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HyPURITY® Columns
TG01-11

Columns with star performance

• Analyze • Detect • Measure • Control™

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HyPURITY Columns Introduction

Thermo Electron Corporation is dedicated to the design and manufacture of high quality HPLC media and columns. Over 20 years of experience has resulted in the development of an excellent quality program and certification with ISO9001:2000. The HyPURITY family, launched in 1995, has established new standards in column characterization and validation.

The quality assurance program has a variety of highly diagnostic chromatographic tests for the investigation of both primary and secondary interactions, ensuring exceptional column-to-column and batch-to-batch reproducibility. The range of stationary phases bonded to the HyPURITY silica includes C18, C8, C4, Cyano and the unique HyPURITY ADVANCE™ and HyPURITY AQUASTAR™ phases. Physical properties are outlined in table 1.

HyPURITY ADVANCE is a polar embedded phase which provides excellent performance for compounds showing poor peak shape with traditional alkyl bonding. HyPURITY AQUASTAR is a polar end-capped phase which provides outstanding retention for polar compounds and is ideal for LC/MS applications as it does not bleed under routine analysis conditions. Both phases also provide the opportunity for alternate selectivity to traditional C18 chemistries. This is useful particularly for closely eluting or co-eluting analyte separations (figure 1). More information on HyPURITY AQUASTAR can be found in this guide and in depth information on HyPURITY ADVANCE can be found in Technical Guide TG01-09.

Packing	Particle Size	Surface Area (m^2/g)	Pore Size (Å)	% Carbon
C18	3 and 5µm	200	190	13%
C8	5µm	200	190	8%
C4	5µm	200	190	4.5%
Cyano	5µm	200	190	4%
HyPURITY ADVANCE	3 and 5µm	200	190	9%
HyPURITY AQUASTAR	3 and 5µm	200	190	10%

table 1 - HyPURITY Phase Characteristics

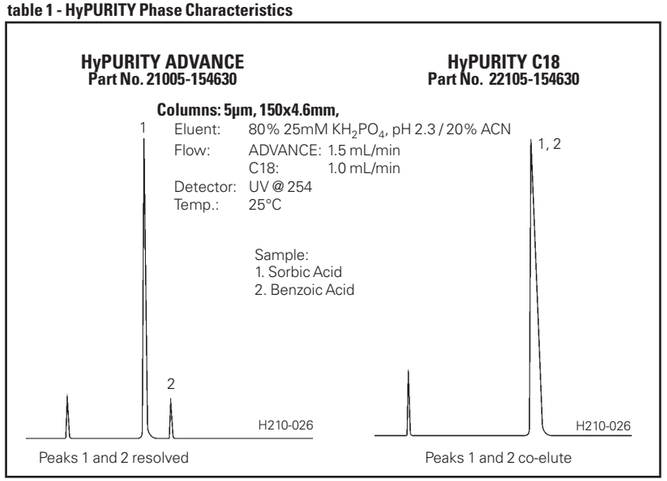


figure 1 - HyPURITY ADVANCE Compared to HyPURITY C18: Benzoic and Sorbic Acids

HyPURITY C18 Columns

The Ultimate in Chromatographic Validation

A series of physical and chromatographic studies have been developed to fully characterize the chromatographic surface of the HyPURITY C18 packing material. The chromatographic probes employed are designed to cover the broad range of possible analyte/stationary phase surface interactions, and have been chosen only after an in-depth literature survey and extensive consultation.

Most current HPLC column manufacturers offer some evidence of stationary phase characterization in terms of physical properties and/or information on column performance, such as efficiency and peak shape parameters. There is little information offered with respect to quality control procedures for batch-to-batch or column-to-column reproducibility.

The following chromatographic tests are used to fully characterize the chromatographic properties of every batch of HyPURITY C18 packing material:

- Steric selectivity
- Hydrophobicity
- Hydrogen bonding
- Ion exchange capacity
- Analysis of bases at pH 7
- Analysis of acids, alcohols and chelators

Every column is tested for efficiency, peak shape and capacity factor. A brief introduction to each of the tests is presented in Table 2. More detailed information is provided in the discussion that follows.

Test	Characteristic Tested	Method
Steric selectivity	Phase selectivity	Relative retention of polyaromatic hydrocarbons
Hydrophobicity	Hydrophobic character and surface coverage of bonded phase	Retention and selectivity of non-polar hydrocarbons
Hydrogen bonding capacity	Measure of residual silanol groups at	Selectivity factor of caffeine relative silica surface to phenol
Ion exchange capacity at pH 2.7 Ion exchange capacity at pH 7.6	Peak tailing caused by ion exchange sites Peak tailing caused by ion exchange and dissociated silanol sites	Retention of benzylamine Retention of benzylamine
Analysis of bases at pH 7	Effect of dissociated silanols on basic analytes	Analysis of tricyclic antidepressants, alpha selectivity parameters
Analysis of chelators	Peak tailing caused by active metal/silanol sites and analyte selectivity sensitive to changes in surface silanol content	Chromatography of acids and chelators

table 2 - chromatographic tests are used to fully characterize the chromatographic properties

Steric Selectivity
Steric selectivity refers to the ability of the stationary phase to recognize and differentiate between molecules with similar structures but different shapes. The nature and orientation of the alkyl ligand (e.g. C18) can effect the extent to which steric selectivity plays a part in a separation. Steric selectivity is often indicative of the surface coverage of the bonding chemistry, and also provides a characteristic by which different HPLC packings can be compared.

Sander and Wise[1] have shown that compounds of similar size and functionality, such as polyaromatic hydrocarbons, may differ in their retention characteristics due to their relative ability to bend and twist out of shape. o-Terphenyl and triphenylene have been selected as probes because the former has the ability to twist and bend while the latter has a fairly rigid structure and will be retained quite differently. A measure of the relative retention of these compounds is indicative of the steric selectivity of the HyPURITY C18 phase (figure 2).

