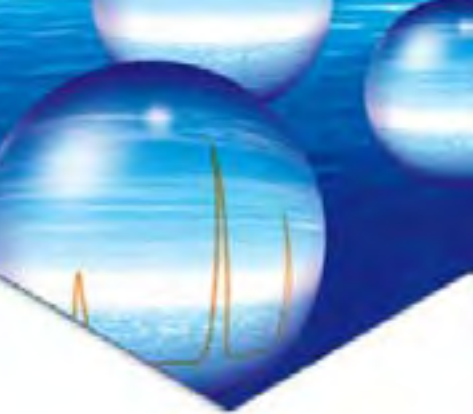




# *GreenSep™* *SFC Columns*

pharmaceutical • environmental • chemical • biochemical  
separation & purification





# GreenSep Innovative & Specifically Designed SFC Column Technologies

- *A Recognized Supplier of Quality SFC Columns*
- *Available in 1.8, 3 and 5 micron for Analytical and Preparative*
- *Comprehensive Technical and Method Development Assistance*
- *A Premium SFC Column Manufacturer Producing Highly Efficient Columns with Superior Reproducibility*
- *Extensive Capabilities to Produce State-of-the-Art Bonded Phase Chemistries*
- *The Experience to Provide the SFC Chromatographer with the Best in Column Technology*

## Supercritical fluid chromatography (SFC)

SFC is a “green” chromatographic technique where the main component of the mobile phase is CO<sub>2</sub> and is useful in the areas of preparative chromatography and rapid analysis chromatography. The use of CO<sub>2</sub> based mobile phases enables the use of high performance preparative columns (10 – 50 mm internal diameter) with a variety of particle sizes from 3 – 20 μm and results in the rapid separation and recovery for purified components. Many SFC separations have utilized “older normal phase HPLC types” of stationary phases such as unmodified silica, diol, amino and cyano. These phases are poorly adapted to SFC and present a number of limitations for SFC separation including low capacity, poor selectivity and poor peak shape.

GreenSep™ stationary phases, on the other hand, have been specifically engineered for SFC separations paying close attention to bonding coverage, density and all factors leading to high capacity phases which exhibit excellent selectivity and peak shape. GreenSep columns, available in 10 to 50 mm internal diameters, based on these phases have been designed to deliver high performance SFC separations. Columns from analytical to preparative sizes are available for all SFC phases including our new high performance 15mm ID columns and particle size from 3 – 20 μm.

### Available GreenSep Phases:

GreenSep Basic  
GreenSep HILIC  
GreenSep Nitro  
GreenSep DEAP  
GreenSep PFP

GreenSep Ethyl Pyridine  
GreenSep Ethyl Pyridine II  
GreenSep 4-Ethyl Pyridine  
GreenSep Pyridyl Amide  
GreenSep Naphthyl

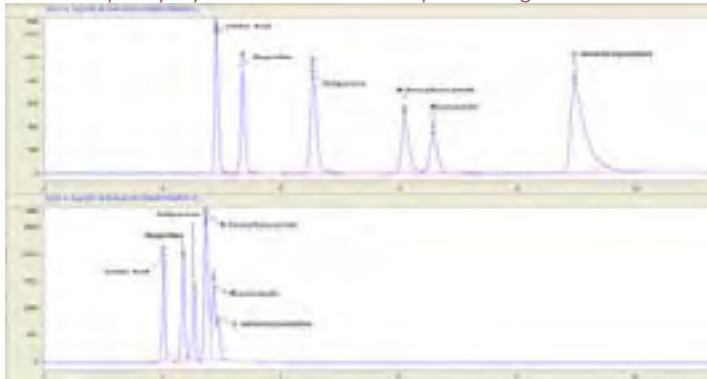
GreenSep Amino Phenyl  
GreenSep Amine  
GreenSep Cyano  
GreenSep Diol  
GreenSep Silica

## GreenSep Basic

GreenSep Basic exhibits a highly basic character and is ideally suited to high performance/high speed SFC preparative chromatography applications of chemicals containing amine groups. The chromatogram shown below contains chemicals that are functionalized with amine and acidic groups and is a prime example of the superior peak shape performance and separation capacity obtainable with the GreenSep Basic column. It also compares GreenSep Basic with GreenSep Ethyl Pyridine showing the superior retention on GreenSep Basic when compared to GreenSep Ethyl Pyridine.

