

A Comparison of MaxPeak Premier Columns With MaxPeak HPS Technology versus PEEK-lined Column Hardware

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This is an Application Brief and does not contain a detailed Experimental section.

Abstract

Anionic or electron-rich analytes often have poor peak shape and low signal intensity in liquid chromatography (LC) analysis due to analyte loss via adsorption on electron-deficient metal surfaces, such as stainless steel.¹ Alternative column hardware made entirely of PEEK (Polyether Ether Ketone), or stainless-steel columns with a PEEK lining, have recently been utilized for these applications to eliminate analyte loss. However, columns that utilize PEEK materials can exhibit other undesirable problems such as lower plate efficiency and more column-to-column variability than traditional stainless-steel hardware.

The MaxPeak Premier class of columns feature MaxPeak High Performance Surfaces (HPS) hardware, making it possible to more easily study metal-sensitive analytes. The MaxPeak High Performance Surface provides an effective barrier to metal-analyte interactions and any related loss of sample due to non-specific adsorption.

In this application brief, we have compared MaxPeak HPS Column hardware to PEEK-lined stainless-steel hardware from two different vendors. We highlight the advantages of the MaxPeak HPS Column hardware versus PEEK-lined stainless-steel hardware in achieving high-quality separations.

Benefits

- Better column efficiency
- Better peak shape
- Lower column backpressure
- More consistent column-to-column reproducibility
- Excellent analyte recovery

Introduction

Adsorption of analytes to metal surfaces has long been a problem in chromatography. Previous mitigation strategies have included passivation of surfaces, use of mobile phase additives, and the incorporation of inert hardware material. While these approaches are successful to some degree, they have their drawbacks.

Passivation of surfaces with either a strong acid, or with sample and/or matrix conditioning are time consuming, require the use of strong acids, and are not longstanding.² Mobile phase additives such as chelators can help to prevent analyte-metal adsorption, but also have drawbacks including ion suppression, solubility issues, and the fact that they must be used consistently in order to remain effective.³

Columns featuring titanium hardware are now being offered commercially as a more bioinert alternative to conventional stainless-steel columns. Titanium is resistant to corrosion and is inert to some compounds, however, due to its metallic nature, it too can cause analyte adsorption and sample loss.⁴

Also offered commercially are PEEK columns or PEEK-lined steel columns, which replace all metal surfaces with non-reactive material. PEEK alone is not tolerant of high-pressure use, a limitation that can be mitigated by using PEEK-lined stainless-steel. However, the other limitations of PEEK remain; compared to stainless-steel, PEEK materials have higher dimensional variability, lower frit permeability, and are incompatible with some solvents.

In this work, we examine the differences in packed bed efficiency and column-to-column reproducibility for MaxPeak HPS hardware versus PEEK-lined stainless-steel hardware from two different vendors. The MaxPeak High Performance Surface used in this comparison is a hybrid organic/inorganic surface technology that has been shown to act as a barrier to the interaction of analytes with metal surfaces.⁵ Both types of hardware are

effective at mitigating analyte loss due to metal adsorption, but MaxPeak HPS hardware shows several clear advantages due to superior packed bed quality.

Results and Discussion

We examined the packed bed efficiency of a single batch of BEH C₁₈, 2.5 µm stationary phase packed into MaxPeak HPS Column hardware versus the same material packed into PEEK-lined stainless-steel hardware from two different vendors. The packing processes were optimized for all columns in this study. Table 1 is a comparison of the column efficiency results. From the averages reported in Table 1, we observe 20–25% lower efficiency in PEEK-lined hardware versus MaxPeak HPS hardware. The column backpressure was approximately 25% higher in PEEK-lined hardware versus MaxPeak HPS hardware, despite all columns being packed similarly. Additionally, the peak symmetry was best in the MaxPeak HPS hardware.