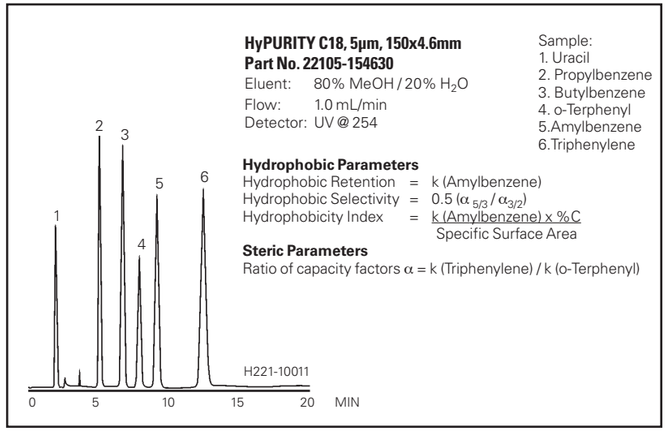


figure 2 - Steric Selectivity and Hydrophobicity Test

Hydrophobicity
The test probes used to determine the hydrophobicity characteristics of HyPURITY packings have been combined with those of the steric selectivity test. Various hydrophobic parameters are measured by comparative retention of a series non-polar hydrocarbons (alkylbenzenes). In a simple binary eluent of methanol and water, the capacity factors of amylbenzene, 1-butyl benzene and n-propylbenzene give a broad measure of hydrophobic retention and selectivity.

Individual packing materials have different levels of bonded phase coverage and specific surface area.

The hydrophobicity index gives a measure of hydrophobic coverage that relates all the factors that can contribute to the overall hydrophobic retention in a column, including surface area, %carbon and chromatographic retention of amylbenzene. The hydrophobicity index provides an indication of the hydrophobic character of the column per unit area.

To quantify these measures of hydrophobicity in the HyPURITY C18 phase the following calculations are made:

(a) **Hydrophobic Retention** = k (amylbenzene)
(b) **Hydrophobic Selectivity** = 0.5 α (amylbenzene, 1-butylbenzene) / α (1-butylbenzene, n-propylbenzene)
(c) **Hydrophobicity Index** = $\frac{k\ (amylbenzene) \times \%C}{\text{specific surface area}}$

where %C is the percentage carbon loading as measured by the Finnigan™ FLASH EA™ 112 Series Carbon Analyzer. A typical % carbon value for the HyPURITY C18 packing material is 13%.

Hydrogen Bonding Capacity
The retention of caffeine is normalized against the retention of phenol to provide an indication of residual silanol groups and hydrogen bonding interactions that can occur at the silica surface[2].

The separation factor k (caffeine) / k (phenol) = α (caffeine / phenol) will vary depending on the hydrogen bonding capacity of the phase.

An α (caffeine / phenol) > 0.6 is said to represent a high capacity for hydrogen bonding, and an a (caffeine / phenol) < 0.6 is said to represent low hydrogen bonding capacity. Phenol is used only as a marker in this test and eliminates other column effects when the caffeine capacity factor is measured relative to it.

The test is sensitive for the reproducibility of the C18 bonding process, and provides a useful measure of the hydrogen bonding capacity available for analyte interactions. Figure 3 shows a typical chromatogram of the hydrogen bonding capacity test.

Ion Exchange Capacity
Tanaka et al[2] showed that the retention of protonated amines at pH< 3 could be used to determine a measure of the ion exchange sites on the silica surface. The majority of silanol groups (Si-OH) are undissociated at pH< 3, and therefore do not contribute to the retention of protonated amines. Acidic silanols still remaining on the silica surface will be in the dissociated form (SiO-). These acidic silanols contribute to the retention of protonated amines by ion exchange. At pH > 7, all of the surface silanol groups are dissociated to form ion exchange sites that increase the retention of protonated amines. To accurately determine the ion exchange character of a bonded phase, retention of amines should be measured at both high and low pH.

The retention of benzylamine is measured and normalized with respect to phenol at pH values of 2.7 and 7.6 to investigate the ion exchange behavior of the HyPURITY C18 phase. Measuring the relative retention of benzylamine in this way shows important ion exchange characteristics of the packing that can be measured on a batch-to-batch basis in order to ensure reproducibility.

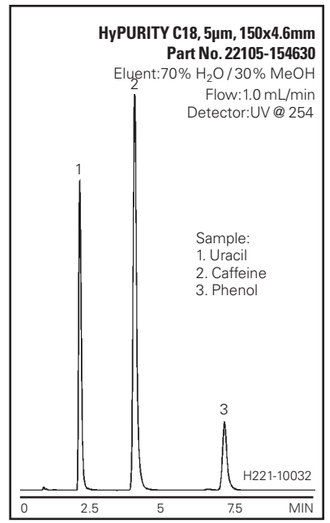


figure 3 - Hydrogen Bonding Capacity

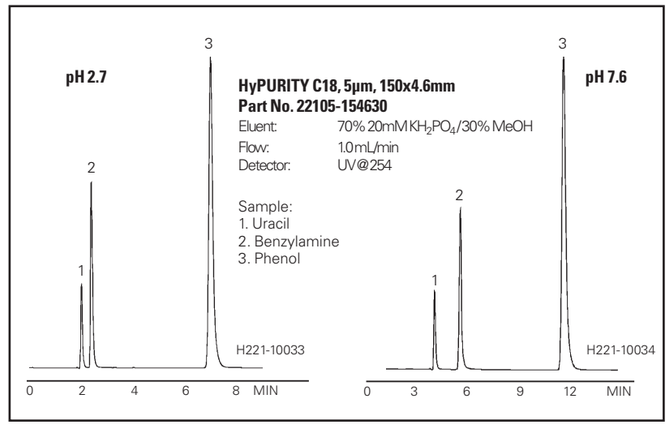


figure 4 - Ion Exchange Quality Assurance Test

Basic Analytes
The analysis of basic compounds such as tricyclic antidepressants (TCAs) that are notorious for poor peak shapes and irreversible adsorption provides a further test to ensure lot-to-lot reproducibility. To further challenge the performance of the HyPURITY C18 phase, the analytes are run at pH 7 where traditional C18 packings typically show poor performance for these analytes.

