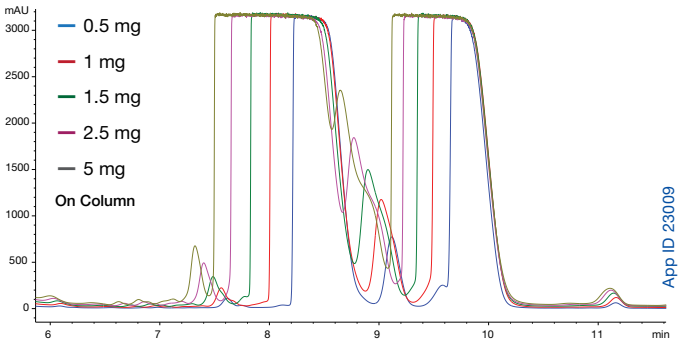
After screening and before purification, we optimized the method and used a Kinetex® 5 µm XB-C18 150 x 4.6 mm ID (Internal diameter) column with a 25 min gradient as depicted in **Figure 5**. We also increased the loading up to 5 mg on-column. (**Figure 6**).

**Figure 5.** Analysis of Crude Green Coffee Extract




**Column:** Kinetex 5 µm XB-C18
**Dimensions:** 150 x 4.6 mm
**Part No.:** 00F-4605-E0
**Mobile Phase:** A: 0.1 % TFA in Water
B: 0.1 % TFA in Acetonitrile
**Gradient:** 5 to 20 % B in 25 min hold
2 min at 20 %
**Flow Rate:** 1.5 mL/min
**Temperature:** 25 °C
**Detection:** UV @ 330 nm
**Instrument:** Agilent 1100
**Injection Volume** 10 µL
**Sample:** 5 mg/mL in water

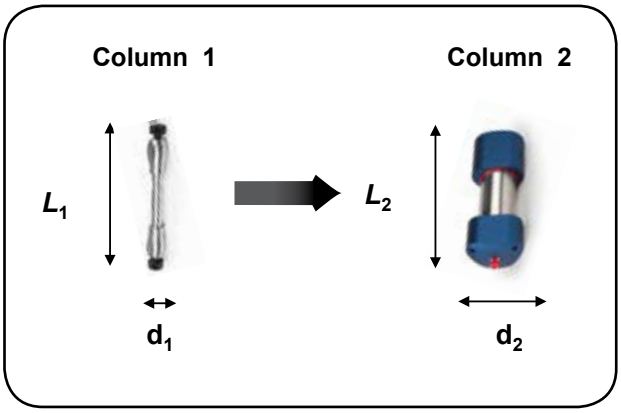
**Figure 6.** Loading Experiments on Analytical Column




**Column:** Kinetex 5 µm XB-C18
**Dimensions:** 150 x 4.6 mm
**Part No.:** 00F-4605-E0
**Mobile Phase:** A: 0.1 % TFA in Water
B: 0.1 % TFA in Acetonitrile
**Gradient:** 5 to 20 % B in 25 min hold
2 min at 20 %B
**Flow Rate:** 1.5 mL/min
**Temperature:** 25 °C
**Detection:** UV @ 330 nm
**Instrument:** Agilent 1100
**Injection Volume** Varied 10 to 100 µL
**Sample:** 50 mg/mL in water

The separation was then scaled-up to a 21.2 mm ID Axia™ preparative column packed with same core-media and the loading was increased accordingly to 100 mg of green coffee extract (scaling factor of 20 from 4.6 to 21.2 mm ID) as represented in **Figure 7**. Fractions of 10 mL were collected, analyzed, and the fractions containing **chlorogenic acid** with purity greater than 94 % at 330 nm, were pooled together (**Fraction 3-5**). Fraction overlays are shown in **Figure 8** and the overlay includes reference standard obtained from ChromaDex, Inc. Analysis of the pool shows a purity greater than 99 % and contained approximately 5 mg of pure product for a recovery of 42 % in one run (**Figure 9**).