A PEEK-lined columns, Vendor A

Column serial	USP plates	RPH	USP tailing	kPrime	PSI
01912101930J01	9378	2.29	1.229	3.72	1516
01912101930J02	8127	2.64	1.256	3.73	1578
01912101930J03	9453	2.27	1.225	3.77	1597
01912101930J04	8465	2.54	1.286	3.80	1642
01912101930J05	8885	2.42	1.245	3.79	1598
Average	8862	2.43	1.25	3.76	1586
Std. dev.	573	0.16	0.02	0.04	46
%RSD	6.5	6.5	2.0	0.9	2.9

B PEEK-lined columns, Vendor B

Column serial	USP plates	RPH	USP tailing	kPrime	PSI
01912102050K06	9527	2.25	1.168	3.72	1583
01912102050K07	9308	2.31	1.144	3.62	1498
01912102050K08	9713	2.21	1.152	3.68	1561
01912102050K09	8594	2.50	1.238	3.68	1589
01912102050K10	9375	2.29	1.196	3.69	1613
Average	9303	2.31	1.18	3.68	1569
Std. dev.	426	0.11	0.04	0.04	44
%RSD	4.6	4.8	3.2	1.0	2.8

C MaxPeak HPS columns

Column serial	USP plates	RPH	USP tailing	kPrime	PSI
01912102050K01	11607	1.85	1.115	3.57	1261
01912102050K02	12215	1.76	1.066	3.59	1281
01912102050K03	12301	1.74	1.059	3.59	1268
01912102050K04	11794	1.82	1.064	3.61	1287
01912102050K05	11782	1.82	1.066	3.60	1284
Average	11940	1.80	1.07	3.59	1276
Std. dev.	301	0.05	0.02	0.01	11
%RSD	2.5	2.2	2.5	0.4	0.9

Table 1. Column efficiency results in 75% acetonitrile, 30 °C, 0.30 mL/min, 254 nm UV detection, for an isocratic

separation of octanophenone using BEH C₁₈, 2.5 μm material packed into (A) PEEK-lined Columns from Vendor A, (B) PEEK-lined Columns from Vendor B, and (C) MaxPeak HPS Column hardware. Analyses were performed with 2.1 x 50 mm columns on an ACQUITY UPLC chromatograph configured with a Fixed Loop Sample Manager.

In addition, we examined the column-to-column reproducibility for the MaxPeak HPS Columns, versus PEEK lined hardware from Vendors A and B. Five columns were packed in each hardware type. All fifteen columns were packed with an identical pack process and tested under identical conditions. Figure 1 shows the chromatograms obtained on each hardware type. Significant differences in retention time and retention variability were seen between the three types of columns. The higher retention time variability in the PEEK-lined hardware is likely due to difficulties in dimensional tolerancing for PEEK material versus stainless steel, as well as differences in how the two types of hardware behave under pressure during packing.