The HyPURITY C18 column provides good peak shape and resolution of all the analytes. The high surface coverage and minimal ion exchange interactions of the phase contribute to the excellent peak shape and chromatographic performance illustrated in figure 5.

The capacity factor of these solutes is indicative of the overall performance of the column. A shift in peak retention can easily result from any of the secondary interactions already highlighted in the previous tests, and consequently the TCA test is a very sensitive one.

Analysis of Acids, Alcohols and Chelators
Surface metal interaction can cause changes in selectivity or peak shape for solutes which are able to chelate. Euerby *et al*[β] have shown that the presence of metals arise not only from the base silica itself but also from the column hardware. Contributions from the latter depend greatly on the conditions under which the column is stored. A useful chromatographic test used to identify the presence of metal ions in the column is to compare the peak symmetry of two regioisomers, 2,3- and 2,7-dihydroxynaphthalene

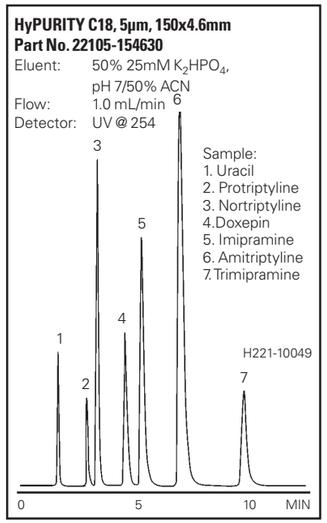


figure 5 - Basic Analyte Quality Control Test

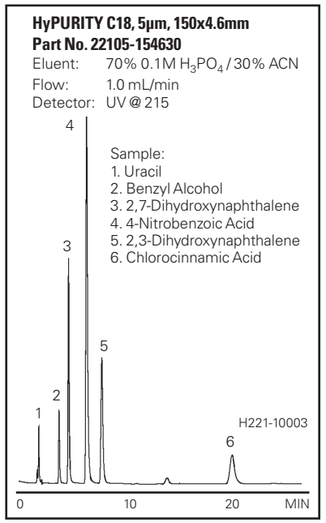


figure 6 - Acids and Chelators

(DHN). The former possesses the ability to chelate while the latter does not. The closer the ratio of the peak symmetries of the 2,7 / 2,3-dihydroxynaphthalene is to 1.0, the lower the metal content.

A mixture of acids, alcohols and chelators is employed to illustrate the applicability of the HyPURITY C18 packing for a wide range of acidic and chelating analytes, where both chelating interactions and hydrogen bonding secondary interactions are possible. If not carefully controlled, both interactions will cause changes to the overall selectivity of the column or performance in terms of peak shape.

Figure 6 shows the separation of acids, alcohols and chelators on a HyPURITY C18 column.

Reproducibility
Each lot of HyPURITY C18 packing must conform to a range of specifications for quality control. The reproducibility of each lot test is then monitored on an ongoing basis.

Figure 7 shows the reproducibility of %carbon observed for 27 batches of HyPURITY C18 packing manufactured over the last three years. The %carbon is measured by Leco Carbon analyzer and is accurate to within plus or minus 0.1%. Note the continuous tightening of the results over the last year, indicating Thermo Electron's strong commitment to continuous improvement of product quality.

Figure 8 illustrates batch-to-batch reproducibility for two of the more sensitive chromatographic selectivity parameters. Only once a batch has passed all the Quality Assurance specifications can it be used for column packing. In this example capacity factors for four of the test analytes (from the acid and chelator test) are used to calculate alpha values. These are then recorded and must conform to a narrow window of specification.

Alpha values represent a ratio of capacity factors (k values measured for two different analytes within a given test mixture). In figure 7 the alpha values measured are a (4/3) and a (6/5).

Where

$$\alpha\ (4/3) = \frac{k\ (4\text{-Nitrobenzoic acid})}{k\ (2,7\text{-Dihydroxynaphthalene})}$$

$$\alpha\ (6/5 = \frac{k\ (\text{Chlorocinnamic acid})}{k\ (2,3\text{-Dihydroxynaphthalene})}$$

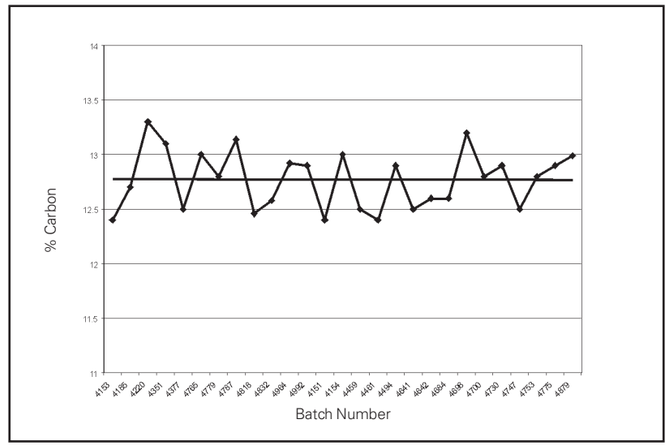


figure 7 - 5µm HyPURITY C18 - Batch to Batch Reproducibility - % Carbon

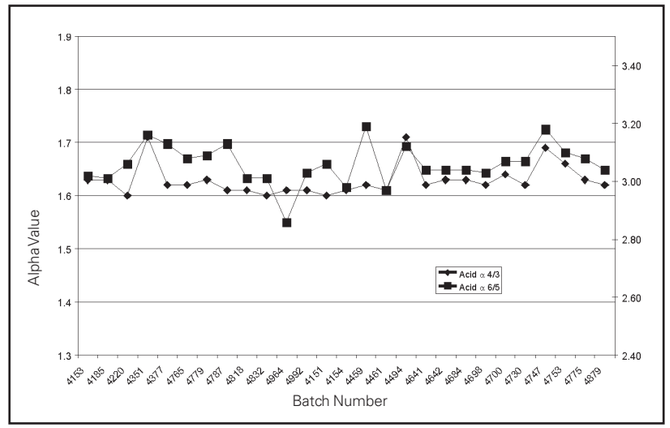


figure 8 - 5µm HyPURITY C18 - Batch to Batch Reproducibility - Selectivity of Acids