**Scaling parameter and basic equations**




Scaling Factor *SF*

$$SF = (d_2/d_1)^2$$

Flow Rate *F*

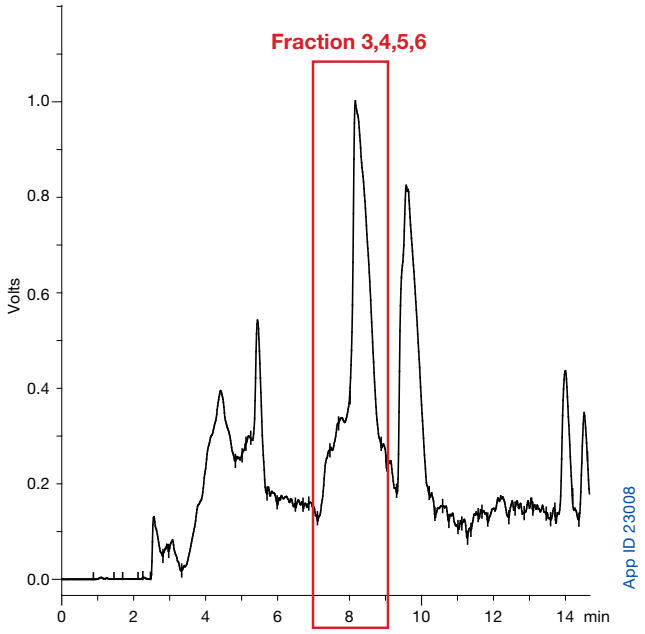
$$F_2 = F_1 \times SF$$

Loading *m*

$$m2 = m1 \times \frac{L_2}{L_1} \times SF$$

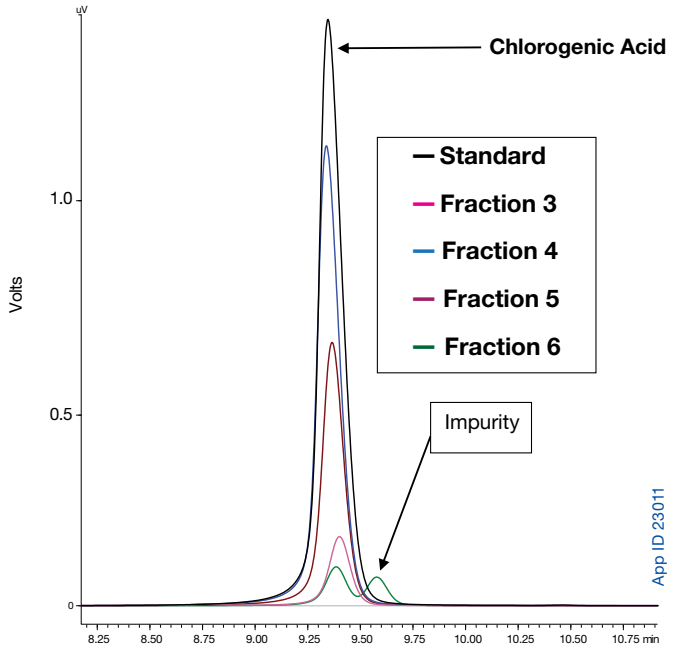
**Notes:**
- Recommended to keep particle size and length constant
- If column length is increased, loading can be increased proportionally and retention time as well as backpressure will also increase.
- With scale up, change in hardware and flow cell may be required

**Figure 7.** Preparative Purification of Chlorogenic Acid




**Column:** Kinetex 5 µm XB-C18
**Dimensions:** 150 x 21.2 mm
**Part No.:** 00F-4605-P0-AX
**Mobile Phase:** A: 0.1 % TFA in Water
B: 0.1 % TFA in Acetonitrile
**Gradient:** 5 to 20 % B in 25 min
**Flow Rate:** 30 mL/min
**Temperature:** 25 °C
**Detection:** UV @ 330 nm
**Instrument:** Shimadzu® LC 20
**Injection Volume** 2 mL
**Sample:** 50 mg/mL in water