GreenSep Basic 250 X 4.6 mm 5 μm Catalog # 155291-GS-BC

GreenSep Ethyl Pyridine 250 X 4.6 mm 5 μm Catalog # 155291-GS-PYE



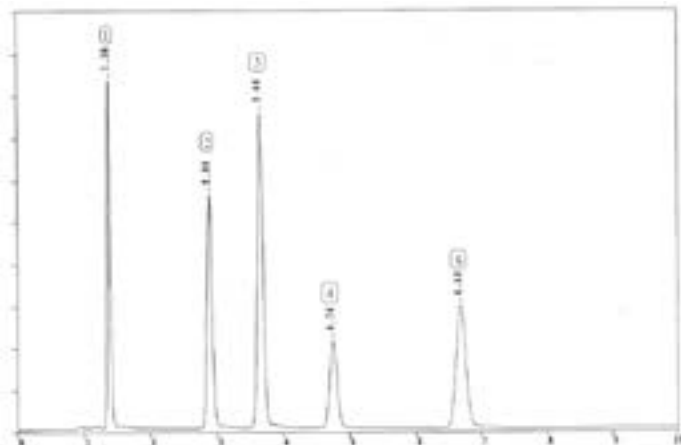
GreenSep Basic (upper) Conditions  
Mobile Phase: 10% MeOH in CO<sub>2</sub>  
Temperature: 25°C  
Flow Rate: 3 mL/min  
Detection: UV @ 254nm

GreenSep Ethyl Pyridine (lower) Conditions  
Mobile Phase: 10% MeOH in CO<sub>2</sub>  
Temperature: 25°C  
Flow Rate: 3 mL/min  
Detection: UV @ 254nm

## GreenSep DEAP

Unlike many SFC columns which require the addition of amine modifiers to the mobile phase to improve peak shape for basic compounds, GreenSep DEAP does not, greatly simplifying mobile phase composition and fraction collection. This makes GreenSep DEAP the SFC column of choice for the retention and rapid separation of chemical compounds containing strong amine groups.

GreenSep DEAP 250 X 4.6 mm 5  $\mu$ m Catalog # 155291-GS-DEAP



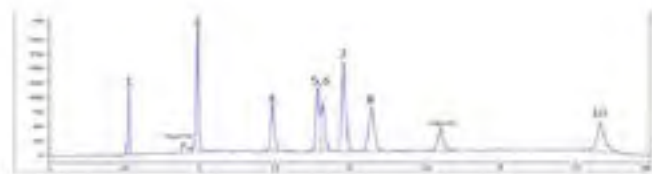
Mobile Phase: 5% - 40%  
MeOH in CO<sub>2</sub>  
Temperature: 40°C  
Flow Rate: 2.5 mL/min  
Detection: UV @ 254 nm

1. Caffeine
2. Thymine
3. Cytosine
4. Sulfamethoxazole
5. Sulfamethizole

## GreenSep HILIC

Is composed of a polyhydroxylated polymer that is coated and bound to silica. This composition provides hydroxyl levels, that are well above conventional silica and diol type stationary phases, and permits higher loading. The chromatogram below is an example of the superior separation performance obtainable for chemicals containing a variety of functional groups with the GreenSep HILIC column.

GreenSep HILIC 250 X 4.6 mm 5  $\mu$ m Catalog # 155291-GS-HILIC



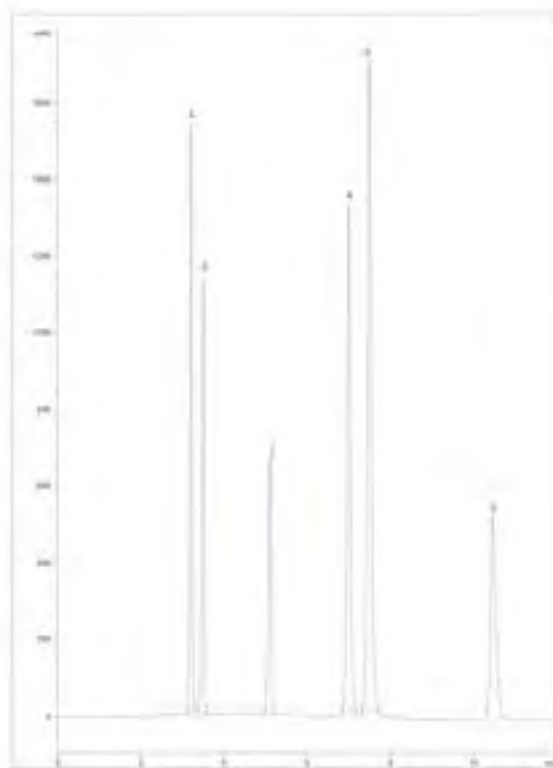
Mobile Phase: 4% - 40%  
Gradient MeOH in CO<sub>2</sub> (0.1% NH<sub>4</sub>OH) over 15 minutes, 2.5 minute hold at 40% Methanol  
Temperature: 40°C  
Flow Rate: 3 mL/min  
Detection: UV @ 254nm