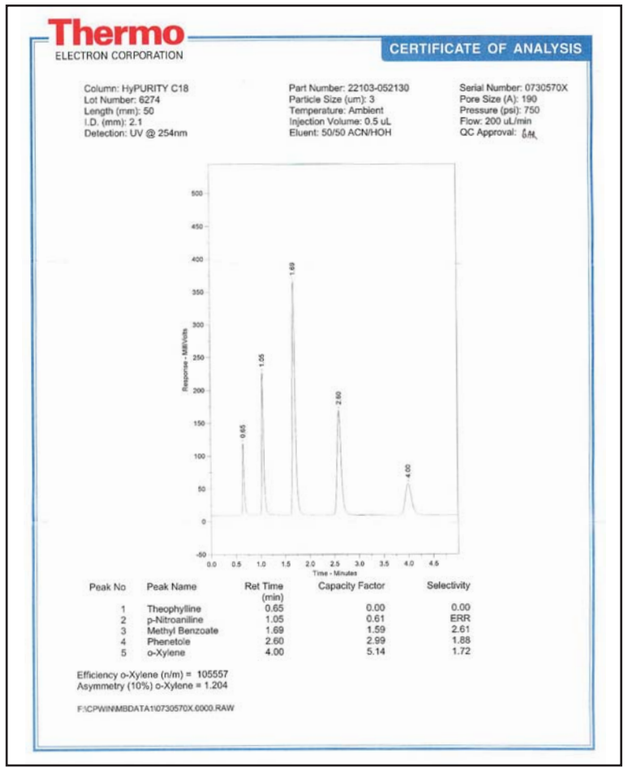
After each lot of HyPURITY C18 packing material has passed all specifications, it is suitable to be packed into columns. Packed columns undergo additional chromatographic testing to ensure the column has been packed efficiently and that it meets only the highest standards. A typical certificate of analysis for this testing is given in figure 9.

References:

1. Sander and Wise, Synthesis and Characterization of Polymeric C18 Stationary Phases for Liquid Chromatography, Anal. Chem, 56 (1984) 504-510

2. K. Kimata, K. Iwaguchi, S. Onishi, K. Jinno, R. Eksteen, K. Hosoya, M. Araki and N. Tanaka, Journal of Chromatographic Science, 27, 721-728(1989)

3. M.R. Euerby, C.M. Johnson, I.D. Rushin, D.A.S.S. Tennekoon, Journal of Chromatography A, 705 (2), 229-245 (17) – (1995)



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CERTIFICATE OF ANALYSIS

Column: HyPURITY C18
Lot Number: 6274
Length (mm): 50
I.D. (mm): 2.1
Detection: UV @ 254nm

Part Number: 22103-052130
Particle Size (um): 3
Temperature: Ambient
Injection Volume: 0.5 uL
Eluent: 50/50 ACN/HOH

Serial Number: 0730570X
Pore Size (A): 190
Pressure (psi): 750
Flow: 200 uL/min
QC Approval:

Peak No	Peak Name	Ret Time (min)	Capacity Factor	Selectivity
1	Theophylline	0.65	0.00	0.00
2	p-Nitroaniline	1.05	0.61	ERR
3	Methyl Benzoate	1.69	1.59	2.61
4	Phenetole	2.60	2.99	1.88
5	o-Xylene	4.00	5.14	1.72

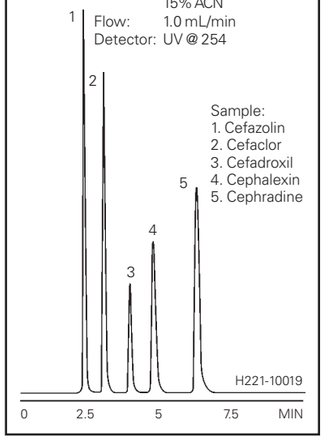
Efficiency o-Xylene (n/m) = 105557
Asymmetry (10%) o-Xylene = 1.204

F:\CPWIN\MBDATA\10730570X.6000.RAW

figure 9 - Sample Certificate of Analysis for HyPURITY C18 columns

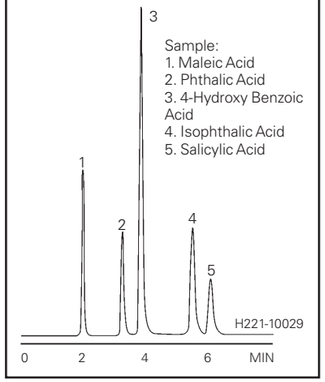
Cephalosporin Antibiotics

HyPURITY® C18, 5µm, 150x4.6mm
Part No. 22105-154630
Eluent: 85% 0.5% CH_3COOH / 15% ACN
Flow: 1.0 mL/min
Detector: UV @ 254



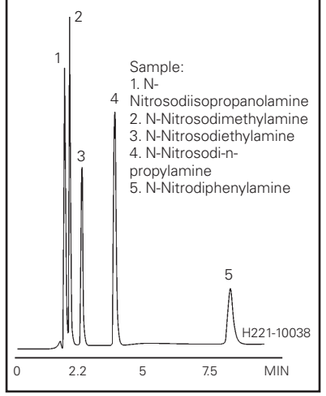
Fungicides / Preservatives

HyPURITY C18, 5µm, 150x4.6mm
Part No. 22105-154630
Eluent: 67% 25mM KH_2PO_4, pH 3.35 33% MeOH
Flow: 1.0 mL/min
Detector: UV @ 210