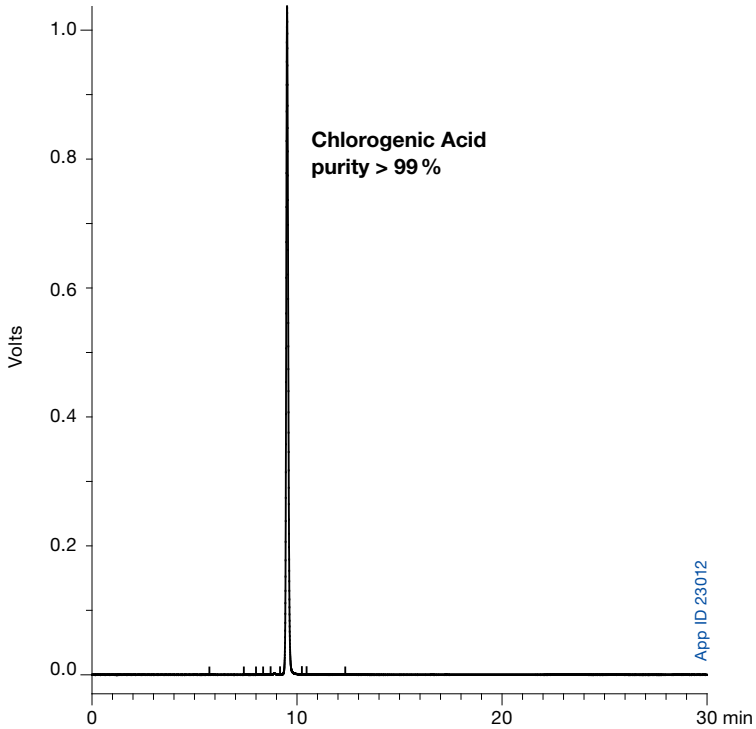
**Figure 8.** Purification Fractions Overlay




**Conditions:** Same as **figure 5**

**Instrument:** Shimadzu Prominence® LC

**Figure 9.** Purity for Pooled Fractions




**Conditions:** Same as **figure 5**

**Instrument:** Shimadzu Prominence LC

## Conclusion

With the release of Kinetex® core-shell 5 µm media, it is now possible to perform lab-scale purifications and as a result take advantage of core-shell technology for both analytical and preparative purposes.

Combination of Kinetex core-shell 5 µm particle and Axia™ patented packing technologies result in preparative columns with high efficiency in the range of 25-60 % greater than columns packed with fully porous media of equivalent particle size.

Scale up from analytical sub-2 µm to preparative columns in 8 different bonded phases is now feasible and readily available.

From green coffee extract, we were able to recover pure chlorogenic acid with purity of 99 % at 330 nm and a recovery of 40 % in one purification run using an Axia preparative column 150 x 21.2 mm ID. This can be scaled up further to a large format such as 250 x 30 mm ID for increased throughput and yield.

## References

1. F. Gritti and G. Guiochon *LC-GC*, **2012**, 30, 586-595.

2. F. Gritti and G. Guiochon *J. Chromatogr. A*, **2013**, 1230, 35–50.

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# APPLICATION

## Kinetex® Ordering Information

| 5 µm Minibore Columns (mm) | | | | | SecurityGuard™ ULTRA Cartridges‡ |
|---|---|---|---|---|---|
| Phases | 30 x 2.1 | 50 x 2.1 | 100 x 2.1 | 150 x 2.1 | 3/pk |
| EVO C18 | 00A-4633-AN | 00B-4633-AN | 00D-4633-AN | 00F-4633-AN | AJ0-9298 |
| Biphenyl | 00A-4627-AN | 00B-4627-AN | 00D-4627-AN | — | AJ0-9209 |
| XB-C18 | 00A-4605-AN | 00B-4605-AN | 00D-4605-AN | — | AJ0-8782 |
| C18 | 00A-4601-AN | 00B-4601-AN | 00D-4601-AN | 00F-4601-AN | AJ0-8782 |
| C8 | — | 00B-4608-AN | 00D-4608-AN | — | AJ0-8784 |
| Phenyl-Hexyl | — | 00B-4603-AN | 00D-4603-AN | — | AJ0-8788 |
| | | | | | for 2.1 mm ID |

| 5 µm MidBore™ Columns (mm) | | | | SecurityGuard ULTRA Cartridges‡ |
|---|---|---|---|---|
| Phases | 50 x 3.0 | 100 x 3.0 | 150 x 3.0 | 3/pk |
| EVO C18 | 00B-4633-Y0 | 00D-4633-Y0 | 00F-4633-Y0 | AJ0-9297 |
| Biphenyl | 00B-4627-Y0 | 00D-4627-Y0 | 00F-4627-Y0 | AJ0-9208 |
| XB-C18 | 00B-4605-Y0 | 00D-4605-Y0 | 00F-4605-Y0 | AJ0-8775 |
| C18 | 00B-4601-Y0 | 00D-4601-Y0 | 00F-4601-Y0 | AJ0-8775 |
| C8 | 00B-4608-Y0 | 00D-4608-Y0 | — | AJ0-8777 |
| Phenyl-Hexyl | 00B-4603-Y0 | 00D-4603-Y0 | — | AJ0-8781 |
| | | | | for 3.0 mm ID |