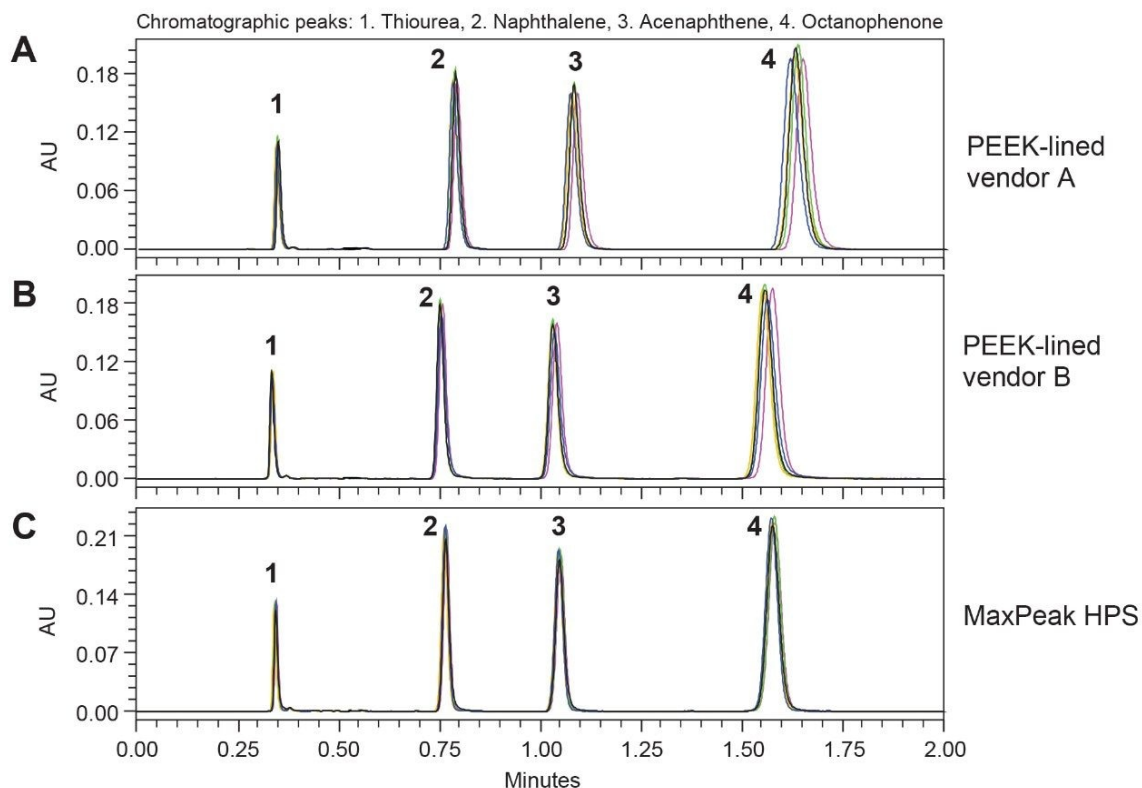


Figure 1. Chromatograms for $N=5$ columns packed in (A) PEEK-lined Vendor A hardware, (B) PEEK-lined Vendor B hardware, and (C) MaxPeak HPS hardware. Analyses were performed with an ACQUITY UPLC chromatograph and 2.1×50 mm columns packed with C_{18} , $2.5 \mu\text{m}$ stationary phase. Isocratic separation conditions included a flow rate of 0.30 mL/min , column temperature of $30 \text{ }^\circ\text{C}$, 75% acetonitrile, 254 nm UV detection, and $1 \mu\text{L}$ injection volumes.

Prior to packing, the inner diameter of each piece of column hardware was measured to the nearest ten thousandth of an inch using a set of precision calibrated pin gages. Each end of the column tube was measured, and the average value is used to represent the inner diameter for each column. A column volume was then calculated for each piece of column hardware, assuming an exact length of 50 mm . Figure 2 shows a plot of the calculated column volume versus V_0 retention time for each of the three hardware types. We note that there is a good linear fit for column volume versus V_0 retention time for the MaxPeak HPS hardware, while no such trend is observed for either vendor of PEEK-lined hardware. From this, we can theorize that the inner diameter of the PEEK-lined hardware is not consistent along the entire length of the column, resulting in differences in linear

velocity with the column under flow.