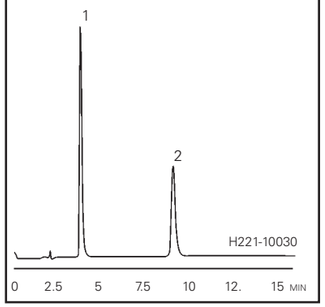
Nitrosamines

HyPURITY C18, 5µm, 150x4.6mm
Part No. 22105-154630
Eluent: 50% 10mM K_2HPO_4, pH 7 50% ACN
Flow: 1.0 mL/min
Detector: UV @ 230



Glucocorticoids

HyPURITY C18, 5µm, 150x4.6mm
Part No. 22105-154630
Eluent: 35% ACN / 65% H_2O
Flow: 1.0 mL/min
Detector: UV @ 254

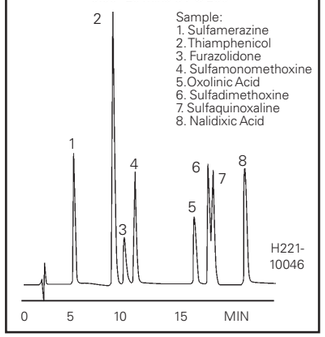


Synthetic Antibacterials

HyPURITY C18, 5µm, 150x4.6mm
Part No. 22105-154630
Gradient: A: ACN
B: 20mM H_3PO_4

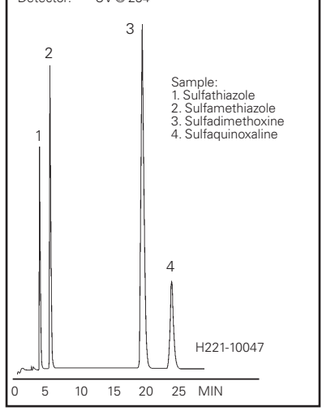
Time (mins)	%B
0	90
4	90
20	70

Flow: 1.0 mL/min
Detector: 0 - 9.55 mins UV @ 230
9.55 - 25 mins UV @ 260



Sulfur Drugs

HyPURITY C18, 5µm, 150x4.6mm
Part No. 22105-154630
Eluent: 72% 5mM Sodium-1-heptanesulfonate 28% MeOH
Flow: 1.0 mL/min
Detector: UV @ 254



HyPURITY AQUASTAR

Introduction

A new member of the HyPURITY® family, HyPURITY AQUASTAR™ columns are a new silica-based polar end-capped C18 which is designed to offer superior retention of polar compounds and increased sensitivity in 100% aqueous conditions. The robust nature of the bonded phase results in a silica-based column that is unsurpassed for LC and LC/MS applications. This next generation column also offers unmatched batch reproducibility over first generation polar end-capped columns.

HyPURITY AQUASTAR columns combine a C18 ligand with polar end-capping to produce a highly stable material for reversed phase liquid chromatography. HyPURITY AQUASTAR columns have the unique ability to retain and separate polar analytes in 100% aqueous conditions with no phase collapse. Selectivity and sensitivity can be maintained at decreased levels of buffer concentrations, making HyPURITY AQUASTAR ideal for applications involving MS detection.

Chromatographic Characterization

The inclusion of polar end-capped functionality within the HyPURITY AQUASTAR media results in additional interactions between the analyte and media other than purely hydrophobic interactions as seen with traditional alkyl chain media. These additional interactions can give rise to different retention behaviour and selectivity compared to an alkyl end-capped media. Generally, analytes with a high degree of polar character will demonstrate the greatest changes in retention and selectivity.

Increased Retention of Polar Compounds

Polar compounds can be difficult to retain on traditional C18 columns, as they tend to elute at or very close to the void volume. HyPURITY AQUASTAR columns provide additional analyte–ligand interactions compared to traditional C18 columns and show increased retention of analytes containing polar character (figure 10).

Traditional alkyl C18 columns' primary interactions are dispersive. Secondary interactions are usually associated with residual silanols and can be reduced considerably by the use of end-capping, high purity silica and increased density of the derivatized ligand. The controlled secondary interactions provided by HyPURITY AQUASTAR are now responsible for the retention of analytes with polar character.

The elimination of secondary silanol interactions results in a column that generates better peak shape than first generation polar end-capped phases for basic analytes but now shows a increase in retention for polar compounds. HyPURITY AQUASTAR columns provide an unparalleled combination of traditional reversed phase and polar interactions to fully exploit the retention of polar analytes. Figure 11 demonstrates the use of HyPURITY AQUASTAR to retain and separate catecholamines without the need for ion pair reagents in a highly aqueous mobile phase.

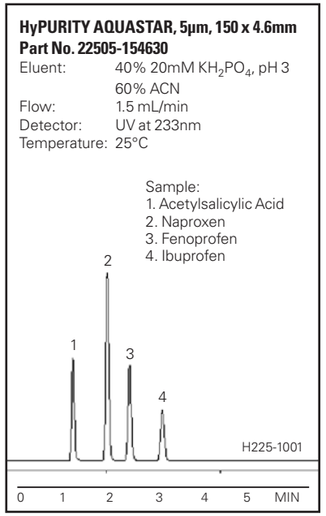


figure 10 - Analgesics

Highly Aqueous Conditions

The wetting characteristic of a media in highly aqueous conditions can be increased by the addition of polar functionality. The additional polar character of the media allows HyPURITY AQUASTAR columns to be used in 100% aqueous conditions without phase collapse and therefore loss of performance.

Traditional alkyl chain C18's, in combination with 100% aqueous conditions, often show some degree of phase collapse which is identified by loss of selectivity, resolution and decreases in retention time. Such media always include at least 5 to 10% organic solvent in the mobile phase to stop these occurrences.

HyPURITY AQUASTAR columns also provide increased sensitivity with LC/MS methodologies. Applications using LC/MS detection often require the use of mobile phase additives to control analyte ionization and retention. However, these additives lead to ion suppression and consequently a reduction in sensitivity. The choice of column in such circumstances is critical. HyPURITY AQUASTAR columns perform exceptionally well and show excellent selectivity even without mobile phase additives.