| 5 µm Analytical Columns (mm) | | | | | SecurityGuard ULTRA Cartridges‡ |
|---|---|---|---|---|---|
| Phases | 50 x 4.6 | 100 x 4.6 | 150 x 4.6 | 250 x 4.6 | 3/pk |
| EVO C18 | 00B-4633-E0 | 00D-4633-E0 | 00F-4633-E0 | 00G-4633-E0 | AJ0-9296 |
| Biphenyl | 00B-4627-E0 | 00D-4627-E0 | 00F-4627-E0 | 00G-4627-E0 | AJ0-9207 |
| XB-C18 | 00B-4605-E0 | 00D-4605-E0 | 00F-4605-E0 | 00G-4605-E0 | AJ0-8768 |
| C18 | 00B-4601-E0 | 00D-4601-E0 | 00F-4601-E0 | 00G-4601-E0 | AJ0-8768 |
| C8 | 00B-4608-E0 | 00D-4608-E0 | 00F-4608-E0 | 00G-4608-E0 | AJ0-8770 |
| Phenyl-Hexyl | 00B-4603-E0 | 00D-4603-E0 | 00F-4603-E0 | 00G-4603-E0 | AJ0-8774 |
| | | | | | for 4.6 mm ID |

| 5 µm Semi-Preparative Columns (mm) | | | SecurityGuard SemiPrep Cartridges*** |
|---|---|---|---|
| Phases | 150 x 10 | 250 x 10 | 10 x 10 |
| C18 | 00F-4601-N0 | 00G-4601-N0 | AJ0-9278 |
| Biphenyl | 00F-4627-N0 | 00G-4627-N0 | AJ0-9280 |
| | | | for 10 mm ID |

| 5 µm Axia™ Packed Preparative Columns (mm) | | | | | SecurityGuard PREP Cartridges* |
|---|---|---|---|---|---|
| Phases | 50 x 21.2 | 100 x 21.2 | 150 x 21.2 | 250 x 21.2 | 15 x 21.2 |
| EVO C18 | 00B-4633-P0-AX | 00D-4633-P0-AX | 00F-4633-P0-AX | 00G-4633-P0-AX | AJ0-9304 |
| Biphenyl | 00B-4627-P0-AX | 00D-4627-P0-AX | 00F-4627-P0-AX | 00G-4627-P0-AX | AJ0-9272 |
| XB-C18 | 00B-4605-P0-AX | 00D-4605-P0-AX | 00F-4605-P0-AX | 00G-4605-P0-AX | AJ0-9145 |
| C18 | 00B-4601-P0-AX | 00D-4601-P0-AX | 00F-4601-P0-AX | 00G-4601-P0-AX | AJ0-9145 |
| C8 | 00B-4608-P0-AX | 00D-4608-P0-AX | 00F-4608-P0-AX | 00G-4608-P0-AX | AJ0-9205 |
| Phenyl-Hexyl | 00B-4603-P0-AX | 00D-4603-P0-AX | 00F-4603-P0-AX | 00G-4603-P0-AX | AJ0-9147 |
| HILIC | — | 00D-4606-P0-AX | 00F-4606-P0-AX | 00G-4606-P0-AX | AJ0-9277 |
| | | | | | for 21.2 mm ID |