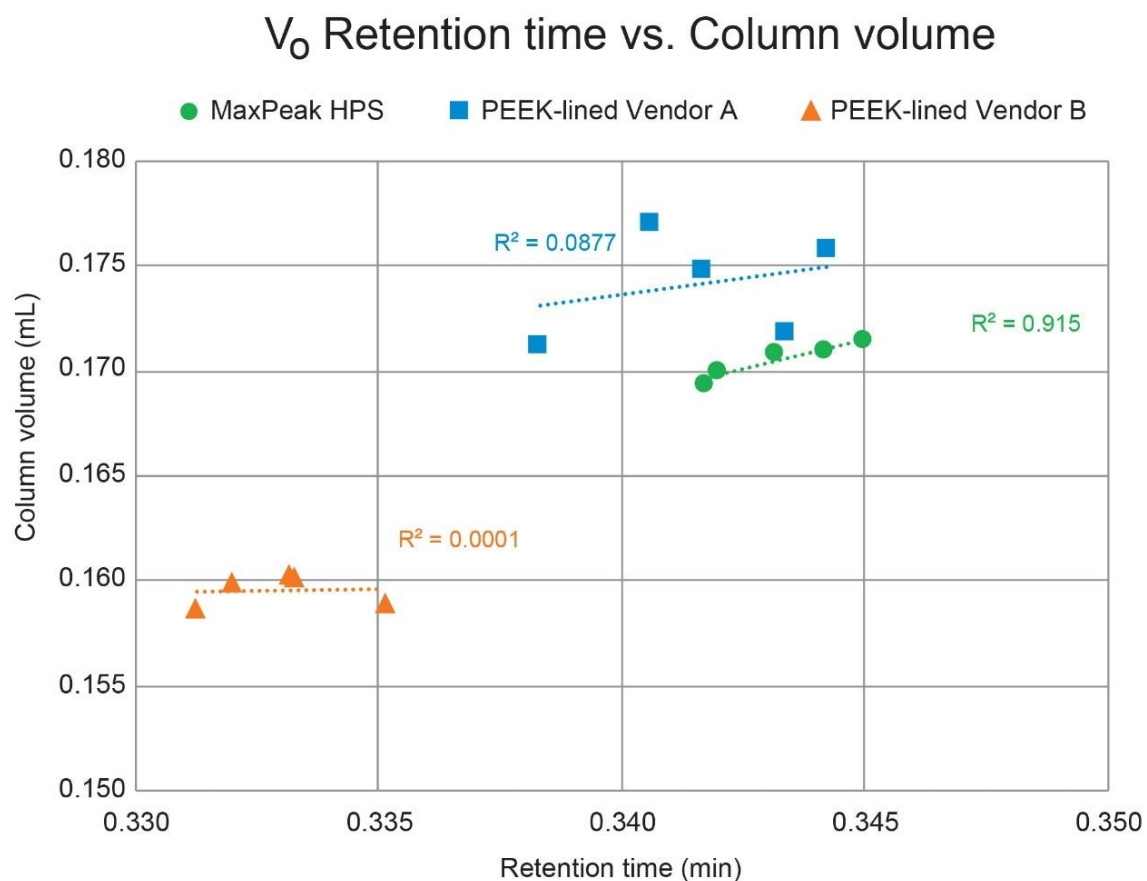


Figure 2. V₀ retention time (thiourea) versus calculated column volume for 2.1 x 50 mm columns packed with a 2.5 μm, C₁₈ stationary phase for MaxPeak HPS, Vendor A PEEK-lined, and Vendor B PEEK-lined column hardware. Column volumes were calculated from measurements of the inner diameter of each column tube. Analyses were performed with an ACQUITY UPLC chromatograph. Isocratic separation conditions included a flow rate of 0.30 mL/min, column temperature of 30 °C, 75% acetonitrile mobile phase, 254 nm UV detection, and 1 μL injection volumes.

Conclusion

MaxPeak Premier Columns featuring MaxPeak High Performance Surfaces (HPS) Technology have enabled significant gains in recovery, resolution, and peak shape for metal sensitive analytes. The hybrid organic/inorganic technology of MaxPeak HPS offers a barrier to analyte-metal adsorption, granting improvements in anionic or electron-rich analyte recoveries. While this may also be true of PEEK-lined stainless-steel column hardware, it comes at the expense of inferior column efficiency and peak shape, higher column backpressure, and more column-to-column variability than MaxPeak HPS hardware.

MaxPeak Premier Columns with MaxPeak HPS Technology offer the benefits of excellent recovery of metal sensitive analytes, combined with the highest column efficiencies and column-to-column reproducibility of commercially available inert column offerings.

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