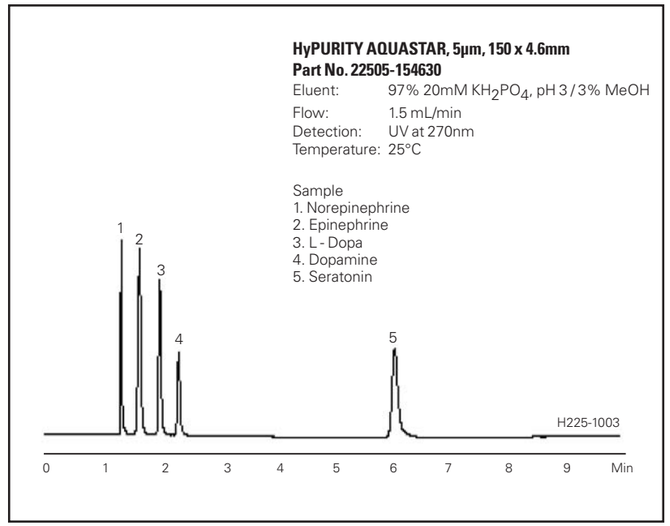


figure 11 - Catecholamines

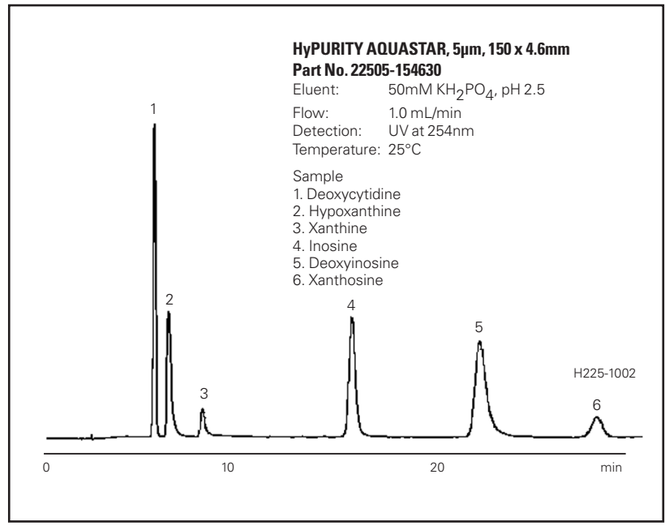


figure 12 - Nucleosides And Bases

Improvements in Chromatography
Figure 13 shows the analysis of antibacterial compounds using a) HyPURITY AQUASTAR and b) HyPURITY C18 columns. The use of an MS-friendly buffer allows the peak retention times to be reduced by approximately 50% on HyPURITY AQUASTAR columns.

Each antibacterial compound is baseline resolved from it's neighbor, even with the faster analysis time, making accurate identification and quantification possible. The faster analysis time means that for high volume analyses, HyPURITY AQUASTAR columns will be able to analyze more samples over a given period of time than a traditional C18 column. Also, the volume of solvent used per analysis is less with HyPURITY AQUASTAR than traditional C18 columns, so overall analysis costs will be lower.

Compounds that are rich in nitrogen and chlorine, for example pesticides, often produce poor peak shape when analyzed on traditional silica based alkyl chain packings. The ideal peak shape is Gaussian with a narrow base, but the peaks produced by these analytes are often non-symmetrical and broad based. Figure 14 demonstrates how, by using a HyPURITY AQUASTAR column in the analysis of pesticides, peak shape can be dramatically improved and fast analyses performed without the traditional use of gradient conditions.

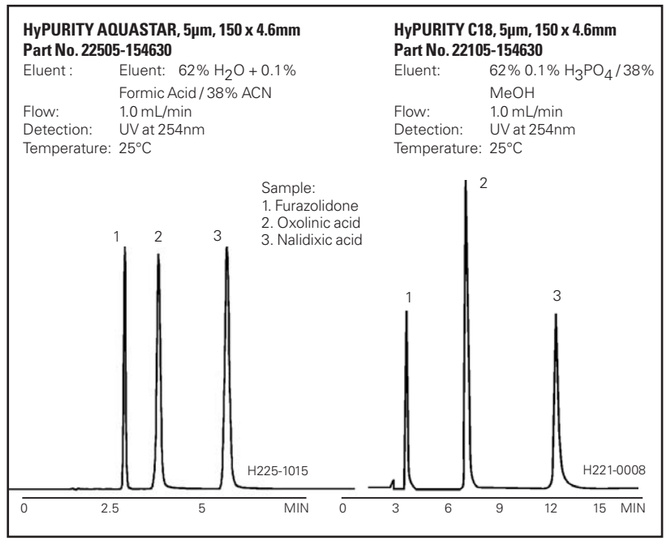


figure 13 - Antibacterials

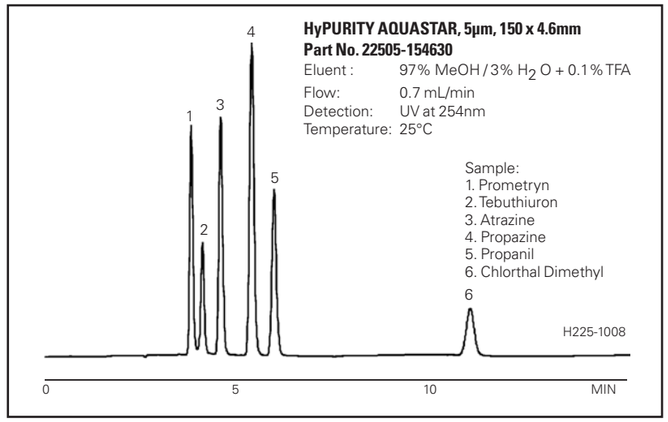


figure 14 - Pesticides

Alternative Selectivity
Although alternative selectivity, or a change in peak elution order, is not always a desired feature of a column packing material, it is something that can prove of benefit when two peaks in a chromatogram co-elute or elute very closely. Often the separation of such peaks requires that chromatographic conditions be drastically changed and/or the column chemistry modified to effect better separation. Alternative selectivity can also prove useful in the decrease of analysis time, for instance in the analysis of insulin from pancreatic extract using pharmacopoeia methods. They require that the level of a named impurity is typically less than 5%. The analysis on a traditional C18 column elutes the impurity after the main insulin peak. Using a HyPURITY AQUASTAR column, the impurity elutes prior to the main insulin peak as illustrated in figure 15, so analysis times can be decreased and higher sample throughput achieved.