1. N-benzylidene-1-naphthylamine
3. Noscapine
4. Trimipramine
5. Amitriptyline
6. Clomipramine
7. 1-aminoisoquinoline
8. Nortriptyline
10. 3,4-diaminopyridine

## GreenSep Ethyl Pyridine II

The column ideally suited for the retention and rapid separation of chemicals containing acidic groups. The chromatogram below shows the separation of chemicals that contain acidic groups and demonstrates the retention and separation capability that GreenSep Ethyl Pyridine II can deliver for the SFC chromatographer.

GreenSep Ethyl Pyridine II  
250 X 4.6 mm 5  $\mu$ m Catalog # 155291-GS-PYEII



Mobile Phase: 5% - 50%  
MeOH in CO<sub>2</sub> over  
10 minutes, 2 minute  
hold at 50% Methanol  
Temperature: 25°C  
Flow Rate: 3 mL/min  
Detection: UV @ 220 nm

1. Sorbic Acid
2. Ibuprofen
3. Ketoprofen
4. 4-Hydroxy-Benzoic Acid
5. 3-Hydroxy-Benzoic Acid
6. Niflumic Acid

For ordering information please see Page 7.

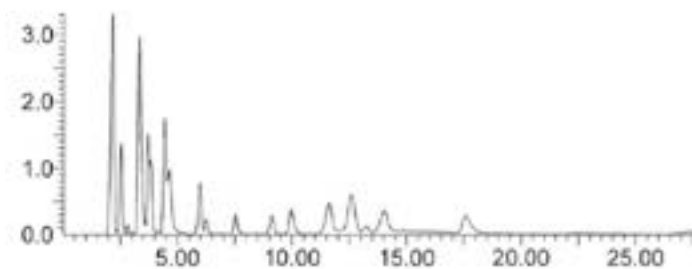




## GreenSep Silica

A metal free, ultra high purity chromatographic media that is pressure stable and specifically engineered for high performance SFC separations. The surface is treated to produce optimum SFC separation interactions and loading capacity while maintaining superior peak shape performance for many chemicals. GreenSep Silica is available for analytical and preparative column formats in particle sizes from 1.8 µm to 20 µm.

GreenSep Silica 250 X 4.6 mm 5 µm Catalog # 155291-GS-SI



Mobile Phase: 15% MeOH in CO<sub>2</sub> Temperature: 25°C  
 Flow Rate: 3 mL/min Detection: PDA

1. Benzyl Benzoate	8. Antipyrine
2. Naphthalene	9. Oxprenolol
3. 2-Nitrophenol	10. N-Benzylbenzamide
4. 4-Nitrotoluene	11. Niacinamide
5. Caffeine	12. 1-Aminoisoquinoline
6. Sorbic Acid	13. Propanolol
7. Ibuprofen	14. Ketoprofen
15. Hypoxanthine	16. 4-Hydroxybenzoic Acid