| 5 µm Axia Packed Preparative Columns (mm) | | | | | SecurityGuard PREP Cartridges** |
|---|---|---|---|---|---|
| Phases | 50 x 30 | 100 x 30 | 150 x 30 | 250 x 30 | 15 x 30 |
| EVO C18 | 00B-4633-U0-AX | 00D-4633-U0-AX | 00F-4633-U0-AX | 00G-4633-U0-AX | AJ0-9305 |
| Biphenyl | — | — | 00F-4627-U0-AX | — | AJ0-9273 |
| XB-C18 | 00B-4605-U0-AX | 00D-4605-U0-AX | 00F-4605-U0-AX | 00G-4605-U0-AX | AJ0-9204 |
| C18 | 00B-4601-U0-AX | 00D-4601-U0-AX | 00F-4601-U0-AX | 00G-4601-U0-AX | AJ0-9204 |
| C8 | 00B-4608-U0-AX | 00D-4608-U0-AX | 00F-4608-U0-AX | 00G-4608-U0-AX | AJ0-9217 |
| Phenyl-Hexyl | 00B-4603-U0-AX | 00D-4603-U0-AX | 00F-4603-U0-AX | 00G-4603-U0-AX | AJ0-9216 |
| | | | | | for 30 mm ID |

‡ SecurityGuard ULTRA Cartridges require holder, Part No.: AJ0-9000
* PREP SecurityGuard Cartridges require holder, Part No.: AJ0-8223
** PREP SecurityGuard Cartridges require holder, Part No.: AJ0-8277
*** SemiPrep SecurityGuard Cartridges require holder, Part No.: AJ0-9281

## Kinetex® Ordering Information

| 2.6 µm Minibore Columns (mm) | | | | | | SecurityGuard™ ULTRA Cartridges‡ |
|---|---|---|---|---|---|---|
| Phases | 30 x 2.1 | 50 x 2.1 | 75 x 2.1 | 100 x 2.1 | 150 x 2.1 | 3/pk |
| EVO C18 | 00A-4725-AN | 00B-4725-AN | — | 00D-4725-AN | 00F-4725-AN | AJ0-9298 |
| F5 | 00A-4723-AN | 00B-4723-AN | — | 00D-4723-AN | 00F-4723-AN | AJ0-9322 |
| Biphenyl | 00A-4622-AN | 00B-4622-AN | — | 00D-4622-AN | 00F-4622-AN | AJ0-9209 |
| XB-C18 | 00A-4496-AN | 00B-4496-AN | 00C-4496-AN | 00D-4496-AN | 00F-4496-AN | AJ0-8782 |
| C18 | 00A-4462-AN | 00B-4462-AN | 00C-4462-AN | 00D-4462-AN | 00F-4462-AN | AJ0-8782 |
| C8 | 00A-4497-AN | 00B-4497-AN | 00C-4497-AN | 00D-4497-AN | 00F-4497-AN | AJ0-8784 |
| HILIC | 00A-4461-AN | 00B-4461-AN | 00C-4461-AN | 00D-4461-AN | 00F-4461-AN | AJ0-8786 |
| Phenyl-Hexyl | 00A-4495-AN | 00B-4495-AN | 00C-4495-AN | 00D-4495-AN | 00F-4495-AN | AJ0-8788 |
| | | | | | | for 2.1 mm ID |

| 2.6 µm MidBore™ Columns (mm) | | | | | | SecurityGuard ULTRA Cartridges‡ |
|---|---|---|---|---|---|---|
| Phases | 30 x 3.0 | 50 x 3.0 | 75 x 3.0 | 100 x 3.0 | 150 x 3.0 | 3/pk |
| EVO C18 | — | 00B-4725-Y0 | — | 00D-4725-Y0 | 00F-4725-Y0 | AJ0-9297 |
| F5 | — | 00B-4723-Y0 | — | 00D-4723-Y0 | 00F-4723-Y0 | AJ0-9321 |
| Biphenyl | — | 00B-4622-Y0 | — | 00D-4622-Y0 | 00F-4622-Y0 | AJ0-9208 |
| XB-C18 | 00A-4496-Y0 | 00B-4496-Y0 | 00C-4496-Y0 | 00D-4496-Y0 | 00F-4496-Y0 | AJ0-8775 |
| C18 | 00A-4462-Y0 | 00B-4462-Y0 | 00C-4462-Y0 | 00D-4462-Y0 | 00F-4462-Y0 | AJ0-8775 |
| C8 | 00A-4497-Y0 | 00B-4497-Y0 | 00C-4497-Y0 | 00D-4497-Y0 | 00F-4497-Y0 | AJ0-8777 |
| HILIC | 00A-4461-Y0 | — | — | — | 00F-4461-Y0 | AJ0-8779 |
| Phenyl-Hexyl | — | 00B-4495-Y0 | — | 00D-4495-Y0 | 00F-4495-Y0 | AJ0-8781 |
| | | | | | | for 3.0 mm ID |