Use with LC/MS Detectors
Modified phases, such as those with polar embedded functionality, are unsuitable for use with LC/MS applications, as the phase tends to "bleed". Spurious trace peaks are produced by ligands or partial ligands which wash off the column during use (type and density are determined by the analysis conditions used). However, HyPURITY AQUASTAR is a polar end-capped media. Tests have shown that HyPURITY AQUASTAR shows excellent performance under normal use conditions.

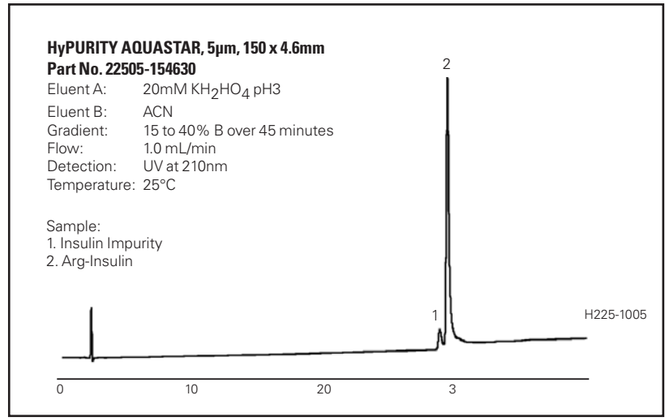


figure 15 - Insulin in Pancreatic Extract

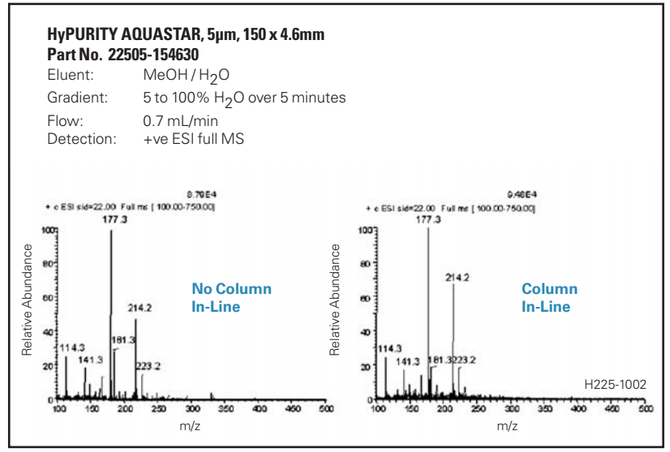


figure 16 - Phase Bleed Study

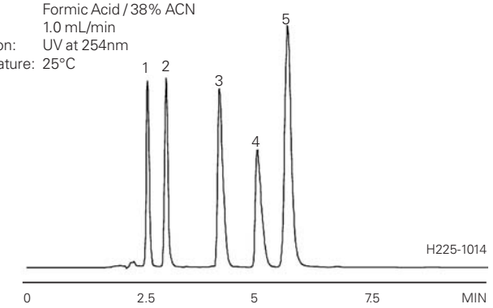
Analysis of Closely Related Compounds

The family of cephalosporin antibiotics, primarily researched and developed by Professor Sir Edward Abraham at Oxford University, UK, is used in place of penicillin to treat bronchial, skin, and other complaints in patients who are sensitive to penicillin products. Each member of the cephalosporin family is structurally very similar, differing by perhaps as little as one functional group. The structures of the compounds analyzed in figure 17 are shown.

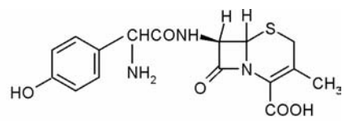
Such small differences make the analysis of a mixture of cephalosporin compounds very difficult using a traditional C18 column. Even under highly aqueous conditions, partial co-elution of compounds may occur.

The analysis of the five named cephalosporin antibiotics using HyPURITY AQUASTAR columns is impressive as all peaks are fully resolved using very simple solvents and show good shape. The additional selectivity shown by HyPURITY AQUASTAR columns over traditional C18's may be due in part to steric interactions of analytes with the stationary phase.

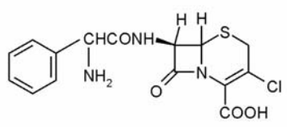
HyPURITY AQUASTAR, 5µm, 150 x 4.6mm
Part No. 22505-154630
Eluent : 62% H_2O + 0.1% Formic Acid / 38% ACN
Flow: 1.0 mL/min
Detection: UV at 254nm
Temperature: 25°C