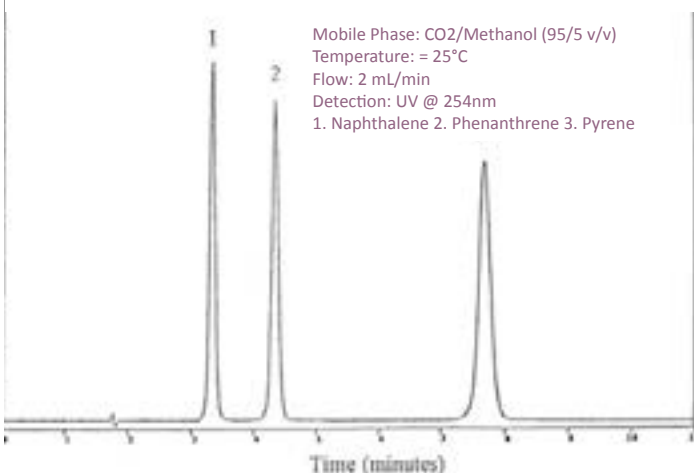
## GreenSep Naphthyl

A naphthalene based SFC material, with high bonding density and intrinsic base deactivation due to a rigid structure that also enables the shape selectivity needed for many diastereomeric separations. It also exhibits strong  $\pi$ - $\pi$  interaction and charge transfer interactions and performs well for diastereomers separations and non-polar compounds. The unique properties of GreenSep Naphthyl place its selectivity between graphitized carbon and alkyl type stationary phases.

## GreenSep PFP

Specifically designed for the separation of geometrical isomers as well as diastereomers. It is the column of choice in separating compounds that contain aromatic groups, polarizable electrons and conjugate systems. In addition, GreenSep PFP is useful for the separation of halogenated compounds. In many cases GreenSep PFP provides orthogonal separations when compared to GreenSep Nitro. GreenSep PFP is unsurpassed for its separation capabilities and is available in analytical columns, preparative columns and bulk media.

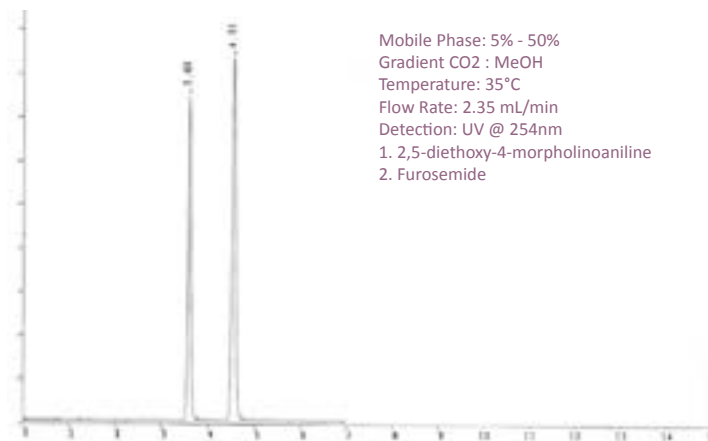
GreenSep PFP 250 X 4.6 mm 5 µm Catalog # 155291-GS-PFP



## GreenSep Pyridyl Amide

The type of chemicals separated on a GreenSep Pyridyl Amide column would normally require the addition of TFA or an amine to the mobile phase as a peak shape modifier; however GreenSep Pyridyl Amide does not require this addition. Ideal for chemicals that contain both basic amine and acidic groups, as shown in the chromatogram below, GreenSep Pyridyl Amide provides flexibility for the SFC chromatographer with mobile phase composition and fraction collection greatly simplified without the use of amino additives.