| 2.6 µm Analytical Columns (mm) | | | | | | SecurityGuard ULTRA Cartridges‡ |
|---|---|---|---|---|---|---|
| Phases | 30 x 4.6 | 50 x 4.6 | 75 x 4.6 | 100 x 4.6 | 150 x 4.6 | 3/pk |
| EVO C18 | — | 00B-4725-E0 | — | 00D-4725-E0 | 00F-4725-E0 | AJ0-9296 |
| F5 | — | 00B-4723-E0 | — | 00D-4723-E0 | 00F-4723-E0 | AJ0-9320 |
| Biphenyl | — | 00B-4622-E0 | — | 00D-4622-E0 | 00F-4622-E0 | AJ0-9207 |
| XB-C18 | — | 00B-4496-E0 | 00C-4496-E0 | 00D-4496-E0 | 00F-4496-E0 | AJ0-8768 |
| C18 | 00A-4462-E0 | 00B-4462-E0 | 00C-4462-E0 | 00D-4462-E0 | 00F-4462-E0 | AJ0-8768 |
| C8 | — | 00B-4497-E0 | 00C-4497-E0 | 00D-4497-E0 | 00F-4497-E0 | AJ0-8770 |
| HILIC | — | 00B-4461-E0 | 00C-4461-E0 | 00D-4461-E0 | 00F-4461-E0 | AJ0-8772 |
| Phenyl-Hexyl | — | 00B-4495-E0 | 00C-4495-E0 | 00D-4495-E0 | 00F-4495-E0 | AJ0-8774 |
| | | | | | | for 4.6 mm ID |

| 1.7 µm Minibore Columns (mm) | | | | | SecurityGuard ULTRA Cartridges‡ |
|---|---|---|---|---|---|
| Phases | 30 x 2.1 | 50 x 2.1 | 100 x 2.1 | 150 x 2.1 | 3/pk |
| EVO C18 | — | 00B-4726-AN | 00D-4726-AN | 00F-4726-AN | AJ0-9298 |
| F5 | — | 00B-4722-AN | 00D-4722-AN | 00F-4722-AN | AJ0-9322 |
| Biphenyl | — | 00B-4628-AN | 00D-4628-AN | 00F-4628-AN | AJ0-9209 |
| XB-C18 | 00A-4498-AN | 00B-4498-AN | 00D-4498-AN | 00F-4498-AN | AJ0-8782 |
| C18 | 00A-4475-AN | 00B-4475-AN | 00D-4475-AN | 00F-4475-AN | AJ0-8782 |
| C8 | 00A-4499-AN | 00B-4499-AN | 00D-4499-AN | 00F-4499-AN | AJ0-8784 |
| HILIC | 00A-4474-AN | 00B-4474-AN | 00D-4474-AN | — | AJ0-8786 |
| Phenyl-Hexyl | — | 00B-4500-AN | 00D-4500-AN | 00F-4500-AN | AJ0-8788 |
| | | | | | for 2.1 mm ID |

| 1.7 µm MidBore Columns (mm) | | | | SecurityGuard ULTRA Cartridges‡ |
|---|---|---|---|---|
| Phases | 30 x 3.0 | 50 x 3.0 | 100 x 3.0 | 3/pk |
| XB-C18 | 00A-4498-Y0 | 00B-4498-Y0 | 00D-4498-Y0 | AJ0-8775 |
| C18 | — | 00B-4475-Y0 | 00D-4475-Y0 | AJ0-8775 |
| C8 | 00A-4499-Y0 | 00B-4499-Y0 | 00D-4499-Y0 | AJ0-8777 |
| HILIC | — | 00B-4474-Y0 | — | AJ0-8779 |
| | | | | for 3.0 mm ID |

| 1.3 µm Minibore Columns (mm) | | |
|---|---|---|
| Phases | 30 x 2.1 | 50 x 2.1 |
| C18 | 00A-4515-AN | 00B-4515-AN |

‡SecurityGuard ULTRA Cartridges require holder, Part No.: AJ0-9000

guarantee

If Kinetex analytical columns do not provide you with at least equivalent separations to a competing column of the same phase, particle size, and dimensions, return the column with comparative data within 45 days for a FULL REFUND.

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