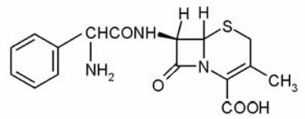
1. Cefadroxil



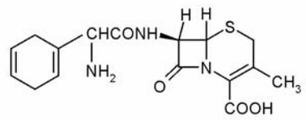
2. Cefaclor



3. Cephalexin



4. Cephradine



5. Cefazolin

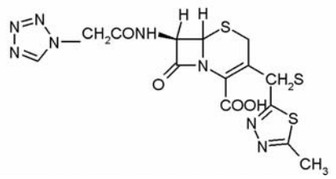
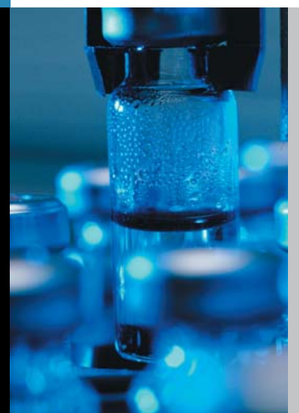


figure 17 - Cephalosporin Antibiotics



5µm HyPURITY Columns						
Description	**Length (mm)**	**4.6mm ID**	**4.0mm ID**	**3.0mm ID**	**2.1mm ID**	**1.0mm ID**
HyPURITY C18	50	22105-054630	22105-054030	22105-053030	22105-052130	22105-051030
	100	22105-104630	22105-104030	22105-103030	22105-102130	22105-101030
	150	22105-154630	22105-154030	22105-153030	22105-152130	22105-151030
	250	22105-254630	22105-254030	22105-253030	22105-252130	22105-251030
HyPURITY C8	50	22205-054630	22205-054030	22205-053030	22205-052130	22205-051030
	100	22205-104630	22205-104030	22205-103030	22205-102130	22205-101030
	150	22205-154630	22205-154030	22205-153030	22205-152130	22205-151030
	250	22205-254630	22205-254030	22205-253030	22205-252130	22205-251030
HyPURITY C4	50	22405-054630	22405-054030	22405-053030	22405-052130	22405-051030
	100	22405-104630	22405-104030	22405-103030	22405-102130	22405-101030
	150	22405-154630	22405-154030	22405-153030	22405-152130	22405-151030
	250	22405-254630	22405-254030	22405-253030	22405-252130	22405-251030
HyPURITY Cyano	50	22805-054630	22805-054030	22805-053030	22805-052130	22805-051030
	100	22805-104630	22805-104030	22805-103030	22805-102130	22805-101030
	150	22805-154630	22805-154030	22805-153030	22805-152130	22805-151030
	250	22805-254630	22805-254030	22805-253030	22805-252130	22805-251030
HyPURITY ADVANCE	50	21005-054630	21005-054030	21005-053030	21005-052130	21005-051030
	100	21005-104630	21005-104030	21005-103030	21005-102130	21005-101030
	150	21005-154630	21005-154030	21005-153030	21005-152130	21005-151030
	250	21005-254630	21005-254030	21005-253030	21005-252130	21005-251030
HyPURITY AQUASTAR	50	22505-054630	22505-054030	22505-053030	22505-052130	22505-051030
	100	22505-104630	22505-104030	22505-103030	22505-102130	22505-101030
	150	22505-154630	22505-154030	22505-153030	22505-152130	22505-151030
	250	22505-254630	22505-254030	22505-253030	22505-252130	22505-251030
To order standard columns with intergral guard (COLUMNPLUS Guard or CPG), please change the last 2 digits of the part number above to 31.						
5µm HyPURITY Drop-In Guard Cartridges 4/pk						
Description	**Length (mm)**	**4.6mm ID**	**4.0mm ID**	**3.0mm ID**	**2.1mm ID**	**1.0mm ID**
HyPURITY C18	10	22105-014001	22105-014001	22105-013001	22105-012101	22105-011001
HyPURITY C8	10	22205-014001	22205-014001	22205-013001	22205-012101	22205-011001
HyPURITY C4	10	22405-014001	22405-014001	22405-013001	22405-012101	22405-011001
HyPURITY Cyano	10	22805-014001	22805-014001	22805-013001	22805-012101	22805-011001
HyPURITY ADVANCE	10	21005-014001	21005-014001	21005-013001	21005-012101	21005-011001
HyPURITY AQUASTAR	10	22505-014001	22505-014001	22505-013001	22505-012101	22505-011001
UNIGUARD Direct-Connect Drop-in Guard Cartridge Holder		850-00	850-00	852-00	852-00	851-00
3µm HyPURITY Columns						
Description	**Length (mm)**	**4.6mm ID**	**4.0mm ID**	**3.0mm ID**	**2.1mm ID**	**1.0mm ID**
HyPURITY C18	50	22103-054630	22103-054030	22103-053030	22103-052130	22103-051030
	100	22103-104630	22103-104030	22103-103030	22103-102130	22103-101030
	150	22103-154630	22103-154030	22103-153030	22103-152130	22103-151030
	250	22103-254630	22103-254030	22103-253030	22103-252130	22103-251030
HyPURITY ADVANCE	50	21003-054630	21003-054030	21003-053030	21003-052130	21003-051030
	100	21003-104630	21003-104030	21003-103030	21003-102130	21003-101030
	150	21003-154630	21003-154030	21003-153030	21003-152130	21003-151030
	250	21003-254630	21003-254030	21003-253030	21003-252130	21003-251030
HyPURITY AQUASTAR	50	22503-054630	22503-054030	22503-053030	22503-052130	22503-051030
	100	22503-104630	22503-104030	22503-103030	22503-102130	22503-101030
	150	22503-154630	22503-154030	22503-153030	22503-152130	22503-151030
	250	22503-254630	22503-254030	22503-253030	22503-252130	22503-251030
To order standard columns with intergral guard (COLUMNPLUS Guard or CPG), please change the last 2 digits of the part number above to 31.						
3µm HyPURITY Drop-In Guard Cartridges 4/pk						
Description	**Length (mm)**	**4.6mm ID**	**4.0mm ID**	**3.0mm ID**	**2.1mm ID**	**1.0mm ID**
HyPURITY C18	10	22103-014001	22103-014001	22103-013001	22103-012101	22103-011001
HyPURITY ADVANCE	10	21003-014001	21003-014001	21003-013001	21003-012101	21003-011001
HyPURITY AQUASTAR	10	22503-014001	22503-014001	22503-013001	22503-012101	22503-011001
UNIGUARD Direct-Connect Drop-in Guard Cartridge Holder		850-00	850-00	852-00	852-00	851-00

All HyPURITY phases are also available in other standard columns dimensions including capillary columns, and unique hardware for LC/MS and high throughput analyses. Please enquire for more information.