GreenSep Pyridyl Amide 150 X 4.6 mm 5 µm Catalog # 135291-GS-PYA





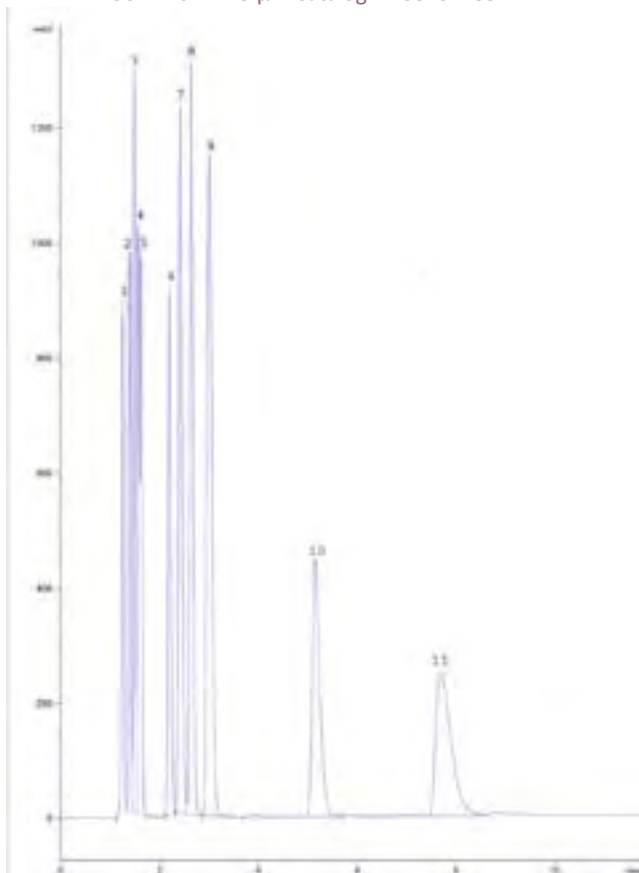
## GreenSep Ethyl Pyridine

The type of chemicals separated on a GreenSep Ethyl Pyridine column would normally require the addition of an amine to the mobile phase as a peak shape modifier; however GreenSep Ethyl Pyridine does not require this addition. Ideal for chemicals that are functionalized with strong amine groups, GreenSep Ethyl Pyridine provides flexibility for the SFC chromatographer with mobile phase composition and fraction collection greatly simplified without the use of amino additives.

## GreenSep 4-Ethyl Pyridine

GreenSep 4-Ethyl Pyridine is an alternative to and provides different selectivity to GreenSep Ethyl Pyridine (2-ethyl pyridine). The chromatogram below shows the separation of chemicals such as ibuprofen, ketoprofen and niflumic acid, without peak shape modifiers, and is a prime example of the superior peak shape performance obtainable with the GreenSep 4-Ethyl Pyridine column.

GreenSep 4-Ethyl Pyridine  
250 X 4.6 mm 5  $\mu$ m Catalog # 135291-GS-PYE4



Mobile Phase: 15% MeOH in CO<sub>2</sub>  
Temperature: 25°C  
Flow Rate: 3 mL/min  
Detection: PDA

- |                   |                      |
|-------------------|----------------------|
| 1. Butyl Benzoate | 6. Ibuprofen         |
| 2. Naphthalene    | 7. Antipyrine        |
| 3. 2-Nitrophenol  | 8. N-Benzylbenzamide |
| 4. 4-Nitrotoluene | 9. Niacinamide       |
| 5. Caffeine       | 10. Ketoprofen       |
|                   | 11. Niflumic Acid    |

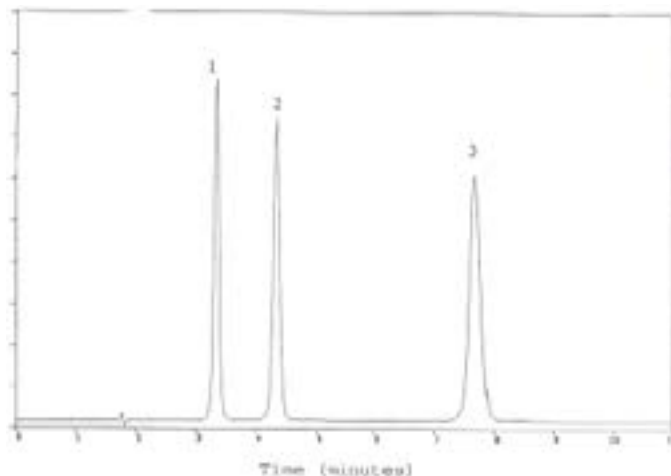
## GreenSep Amino Phenyl

A specialty SFC stationary phase that has proven superior to conventional stationary phases in the areas of separation selectivity and loading capacity which was designed for the separation of amines, alcohols and acids by SFC without the use of additives. Works well in Normal Phase mixed mode offering  $\pi$ - $\pi$  interaction and exhibits good base deactivation.

## GreenSep Nitro

Is a specifically designed SFC material for the separation of geometrical isomers and diastereomers. It is the column of choice in separating compounds that contain double bonds, aromatic groups, polarizable electrons and conjugated systems and exhibits a strong charge transfer system. GreenSep Nitro is unsurpassed for its separation capabilities and is available in analytical columns, preparative columns and bulk media.

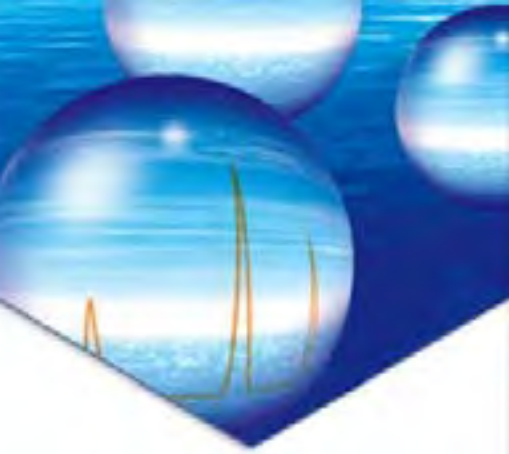
GreenSep Nitro 250 X 4.6 mm 5  $\mu$ m Catalog # 155291-GS-NO2



Mobile Phase: 5% - 40%  
Gradient CO<sub>2</sub> : MeOH  
Temperature: 35°C  
Flow Rate: 2 mL/min  
Detection: UV @ 254nm  
1. Flavone  
2. Coumarin  
3. Cytosine

For ordering information please see Page 7.





### GreenSep Diol

A specialty phase designed for SFC with a high density Diol surface coverage which ensures separations better and more reproducible than conventional unbonded silica. GreenSep Diol is particularly suitable for acidic and basic analytes.

### GreenSep Amine

Is a high density NH<sub>2</sub> bonded material designed specifically for SFC which offers higher loading for preparative uses.

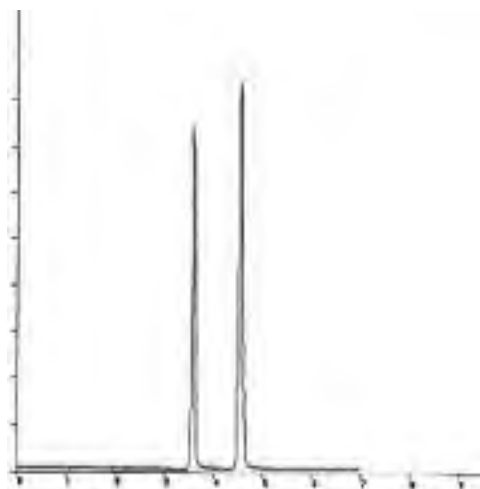
### GreenSep Cyano

Is a high surface area Cyano bonded material designed for SFC resulting in a high surface area loading.

### GreenSep GCS

The GreenSep GCS employs hardware specifically designed for SFC and is packed with highly deactivated high performance silica particles and is designed to maintain the chro-

matographic integrity of the system. For ease of use the GreenSep GCS is packaged with a high performance coupler for attachment to the SFC chromatographic column. A chromatogram using a GreenSep GCS with a GreenSep Pyridyl Amide preparative column is shown opposite which shows the peaks in the chromatogram are unaffected by the introduction of the high performance GreenSep GCS guard column.



Mobile Phase: 5% - 50% Gradient CO<sub>2</sub>:MeOH  
Temperature: 35°C  
Flow Rate: 20 mL/min  
Detection: UV @ 254nm  
1. 2,5-diethoxy-4-morpholinoaniline  
2. Furosemide

matographic integrity of the system. For ease of use the GreenSep GCS is packaged with a high performance coupler for attachment to the SFC chromatographic column. A chromatogram using a GreenSep GCS with a GreenSep Pyridyl Amide preparative column is shown opposite which shows the peaks in the chromatogram are unaffected by the introduction of the high performance GreenSep GCS guard column.

### Column Packing and Hardware

One of the most important parts of the whole SFC column production sequence is the packing of the column. Over the last 35 years of column production, we have developed and refined techniques for packing columns and now utilize the most advanced column packing technology in the industry. This technology enables us to pack the finest columns available. A significant part of our superior packing technology resides in unsurpassed column hardware where only end fittings and column tubing of the highest quality and performance are acceptable. Stainless steel column tubing with highly polished, mirrored finished internal bores are used. As a result, the chromatographer can be confident that they are receiving the highest quality column hardware in the industry.

### Testing

Every step of our column production sequence is strictly monitored and controlled by an extensive battery of tests which are applied to all steps including silica particle formation, bonding reagents and reactions, column hardware, and packing which ensure the quality of the final product - with each test designed to measure a customer-critical parameter.

The final batch test for each product has been carefully designed and tailored to test the performance standard set for each phase and each column is tested individually to check the integrity and performance of the packed bed.

### Guaranteed Performance

Every ES Industries column is guaranteed to deliver the highest plate counts and most symmetrical peaks for even the most difficult analysis. We are confident the GreenSep line of products will deliver the highest quality and most reliable SFC columns available to you.

<b>GreenSep Columns for SFC - Ordering Information</b>					
<b>Description</b>	<b>Analytical (100 x 4.6 mm)</b>	<b>Analytical (150 x 4.6 mm)</b>	<b>Analytical (250 x 4.6 mm)</b>	<b>Semi-Preparative (250 x 20 mm ID)</b>	<b>Preparative (250 x 30 mm ID)</b>
<b>3 micron</b>					
GreenSep Amino Phenyl	125191-GS-APH	135191-GS-APH			
GreenSep Basic	125191-GS-BC	135191-GS-BC			
GreenSep Cyano	125191-GS-CN				
GreenSep DEAP	125191-GS-DEAP	135191-GS-DEAP			
GreenSep Diol	125191-GS-D				
GreenSep Ethyl Pyridine	125191-GS-PYE	135191-GS-PYE			
GreenSep Ethyl Pyridine II	125191-GS-PYE-II				
GreenSep 4-Ethyl Pyridine	125191-GS-PYE4				
GreenSep HILIC	125191-GS-HILIC				
GreenSep Nitro	125191-GS-NO2	135191-GS-NO2			
GreenSep PFP	125191-GS-PFP	135191-GS-PFP			
GreenSep Pyridyl Amide	125191-GS-PYA	135191-GS-PYA			
GreenSep Silica	125191-GS-SI	135191-GS-SI			
<b>5 micron</b>					
GreenSep Amino Phenyl		135291-GS-APH	155291-GS-APH	158291-GS-APH	15N291-GS-APH
GreenSep Basic		135291-GS-BC	155291-GS-BC	158291-GS-BC	15N291-GS-BC
GreenSep Cyano		135291-GS-CN	155291-GS-CN	158291-GS-CN	15N291-GS-CN
GreenSep DEAP		135291-GS-DEAP	155291-GS-DEAP	158291-GS-DEAP	15N291-GS-DEAP
GreenSep Diol		135291-GS-D	155291-GS-D	158291-GS-D	15N291-GS-D
GreenSep Ethyl Pyridine		135291-GS-PYE	155291-GS-PYE	158291-GS-PYE	15N291-GS-PYE
GreenSep Ethyl Pyridine II		135291-GS-PYE-II	155291-GS-PYE-II	158291-GS-PYE-II	15N291-GS-PYE-II
GreenSep 4-Ethyl Pyridine		135291-GS-PYE4	155291-GS-PYE4	158291-GS-PYE4	15N291-GS-PYE4
GreenSep HILIC		135291-GS-HILIC	155291-GS-HILIC	158291-GS-HILIC	15N291-GS-HILIC
GreenSep Nitro		135291-GS-NO2	155291-GS-NO2	158291-GS-NO2	15N291-GS-NO2
GreenSep PFP		135291-GS-PFP	155291-GS-PFP	158291-GS-PFP	15N291-GS-PFP
GreenSep Pyridyl Amide		135291-GS-PYA	155291-GS-PYA	158291-GS-PYA	15N291-GS-PYA
GreenSep Silica		135291-GS-SI	155291-GS-SI	158291-GS-SI	15N291-GS-SI
<b>GreenSep SFC Guard Column &amp; Coupler</b>					
For use with 10 mm ID SFC column	400107	400107	400107		
For use with 20 mm ID SFC column				400108	
For use with 30 mm ID SFC column					400109
<b>Stainless Steel High Pressure Pre-Column/Column Coupler Assembly for SFC</b>					
5 cm X .005" X 1/16" (Red Band) for use with 3.0 - 15 mm ID SFC column/guard	300107	300107	300107		
5 cm X .007" X 1/16" (Black Band) for use with 20 mm ID SFC column/guard				300108	
5 cm X .010" X 1/16" (Blue Band) for use with 30 mm ID SFC column/guard					300109

*Other innovative products available from ES Industries:*

- *Chiral Columns and Media*
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- *State of the art Reverse Phase HPLC Columns*
- *Unique Reverse Phase HPLC Columns*
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- *Phenyl Columns*



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